NEW

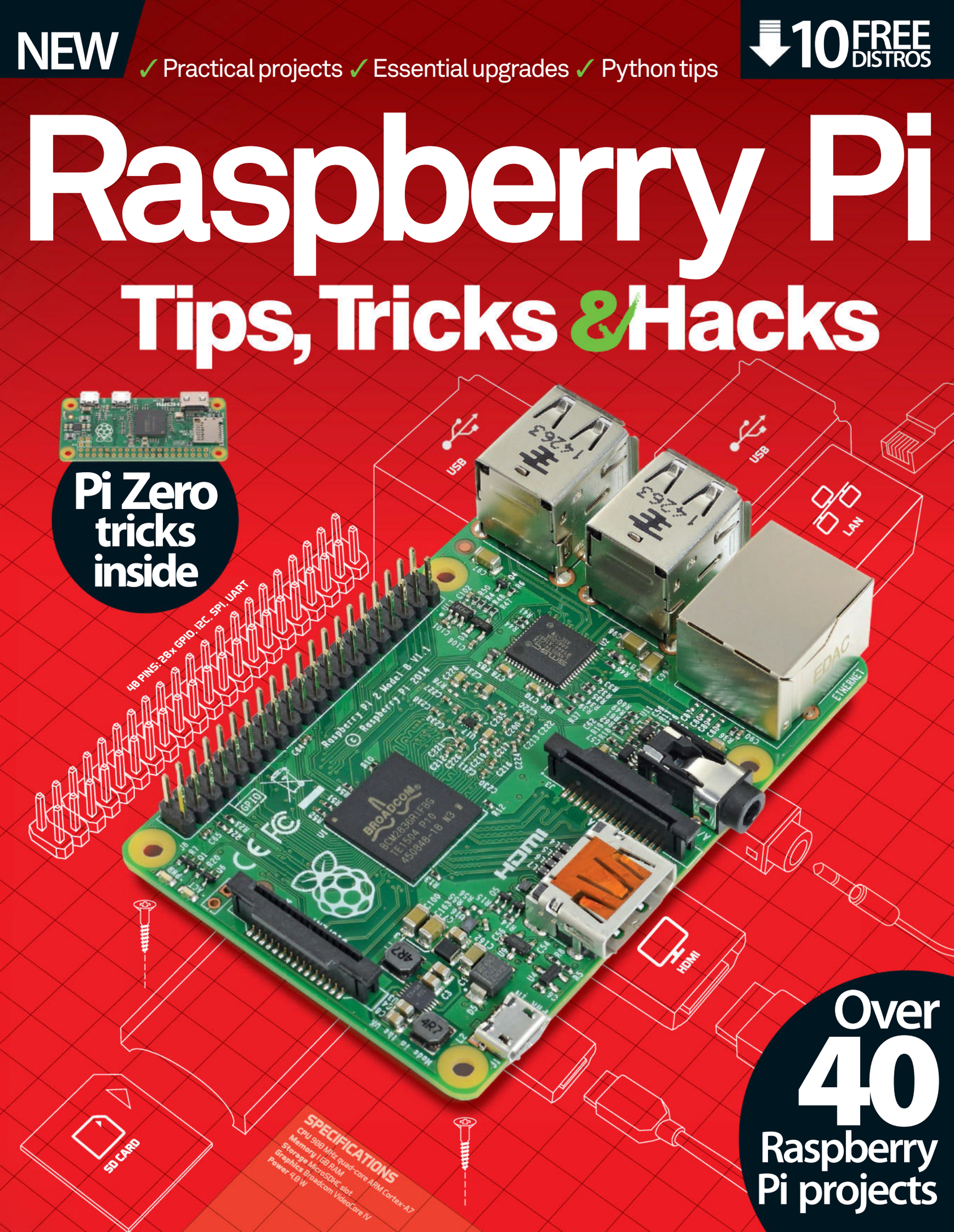
✓ Practical projects ✓ Essential upgrades ✓ Python tips

10 FREE DISTROS

Raspberry Pi

Tips, Tricks & Hacks

Pi Zero tricks inside



Over 40 Raspberry Pi projects

Welcome to

Raspberry Pi

Tips, Tricks & Hacks

The Raspberry Pi is powering a computing revolution that is sweeping the world. It's changed the face of the classroom forever, it's used in amazingly creative projects at Raspberry Jam events everywhere from Yorkshire villages to the capital of Australia, and every weekend families get together to code, create and craft new gadgets. Whether you're six or sixty, there's a Pi project for you. And that's where we come in. In this new edition of Raspberry Pi Tips, Tricks & Hacks we're giving you everything you need to not only get up and running with a brand new Raspberry Pi, but also fire up your imagination and unleash your creativity. From programming-based projects like tethering your Pi to an Android, through hardware projects including digital photo frames, arcade machines and touch-screen video players, all the way to advanced robotics projects that will see you building your own Raspberry Pi-powered, remote control vehicles and car computers, we've got plenty here to keep you busy. All you need is your favourite $35 computer – and a passion for making things!

Raspberry Pi

Tips, Tricks & Hacks

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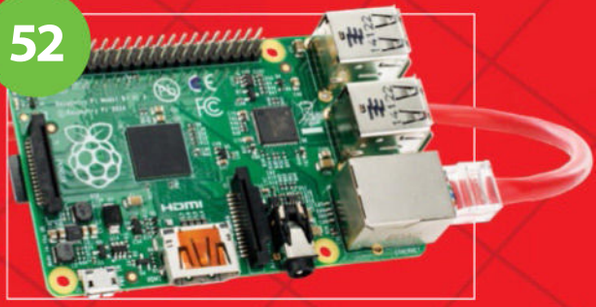

"Use a motion-sensing Raspberry Pi to automatically take pictures"

"It has powered quadcopters, coffee makers, self-sailing boats and even touched the edge of space"

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Master Raspberry Pi in 7 days

From setup to internet sensation in a week...

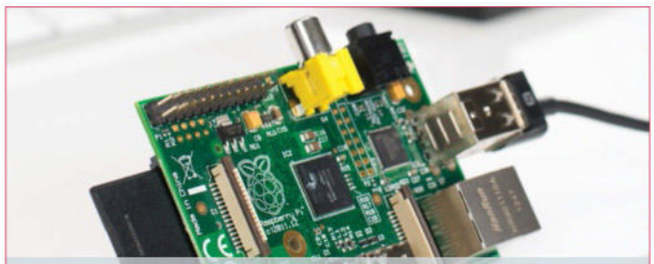
It's amazing what can be accomplished with the Raspberry Pi if you set your mind to it. They've been sent higher into orbit than Felix Baumgartner, they power cutting-edge Bitcoin farms and someone's even using one to try and translate dog thoughts into speech with a Pi-infused collar. No prizes for guessing where the inspiration for **www.nomorewoof.com** came from. No one really knows if it's ever going to work, but does it matter? The mere fact that someone's even trying to bring a piece of Disney fantasy to life using the same technology as your Raspberry Pi is inspiring stuff!

While we won't be taking pictures at four times the altitude of a cruising jumbo jet or translating the musings of a canine companion, the seven projects you'll find over the next 16 pages will certainly get you off on the right foot. Our final big project will be to use a motion-sensing Raspberry Pi to automatically take pictures of local wildlife and tweet them to the world.

Not bad, especially since we're assuming you have no prior experience with the Raspberry Pi. Yes, we expect you to know where to stick the other end of the HDMI cable, but we don't assume that you can program with Python or navigate the command line interface. We'll gradually learn as we go, first by setting up the Pi and learning key programming logic with Scratch and Sonic Pi. We'll then move on to writing simple Python scripts, getting to grips with the Camera module and using the GPIO port among other things. By the end of it you should have all the skills and equipment needed to complete the final project – and much more besides...

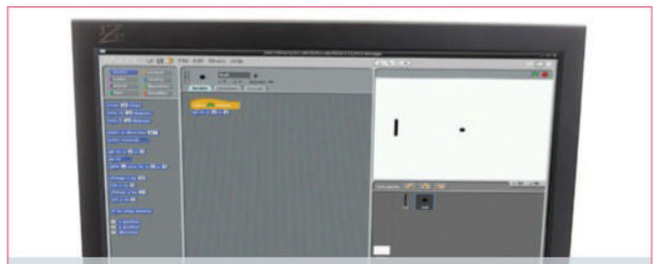
April
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
Scratch
Sonic Pi
Camera
GPIO
Twitter API
Final Project!
PRT-08023
sparkfun

Plan your week



Day 1 Set up your Raspberry Pi

It's not rocket science, but we'll get you started



Day 2 Make a game from Scratch

Learn the basics of coding with graphical feedback

Day 3 Learn code with Sonic Pi

Write functional code while making beautiful music

Day 4 Take photos with your Pi

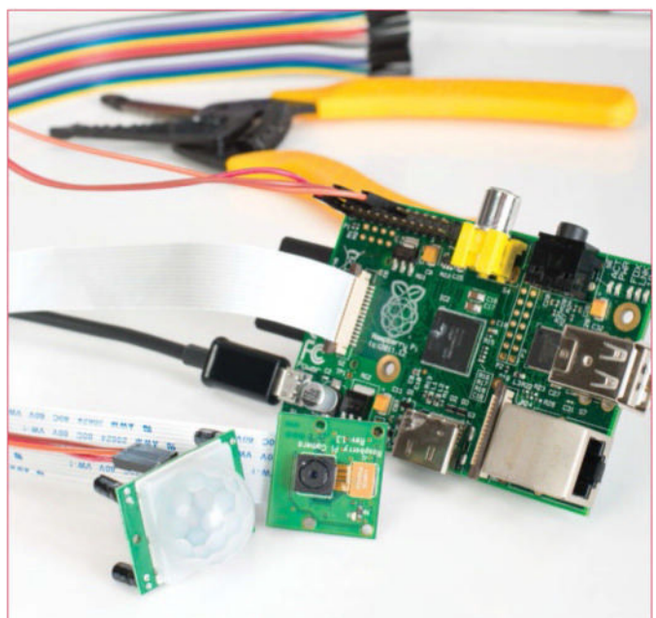
Use Python to take great snaps with your camera

Day 5 Get to grips with GPIO

Create a simple but elegant candlelight project

Day 6 Use the Twitter API

Create an Internet of Things Twitter lamp



Day 7 Put it all together!

Automagically share wildlife shots with this motion-sensing, picture-taking, Twitter-posting project

Pi projects shopping list

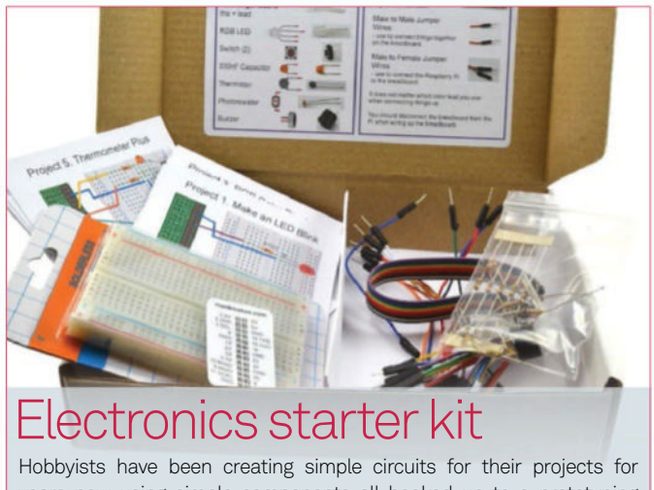
Grab these extra components before taking part in our week of Raspberry Pi...

We'll be covering a variety of different project types over the course of these tutorials, so you may want to stock up on some components and accessories to help you get through the week. This is just the tip of the iceberg, though - each supplier offers plenty of kit for new projects...

Pibow case

A beautiful and functional case for your Raspberry Pi, with all the necessary openings that will allow you to access the camera module ribbon and the GPIO port on the board itself. The Pibows come in a variety of different colours, and there's even a special version for the Model A, with even greater access to the technical ports. It can also be modified with an extra platter to attach to a TV if you plan on using the Pi in your home theatre setup.

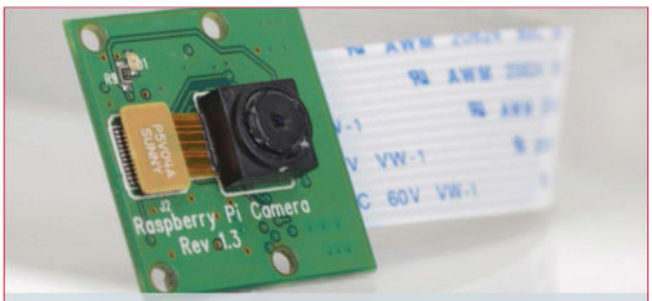
£12.95 | shop.pimoroni.com



Electronics starter kit

Hobbyists have been creating simple circuits for their projects for years now using simple components all hooked up to a prototyping breadboard. While you can hunt around and get all the parts you need for this, there are a handful of electronic starter kits that include everything you need for our projects this issue (and much more besides). Simon Monk has created one of these kits, which includes a breadboard, pre-cut cables, switches, resistors and a whole host of other little components and sensors for any electronics project.

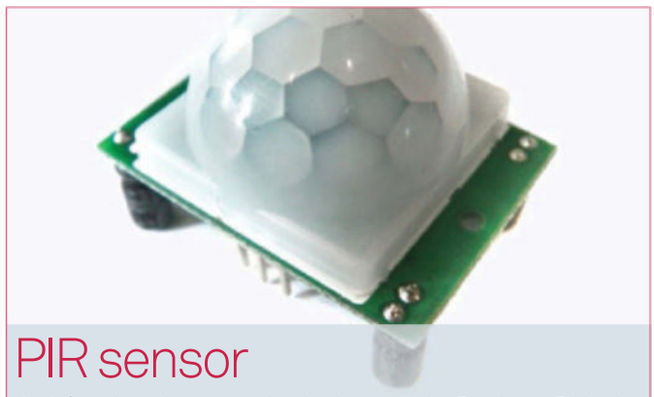
£15 | bit.ly/1oE9BYC



Raspberry Pi camera board

The Pi-specific camera board has been created in such a way that it connects to one of the video in ports for the Raspberry Pi on the actual board itself. This means it won't use up any of the limited USB ports or other inputs, so that you don't need to get a USB hub to have everything working. The camera isn't the highest resolution offering in the world, but it's a respectable 5MP that can take images at 2592 x 1944 and record video at 1080p at 30 fps, which is more than enough for most projects.

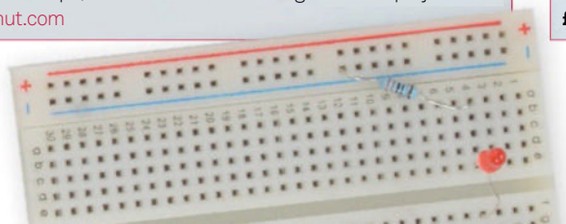
£19.99 | thepihut.com



PIR sensor

An infrared motion sensor that hooks up to the Raspberry Pi via the GPIO port. It sends a constant signal depending on the level of infrared radiation that it detects, which can be used to determine when to activate a piece of code. For example, IR sensors are classically used in alarm systems, however they can also be used to take pictures or video on demand, which is how we're planning to use it at the end of the week.

£2.99 | modmypi.com



What you'll need

- 1A micro USB
- Internet connection
- USB mouse and keyboard
- HDMI cable and compatible monitor
- 4GB SD card

Set up your Raspberry Pi

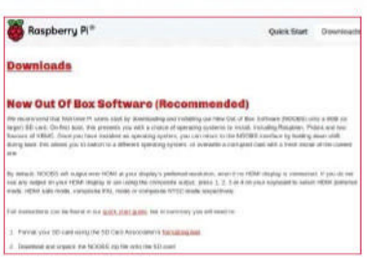
Turn your Raspberry Pi into a fully functional PC and get to know the basics of setting it up

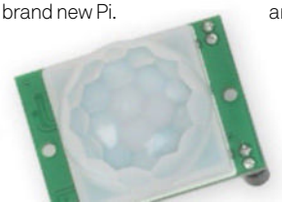
So you've just got your Raspberry Pi – you're probably wondering how exactly you're going to get started with it. If you're used to more traditional PCs, you might be expecting a CD drive or a USB installer to set up your Raspberry Pi. The Pi requires a little more than sticking in a CD though, so we'll show you how to get everything working properly.

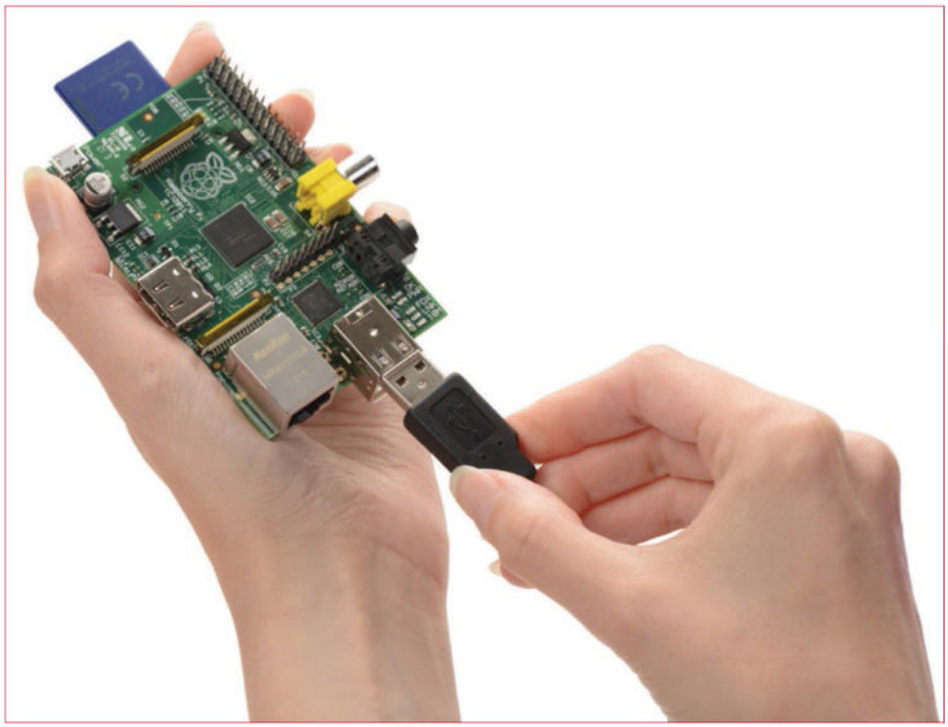
In this tutorial we'll also give you some quick tips on how to improve your Raspberry Pi experience, including extra software packages and ways you can use your brand new Pi.

01 Get your operating system

Head over to the Raspberry Pi website (**www.raspberrypi.org**) and download NOOBS, the New Out Of Box Software. This will come in a zip file; download it onto the SD card for your Raspberry Pi and extract the files from it here. Do not extract the files elsewhere and copy them over.

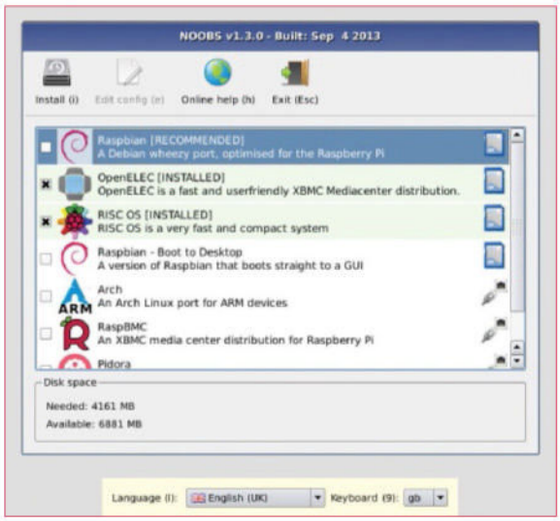






02 Connect your Pi

Without inserting the power cable, hook up everything to your Pi. You'll need a wired ethernet connection or a compatible wireless dongle, a USB mouse, a USB keyboard and a monitor or other form of display connected via HDMI.

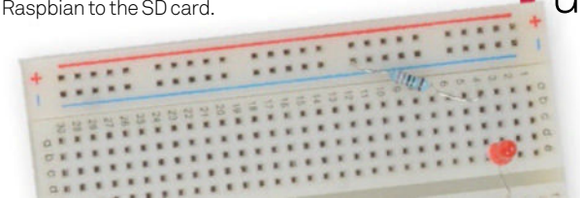


03 Choose your distro

Plug in your SD card and finally connect the power. The Raspberry Pi will boot into NOOBS' distro selection menu. For all of our tutorials we will be using Raspbian, however the other distros each have their uses and you may want to consider using them at a later date.

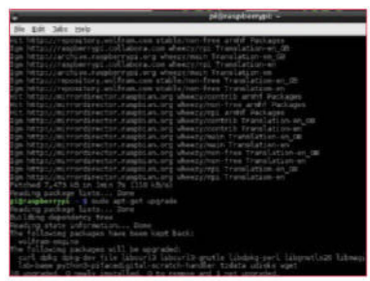
04 Install Raspbian

Select Raspbian by clicking the check box to the left of it, and then click Install at the top of the Window. Confirm that you want to install, and it will go through the process of adding Raspbian to the SD card.



05 Set up Raspbian

There are a few things you need to do before Raspbian is ready. On the config screen, select Expand Filesystem to make sure the SD is being used properly. Then, go to Enable Boot to Desktop and select Desktop from the list. Go to Finish, and it will reboot Raspbian.



06 Update Raspbian

Make sure all the software on Raspbian is now up to date. To do this, open the LXTerminal and type:

```
$ sudo apt-get update
```

Once that's finished, follow it up with:

```
$ sudo apt-get upgrade
```

This may end up taking a few minutes, but it will update the software throughout Raspbian.

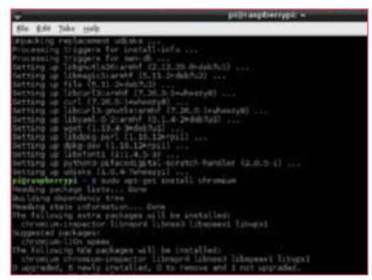
> The other distros each have their uses and you may want to use them at a later date

07 Get new software

There are two ways to get more packages for Raspbian – either through the Pi Store link, or via the package manager in the terminal. You'll get a different selection of apps on the two services, with a greater focus on general software tools in the package manager

08 Get an office suite

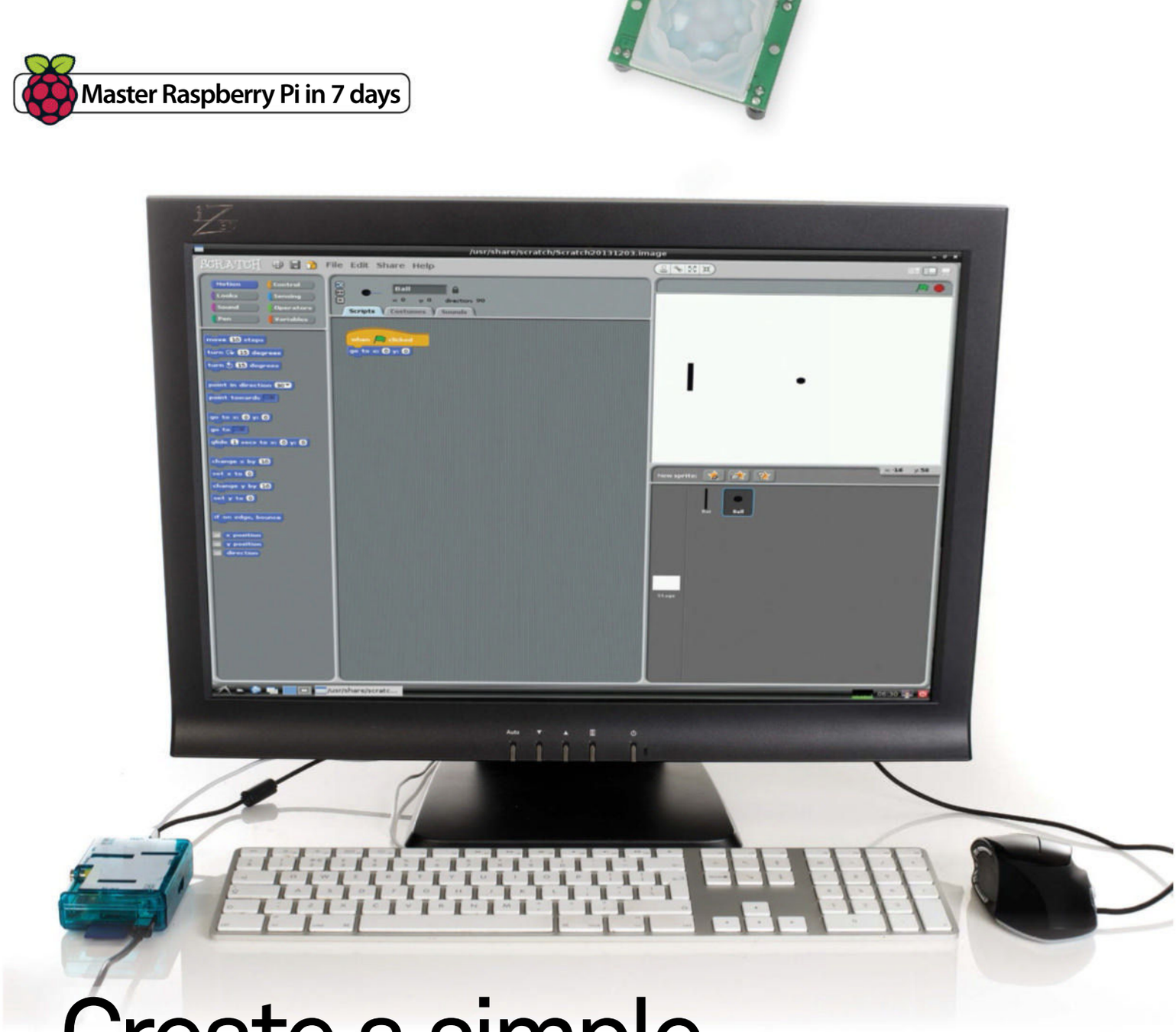
Raspbian does not have any form of office functionality by default, only a basic text editor. You can add LibreOffice though, which can be done via the Pi Store. Open up the Store and go to Apps; here you'll find LibreOffice as a free download. Once you've created an account, it will download and install it.



09 Get a better browser

Midori is an excellent browser, however you can also get Chromium to work on Raspbian. This is the open source version of Google's Chrome browser, which you can get by opening the terminal and typing:

```
$ sudo apt-get install chromium
```



Create a simple game with Scratch

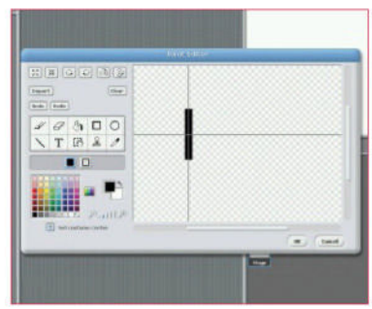
Learn the basics of coding logic by creating a squash-like Pong clone in Scratch that you can play at the end of the day

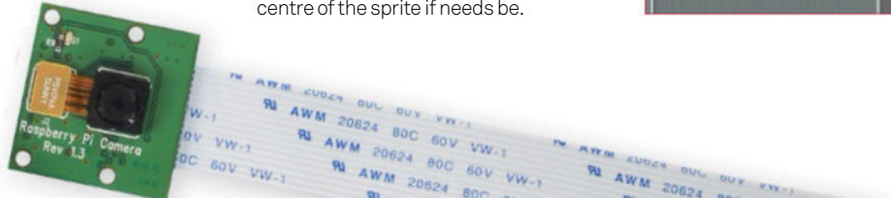
While Scratch may seem like a very simplistic programming language that's just for kids, you'd be wrong to overlook it as an excellent first step into coding for all age levels. One aspect of learning to code is understanding the underlying logic that makes up all programs; comparing two systems, learning to work with loops and general decision-making within the code.

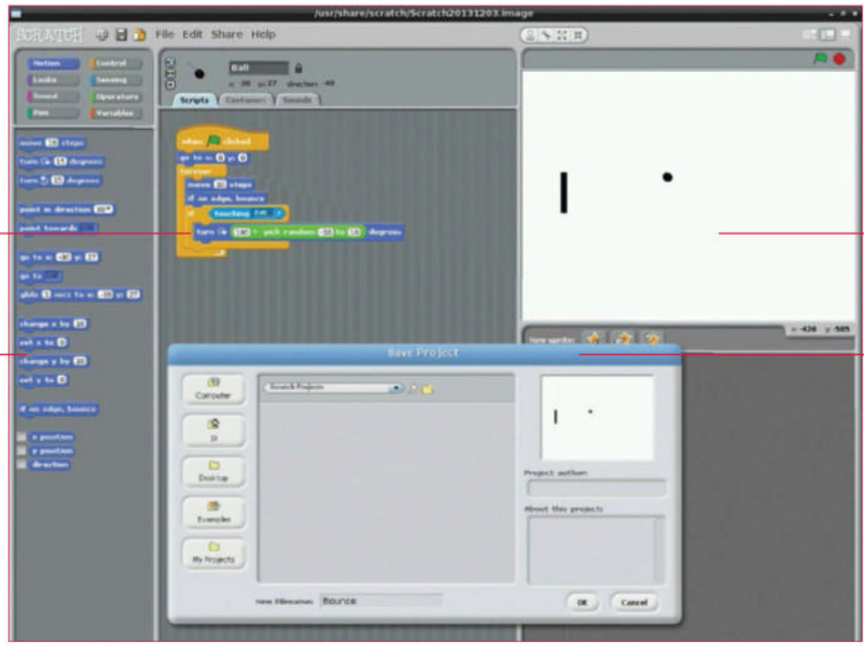
Scratch strips away the actual code bit and leaves you with just the logic to deal with. This makes it a great starting point for beginners, separating the terminology so you can learn that later on when you choose to make a proper program. It's also included on every copy of Raspbian.

01 The first sprite

Opening up Scratch will display a blank game with the Scratch cat; right-click on it and delete to remove it. Click the Paint New Sprite button below the game window and draw a slim rectangle as the bat using the square drawing tool. Click Set Costume Center so that Scratch knows the basic dimensions of your bat; drag it to the centre of the sprite if needs be.

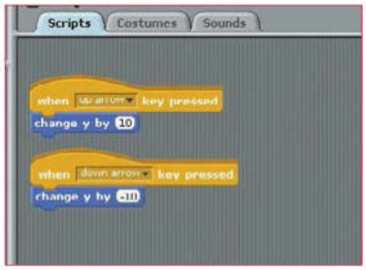






02 Move the bat

Click OK, and name the new sprite 'Bat'. Select the Control block from the top-left menu, and drag the When Space Key Pressed block into the script area. Change Space to Up arrow from the drop-down menu, then select the Motion options and drag the Change Y By 10 block to connect to the key pressed block.

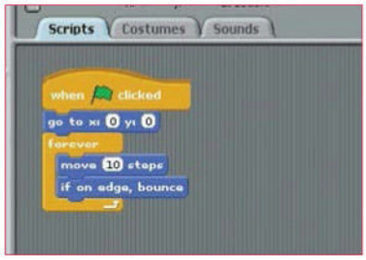


03 Reverse the direction

Whenever we press up, the bat will move up by ten pixels, as set. By repeating the process using the down arrow and setting Change Y To -10, we can also make it move down as well. Move the rectangle to the left side of the screen. This will be our starting position.

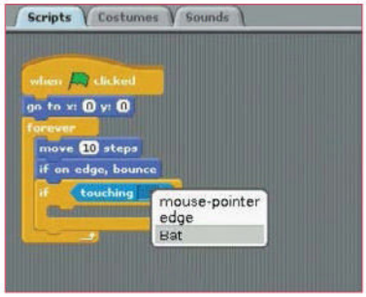
04 Create the ball

Create a sphere from the new sprite menu like we did with the bat, including setting the Costume Center. Name it ball, and bring the When Green Flag Clicked block from the Control menu into the scripts pane. Add the go to x:0 y:0 block underneath it so that whenever you click the green flag it resets to the ball.



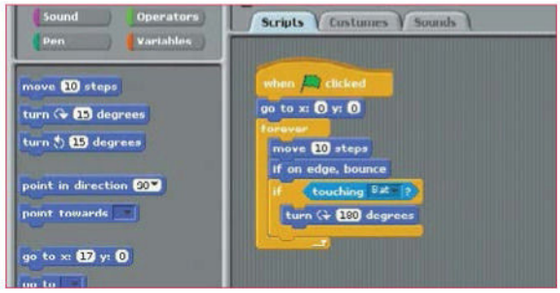
05 Move the ball

Find the Forever block in the control menu, and attach it under our existing block on Ball. Then, go back to the Motion menu and add Move 10 Steps so that the ball moves around the screen. Add the If On Edge, Bounce block from Motion below that so that it will stay within the playing field.



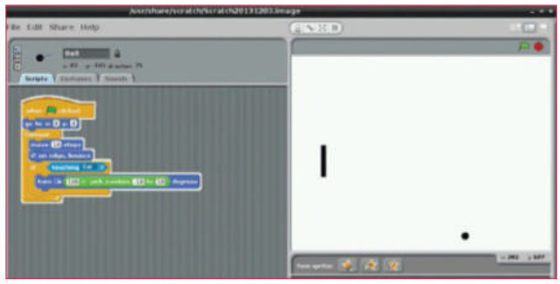
06 Hit the ball

Drag the If block from Control to below If On Edge, and then add touching from Sensing to the empty space on the If block. From the drop-down menu, select Bat so that it will interact with our bat sprite. Add one of the Turn 15 degrees blocks from Motion to the If block, and change it to 180.



07 Simple bouncing

Pressing the green flag now, the ball will bounce between the left and right edges of the screen, or off the bat if it comes into contact with it. We can make it slightly more interactive to make use of the moving bat, and more like Pong.

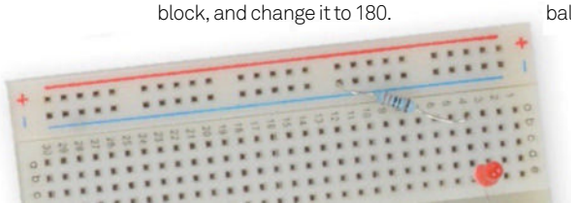


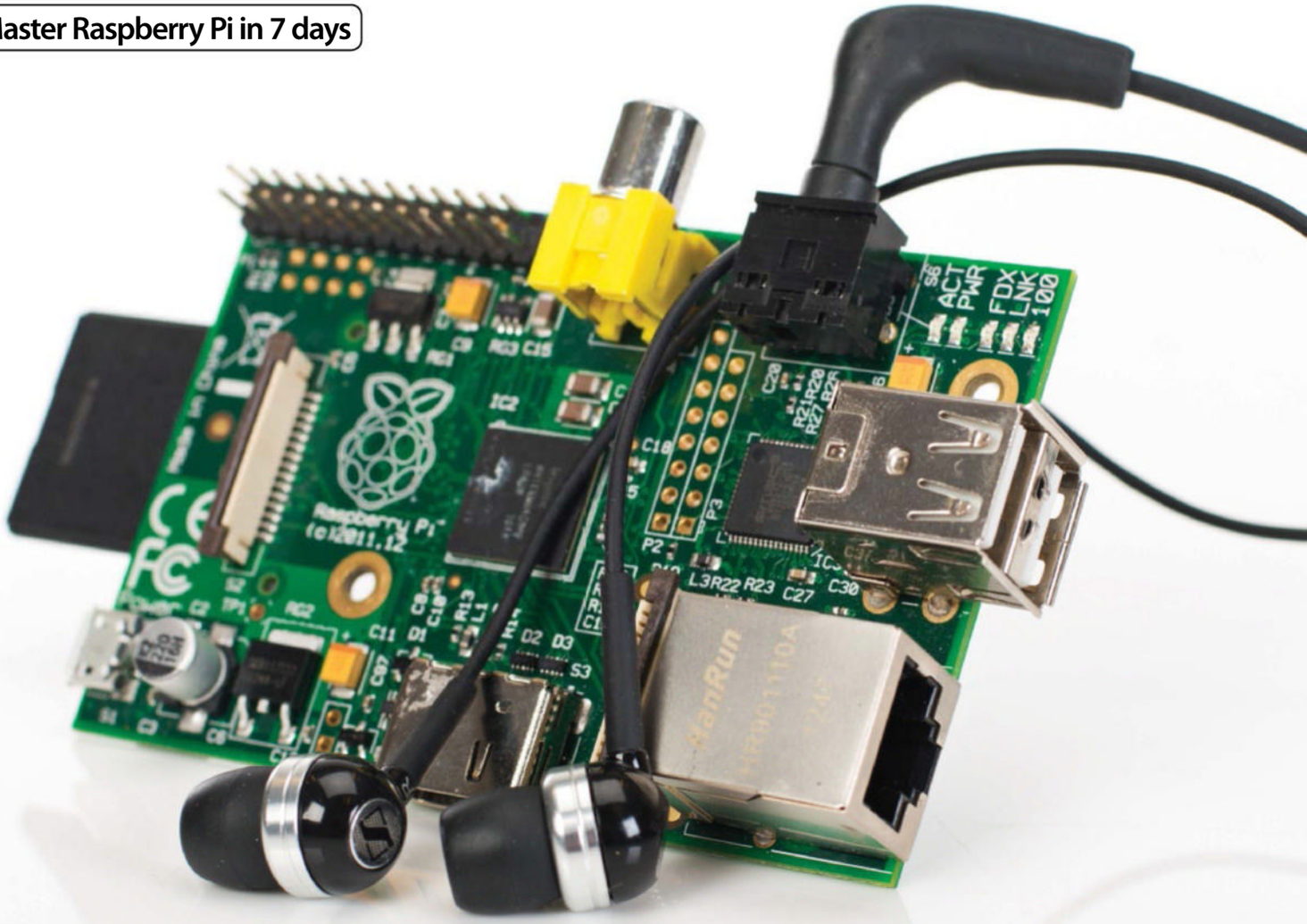
08 Random bouncing

Go the Operators menu and select the first value, blank + blank. Drag it to where we have 180 degrees in the turn block, and add 180 to the first blank space. Place the Pick Random 1 to 10 block in the second space and change the values to -10 and 10 so that whenever the ball hits the bat, it bounces off at a random angle between 170 and 190 degrees.

09 Further developments

While you now have a functional game of sorts, you can also add in a second player to make it truly Pong-like, and add a scoring system by having a number increase when the ball hits one of the sides.





Learn to code with Sonic Pi

Take the next step in programming and create your own melodies with Sonic Pi, the musical programming language

What you'll need

- Speakers or headphones
- Sonic Pi

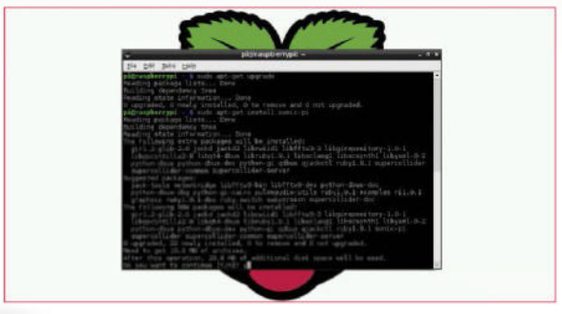
With Scratch we've learned how to operate under the logic of programming. The next step is to then use that within a programming language – the problem is that many of the available languages can look a little intimidating. This is where Sonic Pi comes in, offering a very simple language style that can ease you in to the basics of working with code.

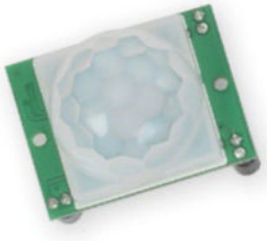
It's quite straightforward to use as well – Sonic Pi allows you to choose from a small selection of instruments and select a tone to play with it. These can be turned into complex melodies using loops and threads and even some form of user input.

01 Install Raspbian

If you've installed the latest version of Raspbian, Sonic Pi will be included by default. If you're still using a slightly older version, then you'll need to install it via the repos. Do this with:

```
$ sudo apt-get install sonic-pi
```





02 Get started with Sonic Pi

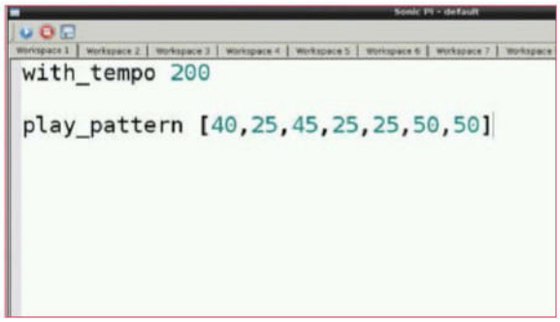
Sonic Pi is located in the Education category in the menus. Open it up and you'll be presented with something that looks like an IDE. The pane on the left allows you to enter code, and then you can save and preview it as well. Any errors are displayed separately from the output.

03 Your first note

Our first thing to try out with Sonic Pi is simply being able to play a note. Sonic Pi has a few defaults already pre-set, so we can get started with:

```
play 50
```

Press run and the output window should show you exactly what is happening.

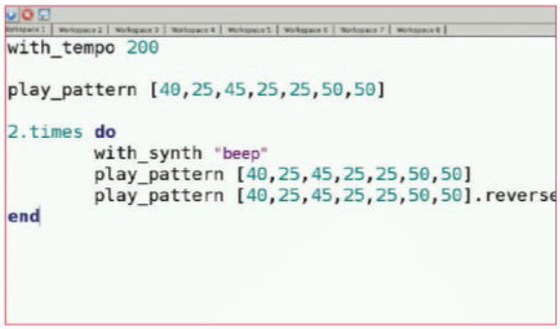


04 Set the beat

For any piece of music, you'll probably want to set the beat. We can start by putting:

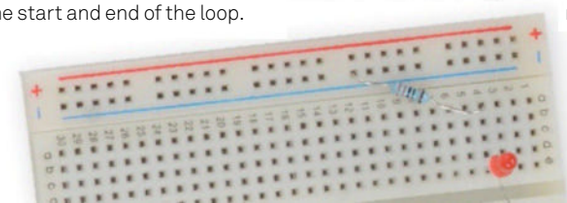
```
with_tempo 200
```

At the start of our code. We can then test this out by creating a string of midi notes using play_pattern.



05 Advance your melody

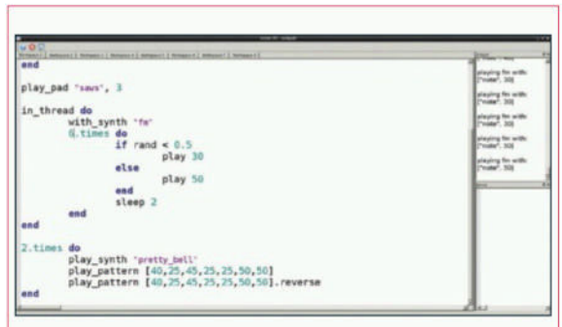
We can start making more complex melodies by using more of Sonic Pi's functions. You can change the note type by using with_synth, reverse a pattern, and even create a finite loop with the x.times function. 'Do' and 'end' signify the start and end of the loop.



> Sonic Pi offers you a very simple language style that can ease you into the basics of working with code

Full code listing

```
with_tempo 200

play_pattern [40,25,45,25,25,50,50]

2.times do
   with_synth "beep"
   play_pattern [40,25,45,25,25,50,50]
   play_pattern [40,25,45,25,25,50,50].reverse
end

play_pad "saws", 3

in_thread do
   with_synth "fm"
   6.times do
        if rand < 0.5
                play 30
        else
                play 50
        end
        sleep 2
   end
end

2.times do
   play_synth "pretty_bell"
   play_pattern [40,25,45,25,25,50,50]
   play_pattern [40,25,45,25,25,50,50].reverse
end
```



06 Play a concert

Using the in_thread function, we can create another thread for the Sonic Pi instance and have several lines of musical code play at once instead of in sequence. Here we've made it create a series of notes in a random sequence.

Take photos with Raspberry Pi

What you'll need

- Raspberry Pi camera board
- picamera
  github.com/waveform80/picamera

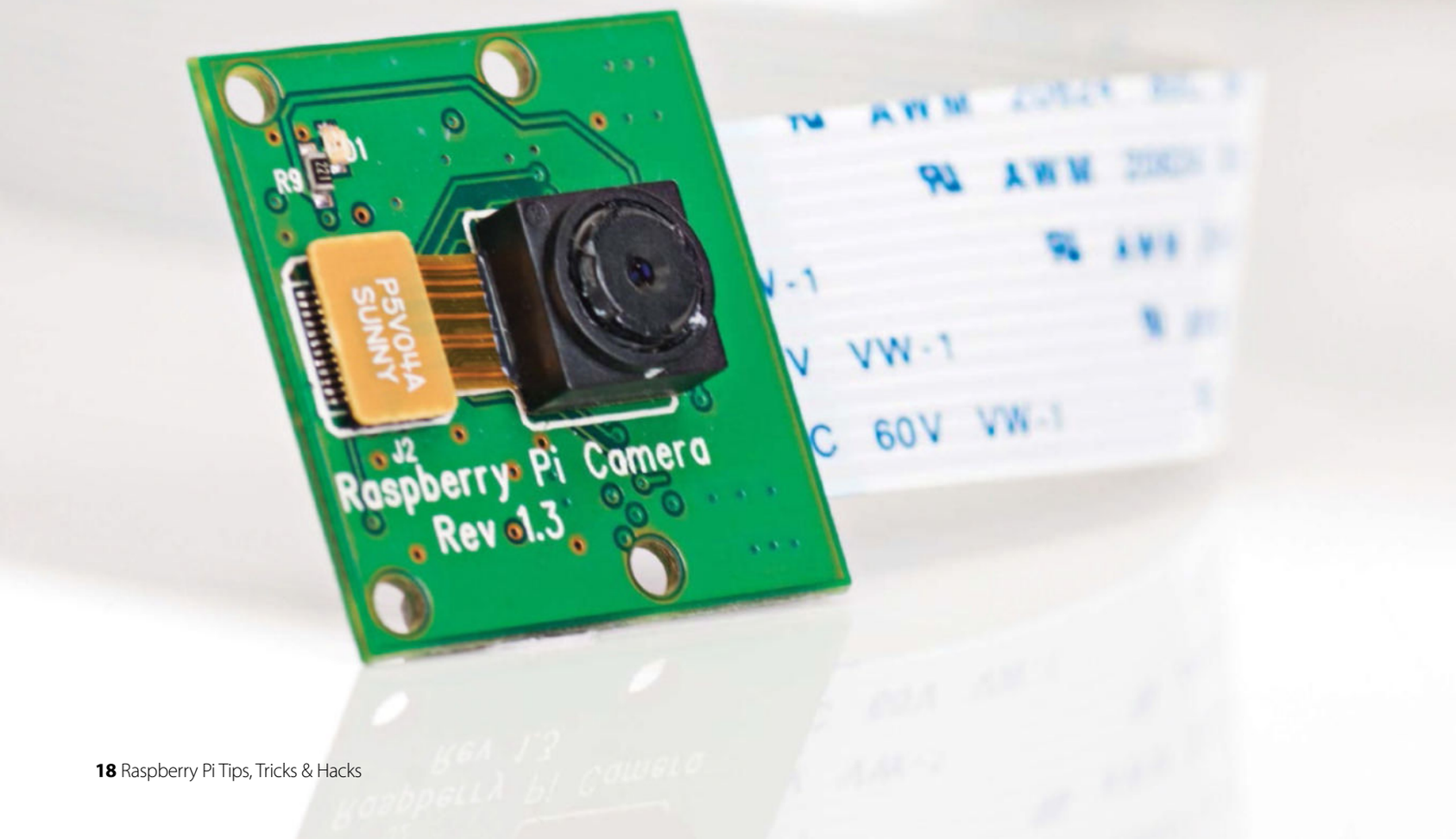
Use the Raspberry Pi camera module to capture photos and video, so you have a portable camera for any situation

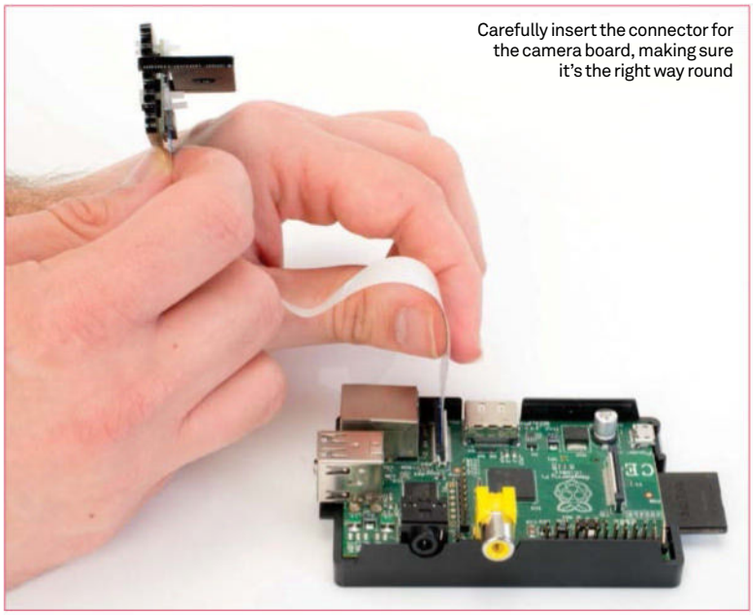
As we mentioned earlier, the Raspberry Pi camera module is an excellent addition to the Raspberry Pi. Not only does it slot into one of the non-traditional ports on the board itself, but it's also easily programmable within Raspbian. This gives it a few benefits over a USB webcam by not taking up any USB slots and being easier to control with code. It's also tiny, making it as portable as the Raspberry Pi itself.

By the end of today, you'll be able to use the camera like a pro to create time delays and specific image formatting.

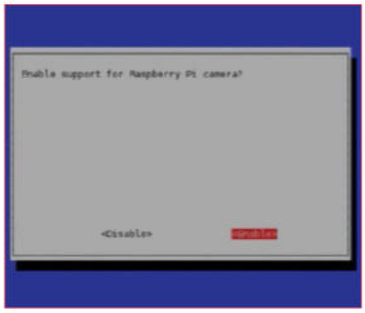
01 Plug in your camera

To attach the camera to the Raspberry Pi, locate the connectors between the ethernet and HDMI port and gently lift up the fastener. Insert the camera board ribbon, with the metal connectors facing away from the ethernet port.





Carefully insert the connector for the camera board, making sure it's the right way round

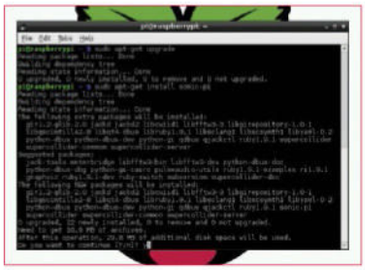


02 Enable the camera

First you'll need to make sure the camera modules are enabled. To start the standard configuration screen, open a terminal and type:

```
$ sudo raspi-config
```

Navigate down to Enable Camera, press Enter, and then simply key over to enable and confirm with another press of Enter. Select Finish and then reboot.

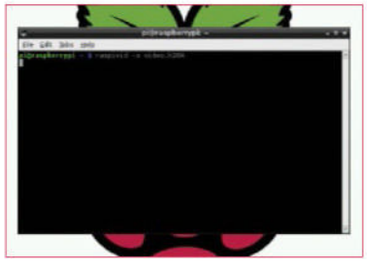


03 Take your first picture

Capturing pictures with the Raspberry Pi Camera is straightforward, all you have to do is enter:

```
$ raspistill -o image.png
```

This will show a five-second preview of the input of the camera and then capture the last frame of the video.



04 Record some video

To record a video, we use a similar command, raspivid, like so:

```
$ raspivid -o video.h264
```

Just like with the image-capturing that we did in the previous step, this will display a preview of what the camera is seeing. However, the video actually records the five seconds that make up the preview as well.

05 Advanced Pi camera uses

If you want to be able to do a little more with the camera, there's a simple Python wrapper currently available called picamera. You'll need to install it first though, and you can do so from the terminal, using the following command:

```
$ sudo apt-get install python-picamera
```

06 Python test

Let's make sure that everything we've done still works. Enter a Python shell by typing 'python' into the terminal, and then type the following three lines:

```
import picamera
camera = picamera.PiCamera()
camera.capture('pythontest.png')
camera.close()
```

07 Test explained

Press Ctrl+D to exit the Python shell. We just used code similar to the command line tools to take a simple image called 'pythontest.png'. The most important thing we did after that was 'camera.close', to make sure that the camera was turned off after use.

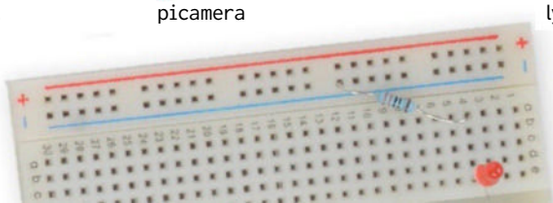
08 Python video

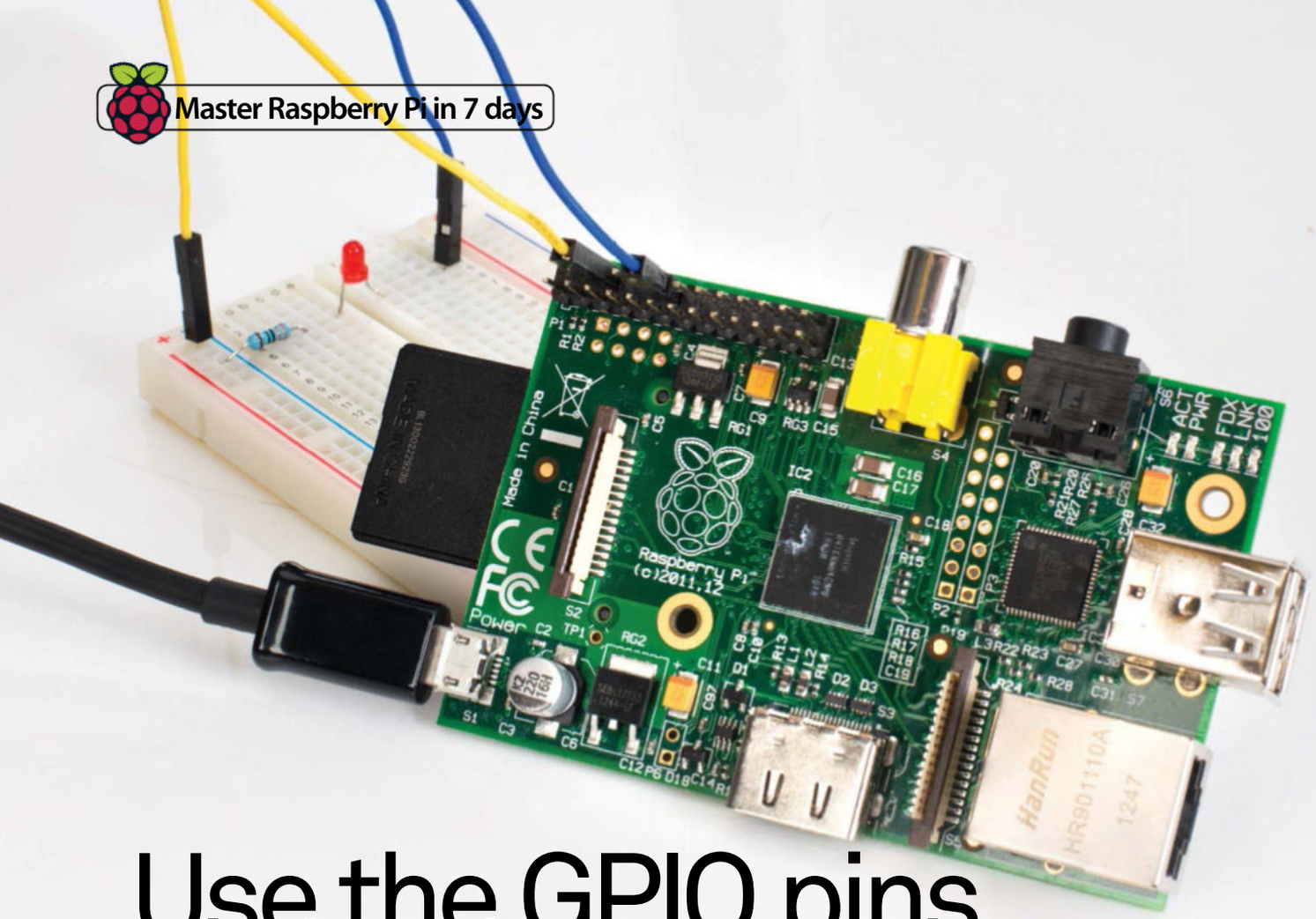
To record video with picamera, you need to first set the resolution and then set a recording time.

```
import picamera
camera = picamera.PiCamera()
camera.resolution = (640, 480)
camera.start_recording('firstvideo.h264')
camera.wait_recording(60)
camera.stop_recording()
camera.close()
```

09 More code

The above works a lot better in a Python script – the wait is only really required if you can't manually stop the recording. Picamera allows you to create time lapses, modify the frame rate of recordings and much more. For more ways to use it, check out issue 137 of **Linux User & Developer** (**bit.ly/11lxQ7n**) or the docs on the picamera GitHub page.





Use the GPIO pins

Learn to use the GPIO pins to interact with the outside world – this is where Raspberry Pi projects get really interesting…

What you'll need

- Small breadboard
- Small LED (any colour)
- 330ohm resistor
- 2x male-to-female prototyping cables

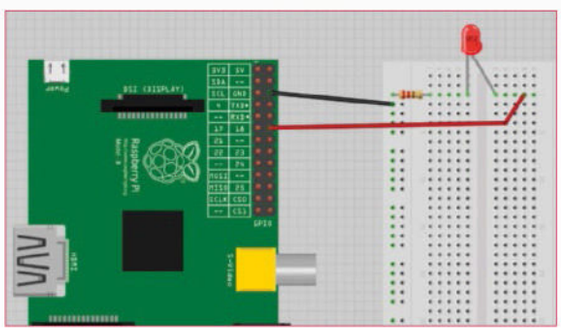
The General Purpose Input/Output pins (GPIO) give you power to interact with the real world using your Raspberry Pi. This project will get you comfortable with using the GPIO pins, which will form the backbone of the final project.

Traditionally the 'Hello World' program for electronics prototyping is simply turning a light on and off. We're going to go one better than that here though, by simulating candlelight.

To do this we're going to use the Random and Time modules from Python's standard library to continually change the brightness of the light while using the RPi-GPIO library to control the LED with Pulse Width Modulation (PWM).

01 Prepare your circuit

Before we turn on our Raspberry Pi we'll make all the physical cable connections to it. This requires us to place a male-to-female cable on the first ground pin on the GPIO port and another male-to-female cable on the PWM pin (pin 18). Connect it to the breadboard along with the LED and resistor as shown, ensuring the short leg of the LED goes to ground.



02 Power up the Pi

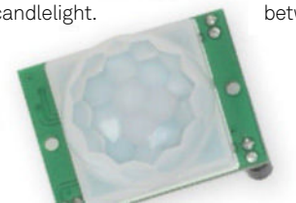
With the circuit complete we can power up the Pi. Open Leafpad and we'll start creating the script (found to the right) we need to control the LED light. The first thing we do is import the modules we need. The `RPi.GPIO` library is key to our project – we use it to read and write to pins and control their functionality. We're also using Random and Time modules in order to help simulate the effect of candlelight.

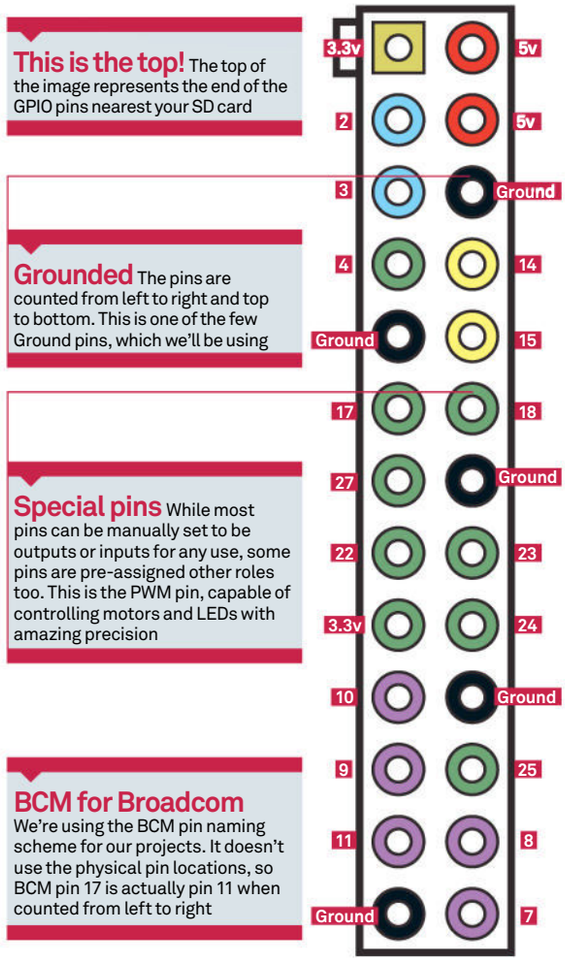
03 Configure the GPIO module

Next we assign a name to the LED pin and set up the GPIO module for our project. Notice we're using '`setmode`' and calling it `BCM`. This means we're using the Broadcom naming scheme. We then assign the LED pin to `OUTPUT`, which means we'll be outputting to that pin (as opposed to reading from it). If we simply wanted to turn the light on and off, at this point we could use `GPIO.output(led,GPIO.HIGH)` and `GPIO.output(led,GPIO.LOW)`. Instead we're using PWM, so we assign a variable PWM to control it.

04 Basic functions

Next we create two very basic functions that we can call in our main program loop to randomly control the physical brightness of the LED and the amount of time that the light pauses on a set brightness. To do this we first use the `random.randint` method. The numbers 5 and 100 represent the lowest and highest brightness (in per cent) – the function will then pick a number between these percentages during each





This is the top! The top of the image represents the end of the GPIO pins nearest your SD card

Grounded The pins are counted from left to right and top to bottom. This is one of the few Ground pins, which we'll be using

Special pins While most pins can be manually set to be outputs or inputs for any use, some pins are pre-assigned other roles too. This is the PWM pin, capable of controlling motors and LEDs with amazing precision

BCM for Broadcom We're using the BCM pin naming scheme for our projects. It doesn't use the physical pin locations, so BCM pin 17 is actually pin 11 when counted from left to right

loop through the program. `random.random` picks a floating point number between 0 and 1 – we divide this by `WIND` to help achieve our flicker effect.

05 The main loop

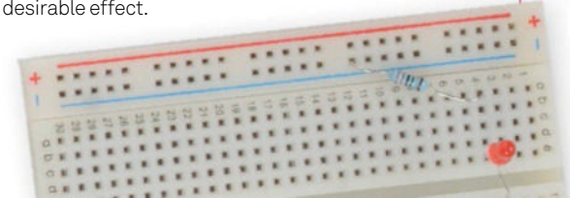
Finally, we use a while loop to activate the light with PWM and then change the brightness of the light with the `ChangeDutyCycle` method, which calls our brightness function. We do similar with time.sleep next to get the brightness to maintain for a short, random, amount of time by calling the flicker function. When we want to quit this otherwise infinite loop, we can raise a `KeyboardInterrupt` by pressing Ctrl+C. When we do, we need to free up the pins so that they can be used again, by calling `pwm.stop` and GPIO.cleanup respectively.

06 Test your project

Once your script has been written, save it as `candle_light.py`. The '`.py`' informs your Pi that this is a Python script. To run it, simply open the Terminal and type the following:

```
sudo python candle_light.py
```

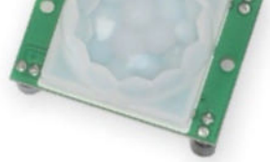
You need to call sudo here since you need to have admin privileges to access the GPIO port on your Raspberry Pi. Assuming you've set up the breadboard and copied the script correctly, your LED light should start flickering as if it's a candle in a light breeze. Take some time to experiment with the variables in the brightness and flicker functions to achieve a more desirable effect.



The General Purpose Input/ Output pins give you the power to interact with the real world using your Raspberry Pi

Full code listing

```
#!/usr/bin/env python

# Import the modules used in the script
import random, time
import RPi.GPIO as GPIO

# Assign the hardware PWM pin and name it
led = 18

# Configure the GPIO to BCM and set it to output mode
GPIO.setmode(GPIO.BCM)
GPIO.setup(led, GPIO.OUT)

# Set PWM and create some constants we'll be using
pwm = GPIO.PWM(led, 100)
RUNNING = True
WIND = 9

def brightness():
    """Function to randomly set the brightness of
    the LED between 5 per cent and 100 per cent power"""
    return random.randint(5, 100)

def flicker():
    """Function to randomly set the regularity of the'flicker ↵
effect'"""
    return random.random() / WIND

print "Candle Light. Press CTRL + C to quit"

# The main program loop follows.
# Use 'try', 'except' and 'finally' to ensure the program
# quits cleanly when CTRL+C is pressed to stop it.

try:
    while RUNNING:
        # Start PWM with the LED off
        pwm.start(0)
        # Randomly change the brightness of the LED
        pwm.ChangeDutyCycle(brightness())
        # Randomly pause on a brightness to simulate flickering
        time.sleep(flicker())

# If CTRL+C is pressed the main loop is broken
except KeyboardInterrupt:
    running = False
    print "\nQuitting Candle Light"

# Actions under 'finally' will always be called, regardless of
# what stopped the program (be it an error or an interrupt)
finally:
    # Stop and cleanup to finish cleanly so the pins
    # are available to be used again
    pwm.stop()
    GPIO.cleanup()
```



Build a Twitter-powered lamp with Python

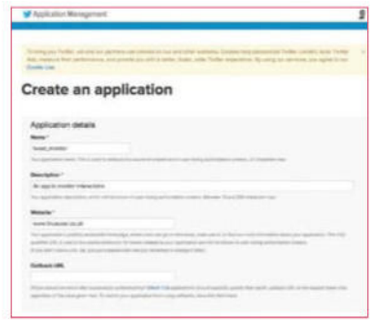
Now we know how to use the GPIO port, let's see if we can make our LED light work in response to the Twitter API...

Over the last eight years Twitter has become one of the most prominent social media networks in the world. Twitter is built on excellent open source technology and code, meaning it's very easy to work with. With all the focus on the tiny 140-character limit, you'd probably be surprised to hear that behind each tweet is over 3,000 characters of raw data!

While we're not going to harness the full power of Twitter's API today, we are going to do enough to allow us to make a Twitter lamp – a light that flashes whenever our chosen phrase or word is mentioned on Twitter. It's actually a lot easier than you might think, so let's get started...

01 Set up an app

Before you can do anything else, you need to make sure that you've got a Twitter account and that you're signed in. In order to be able to use the API, you need to create a Twitter app, so head over to **https://apps.twitter.com** and click 'Create New App'. Fill out the form, but don't worry about the URL sections – just put any website for now, since we won't be using this functionality.

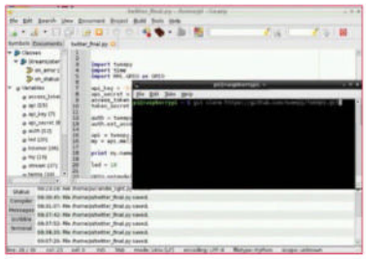


02 Configure the app

Once the app has been created you can alter the access to Twitter by modifying app permissions. While we don't need the ability to 'write' to Twitter for this project, we will do in the next one, so click 'Modify App Permissions' and change it to 'Read and write'. Once this changed, you can click the 'Create my access token' button at the bottom of the page. When this has refreshed, you'll have access to the info you need in the 'API Keys' tab. Copy the API key along with its secret and the access token and its secret into a new document called '`twitter_lamp.py`' in the format shown in our code listing on the right.

What you'll need

- tweepy
- Internet connection
- Breadboard
- Male-to-female cables
- 300ohm resistor
- LED



03 Install tweepy

The next step in creating our Twitter-powered lamp is installing and setting up tweepy. In the terminal, type:

```
git clone https://tweepy/tweepy.git
```

Once it's downloaded, move into the directory (`cd tweepy`) and install it like so:

```
sudo python setup.py install
```

Once tweepy is installed we don't need the contents of the folder anymore. Go back to your home folder (`cd ~`) and delete it with:

```
rm -rf tweepy
```

You can test that the library is installed correctly by typing `python` in the terminal to open the Python Interpreter. Now type `import tweepy` – if you don't get an error when you hit Enter, you're all set!

04 Connect the LED

We're going to use exactly the same simple breadboard circuit we used in the candlelight project on the previous two pages – we're even using the same GPIO pins. With the circuit connected, we can turn our attention to the code listing on the right. The GPIO aspect of the code is very similar to the last project, other than the fact we're using the `GPIO.HIGH` and `GPIO.LOW` commands to flash the light, as opposed to PWM. After our required imports at the top of the code listing, we've laid out the `api_key` and `access_token` phrases that point to our Twitter app attached to our Twitter account. Obviously we've masked over ours, since they're meant to be a secret. Don't share yours (even on GitHub)!

05 Using tweepy

After setting the keys and secrets as variables, we need to get tweepy to use them to authorise us. Create the `auth` variable and use the `OAuthHandler` to call them and then set the access token details as shown.

It's amazing what you can achieve in just 50 lines of Python

We then use `auth` to allow us access to the Twitter API on our account and test the connection by printing our Twitter handle using the `api.me()` method. We want to use the real-time Twitter stream for our project, though, so we need to override the `StreamListener` class in tweepy to make our lamp work. The `on_status` method in that class is where the magic happens; whenever there's a status update that's relevant to us, it pings `on_status` and we trigger our GPIO pins to make the light flash.

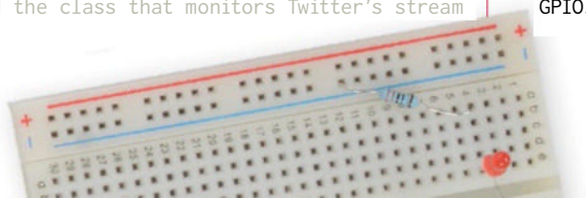
06 Test and tweak

Next we put our search terms into a list called `terms`. As you can see, we've elected for our lamp to flash whenever one of the Raspberry Pi terms we've set is mentioned. You don't need to include '@' or '#' tags – the API takes care of that for us. Now all that's left to do is create an instance of the `StreamListener()` class, start the Twitter live stream and then use the filter method to set it to only track the search terms we're interested in. It's amazing what you can achieve in just 50 lines of Python! To test your new Twitter-powered lamp prototype, at the terminal type:

```
sudo python twitter_lamp.py
```

Full code listing

```
#!/usr/bin/env python

#import the required libraries
import tweepy
import time
import RPi.GPIO as GPIO

# Set your access keys as configured
# at https://apps.twitter.com
api_key = 'your_api_key'
api_secret = 'your_api_secret'
access_token = 'your_access_token'
token_secret = 'your_token_secret'

# Initiate the OAuth process
auth = tweepy.OAuthHandler(api_key, api_secret)
auth.set_access_token(access_token, token_secret)

# Assuming the keys are good, you'll be
# able to test your Twitter app
api = tweepy.API(auth)
my = api.me()

print my.name, "is connected! Press CTRL + C to quit."

# Configure the GPIO port as we did in the last project
led = 18

GPIO.setmode(GPIO.BCM)
GPIO.setup(led, GPIO.OUT)

# Set the led light to be 'on'
GPIO.output(led, GPIO.HIGH)

# We've tweaked the class that monitors Twitter's stream
class StreamListener(tweepy.StreamListener):

# Whenever a status occurs that we're interested
# in we flash the LED
  def on_status(self, data):
    print "Flash the light"
    # We're using a simple for loop that turns the light
    # off and on three times using an interval of a
    # quarter of a second
    for i in xrange(3):
      GPIO.output(led, GPIO.LOW)
      time.sleep(0.25)
      GPIO.output(led, GPIO.HIGH)
      time.sleep(0.25)

  def on_error(self, error_code):
    print "Error:", error_code
    return False

# These are the words we're looking out for on Twitter
terms = ['raspberry pi', 'raspberrypi', 'raspi']

# Configure the stream and filter only our chosen terms
try:
  listener = StreamListener()
  stream = tweepy.Stream(auth, listener)
  stream.filter(track = terms)

except KeyboardInterrupt:
  print "\nQuitting"

# Don't forget to clean up after so we
# can use the GPIO next time
finally:
  GPIO.cleanup()
```



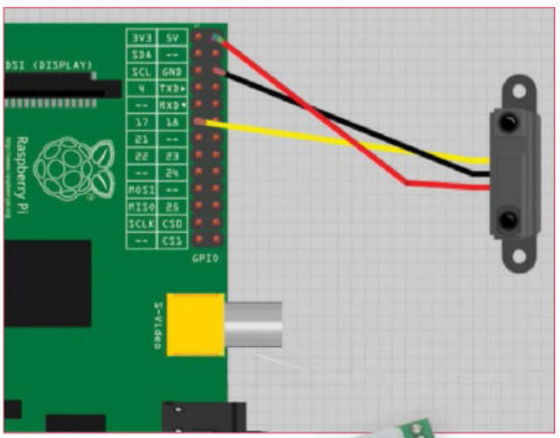
What you'll need

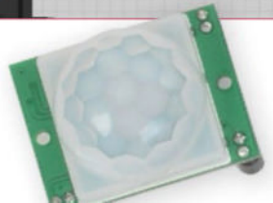
- tweepy
- Internet connection
- HC-SR501 PIR Infrared sensor
- Camera board & picamera library

The tweeting bird watcher

Our final project! Create an Internet of Things device able to takes pictures of wildlife before tweeting them to the web

We've reached the end of the week and we're now ready to take on our biggest project yet. Our final project uses all of the skills and technology we've covered so far and raises the bar to include things like automated Twitter updates and event detection. We're going to create our own little Internet of Things device that incorporates a simple PIR sensor (just £2.99/$5 from **modmypi.com**), the Raspberry Pi Camera board and the power of the internet to let us automagically capture images of birds (and other wildlife) before tweeting to a Twitter account of our choice whenever activity occurs.





01 Configure the infrared sensor

Since this an automated device, we need a way to trigger the camera when movement is sensed in our camera's target area. One affordable and easy-to-configure solution is the HC-SR501 Infrared Motion Sensor. The device itself has three pins – VCC (5V), Ground and a signal pin that sits in the middle. We've configured our script for the `pir` pin to trigger GPIO pin 17 (it sits opposite the PWM pin). The VCC pin is connected directly to the 5V power pin and the Ground to the same Ground pin we've used throughout the tutorials.

02 Test the PIR

We don't want to send millions of accidental tweets to Twitter, so we should do some pretty extensive testing with the PIR first, using simple print statements to show when motion has been detected. Visit **github.com/russb78/tweety-pi** and explore the project to find the **pir_testing.py** script. Copy it onto your Pi and run it with your PIR connected. You'll probably find that it's over-sensitive for your needs by default. You'll find two tiny adjustable screws on the PIR. Gently adjust them to the left to lower the sensitivity and test thoroughly until you get the desired result.

03 Set up the project

With the camera connected as per our previous camera project earlier in the week, we need to tie the camera, motion sensor and Twitter code together to make a tangible project that can be left to do its job. We'll walk through the script, but it's worth looking around our project by cloning it from GitHub. In the terminal type:

```
git clone https://github.com/russb78/tweety-pi.git
```

Enter the project with `cd tweety-pi` to take a look around. It's been set up as a full (if a little basic) project with a readme, licence and even a folder for our pictures to sit in.

04 The callback function

One of the big changes in this project compared to our previous ones is that we're using the GPIO as an input, instead of an output. Since we want the PIR sensor to alert us to movement, we really want the PIR to interrupt our script to let us know – that's where our callback function `motion_sense()` comes in. Looking further down the script to the main program loop you'll see a `GPIO.add_event_detect.` Whenever the assigned GPIO pin gets pinged, the script will stop what it is doing and jump to the named callback function (in this case `motion_sense`). This simple function then calls the `take_picture` function below it.

05 Simple chain

The entire chain of main functions that make up the meat of the project are laid out in trigger order and all initiated from that initial callback function. Once motion is detected the **take_picture** function is called. As soon as the image has been saved to the **/pics** folder we call the **update_twitter** function. Here, we're loading our previously saved image and using the Twitter API's **update_with_media** method to allow us to tweet our picture to the outside world. We can set our status from within this line, but instead of repeating the same phrase we use the random module's choice method to pick from a list of three we'd assigned to the variable `tweet_text` earlier in the script.

06 Main program loop

As we've done before, we're placing our main program loop in **try**, **except**, **finally** blocks to ensure we can cleanly quit the program or clean up should it crash for any reason. After we call our GPIO event detect line, we create a simple infinite loop to ensure the script keeps running. Pressing **Ctrl+C** will break this loop, causing the program to end, but not before finally calling the methods that close the camera and shut-off the GPIO pins. If you don't do this, all kinds of issues can arise the next time you run the script. And that's all there is to it! Be sure to use your knowledge on experimenting with other Raspberry Pi projects – and have fun!

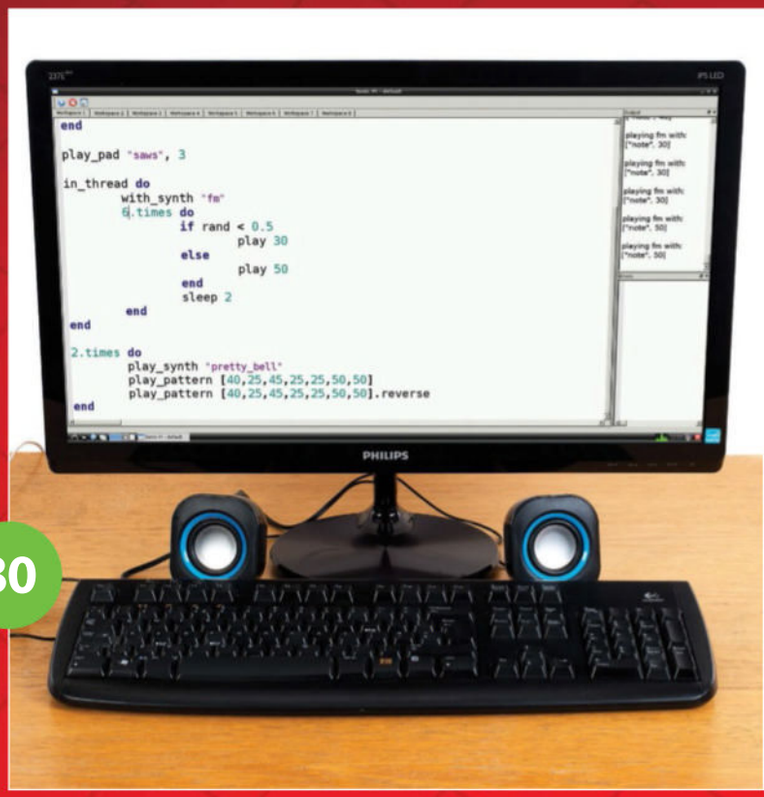
Full code listing

```
#!/usr/bin/env python
import RPi.GPIO as GPIO
import random, time, os
import tweepy
import picamera

pir = 17
GPIO.setmode(GPIO.BCM)
GPIO.setup(pir, GPIO.IN)

### TWITTER SETTINGS ###
# Set your access keys via https://apps.twitter.com
api_key = 'your_api_key_number'
api_secret = 'your_api_secret_number'
access_token = 'your_access_token_number'
token_secret = 'your_token_secret_number'
auth = tweepy.OAuthHandler(api_key, api_secret)
auth.set_access_token(access_token, token_secret)
api = tweepy.API(auth)
my_twitter = api.me()
print my_twitter.name, "is connected! Press CTRL + C to quit."
# Three  statuses. We'll pick one at random to go with our pic
tweet_text = ['Another shot taken with tweety-pi!',
              'Just spotted with my Raspberry Pi',
              'Snapped automagically with my Raspberry Pi camera!']

### CAMERA SETTINGS ###
camera = PiCamera()
cam_res = (1024, 768)
camera.led = False # Turn off LED so we don't scare the birds!
pics_taken = 0
time.sleep(1)

### MAIN FUNCTIONS ###
def motion_sense(pir):
  print "Motion detected... Taking picture!"
  take_picture(cam_res)

def take_picture(resolution):
  global pics_taken
    camera.resolution = resolution
    # Capture a sequence of frames
    camera.capture(os.path.join(
      'pics', 'image_' + str(pics_taken) + '.jpg'))
    pics_taken += 1
    print "Picture taken! Tweeting it..."""
    update_twitter()

def update_twitter():
  api.update_with_media(os.path.join(
    'pics', 'image_' + str(pics_taken -1) + '.jpg'),
    status = random.choice(tweet_text))
  print "Status updated!"
  #We don't want to tweet more than once per minute!
  time.sleep(60)

### MAIN PROGRAM LOOP ###
try:
  GPIO.add_event_detect(pir, GPIO.RISING, callback=motion_sense)
  while True:
    time.sleep(60)
except KeyboardInterrupt:
  print "\nQuitting"
finally:
  camera.close()
  GPIO.cleanup()
```

Tips

28 5 Practical Raspberry Pi Projects

- Make music with the Raspberry Pi
- Raspberry Pi voice synthesiser
- Program Minecraft-Pi
- Get interactive with Scratch
- Build a Raspberry Pi web server



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64 Add a reset switch

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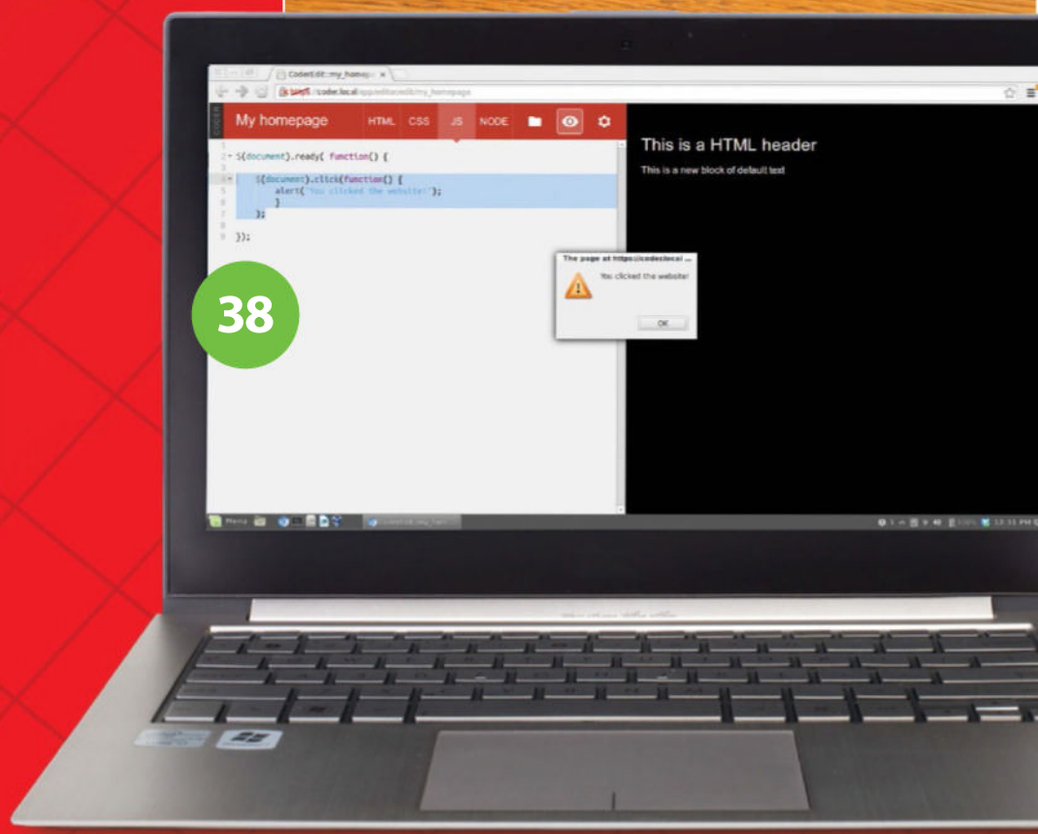
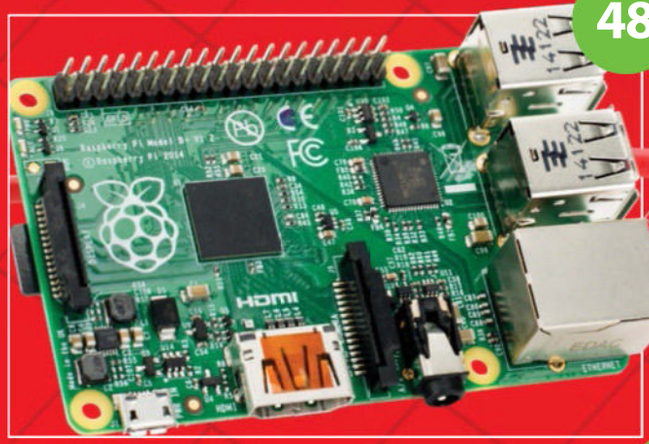
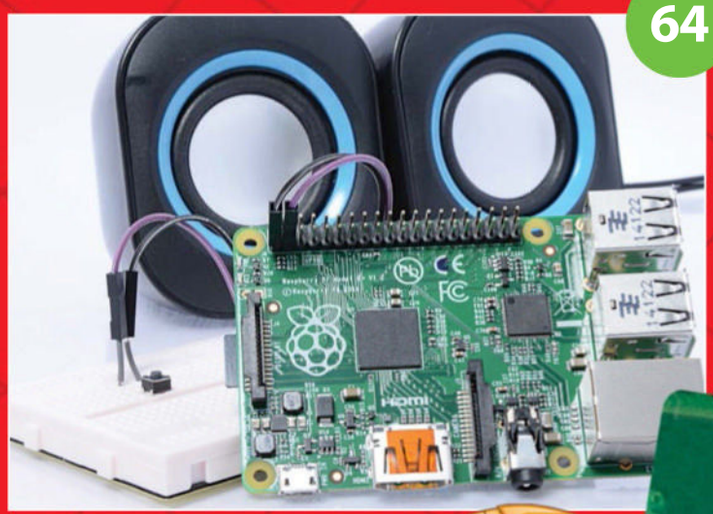
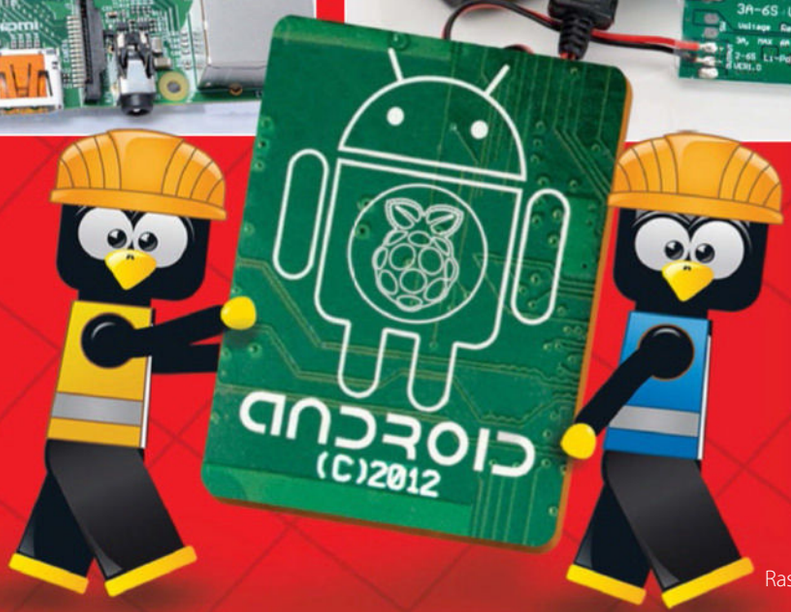
76 Add a battery pack to Raspberry Pi

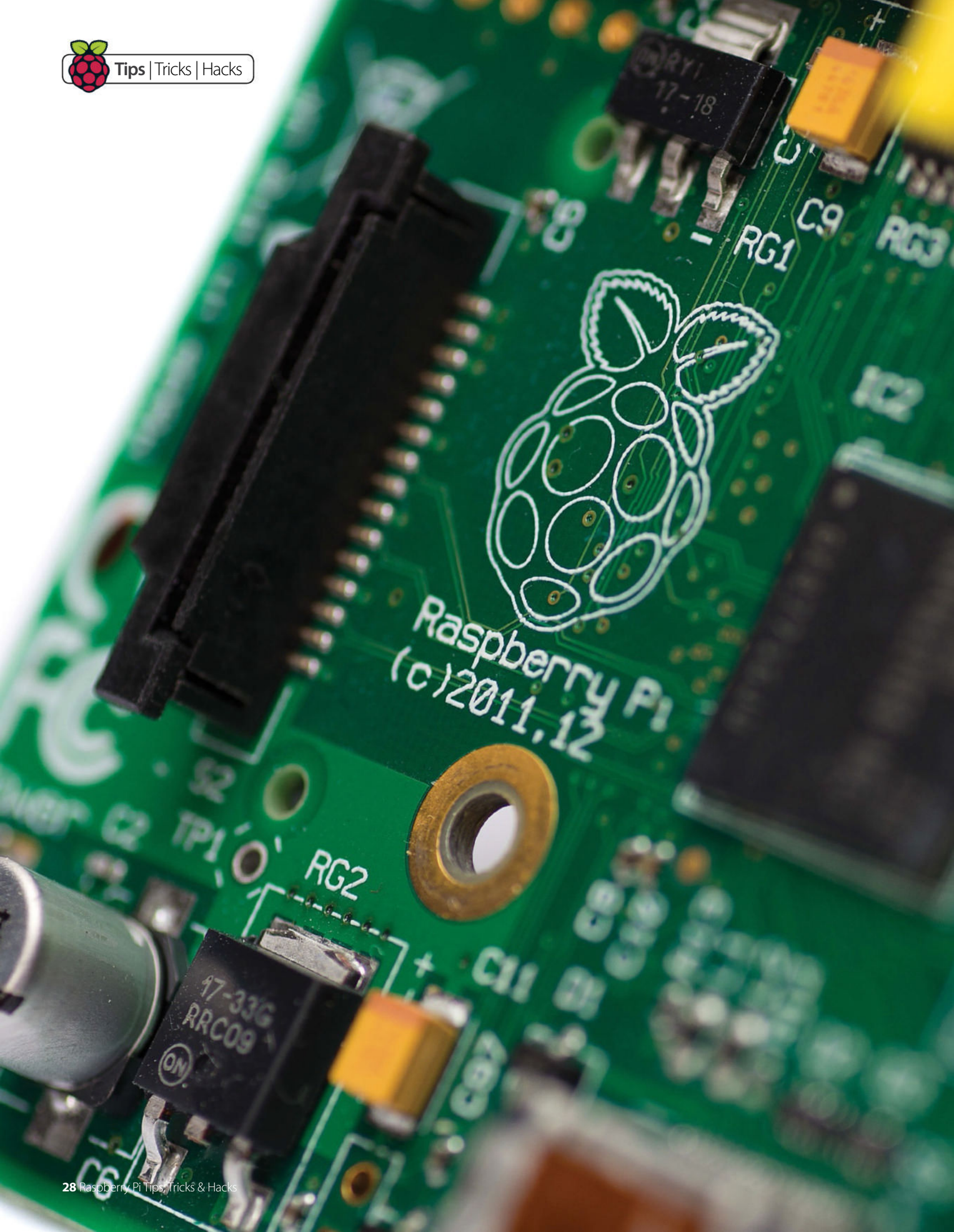


"This isn't a random selection. These are practical ideas designed to help kick-start bigger and better things"





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5 PRACTICAL RASPBERRY PI PROJECTS

Still haven't done anything with your Raspberry Pi? Follow along with our expert advice and kick-start your own amazing Raspberry Pi projects

From our time experimenting with this incredible credit card-sized computer, it's become clear there are two types of Raspberry Pi owners: those that use theirs and those that don't. Whether it's fear of the unknown, a lack of time or inspiration, when we ask people what they do with their Pi we'll often hear that it's still in the box. If that's you, then you're in the right place. In this feature we've handcrafted ten Raspberry Pi projects practically anyone can enjoy.

These aren't just a random selection of side-projects, though. These are practical ideas designed to help kick-start bigger and better things. Knowledge gained from one project can also be applied to another to create something completely new. For example, you could take what you'll learn with the Sonic Pi tutorial and go on to create a text-to-morse code translator. You could go on to make Pong in Minecraft-Pi or use a button attached to Scratch to take photos with your Raspberry Pi camera module. The list goes on.

All these projects are open source, so you're encouraged to tweak and develop them into something entirely new. If you share your tweaks and changes with the community, you're sure to start benefitting from doing things the open source way...

Make music with the Raspberry Pi

Program your own melodies using Sonic Pi and create musical cues or robot beeps

What you'll need

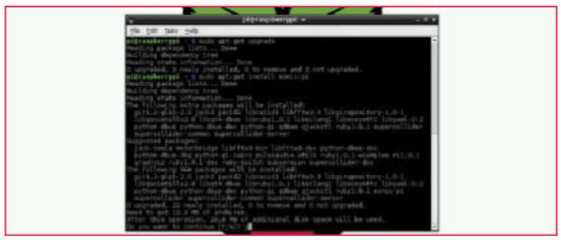
- Portable speakers
- Sonic Pi
  www.cl.cam.ac.uk/projects/raspberrypi/sonicpi/teaching.html

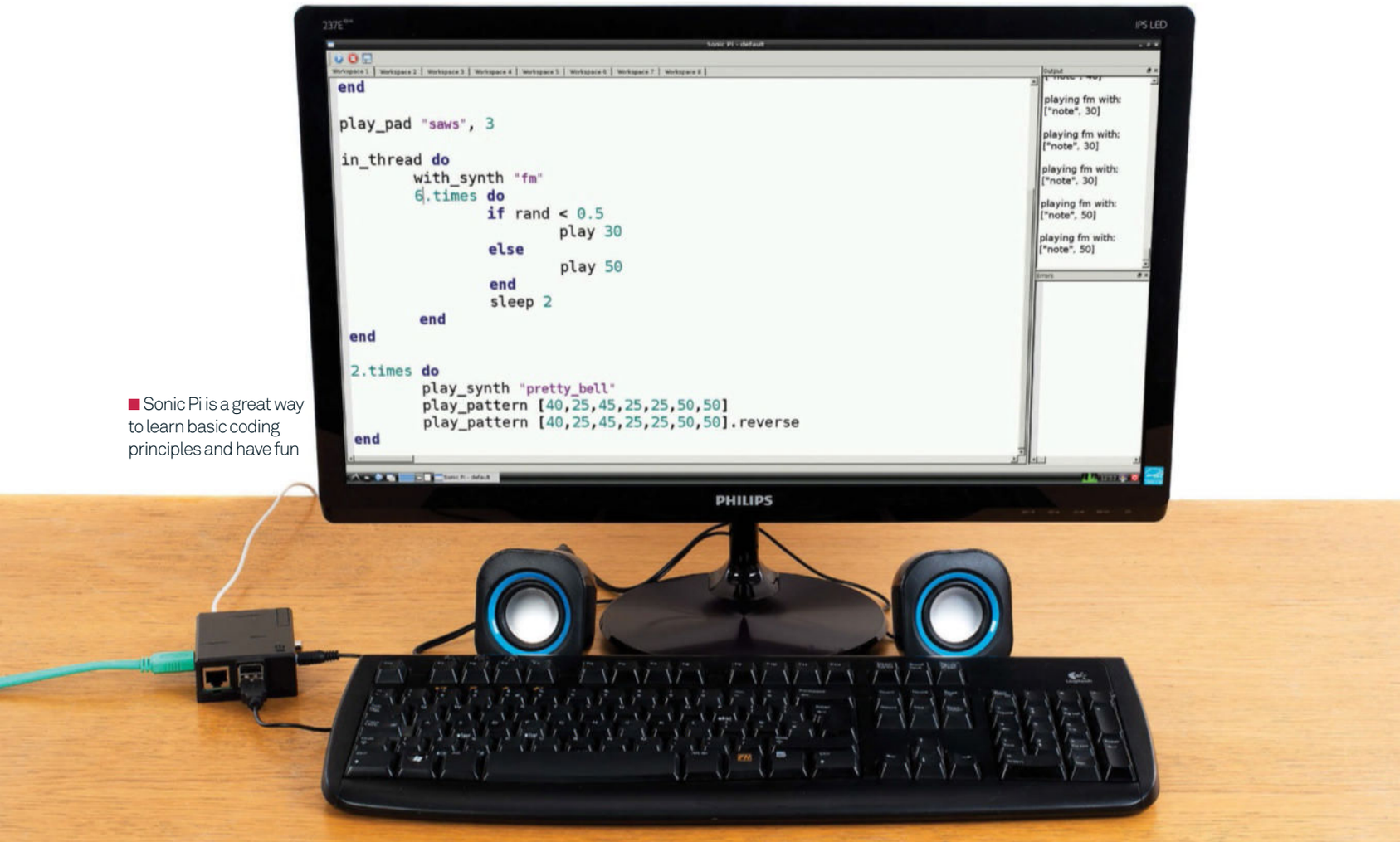
One of the major features of Scratch is its ability to teach the fundamentals of coding to kids and people with no computing background. For kids, its especially appealing due to the way it allows them to create videogames to interact with as part of their learning. In this kind of vein then, Sonic Pi teaches people to code using music. With a simple language that utilises basic logic steps but in a more advanced way than Scratch, it can either be used as a next step for avid coders, or as a way to create music for an Internet of Things or a robot.

01 Getting Sonic Pi

If you've installed the latest version of Raspbian, Sonic Pi will be included by default. If you're still using a slightly older version, then you'll need to install it via the repos. Do this with:

```
$ sudo apt-get install sonic-pi
```



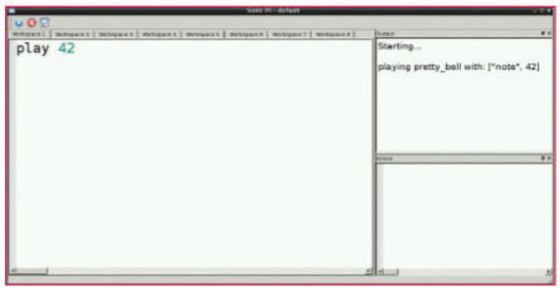


Sonic Pi is a great way to learn basic coding principles and have fun

> "We can start making more complex melodies by using more of Sonic Pi's functions"

02 Starting with Sonic Pi

Sonic Pi is located in the Education category in the menus. Open it up and you'll be presented with something that looks like an IDE. The pane on the left allows you to enter the code for your project, with proper syntax highlighting for its own style of language. When running, an info pane details exactly what's being played via Sonic Pi – and any errors are listed in their own pane as well, for reference.



03 Your first note

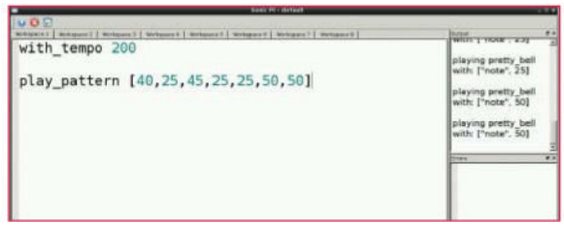
Our first thing to try on Sonic Pi is simply being able to play a note. Sonic Pi has a few defaults preset, so we can get started with:

```
play 50
```

Press the Play button and the output window will show you what's being played. The **pretty_bell** sound is the default tone for Sonic Pi's output, and **50** determines the pitch and tone of the sound.

Full code listing

```
with_tempo 200

play_pattern [40,25,45,25,25,50,50]

2.times do
    with_synth "beep"
    play_pattern [40,25,45,25,25,50,50]
    play_pattern [40,25,45,25,25,50,50].reverse
end

play_pad "saws", 3

in_thread do
    with_synth "fm"
    6.times do
          if rand < 0.5
                play 30
          else
                play 50
          end
          sleep 2
    end
end

2.times do
    play_synth "pretty_bell"
    play_pattern [40,25,45,25,25,50,50]
    play_pattern [40,25,45,25,25,50,50].reverse
end
```



04 Set the beat

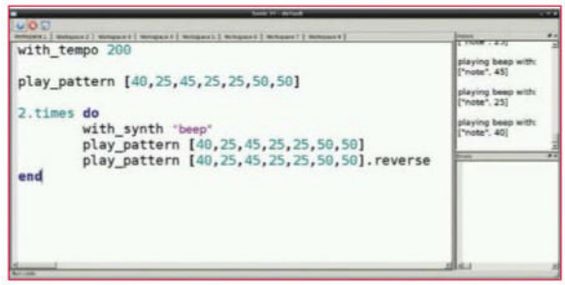
For any piece of music, you'll want to set the tempo. We can start by putting:

```
with_tempo 200
```

...at the start of our code. We can test it out by creating a string of midi notes using play_pattern:

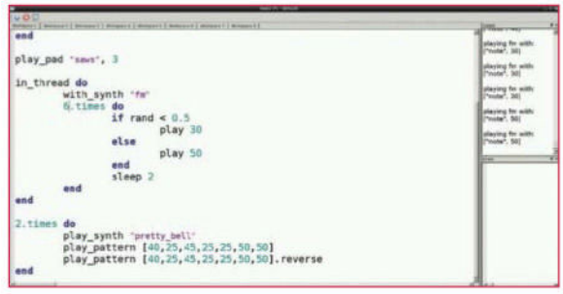
```
play_pattern [40,25,45,25,25,50,50]
```

This will play pretty_bell notes at these tones at the tempo we've set. You can create longer and shorter strings, and also change the way they play.



05 Advance your melody

We can start making more complex melodies by using more of Sonic Pi's functions. You can change the note type by using **with_synth**, reverse a pattern, and even create a finite loop with the **x.times** function; **do** and **end** signify the start and end of the loop. Everything is played in sequence before repeating, much like an if or while loop in normal code.



06 Playing a concert

Using the **in_thread** function, we can create another thread for the Sonic Pi instance and have several lines of musical code play at once instead of in sequence. We've made it create a series of notes in a random sequence, and have them play alongside extra notes created by the position and velocity of the mouse using the **play_pad** function.

You'll learn...

1 How to code

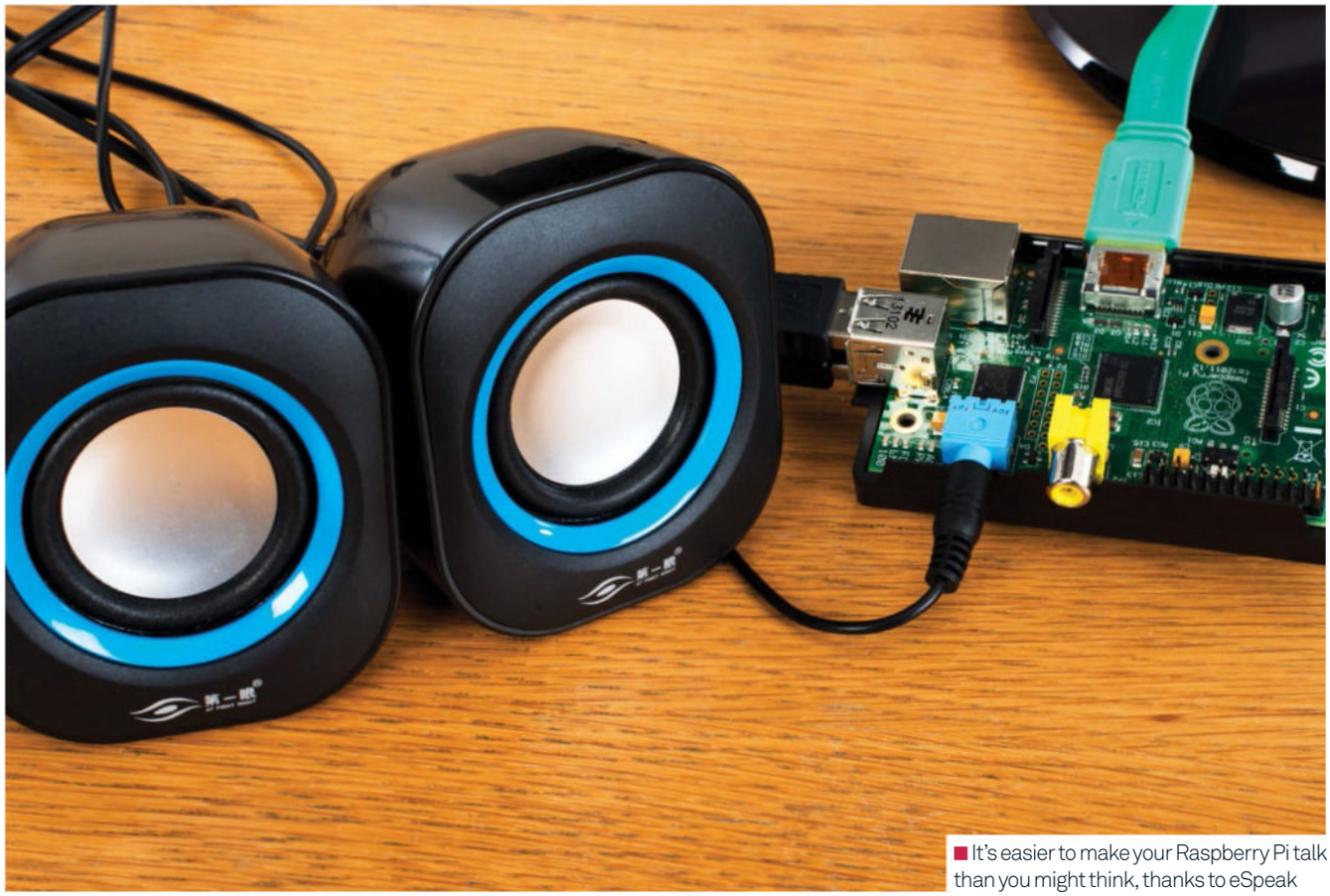
The coding style of Sonic Pi uses concepts from standard programming languages – if statements, loops, threads etc. Whereas Scratch teaches this logic, Sonic Pi teaches their structure.

2 Robotic voice

Employ Sonic Pi to create context-sensitive chips, chirps and beeps and use it to give a familiar voice while it tootles around.

3 MIDI

The Musical Instrument Digital Interface is a standard for digital music, and the numbers and tones used in Sonic Pi make use of this.



It's easier to make your Raspberry Pi talk than you might think, thanks to eSpeak

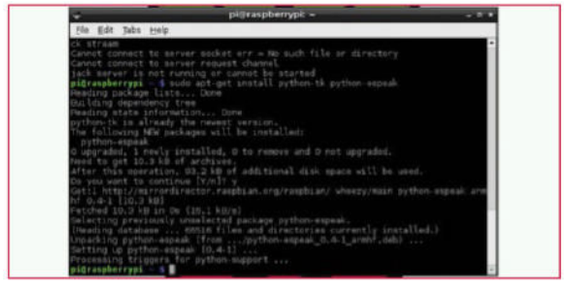
Raspberry Pi voice synthesiser

Add the power of speech to your Raspberry Pi projects with the versatile eSpeak Python library

What you'll need

- Portable USB speakers
- python-espeak module
- eSpeak
- Raspbian (latest image)

We've already mentioned how the Raspberry Pi can be used to power robots, and as a tiny computer it can also be the centre of an Internet of Things in your house or office. For these reasons and more, using the Raspberry Pi for text-to-voice commands could be just what you're looking for. Due to the Debian base of Raspbian, the powerful eSpeak library is easily available for anyone looking to make use of it. There's also a module that allows you to use eSpeak in Python, going beyond the standard command-line prompts so you can perform automation tasks.

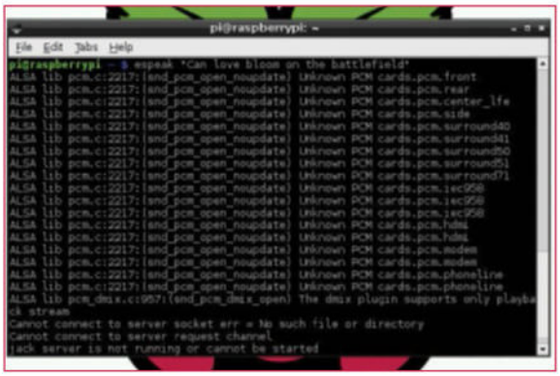


01 Everything you'll need

We'll install everything we plan to use in this tutorial at once. This includes the eSpeak library and the Python modules we need to show it off. Open the terminal and install with:

```
$ sudo apt-get install espeak python-espeak python-tk
```

> "You can change the way eSpeak will read text with a number of different options"



02 Pi's first words

The eSpeak library is pretty simple to use – to get it to just say something, type in the terminal:

```
$ espeak "[message]"
```

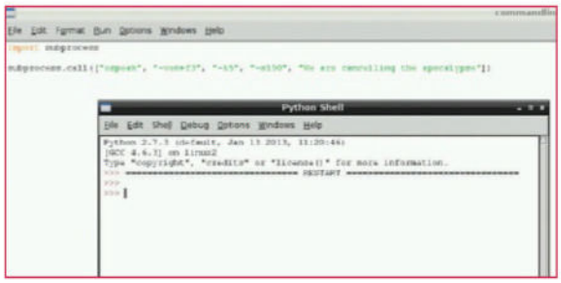
This will use the library's defaults to read whatever is written in the message, with decent clarity.

03 Say some more

You can change the way eSpeak will read text with a number of different options, such as gender, read speed and even the way it pronounces syllables. For example, writing the command like so:

```
$ espeak -ven+f3 -k5 -s150 "[message]"
```

...will turn the voice female, emphasise capital letters and make the reading slower.



04 Taking command with Python

The most basic way to use eSpeak in Python is to use **subprocess** to directly call a command-line function. Import subprocess in a Python script, then use:

```
subprocess.call(["espeak", "[options 1]", "[option 2]",..."[option n]", "[message]"])
```

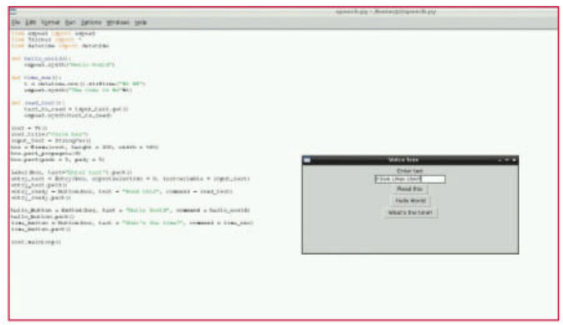
The message can be taken from a variable.

05 The native tongue

The Python eSpeak module is quite simple to use to just convert some text to speech. Try this sample code:

```
from espeak import espeak
espeak.synth("[message]")
```

You can then incorporate this into Python, like you would any other module, for automation.



06 A voice synthesiser

Using the code listing, we're creating a simple interface with Tkinter with some predetermined voice buttons and a custom entry method. We're showing how the eSpeak module can be manipulated to change its output. This can be used for reading tweets or automated messages. Have fun!

Full code listing

Get the code: bit.ly/14XbLOC

Import the necessary eSspeak and GUI modules, as well as the module to find out the time

```
from espeak import espeak
from Tkinter import *
from datetime import datetime
```

Define the different functions that the interface will use, including a simple fixed message, telling the time, and a custom message

```
def hello_world():
    espeak.synth("Hello World")

def time_now():
    t = datetime.now().strftime("%k %M")
    espeak.synth("The time is %s"%t)

def read_text():
    text_to_read = input_text.get()
    espeak.synth(text_to_read)
```

Create the basic window with Tkinter for your interface, as well as creating the variable for text entry

```
root = Tk()
root.title("Voice box")
input_text = StringVar()
box = Frame(root, height = 200, width = 500)
box.pack_propagate(0)
box.pack(padx = 5, pady = 5)
```

The text entry appends to the variable we created, and each button calls a specific function that we defined above in the code

```
Label(box, text="Enter text").pack()
entry_text = Entry(box, exportselection = 0, ↵
textvariable = input_text)
entry_text.pack()
entry_ready = Button(box, text = "Read this", ↵
command = read_text)
entry_ready.pack()

hello_button = Button(box, text = "Hello World", ↵
command = hello_world)
hello_button.pack()
time_button = Button(box, text = "What's the ↵
time?", command = time_now)
time_button.pack()

root.mainloop()
```

Program Minecraft-Pi

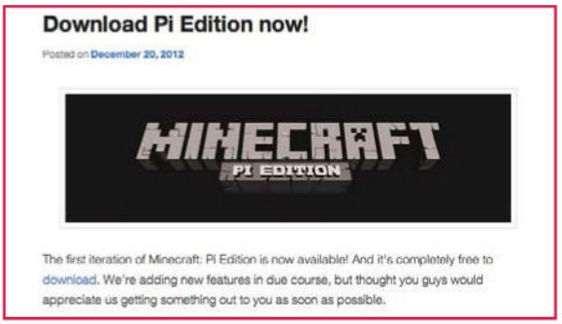
Learn to program while playing one of the greatest games ever made!

What you'll need

- Raspbian (latest release)
- Minecraft-Pi tarball
- Keyboard & mouse
- Internet connection

***Minecraft* is probably the biggest game on the planet right now.** It's available on just about any format you can imagine, from PCs to gaming consoles to mobile phones. It should probably come as no surprise that it's also available on the Raspberry Pi. While at first glance Minecraft-Pi is a simplified version of the Pocket Edition (designed for tablets and smartphones), the Raspberry Pi edition is very special, in that it's the only version of *Minecraft* to gives users access to its API (application programming interface).

In this project we're going to show you how to set up Minecraft-Pi and configure it so you can interact with *Minecraft* in a way you've never done before. This small project is just the tip of the iceberg...



01 Requirements

Minecraft-Pi requires you to be running Raspbian on your Raspberry Pi, so if you're not already running that, take a trip to **raspberrypi.org** and get it setup. It also requires you have X Window loaded too. Assuming you're at the command prompt, you just need to type `startx` to reach the desktop.

Unlike all other versions of *Minecraft*, the Pi version encourages you to hack it

02 Installation

Make sure you're already in your home folder and download the **Minecraft-Pi** package with the following commands in a terminal window:

```
cd ~
wget  https://s3.amazonaws.com/assets.minecraft.net/pi/minecraft-pi-0.1.1.tar.gz
```

To use it we need to decompress it. Copy the following into the terminal window:

```
tar -zxvf minecraft-pi-0.1.1.tar.gz
```

Now you can move into the newly decompressed Minecraft-Pi directory and try running the game for the first time:

```
cd mcpi
./minecraft-pi
```

03 Playing Minecraft-Pi

Have a look around the game. If you're not familiar with *Minecraft*, you control movement with the mouse and the WASD keys. Numbers 1-8 select items in your quickbar, the space bar makes you jump and Shift makes you walk slowly (so you don't fall off edges). 'E' will open your inventory and double-tapping the space bar will also toggle your ability to fly.

04 Configuring the Python API

To take control of *Minecraft* with the Python API, you next need to copy the Python API folder from within the **/mcpi** folder to a new location. In the terminal, type the following:

```
cp -r ~/mcpi/api/python/mcpi ↵
~/ minecraft
```

In this folder, we want to create a 'boilerplate' Python document that connects the API to the game. Write the following into the terminal:

```
cd ~/minecraft
nano minecraft.py
```

With nano open, copy the following and then save and exit with **Ctrl+X**, pressing **Y** (for yes), then **Enter** to return to the command prompt:

```
from mcpi.minecraft import ↵
Minecraft
from mcpi import block
from mcpi.vec3 import Vec3
mc = Minecraft.create()
mc.postToChat("Minecraft API ↵
Connected")
```

05 Testing your Python script

The short script you created contains everything you need to get started with hacking Minecraft-Pi in the Python language. For it to work, you need to have the game already running (and be playing). To grab control of the mouse while in-game, you can press **Tab**. Open a fresh terminal window, navigate into your **minecraft** folder and start the script with the following commands:

```
cd ~/minecraft
python minecraft.py
```

You'll see a message appear on screen to let you know the API connected properly. Now we know it works, let's get coding!

Full code listing

```
# !/usr/bin/env python

from mcpi.minecraft import Minecraft
from mcpi import block
from mcpi.vec3 import Vec3
from time import sleep, time
import random, math

mc = Minecraft.create() # make a connection to the game
playerPos = mc.player.getPos()

# function to round players float position to integer position
def roundVec3(vec3):
    return Vec3(int(vec3.x), int(vec3.y), int(vec3.z))

# function to quickly calc distance between points
def distanceBetweenPoints(point1, point2):
    xd = point2.x - point1.x
    yd = point2.y - point1.y
    zd = point2.z - point1.z
    return math.sqrt((xd*xd) + (yd*yd) + (zd*zd))

def random_block(): # create a block in a random position
    randomBlockPos = roundVec3(playerPos)
    randomBlockPos.x = random.randrange(randomBlockPos.x - 50, randomBlockPos.x + 50)
    randomBlockPos.y = random.randrange(randomBlockPos.y - 5, randomBlockPos.y + 5)
    randomBlockPos.z = random.randrange(randomBlockPos.z - 50, randomBlockPos.z + 50)
    return randomBlockPos

def main(): # the main loop of hide & seek
    global lastPlayerPos, playerPos
    seeking = True
    lastPlayerPos = playerPos

   randomBlockPos = random_block()
    mc.setBlock(randomBlockPos, block.DIAMOND_BLOCK)
    mc.postToChat("A diamond has been hidden somewhere nearby!")

    lastDistanceFromBlock = distanceBetweenPoints(randomBlockPos, lastPlayerPos)
    timeStarted = time()
    while seeking:
        # Get players position
        playerPos = mc.player.getPos()
        # Has the player moved
        if lastPlayerPos != playerPos:
            distanceFromBlock = distanceBetweenPoints(randomBlockPos, playerPos)

            if distanceFromBlock < 2:
                #found it!
                seeking = False
            else:
                if distanceFromBlock < lastDistanceFromBlock:
                    mc.postToChat("Warmer " + str(int(distanceFromBlock)) + " blocks away")
                if distanceFromBlock > lastDistanceFromBlock:
                    mc.postToChat("Colder " + str(int(distanceFromBlock)) + " blocks away")

            lastDistanceFromBlock = distanceFromBlock

        sleep(2)

    timeTaken = time() - timeStarted
    mc.postToChat("Well done - " + str(int(timeTaken)) + " seconds to find the diamond")

if __name__ == "__main__":
    main()
```

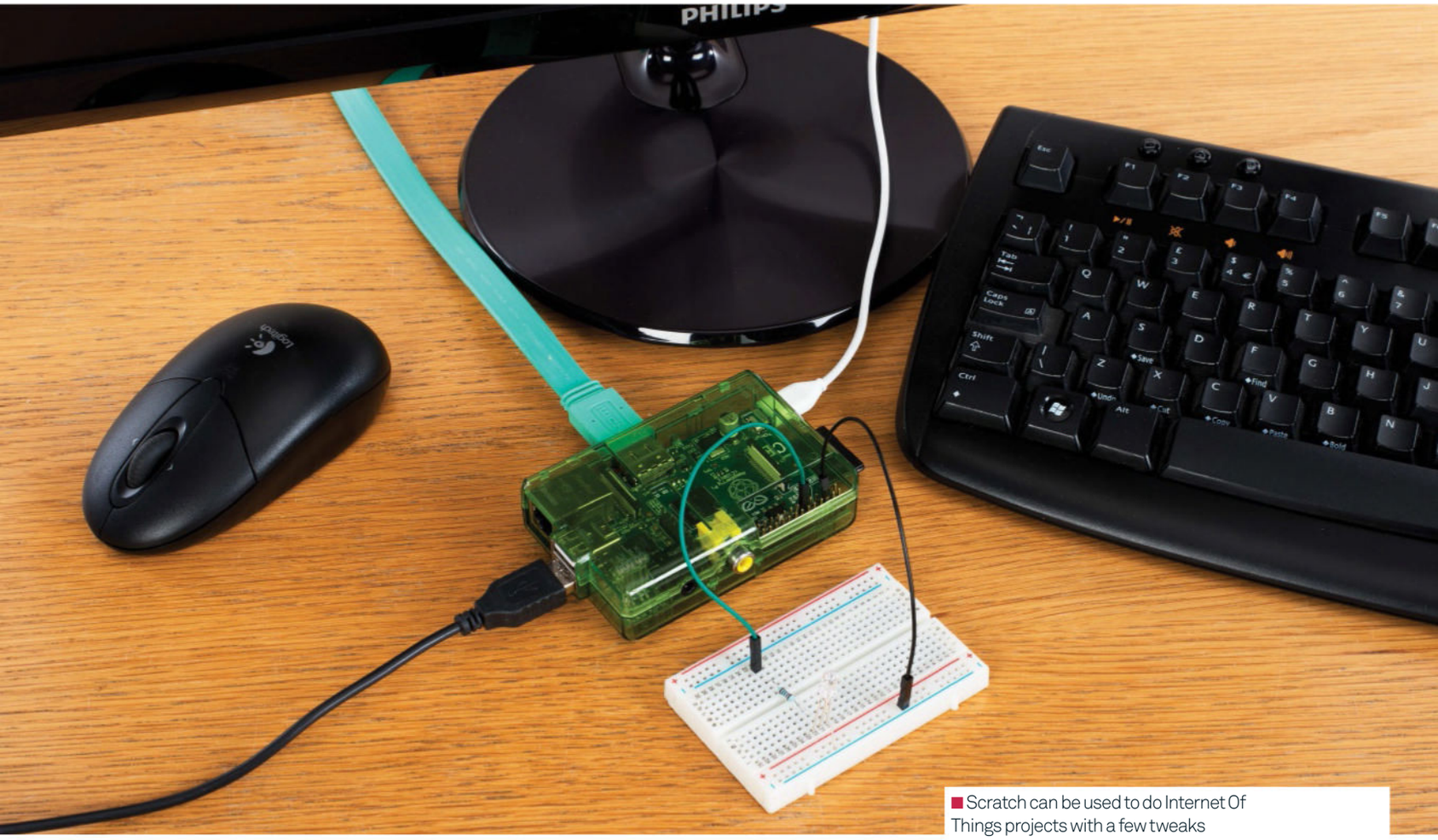
You'll learn...

Functional, & fun coding

There's nothing too taxing about our code. We've created a couple of simple functions (starting with **def**) and used **if**, **else** and **while** to create the logic.

06 Hide & Seek

As you can see from the code above, we've created a game of Hide & Seek adapted from Martin O'Hanlon's original creation (which you can find on **www.stuffaboutcode.com**). When you launch the script, you'll be challenged to find a hidden diamond in the fastest time possible. We've used it to demonstrate some of the more accessible methods available in the API. But there's much more to it than this demonstrates. If you're up for another Minecraft-Pi tutorial, see: **bit.ly/1v4DR2F**.



Scratch can be used to do Internet Of Things projects with a few tweaks

Get interactive with Scratch

Experiment with physical computing by using Scratch to interact with buttons and lights on your Pi

What you'll need

- Breadboard
- LEDs
- Buttons
- Resistors
- Jumper wires
- ScratchGPIO3

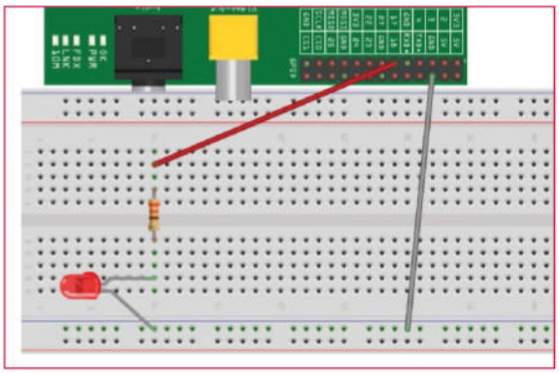
Scratch is a very simple visual programming language, commonly used to teach basic programming concepts to learners of any age. In this project we'll learn how to light up an LED when a button is pressed in Scratch, and then change a character's colour when a physical button is pressed. With these techniques you can make all manner of fun and engaging projects, from musical keyboards to controllers for your Scratch games and animations.

01 Installing the required software

Log into the Raspbian system with the username **Pi** and the password **raspberry**. Start the LXDE desktop environment using the command **startx**. Then open LXTerminal and type the following commands:

```
wget http://liamfraser.co.uk/lud/install_scratchgpio3.sh
chmod +x install_scratchgpio3.sh
sudo bash install_scratchgpio3.sh
```

This will create a special version of Scratch on your desktop called ScratchGPIO3. This is a normal version of Scratch with a Python script that handles communications between Scratch and the GPIO. ScratchGPIO was created by simplesi (**cymplecy.wordpress.com**).



02 Connecting the breadboard

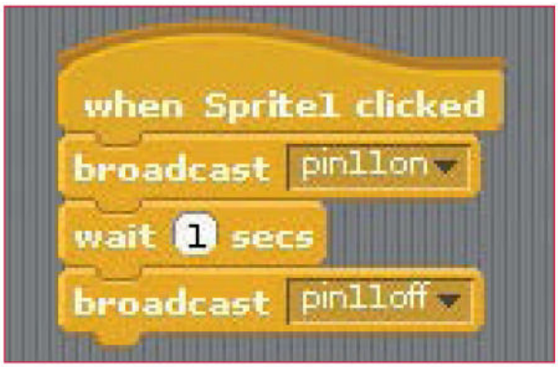
Power off your Pi and disconnect the power cable. Get your breadboard, an LED, a 330-ohm resistor and two GPIO cables ready. You'll want to connect the 3.3V pin (top-right pin, closest to the SD card) to one end of the 330-ohm resistor, and then connect the positive terminal of the LED (the longer leg is positive) to the other end. The resistor is used to limit the amount of current that can flow to the LED.

Then put the negative terminal of the LED into the negative rail of the breadboard. Connect one of the GROUND pins (for example, the third pin from the right on the bottom row of pins) to the negative lane. Now connect the power to your Pi. The LED should light up. If it doesn't, then it's likely that you've got it the wrong way round, so disconnect the power, swap the legs around and then try again.

03 Switching the LED on and off

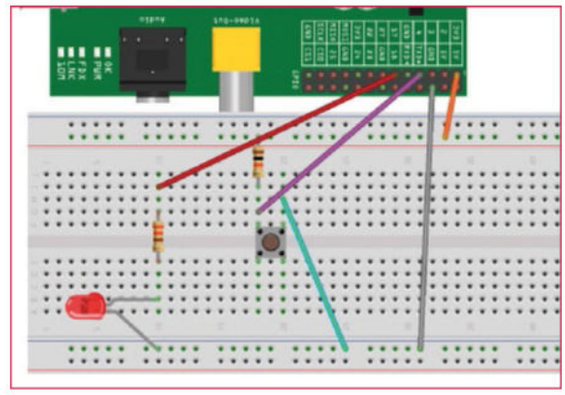
At the moment, the LED is connected to a pin that constantly provides 3.3V. This isn't very useful if we want to be able to turn it on and off, so let's connect it to GPIO 17, which we can turn on and off. GPIO 17 is the sixth pin from the right, on the top row of pins. Power the Pi back on. We can turn the LED on by exporting the GPIO pin, setting it to an output pin and then setting its value to 1. Setting the value to 0 turns the LED back off:

```
echo 17 > /sys/class/gpio/export
echo out > /sys/class/gpio/gpio17/direction
echo 1 > /sys/class/gpio/gpio17/value
echo 0 > /sys/class/gpio/gpio17/value
```



04 Controlling the LED from Scratch

Start the LXDE desktop environment and open ScratchGPIO3. Go to the control section and create a simple script that broadcasts **pin11on** when Sprite1 is clicked. Then click the sprite. The LED should light up. Then add to the script to wait 1 second and then broadcast **pin11off**. If you click the sprite again, the LED will come on for a second and then go off. ScratchGPIO3 uses pin numbers rather than GPIO numbers to identify pins. The top-right pin (the 3.3V we first connected our LED to) is pin number 1, the pin underneath that is pin number 2, and so on.



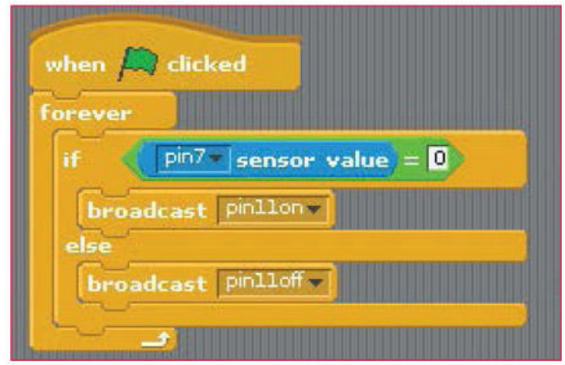
05 Wiring up our push button

Power off the Pi again. This circuit is a little bit more complicated than the LED one we created previously. The first thing we need to do is connect 3.3V (the top-right pin we used to test our LED) to the positive rail of the breadboard. Then we need to connect a 10Kohm resistor to the positive rail, and the other end to an empty track on the breadboard. Then on the same track, add a wire that has one end connected to GPIO 4. This is two pins to the right of GPIO 17. Then, on the same track again, connect one pin of the push button. Finally, connect the other pin of the push button to ground by adding a wire that is connected to the same negative rails that ground is connected to.

When the button is not pressed, GPIO 4 will be receiving 3.3V. However, when the button is pressed, the circuit to ground will be completed and GPIO 4 will be receiving 0V (and have a value of 0), because there is much less resistance on the path to ground.

We can see this in action by watching the pin's value and then pressing the button to make it change:

```
echo 4 > /sys/class/gpio/export
echo in > /sys/class/gpio/gpio4/direction
watch -n 0.5 cat /sys/class/gpio/gpio4/value
```



06 Let there be light!

Boot up the Pi and start ScratchGPIO3 as before. Go to the control section and add **when green flag clicked**, then attach a **forever** loop, and inside that an **if else** statement. Go to the operators section and add an **if [] = []** operator to the if statement. Then go to the sensing section and add a value sensor to the left side of the equality statement, and set the value to pin7. On the right side of the equality statement, enter 0. Broadcast **pin11on** if the sensor value is 0, and broadcast **pin11off** otherwise. Click the green flag. If you push the button, the LED will light up!

You'll learn...

1 Simple circuits

While these are very simple circuits, you'll get a great feel of how the Raspberry Pi interfaces with basic prototyping kit. If you need to buy the bits and pieces, we recommend you check out: shop.pimoroni.com

2 Coding principles

If you're new to programming, Scratch is the perfect place to learn the same programming principles employed by all programming languages out there.

3 Physical computing

There's nothing more magical than taking code from your computer screen and turning it into a real-life effect. Your first project might just turn a light on and off, but with that skill banked, the sky is the limit.

Google Coder is a brilliant way to introduce yourself to web development

Build a Raspberry Pi web server

Use Google Coder to turn your Raspberry Pi into a tiny, low-powered web server and web host

What you'll need

- Internet connectivity
- Web browser
- Google Coder
  googlecreativelab.github.io/coder/raspberrypi/sonicpi/teaching.html

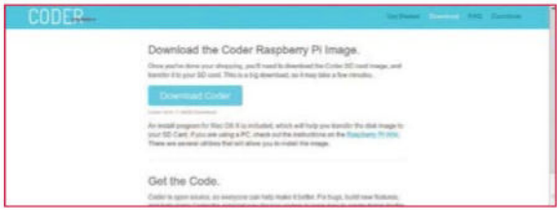
We're teaching you how to code in many different ways on the Raspberry Pi this issue, so it only seems fitting that we look at the web too.

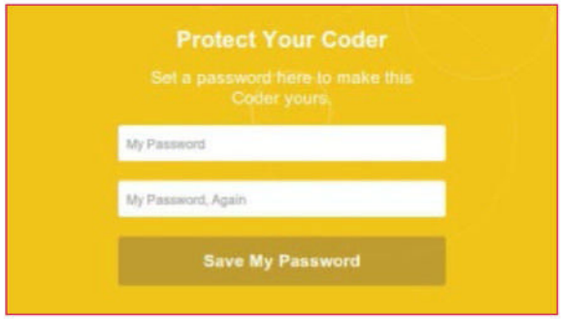
There's a new way to use the web on the Raspberry Pi as well: internet giant Google has recently released Coder specifically for the tiny computer. It's a Raspbian-based image that turns your Pi into a web server and web development kit. Accessible easily over a local network and with support for jQuery out of the box, it's an easy and great way to further your web development skills.

01 Get Google Coder

Head to the Google Coder website, and download the compressed version of the image. Unpack it wherever you wish, and install it using **dd**, like any other Raspberry Pi image:

```
$ dd if=[path to]/raspi.img of=/dev/[path to SD card] bs=1M
```



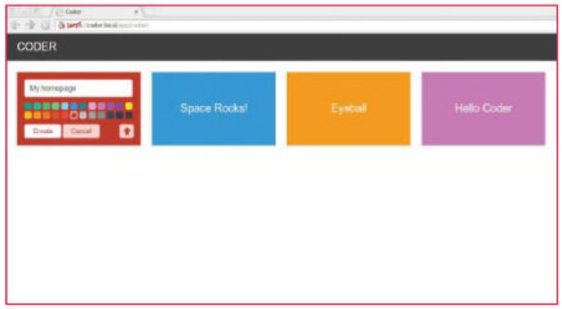


02 Plug in your Pi

For this tutorial, you'll only need to connect a network cable into the Pi. Pop in your newly written SD card, plug in the power and wait a few moments. If you've got a display plugged in anyway, you'll notice a Raspbian startup sequence leading to the command-line login screen.

03 Connect to Coder

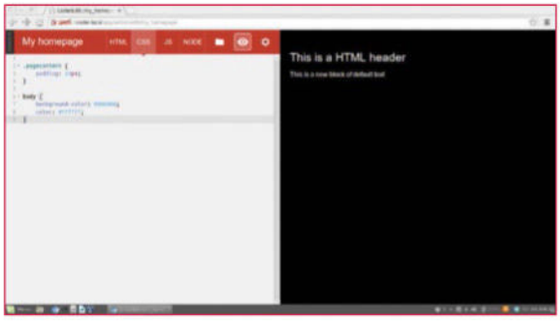
Open up the browser on your main system, and go to **http://coder.local**. You may have to manually accept the licence. It will ask you to set up your password, and then you'll be in and ready to code.



04 Language of the web

Now it's time to create your own app or website. Click on the '+' box next to the examples, give your app a name and then click Create. You'll be taken to the HTML section of the app. Change the Hello World lines to:

```
<h1>This is a HTML header</h1>
<p>This is a new block of default text</p>
```



05 Styled to impress

Click on the CSS tab. This changes the look and style of the webpage without having to make the changes each time in the main code. You can change the background colour and font with:

```
body {
    background-color: #000000;
    color: #ffffff;
}
```

Full code listing

HTML

Some simple HTML code that can point us to some important websites. The h2 tag is used to display the time thanks to Java

```
<h1>Welcome to the internet...</h1>
<h2></h2>
<p><a href="http://www.linuxuser.co.uk">Linux User & Developer</p>
<p><a href="http://www.reddit.com/">Reddit</p>
<p><a href="http://www.linuxfoundation.org/">The Linux Foundation</p>
<p><a href="http://www.fsf.org/">Free Software Foundation</p>
```

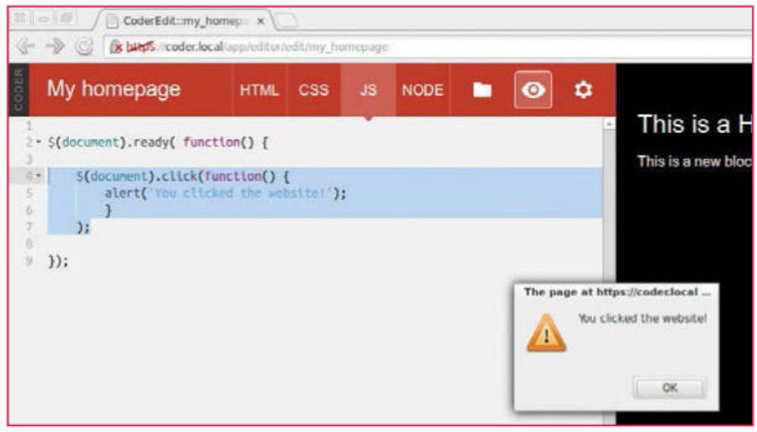
Java

We're calling the current time using jQuery in the JS tab so that we can ultimately display it on the webpage

We're going to display the time as a 12-hour clock in the first **if** statement, and use AM and PM to differentiate the time

We make the minutes readable by adding a 0 if it's below 10, then concatenate all the variables and assign to the tag h2

```
var d = new Date;
    var hours = d.getHours();
    var mins = d.getMinutes();
    if (hours > 12) {
        var hour = (hours - 12);
        var ampm = "PM";
    }
    else {
        var hour = hours;
        var ampm = "AM";
    }
    if (hours == 12) {
        var ampm = "PM";
    }
    if (mins > 9){
        var min = mins;
    }
    else {
        var min = "0" + mins;
    }
    var time = "The time is " + hour + ":" + min + " " + ampm;
    $("h2").html(time);
```



06 Querying your Java

The third tab allows you to edit the jQuery, making the site more interactive. We can make it create a message on click with:

```
$(document).click(function() {
    alert('You clicked the website!');
    }
);
```

50 WAYS TO MASTER RAS PI

Get the most out of your Pi with these expert tips and tricks

Whether you've just got your lucky hands on a powerful, petite Raspberry Pi Zero or you're looking to maximise the efficiency of the faithful Raspberry Pi you already own, this is everything you need to get started on boosting not only your Raspberry Pi but your own knowledge. The Raspberry Pi is a versatile little piece of hardware, with a wonderfully creative amount of potential, and though most of you will be familiar with its more day-to-day functions, there are always tweaks and adjustments to be explored that can tailor the Raspberry Pi to your own desired user experience.

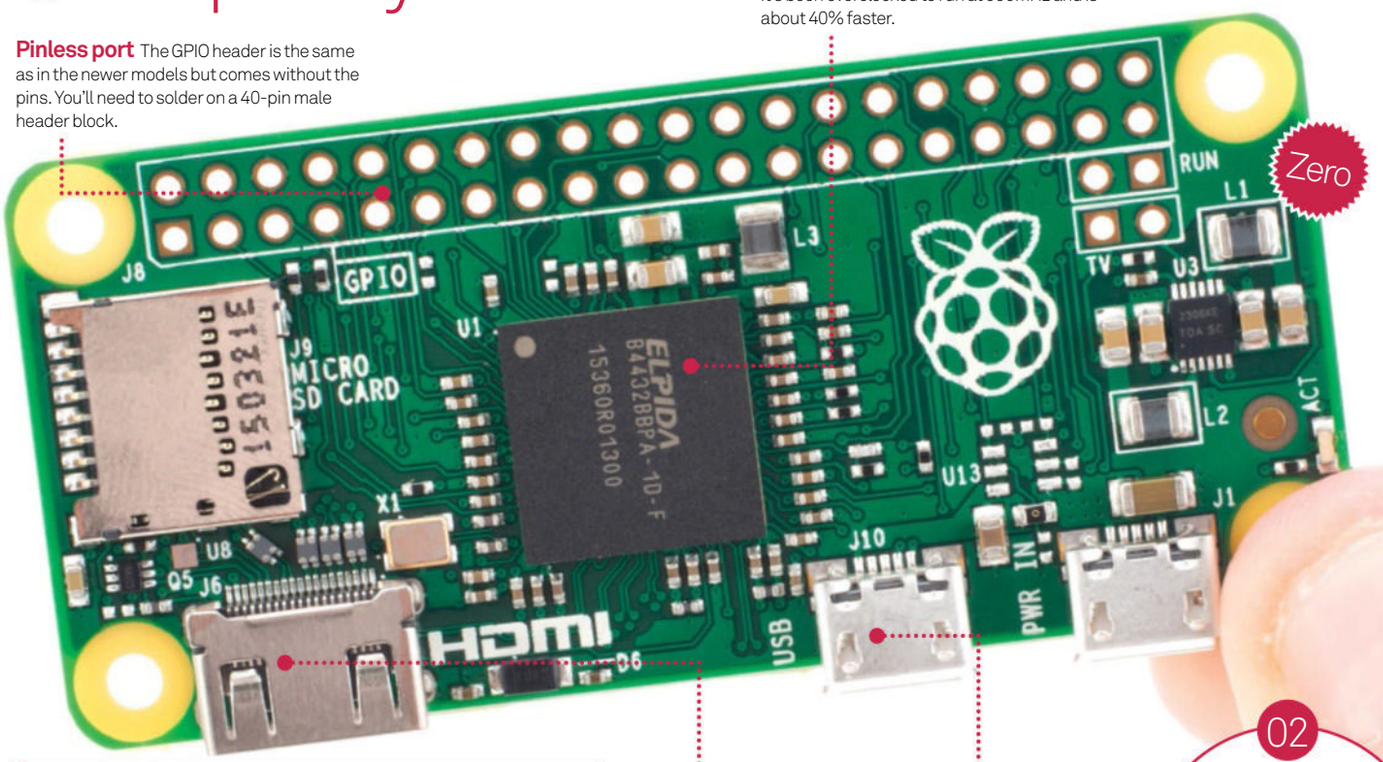
From soldering to useful Python features, GPIO interrupts to remote access, and a whole lot more, this masterclass in technical and practical skills covers fifty useful ways to get the most out of your Raspberry Pi. If you're anything like us, you'll have been tinkering around with your Raspberry Pi Zero, but whatever your skill level there's still something here for you to get your teeth into.

Every single tip here will work on your Pi Zero; just keep an eye out for the 'Zero' flash, indicating which are relevant to the Pi Zero only. Those of you using an earlier model won't be missing out, though – how could we ever neglect our favourite single-board computer? – the majority of tips, tricks and tweaks are still suitable for any other official Raspberry Pi as well. Have fun tinkering!

01 Raspberry Pi Zero

BCM2835 This is the same processor used in the original Raspberry Pi models, although it's been overclocked to run at 900MHz and is about 40% faster.

Pinless port The GPIO header is the same as in the newer models but comes without the pins. You'll need to solder on a 40-pin male header block.



The newest member of the Raspberry Pi family, this tiny board is the result of the Raspberry Pi Foundation's efforts to reduce the cost of the computer even further. Not content with reducing its $35 computer to $25, which can still be a little pricy for some people, it has cut it right down to $5 by making a few adjustments. Here's what you need to know.

Mini-HDMI You'll need a mini-HDMI to HDMI cable to use your monitor as a display. You can use your TV with the RCA video-out if you solder the pin.

Micro-USB One of these ports is for your micro-USB power supply. To use peripherals and a Wi-Fi dongle, you'll need a micro-USB to USB adaptor so you can attach a powered USB hub.

02 Ensure you have the latest packages on Raspbian by running **sudo apt-get update; sudo apt-get upgrade** from a terminal

Vital knowledge

Essential tricks to improve day-to-day use

03 Find your Pi on a network

If you can't log into your router to view DHCP leases, you can use **nmap** (available for Linux, Windows and Mac) to scan the local network to find a Raspberry Pi. You need to know the address range of your local network (common networks are 192.168.1.0/24, and 192.168.2.0/24). **nmap -sn 172.17.173.0/24** will run a ping scan and output a list of devices. An example output is:

```
Nmap scan report for raspberrypi.home.org (172.17.173.21)
Host is up (0.0011s latency).
```

04 Experiencing stability issues?

By far the biggest cause of stability issues is the power supply you are using, especially now the Raspberry Pi 2 has more CPU cores and so uses more energy. The recommended current supply for a Raspberry Pi 2 or B+ is 1.8 amps. If you are still having issues, your SD card may be worn out.

05 Forgot to type sudo?

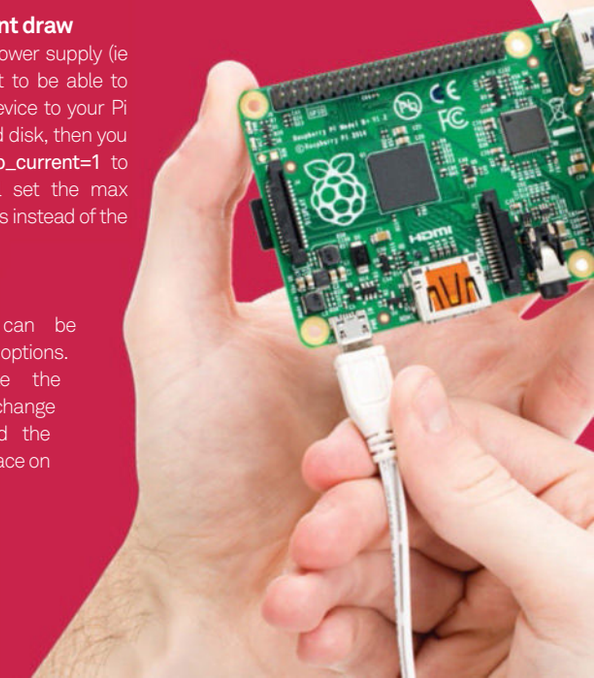
Sudo is used to get root privileges for a specific command (for example, editing a file in /boot or /etc). The variable **!!** in bash is the previous command that you typed. So if you need root privileges for something but forgot to type **sudo** then you can simply type **sudo !!**, provided you haven't typed anything else since.

06 Enable max current draw

If you have a good power supply (ie 2 amps or more) and want to be able to connect a current-heavy device to your Pi 2 or B+, such as a USB hard disk, then you can add the line **max_usb_current=1** to /boot/config.txt, which will set the max current over USB to 1.2 amps instead of the default 600mA.

07 Control options

sudo raspi-config can be used to change several options. For example, to enable the camera, overclock the Pi, change boot options, and expand the filesystem to use the full space on the SD card.



Transferable tips

Handy hints and vital info to get the most out of any Raspberry Pi model

08 Remote access with SSH

SSH stands for Secure Shell. You can use SSH to connect to a terminal session on your Raspberry Pi over your local network. This means that you can use the Pi with only a network cable and power cable connected, which is much more convenient than needing a screen and keyboard. Once you have found your Pi on the network you can log into it using the default username of 'pi' and the default password of 'raspberry'. Both Linux and Mac will have built-in SSH clients, so simply open the terminal and type **ssh pi@192.168.1.5**, assuming that 192.168.1.5 is the address of your Pi. On Windows, you can use an SSH client called PuTTY, which is free to download, doesn't need installing and is easy to find with a search engine.

09 Copy files using SCP

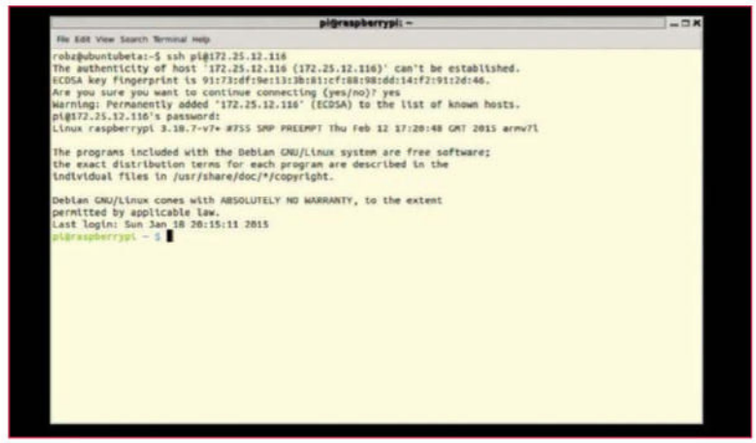
SCP stands for Secure Copy Protocol, and is a way for you to copy files (and directories) to and from your Raspberry Pi over the network. A good use of this would be if you have art for a PyGame project and you need to copy it over. FileZilla is a decent graphical SCP client to use (connect to your Pi on port 22 with the username 'pi' and password 'raspberry'). If you are using SCP from the terminal then the syntax is as follows:

```
scp -r testdir/pi@172.17.173.21:~/
```

The `-r` switch is for recursive, which means entire directories are copied in addition to files. This will place your test directory in /home/pi/ (because `~` points at the logged-in user's home directory on Linux). Simply swap the syntax for copying from the Raspberry Pi instead:

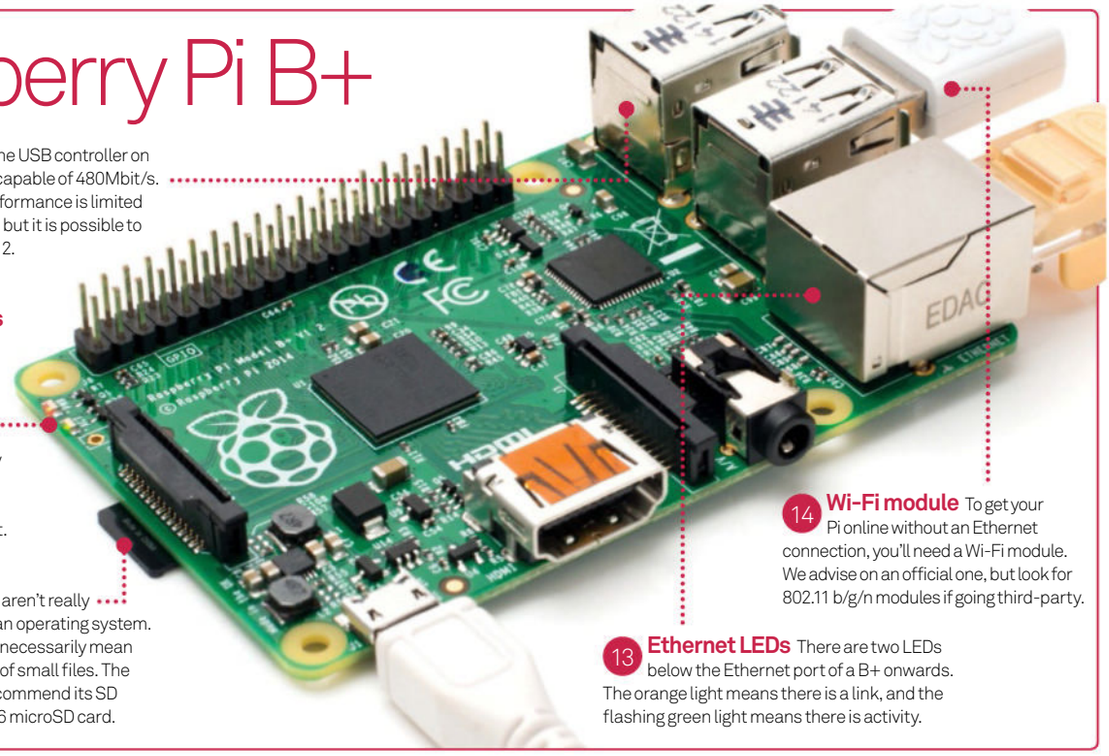
```
scp -r pi@172.17.173.21:~/testdir .
```

The dot refers to the current directory in Linux, so the **testdir** directory would be copied to the current directory.



Above Get a terminal on your Raspberry Pi from the convenience of your main computer

Raspberry Pi B+



10 USB controller The USB controller on the Pi is theoretically capable of 480Mbit/s. On earlier Pi models the performance is limited by the single core ARM chip, but it is possible to get close to that limit on a Pi 2.

11 Power / Act LEDs The remaining LEDs are for power and SD card activity. The power LED is red, and the activity LED flashes green when there is SD card activity. The activity LED also flashes when powering down to indicate when it is safe to disconnect.

12 SD cards SD cards aren't really designed for running an operating system. Higher class SD cards don't necessarily mean better performance for lots of small files. The Raspberry Pi foundation recommend its SD card, which is an 8GB class 6 microSD card.

13 Ethernet LEDs There are two LEDs below the Ethernet port of a B+ onwards. The orange light means there is a link, and the flashing green light means there is activity.

14 Wi-Fi module To get your Pi online without an Ethernet connection, you'll need a Wi-Fi module. We advise on an official one, but look for 802.11 b/g/n modules if going third-party.

15 Get your Pi Zero online

Using an Ethernet adapter with your Pi Zero

▶ Step One: The parts

You'll need an adapter to connect the micro-USB port to a full size USB port. This adapter, along with a mini-HDMI to HDMI adapter and GPIO pin headers can be found here: **http://swag.raspberrypi.org/products/pi-zero-cables**. You'll also need a USB to Ethernet adapter that works with Linux (most will work out of the box), These can easily be found on Amazon for around £10.

▶ Step Two: Configuration

As the Pi Zero uses the normal Raspbian image, and eth0 (ie the built-in Ethernet card) is missing, there is no configuration necessary because the USB Ethernet card will take the missing LAN chip's place as eth0.

▶ Step Three: Testing it out

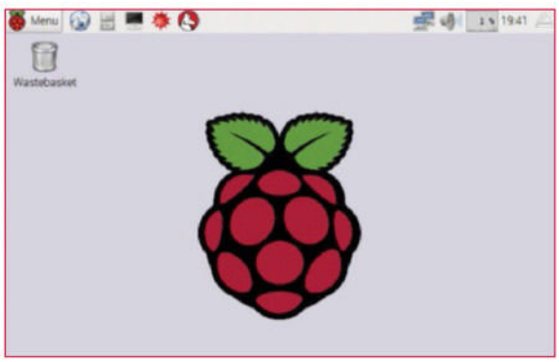
If the activity lights on your USB to Ethernet adapter are lit, then it should be working fine. You can now use the remote access tips from other sections of the article with your Pi Zero!

16 Set up a VNC server

VNC stands for Virtual Network Computing. Using VNC, you can access the Raspbian desktop over the network (meaning you only need power and Ethernet connected). There is no audio support but for any other tasks (including the use of Pygame), VNC should provide acceptable performance. You can install a VNC server with the following commands...

```
sudo apt-get update
sudo apt-get install tightvncserver
```

There are several free VNC clients available, so a search engine will help find a suitable one. To start a VNC session on your Pi, log in over SSH and then run **tightvncserver**. You will be prompted to enter a password the first time you run it. You can specify a screen resolution with the **-geometry** option, for example **-geometry 1024x768**. You can kill an existing VNC session with **tightvncserver -kill :1**, where **1** is the session number. To connect to that session on a Linux machine, you could use the command: **vncviewer 172.17.173.21:1**, substituting for the IP address of your Raspberry Pi.



Left Access the Raspbian desktop from your main computer over your local network

17 The **sync** command ensures that everything has been flushed to permanent storage from the cache. It can be useful to run after updating packages, for example.

Five terminal tricks

Navigate your way around the command line with ease

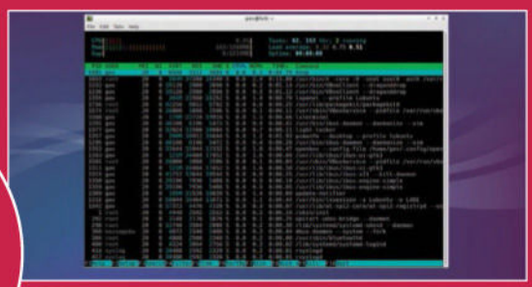
18 Listing open ports

Lsof stands for List Open Files, and you can install it with **sudo apt-get install lsof**. If you run **sudo lsof -i** you will see a list of all open network connections on the machine, including applications that are listening for new connections (for example, the SSH daemon).

19 Using wget to download files

Wget can be used to download files from the Internet from the terminal. This is convenient if you need to download a zip file containing source code and then extract it. For example:

```
wget http://liamfraser.co.uk/test.zip
unzip test.zip
```



20 Using htop to monitor load

Htop is an improvement on the original **top** utility. It lets you see the CPU and memory load on your machine in real time, which is useful to know how intensive your application is being on a Raspberry Pi. You can install it with **sudo apt-get install htop**.

21 Reboot from the terminal

It seems like a simple tip but not everyone knows that you can reboot your Pi with the command **sudo reboot**, and similarly power it off with **sudo poweroff**. You need to disconnect and reconnect the power after powering off the Pi, though, as there is no on/off switch.

22 Using screen

Screen (available via **apt-get**) is great if you have something you want to run that takes a long time. You can run it in a screen session, detach from it and reconnect later on. Example usage:

`screen -S test` (Ctrl + A, d to disconnect)
`screen -ls` to list sessions.
`screen -r` test to reconnect
`exit` will kill bash and therefore end the screen session.

23 split files

If your program is large, you can split it up into multiple files. If you have a file called MyClass.py containing a class MyClass, you can use it from another script with from MyClass import MyClass

Become a Python Pro

Here are some handy Python features that will make your code really stand out

24 The main function

Having a main function (**if __name__ == __main__**) in Python is useful. It makes it easier to see the difference between where your functions/classes are defined and where your entry point is. More importantly, it allows you to only run code from that Python script in the case that it is the main script being run. This means that you can create a class and have code that tests that class to make sure it works. However, if you were to include your file in another program, the code in the main method would not be run and you can just use the class that you require.

```
class MyClass:
  def __init__(self):
    self.x = 1

  def print_increment(self):
    print "x = {0}".format(self.x)
    self.x += 1

if __name__ == "__main__":
  # Test MyClass
  m = MyClass()
  m.print_increment()
  m.print_increment()
```

25 Command line arguments

Command line arguments enable your program to run in various modes depending on the options that the user passes to the program when running it. Command line arguments in Python are given in sys.argv, which is a list of arguments. The first argument is always the name of the script that has been executed. For example, some code that prints the argv array produces the following outputs:

```
$ python args.py
['args.py']
$ python args.py --foo
['args.py', '--foo']
```

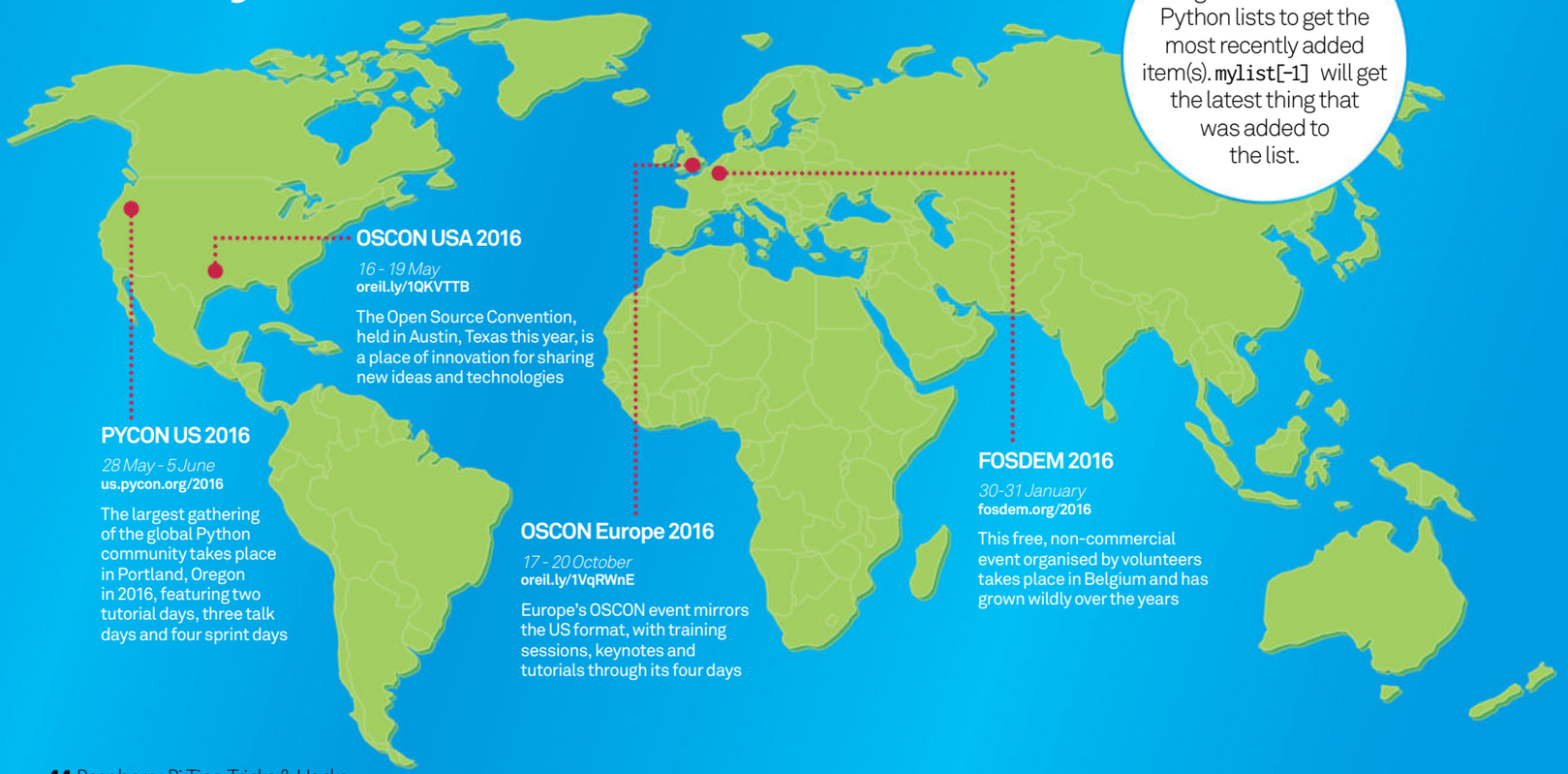
You can check for command line arguments in this list. If the length of the list is 1 and you require arguments, print a help message with instructions.

```
import sys

help_msg = "My help message"
debug_mode = False
if __name__ == "__main__":
  if len(sys.argv) == 1:
    print help_msg
    sys.exit()

  if "--debug" in sys.argv:
    debug_mode = True
    print "Using debug mode"
```

26 Using properties and setters

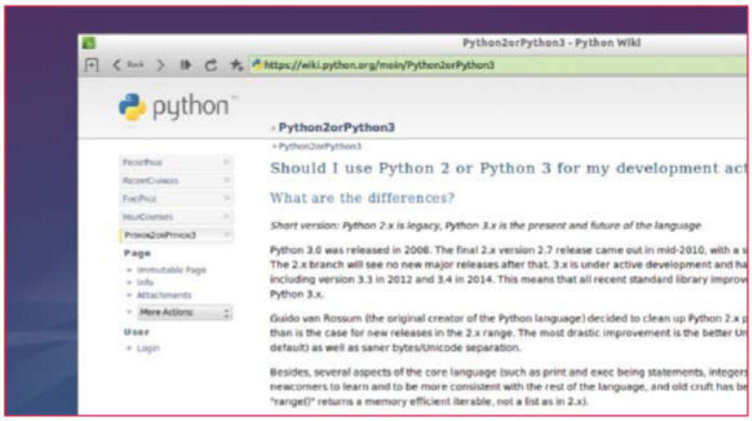
Properties in Python are a way to write getters and setters for variables. You need new-style classes (you need to inherit from object). We

27 Python conferences



28

You can use negative indexes on Python lists to get the most recently added item(s). `mylist[-1]` will get the latest thing that was added to the list.



Above Not sure whether to pick Python 2 or 3? There's a guide to help in the docs: **bit.ly/1jyd799**

have created a class called **distance** where the distance in miles is a variable, and the distance in kilometres is a property. Getting from that variable multiplies the distance in miles to be kilometres and setting the variable sets the value in miles.

```
class Distance(object):
  KM_PER_MILE = 1.60934

  def __init__(self, mi):
    self.miles = mi
  @property
  def km(self):
      return self.miles * Distance.
KM_PER_MILE

  @km.setter
  def km(self, value):
    self.miles = value / Distance.
KM_PER_MILE

if __name__ == "__main__":
  d = Distance(3.1)
  print d.km
  d.km = 10
  print d.miles
  print d.km
```

29 Using the GPIO

Get to grips with the GPIO library

Step One: Import library

Start by importing Rpi.GPIO:

```
import RPi.GPIO as GPIO
```

Then, you want to set the pin numbering convention to the Broadcom mode (as in GPIO17 will be pin 17, rather than being pin 11 on the Pi):

```
GPIO.setmode(GPIO.BCM)
```

Step Two: Pin setup

Now you need to set up your pins as either inputs or outputs with the following syntax:

```
GPIO.setup(5, GPIO.OUT)
GPIO.setup(6, GPIO.IN)
```

If you have several pins to set up, it makes sense to put them in a list and then do something like:

```
for p in pins:
    GPIO.setup(p, GPIO.OUT)
```

Step Three: Get values

Once the pins are set up, getting values from them is easy. To get the value of a pin (0 for low, and 1 for high), use the following syntax:

```
value = GPIO.input(6)
```

...and to set the value of a pin (with either 0 or 1, or True or False) use the following syntax:

```
GPIO.output(5, True)
```

Please note that if you are starting with Raspbian Jessie, you shouldn't need **sudo** to access the GPIO pins, but in previous versions of Raspbian you will need to use **sudo** to run your code.

Five hidden features

Uncover the secrets to be found in Python

30 List comprehension

List comprehension is a way of generating a list on a single line. You can use list comprehension to extract values from other list-type data structures. For example, if you have a collection of distance classes, you could get just the distance in miles into a list: `miles = [x.miles for x in distances]`. Here is a sample output:

```
>>> [x/2.0 for x in range(0, 10)]
[0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5]
```

31 Assertions

Assertions are useful when writing algorithms. They are used to check the data is valid before and after your algorithm. So, for example, if you are expecting your results in a certain range you can check them. The syntax is **assert(boolean expression)**. For example:

```
>>> assert(0 < 1)
>>> assert(1 < 0)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AssertionError
```

32 Throwing exceptions

It's useful to throw exceptions in your code if it's possible that it can go wrong. That way the person calling your code can put it in a try-catch block and handle the exception if it is raised. If the caller does not handle it then their application will crash.

```
>>> raise ValueError("Supplied value out of range")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: Supplied value out of range
```

33 Running your script from a terminal

If you begin your Python script with **#!/usr/bin/env python** and then mark it as executable, you can execute it from bash just like a normal script without having to type **Python** before it:

```
$ echo '#!/usr/bin/env python' > test.py
$ echo 'print "Hello World from Python!"' >> test.py
$ chmod +x test.py
$ ./test.py
Hello World from Python!
```

34 Using the interpreter

Did you know you can start a Python interpreter to test things are working without having to write a Python script? Just type **python** into the terminal and then simply start writing Python.

35 remove static

Make sure you haven't built up any static charge when working with electronics. Touching a grounded radiator in your house can be a good way of getting rid of static charge.

Hardware how-to

GPIO interrupts, pulse width modulation, soldering and more

GPIO explained

36 GPIO orientation

The best way to verify you have the Pi oriented the right way is to flip it over. The underneath of pin 1 has a square hole for the solder instead of a circular hole.

37 Serial console

If you connect the UART0_TXD pin to the receiver pin of a USB-to-serial converter, and the UART0_RXD pin to the transmitter pin of that converter, you can set up a serial console.

38 Unused GPIO pins

The green coloured GPIO pins are unused by default and are therefore the best pins to use in your own personal hardware projects. The other pins may have more than one available purpose.

39 Soldering headers

With the Pi Zero, you will need to solder GPIO headers onto the board. Using a reusable adhesive like Blu-Tack to hold the headers in place will make the job much easier.

Zero

40 Pin layout

3V3 Power	01	02	5V Power
GPIO2 SDA1 I2C	03	04	5V Power
GPIO3 SCL1 I2C	05	06	Ground
GPIO4	07	08	GPIO14 UART0_TXD
Ground	09	10	GPIO15 UART0_RXD
GPIO17	11	12	GPIO18 PCM_CLK
GPIO27	13	14	Ground
GPIO22	15	16	GPIO23
3V3 Power	17	18	GPIO24
GPIO10 SPIO_MOSI	19	20	Ground
GPIO9 SPIO_MISO	21	22	GPIO25
GPIO11 SPIO_SCLK	23	24	GPIO8 SPIO_CE0_N
Ground	25	26	GPIO7 SPIO_CE1_N
ID_SD I2C ID EEPROM	27	28	ID_SC I2C ID EEPROM
GPIO5	29	30	Ground
GPIO6	31	32	GPIO12
GPIO13	33	34	Ground
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
Ground	39	40	GPIO21

41 How to solder

Solder with ease in just a few steps

Step One: The tools

You need a soldering iron (30-40 watts, or ideally a temperature-controlled one), a stand to put it in, a damp sponge to clean the tip, and some thin solder. Lead solder is easier to work with than lead-free, and an iron with a square tip conducts heat better than a pointy one.

Step Two: Soldering

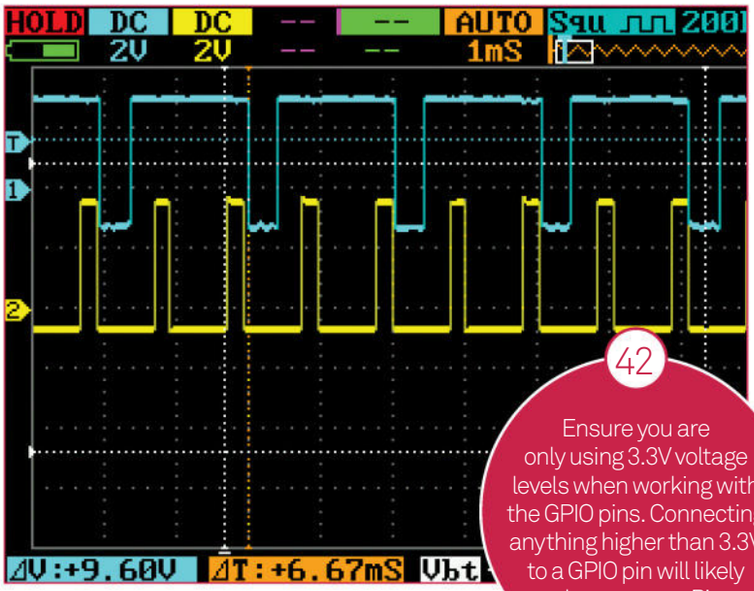
Once the iron is hot, apply some solder to the tip of the iron and wipe off any excess on the sponge. When pressing the iron to the joint, the tip should be touching both the joint and the wire you are soldering. Do not apply solder directly to the iron; apply it to the joint/wire.

Step Three: If you make a mistake

You probably won't need as much solder as you think you will, so be sparing. Still, accidents can happen, and the best way to remove excess solder is to get some de-soldering braid. This is copper that you put over solder, before putting the iron over the top. The solder is sucked onto the braid.

Five-minute practical fixes

Quick and easy things you can try in a few minutes



Above Here are two waves with duty cycles of roughly 80% (top) and 20% (bottom)

42 Ensure you are only using 3.3V voltage levels when working with the GPIO pins. Connecting anything higher than 3.3V to a GPIO pin will likely damage your Pi.

43 Pulse width modulation

Pulse width modulation is where the output of a GPIO pin is high for a percentage of time and low for the remaining percentage of time. The percentage where the pin is high is called a duty cycle. Pulse width modulation is very useful in electronics, especially when it comes to tasks like controlling the brightness of LEDs. To do this in Python:

```
GPIO.setup(5, GPIO.OUT)
# Frequency of 50 hz
p = GPIO.PWM(5, 50)
# 50 percent duty cycle
p.start(50)
# Do work or wait here so
# program doesn't exit
# 70 percent duty cycle
p.ChangeDutyCycle(70)
p.stop()
```

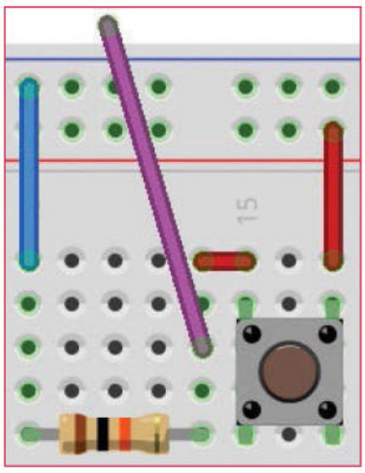
44 GPIO interrupts

An interrupt is when a hardware event triggers an interrupt on the CPU, causing it to stop what it is dealing with and run an interrupt request handler. The Raspberry Pi can trigger inputs when a GPIO pin goes high (ie from 0V to 3.3V) or low (from 3.3V to 0V). This can be more efficient than polling for the state of a GPIO pin, as you only have to deal with the pin changing when it happens. Plus, it can actually simplify the flow of your code.

The use of interrupts requires root privileges so you will have to execute your code with **sudo**. The code provided demonstrates how to set up a callback function to deal with a rising edge.

45 Using a push button

Refer to the circuit diagram below. When the push button is pressed, the left pins are connected to the right pins. By using a 10K pull down resistor connected to ground, the purple output wire (connected to a GPIO pin configured as an input) defaults to 0V when the button is not pressed. The right-hand side of the button is connected to 3.3V, so when the button is pressed, the left-hand side of the button will also be connected to 3.3V. The left-hand side is connected in parallel with the purple signal wire, and also the 10K resistor to ground. Because electricity takes the path of least resistance, the purple signal wire will output 3.3V.



Above The blue wire is the ground, the red one is 3.3V and purple is for the output

46 Need more current?

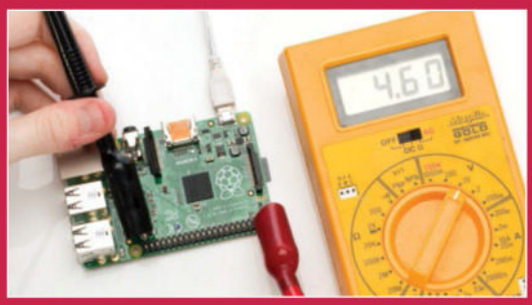
You should only draw a few milliamps of current from the GPIO pins of the Raspberry Pi. If you need more current than that (or you need to switch a higher voltage), then you can use the GPIO pin to switch a transistor connected to a stronger voltage source.

47 Disable built-in sound card

If you are using a USB sound card then it can be easier to disable the built-in sound card completely:

```
sudo rm /etc/modprobe.d/alsa*
sudo editor /etc/modules
```

Change **snd-bcm2835** to **#snd-bcm2835** and save, then **sudo reboot**.



48 Use a multimeter to verify orientation

You can use a multimeter to verify the orientation of the GPIO pins. Looking vertically, with the USB ports at the bottom, the bottom-left pin (39) is ground and the top-right pin (2) is 5V. Using the negative terminal on ground and the positive terminal on 5V should show ~5V.

49 Set up serial console

You can use **raspi-config** to set up a serial console so you can get a login shell using the UART0_TX and UART0_RX pins by connecting them to a USB to serial adapter:

```
sudo raspi-config
8 (Advanced Options)
A8 (Serial)
```

Select Yes to enable serial console. Finish, then reboot.

50 LED resistor calculations

To calculate an LED's resistance value, use Ohm's law: Resistance = voltage / current. The voltage of a GPIO pin is 3.3V. You need to know the voltage drop of the LED and its suggested current, so R = (3.3V – voltage_drop) / led_current. Using 2V as the voltage drop and 20mA as the current: (3.3 – 2.0) / 0.02 = 65 ohms. Round up to the next available resistor.

Use an Android device as a Raspberry Pi screen

Connect to a Pi with your phone or tablet using VNC as a secondary or actual display

There are a few ways to attach a display to a Raspberry Pi. The ones that everyone is most familiar with are the HDMI port, which can go straight into your monitor or TV, or via the GPIO ports with a portable screen. One avenue that is rarely pursued is using VNC software to remotely view the Raspberry Pi desktop using another computer entirely.

It's actually fairly simple and we are going to concentrate on viewing your Pi screen via Android for maximum portability. With further tweaks you will be able to use this on the go if you find yourself commuting and wanting to catch up on your favourite program, for example.

There are a few things that you should be aware of when doing this project – it can be quite taxing on the Pi and is likely to drain a bit of battery from your phone too. We will talk about some options to help take the strain off the Pi if the connection seems a little laggy and how this method can be used on normal PCs as well, so you can use a range of devices and get the most from your Raspberry Pi.

01 Update your Raspberry Pi

Before starting, you should absolutely make sure that your Raspberry Pi is up to date. With the limited resources on the Pi, any optimisations can make the experience better. You'll first want to update the software by opening the terminal and using:

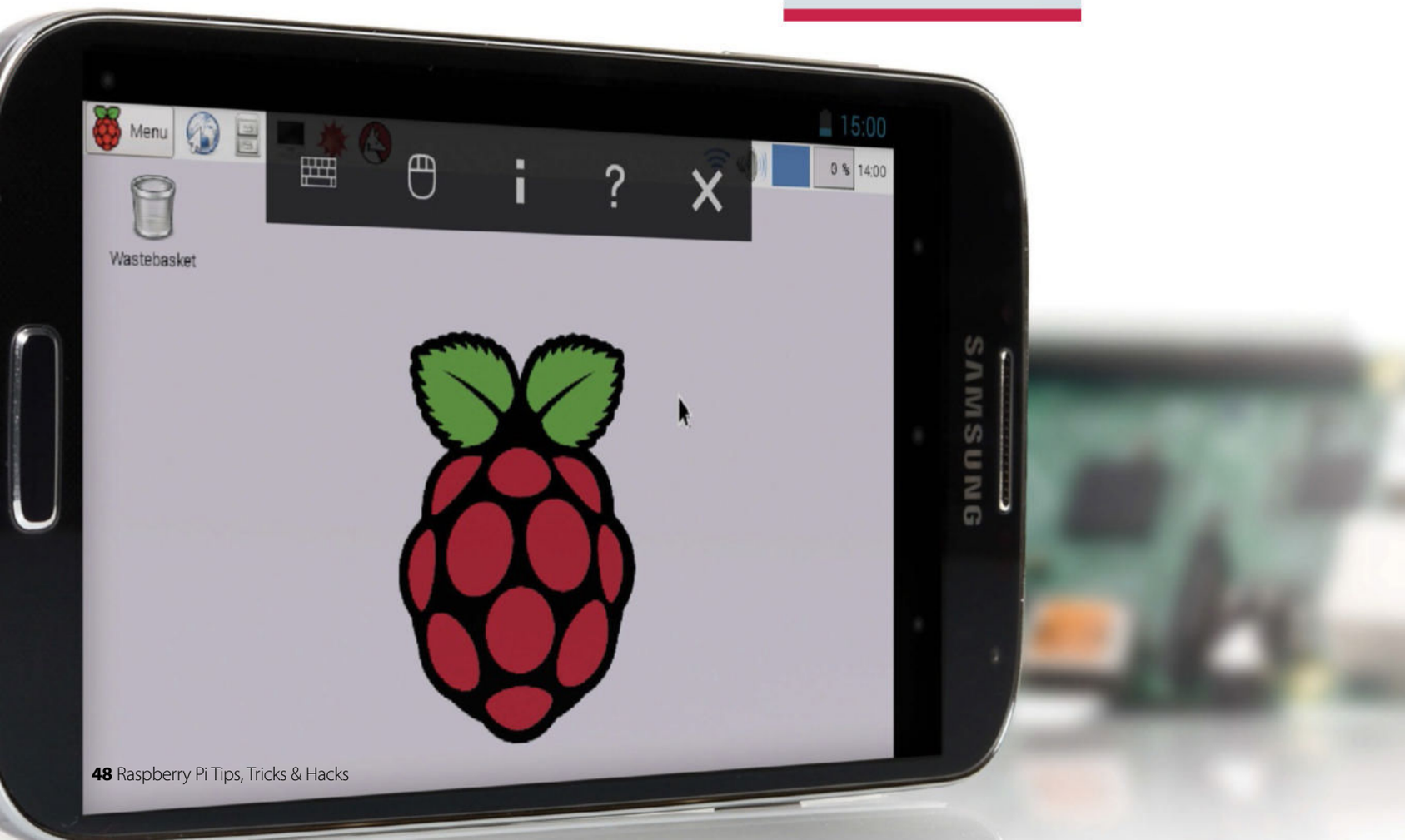
```
$ sudo apt-get update && sudo apt-get upgrade
```

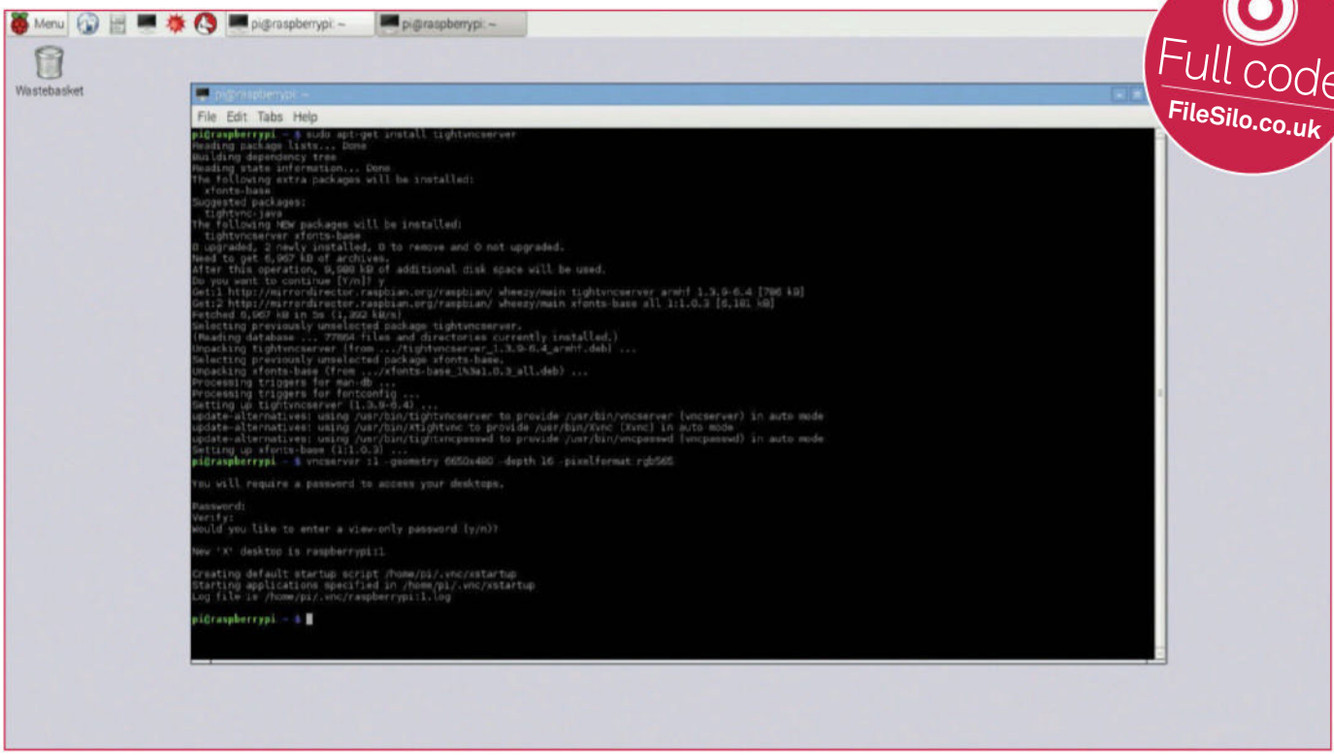
... and then follow it up with a firmware upgrade by running:

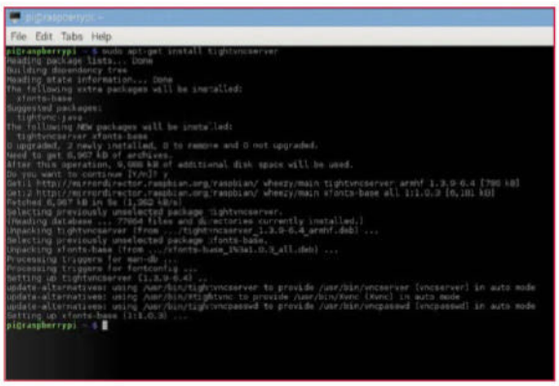
```
$ sudo rpi-update
```

What you'll need

- TightVNC tightvnc.com
- VNC Viewer bit.ly/1jCzBRJ







02 Install the software

We're going to be using TightVNC for our VNC needs here – specifically, the server side of the software. We'll need to install it first though, so head back to the terminal and type:

```
$ sudo apt-get install tightvncserver
```

You may have to run through a setting or two as it installs, hit 'yes' (or 'y') to them to continue.

03 Start up VNC

Once everything's installed we can actually start up the VNC server – it's probably a good idea to do so now and check to make sure it's all working. We'll do a test run with the following:

```
$ vncserver :1 -geometry 640x480 -depth 16
-pixelformat rgb565
```

As long as everything is installed correctly, it should start without any problems at all.

> Look up the resolution of your Android device and then modify the line used to start up the server

04 First time setup

The first time you turn it on, you will have to set a password. You'll need to pick a password you can remember as it will also be used by the client as it connects via VNC. You can only use a maximum of eight characters for the password though, so think carefully about how you want to make it secure.

05 Stop and restart

As TightVNC doesn't quite work like a normal service, you can't do a usual **service X restart** (or equivalent) to turn it off or whatever you wish to do with it. Instead, if you want to restart it, you'll have to manually turn it off and then restart it with the original command. To kill it, use:

```
$ vncserver -kill :1
```

... replacing 1 with the display number that you originally create.

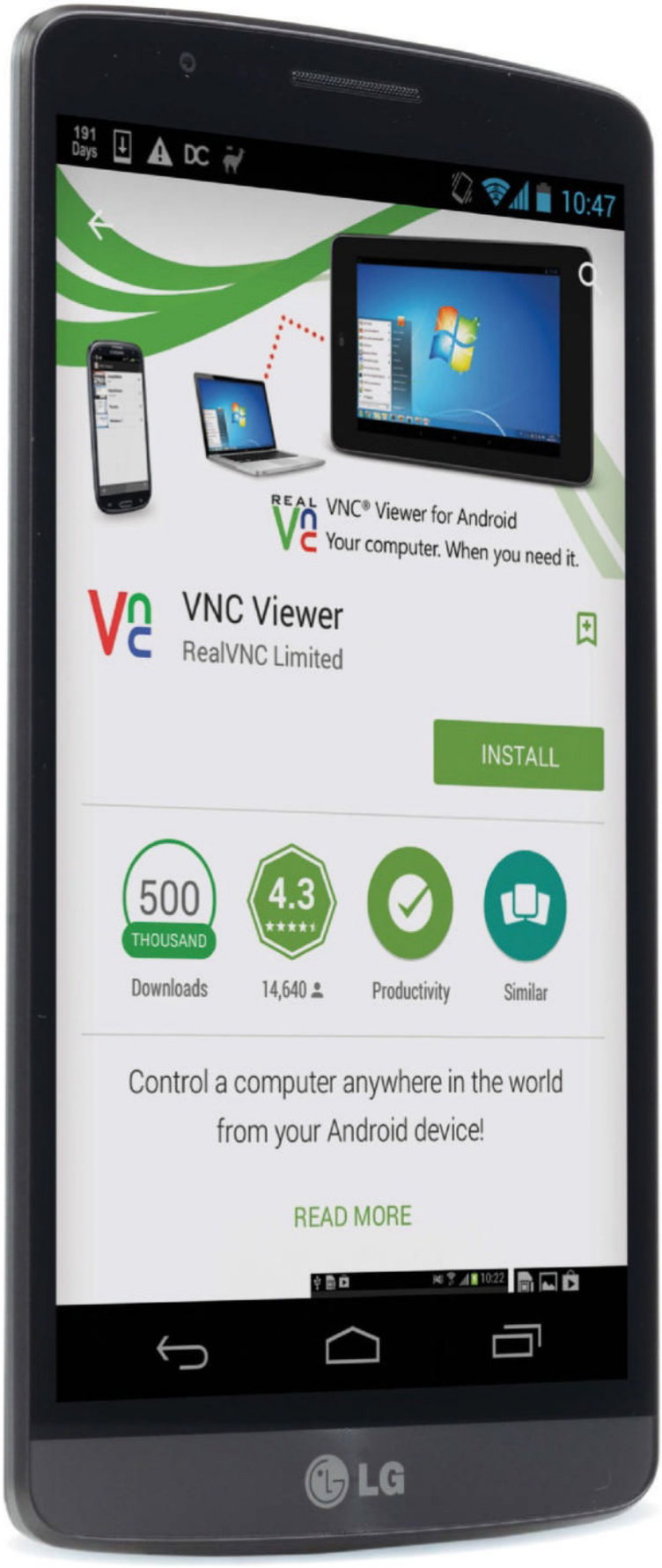
06 Correct resolution

We created our test server with a resolution of 640 x 480, just to get it running. However, this is unlikely to be the resolution of your phone. Luckily, this resolution is not fixed every time, so the best thing to do is to look up the resolution of your Android device and then modify the line used to start up the server. For example, if you have a 1080p tablet, you would use:

```
$ vncserver :1 -geometry 1920x1080 -depth 16
-pixelformat rgb565
```

Running slow

If you find the server is running a bit too slow for your liking, our best tip is to reduce the resolution to something your Pi can more easily create a server for. If that's not helping, your network connection may well be the issue.



Above VNC Viewer is made by RealVNC, the original developers of VNC technology

07 Get the app

On your Android device, go to the Play Store and look for VNC Viewer (you can also install it from the web store via this link: **bit.ly/1jCzBRJ**). Install it to your device and run it to make sure it works fine. We can now begin to try and connect it to the Raspberry Pi.

08 Raspberry Pi IP

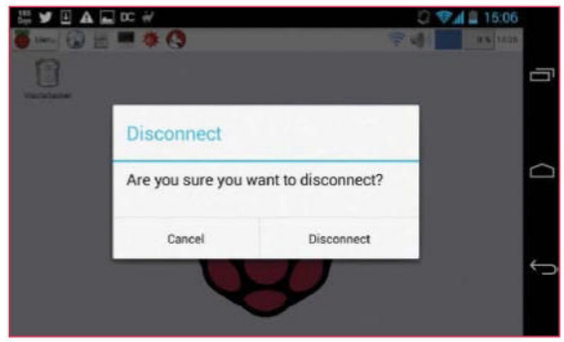
We need the IP address of your Raspberry Pi so that we can connect to it. You can get it via two methods – our preferred method is to open the terminal and use **ifconfig** to list the status of the Pi's network interfaces; this will include the IP address of whatever is connected. If you're using wireless to connect, you can also access the wireless config interface (**iwconfig**) and see what the wireless has been assigned as an IP.

09 Connect to the Pi

Now that we have the IP address, we can look at connecting to the Raspberry Pi. Open VNC Viewer and click the '+' sign to set up a new connection. Leave the name blank for the moment, enter an IP address and choose 'Save password'. It will ask for the password when you attempt to connect, after which it will then save it and not require it in the future.

10 Use VNC

If this is the first time that you are using VNC software, you will notice that there can be a little lag between what you do and what happens on-screen. Luckily, you can use your finger on the screen to move the mouse and tap to click, and the Android keyboard can be used as the keyboard. It can take a bit of getting used to and is not good for anything that you need to do fast, but it's still very useful.



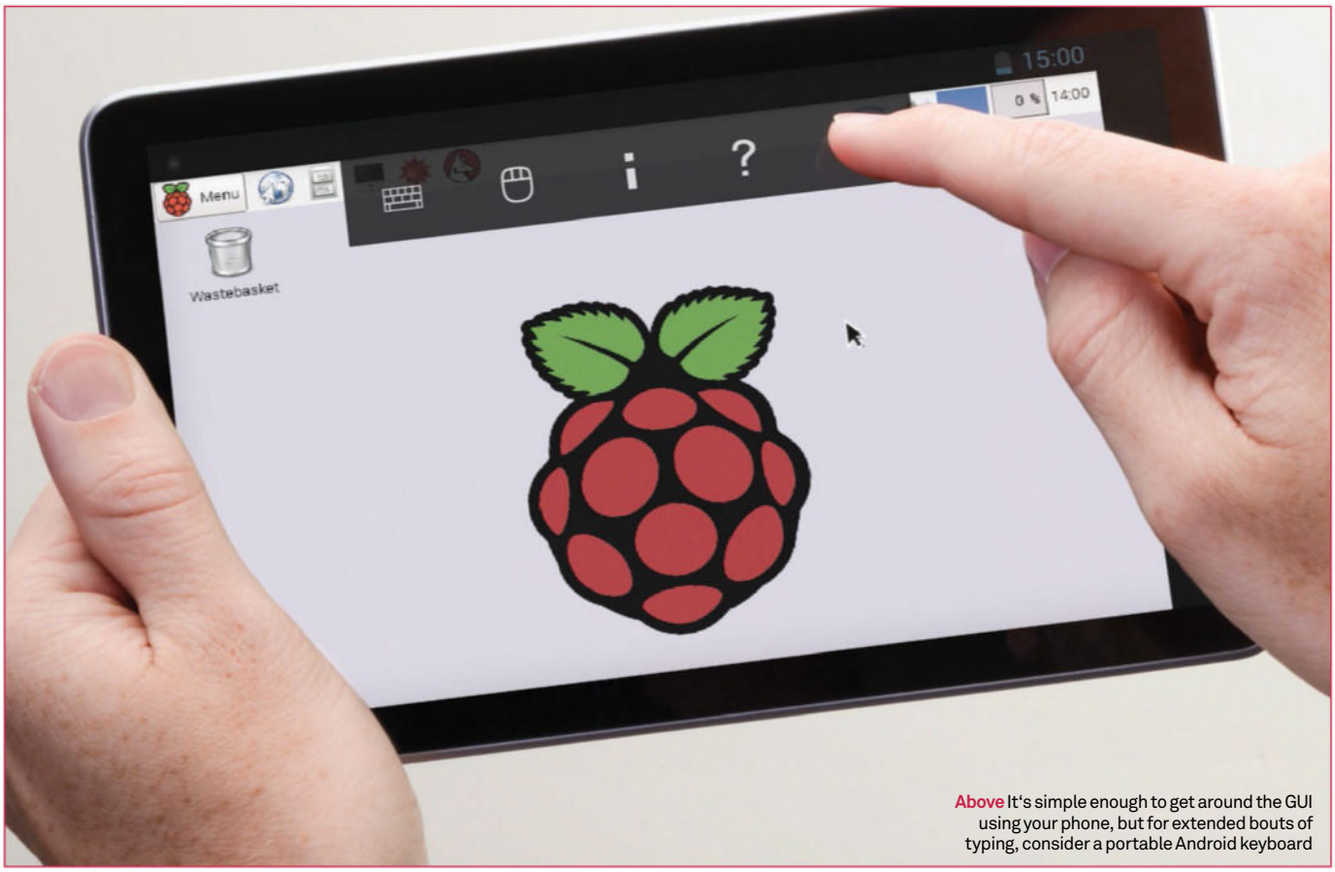
11 Turn it all off

Killing the VNC server, as we talked about in Step 5, can still be done when connected – your Android device will just disconnect. The same occurs if you just turn off the Pi. If you disconnect the VNC client from the Pi though, the server on the Pi will still be turned on; this means that you can at least reconnect at any time.

12 Turn server on at startup

Currently, every time you turn on the Pi you'll have to turn on the VNC server. There's no config setting or service setting that we can set to have it turn on by default, so to actually do this we need to write a script. Create a file using **nano** in the terminal at the following location:

```
$ sudo nano /etc/init.d/vncserver
```



Above It's simple enough to get around the GUI using your phone, but for extended bouts of typing, consider a portable Android keyboard

13 Write the script

This script will do everything we need it to do, but be sure to edit the resolution for your specific use case:

```
#!/bin/sh -e
export USER="pi"
# parameters for tightvncserver
DISPLAY="1"
DEPTH="16"
GEOMETRY="1920x1080"
NAME="VNCserver"
OPTIONS="-name ${NAME} -depth ${DEPTH} -geometry
${GEOMETRY} :${DISPLAY}"
. /lib/lsb/init-functions
case "$1" in
start)
log_action_begin_msg "Starting vncserver for user
'${USER}' on localhost:{$DISPLAY}"
su ${USER} -c "/usr/bin/vncserver ${OPTIONS}"
;;
stop)
log_action_begin_msg "Stopping vncserver for user
'${USER}' on localhost:{$DISPLAY}"
su ${USER} -c "/usr/bin/vncserver -kill :${DISPLAY}"
;;
restart)
$0 stop
$0 start
;;
esac
exit 0
```

14 Or download it

We've also got this ready for you to download and put right into the /etc/init.d directory. You can download it using:

```
$ wget http://www.linuxuser.co.uk/wp-content/
uploads/2015/06/vncserver.zip
```

Unzip it and move it into the correct folder, then make any modifications that you want before heading to the next step.

15 Make the file executable

Once the script is written, customised to your liking and saved, we now need to make it executable. To do this, use:

```
$ sudo chmod +x /etc/init.d/vncserver
```

As long as it is in the right place and named properly, this will make it executable. This command is also good to remember in general as it enables you to make any script executable.

16 Update and test

The final step is to update the file rc.d (which handles startup scripts and such) so that it knows our new script is there. Do this with the following:

```
$ sudo update-rc.d vncserver defaults
```

You can then also test it by using the following to make sure it works and also to turn it on for this session:

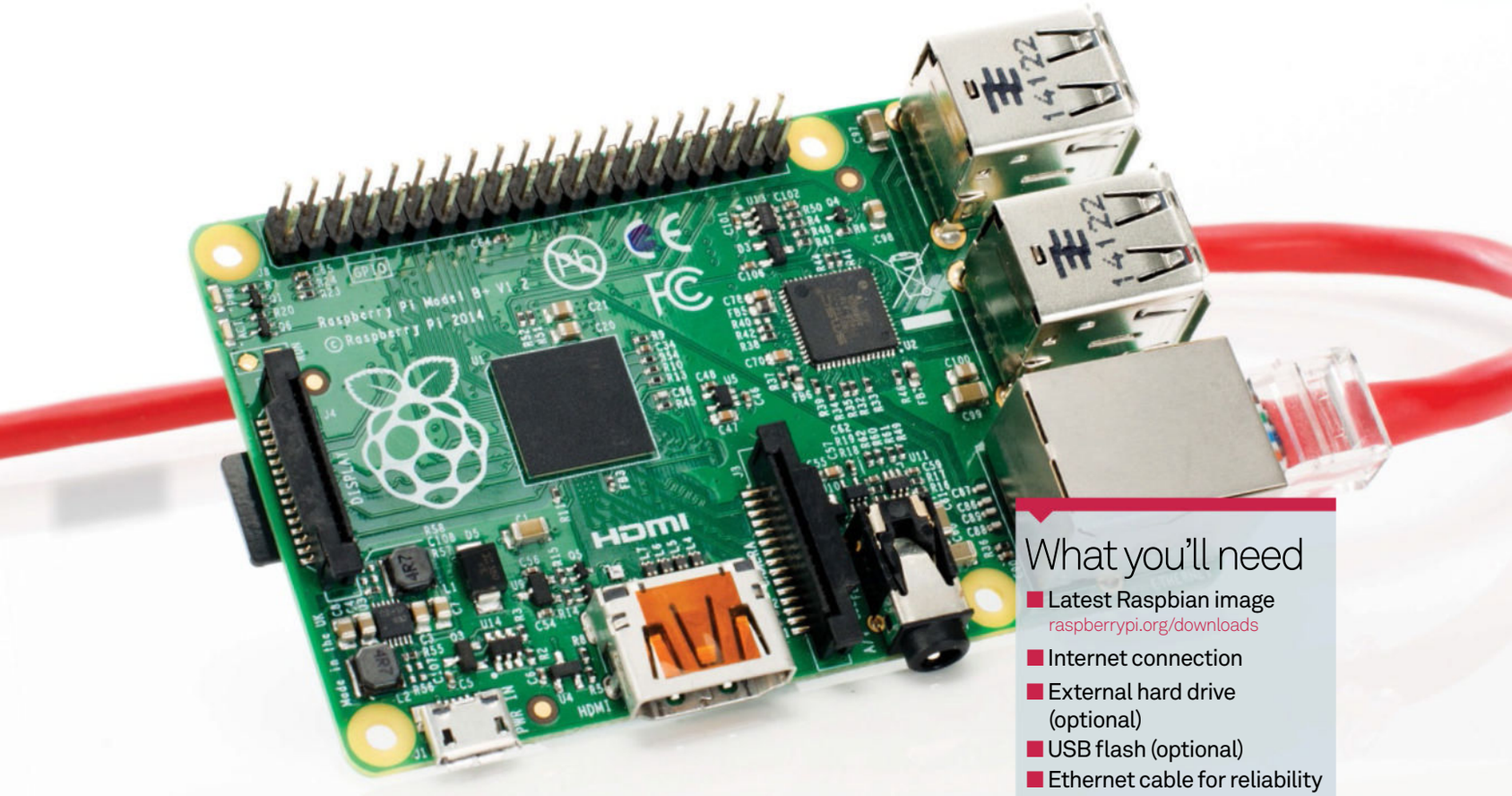
```
$ sudo /etc/init.d/vncserver start
```

Other VNC clients

You can use this setup with other systems as the client – your PC, a laptop, anything that you can put VNC on. It will use the same settings for each device though (such as resolution and colour depth), and you can't each have a separate screen to work from. This can be a good way to connect to a file server Pi or similar.

Host your own website on Raspberry Pi

Don't pay for web hosting. Configure your Raspberry Pi to act as a web server and host modest websites



What you'll need

- Latest Raspbian image raspberrypi.org/downloads
- Internet connection
- External hard drive (optional)
- USB flash (optional)
- Ethernet cable for reliability

Need a lightweight, low-cost web server? Your Raspberry Pi is all you need! Whether you're planning on hosting a static homepage (or one with minimal database use) or need an easy home for development websites, setting up your Raspberry Pi as a web server is surprisingly easy.

Ideal as an always-on device thanks to its low-power requirements, the Raspberry Pi can sit beside your router and serve a basic website to visitors, allowing you to put hosting fees to better use. You might wish to serve pages for some of your Pi projects, or even a personal page to host photos or your CV.

If you're planning on using it as a web-facing device, your Pi will need to be set up with a static IP address. You'll also need to ensure your internet provider offers static IP addresses for their users. Often a price is charged for leasing a static IP, but there are services you can use (such as **noip.com**).

01 Connect your Ethernet cable

For this project it makes more sense to use an Ethernet cable. You may need your existing USB ports to attach flash drives or an external HDD to serve your web page. With Ethernet you will need to rule out any wireless issues that are causing interruptions for your visitors.

02 Get Raspbian updates and Apache

As ever, begin by checking for Raspbian updates:

```
sudo apt-get update
```

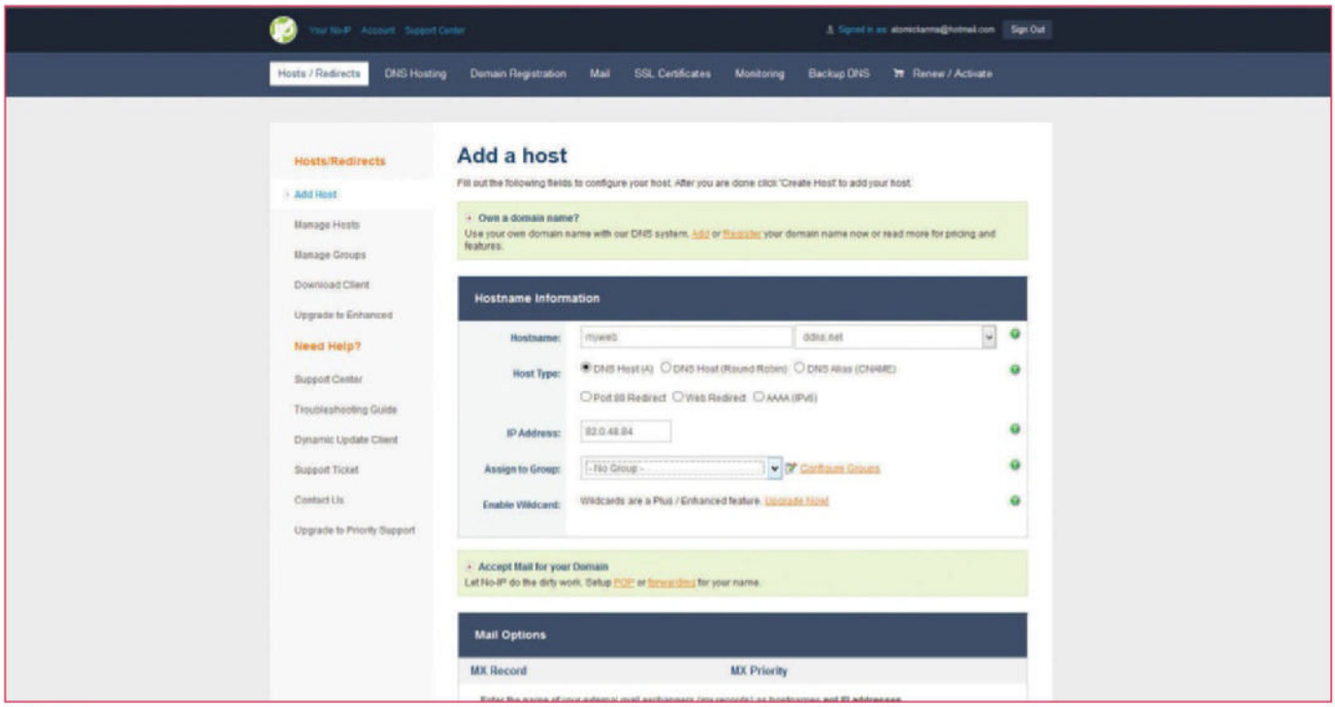
You'll then need to install Apache and PHP:

```
sudo apt-get install apache2 php5 libapache2-mod-php5
```

Finally, restart Apache:

```
sudo service apache2 restart
```

Your Raspberry Pi is now ready to be used as a web server.



You can upload files to /vav/www

03 Check your Pi web server

With Apache installed, open the browser on another computer on your network and enter your Pi's IP address to view the Apache confirmation page.

As things stand right now, all you will be able to view is the Apache index.php page. To add your own HTML and PHP pages, you will need FTP.

04 Install FTP for uploading files

Create a www folder, then install the following vsftpd FTP server software:

```
sudo chown -R pi /var/www
sudo apt-get install vsftpd
```

You'll need to make some changes to Very Secure FTP Daemon, so open it in nano. First, switch:

```
anonymous_enable=YES
```

...to...

```
anonymous_enable=No
```

Next, uncomment the following by removing the # symbols:

```
#local_enable=YES
#write_enable=YES
```

05 Restart the FTP Server

Complete configuration of the FTP software by adding a command to the end of the file which will display server files starting with "." such as .htaccess:

```
force_dot_files=YES
```

Save and exit nano (Ctrl+X) and restart FTP:

```
sudo service vsftpd restart
```

Using the default Raspbian credentials you can upload files to /var/www.

06 Make Pi a LAMP server

By adding MySQL into the mix you can use the Pi to host a database-driven website or even WordPress (although this is best limited to using the device as a development server).

```
sudo apt-get install mysql-server mysql-client
php5-mysql
```

The LAMP bundle is useful of course, but for the best results your site should remain streamlined.

07 Get your site online

Can't afford a static IP for your router? A great solution is available with the free service from **www.noip.com**.

This enables you to point a hostname at your computer by using a client application that will remain in contact with the No-IP servers.

08 Install No-IP

Make a new directory and switch it to:

```
mkdir /home/pi/noip
cd /home/pi/noip
```

Download No-IP on your Pi with:

```
wget http://www.no-ip.com/client/linux/noip-duc-
linux.tar.gz
```

Extract:

```
tar vzxf noip-duc-linux.tar.gz
```

Next, navigate to the directory and use **sudo make** and **sudo make install**, following any instructions. Finish by running:

```
sudo /usr/local/bin/noip2
```

09 Change your password for security

Before using your Pi as a live web server, it's a good idea to change the default password to something more imaginative than 'raspberry'.

In the command line, enter passwd and then follow the prompts to add your new, secure password. You're doing this step because you obviously would not want your Pi web server to get hacked!

Left Running a private cloud? Make sure no one can break into it...

Secure your Raspberry Pi

Concerned about the security of data stored on your Raspberry Pi? Protect yourself with passwords, firewalls and some physical security

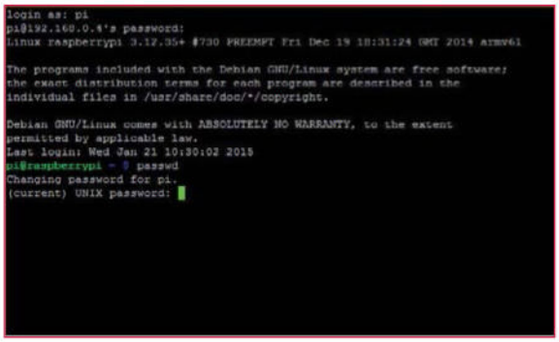
There is a distinct security risk around your Raspberry Pi. Storing anything from passwords to firewalls, this important saved data can be stolen or pocketed with minimal effort if someone knows how.

Therefore it's a relief to learn that several tools, tricks and methods can be applied to keep your device and data away from prying eyes. You might, for example, be running a home security cam with images uploaded to a cloud account. These images would be visible to anyone who possesses your Raspberry Pi's login details if you haven't bothered to change the defaults. Such a project (and many others) also demands that a firewall is installed for further improved security on a network.

Whether you're simply changing passwords, keeping your Pi under lock and key or installing a firewall, you'll be surprised at how easy it is to secure your Raspberry Pi and protect all of your important information and files.

What you'll need

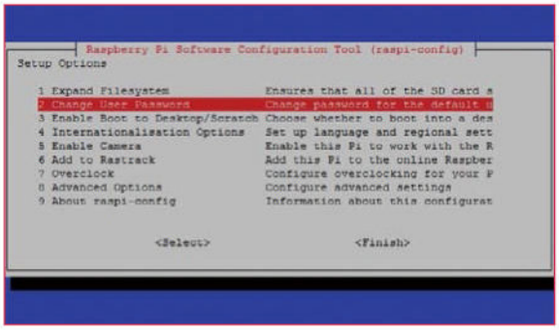
- Velcro
- Adhesive putty
- Lockable cupboard, strongbox, etc.



01 Stop using the default password

Everyone who uses a Raspberry Pi knows that the default Raspbian credentials are 'pi' and 'raspberry'. Naturally, this means that anyone can sign into your computer if you haven't changed these defaults – something you'll need to do as a matter of urgency. After signing in, open the terminal and set a new password with:

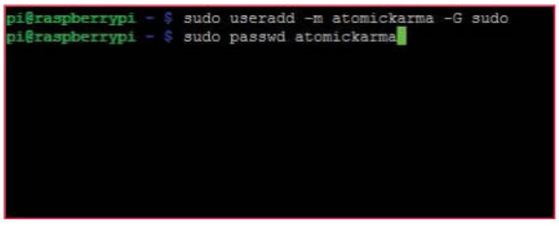
```
passwd
```



02 Change password with raspi-config

If you're setting up a new installation of Raspbian, changing the password is one of the first things that you should do. With a new install, the first boot will automatically run the raspi-config screen.

Here, use the arrow keys to find the second option, change User Password and then follow the on-screen prompts to set yourself a new passcode.



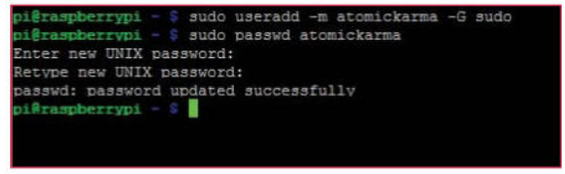
03 Create a new user account

To completely baffle anyone attempting to gain access using default credentials, take the most secure option and create a new user account. In the command line, enter:

```
sudo useradd -m username -G sudo
```

The –m switch creates a new home directory, while the second sudo adds the new account to the superuser group.

With a desktop computer and SD card reader, there is a way that you can recover your password

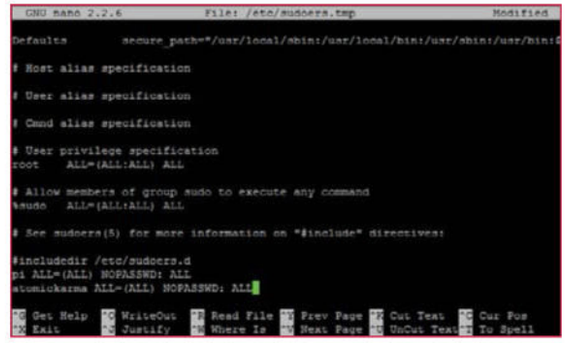


04 Give the new account a password

With the new account set up, the next step is to set a password. As you're not signed into the account at this stage, you won't be using the **passwd** command. Instead, enter:

```
sudo passwd username
```

With the new account ready to use, you should be ready to remove the default pi account from Raspbian altogether.



05 Delete the default Raspbian account

You no longer need the default user account, pi. Sign out and login to your new account, and confirm it is correctly set up by opening:

```
sudo visudo
```

...and adding...

```
username ALL=(ALL) NOPASSWD: ALL
```

...to the final line. Save and exit with Ctrl+X. Now that's done, simply delete the old account with:

```
sudo deluser pi
```

Then remove the home directory:

```
sudo deluser -remove-home pi
```

06 Recover a lost password

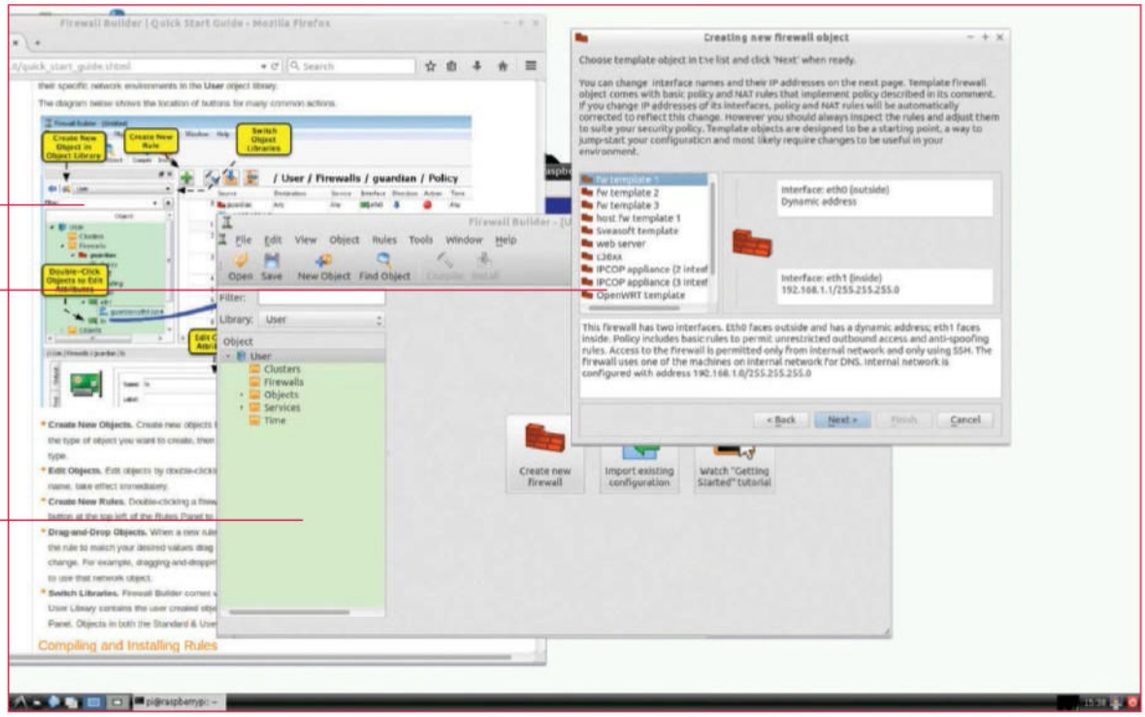
If you've somehow forgotten your Raspberry Pi user account password or suspect that someone has changed it, what can you do?

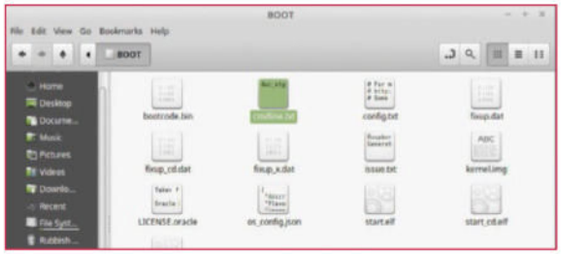
With a desktop computer and SD card reader, there is a way that you can recover your password. Begin by inserting the Pi's SD card into your PC's card reader.

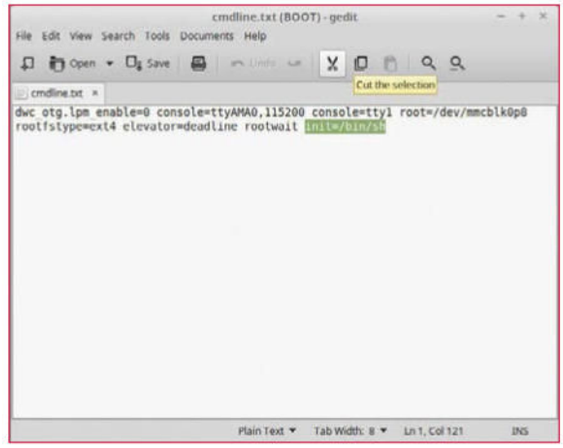
Use a proximity sensor

If you're genuinely concerned about your Raspberry Pi's physical security, you may consider employing some additional hardware to make it less of a target.

Your best option here is probably a proximity sensor configured to detect an unauthorised presence. When coupled with a buzzer, this can detect the presence of an intruder and alert you. It's even possible to configure such an alert as an email message if you're likely to be elsewhere, and it makes for a great side project.







Hiding hardware

Putting your hardware out of sight and/or out of reach is a good option for security, and for something as small as the Raspberry Pi and an SD card you have quite a few options.

For instance, using Velcro or some adhesive putty you might attach the computer to the back of a cupboard or unit, kitchen kickboards or even under a car seat. The SD card, meanwhile, is so compact that you could easily place it under a carpet or even make a home for it in a cushion or shelf – just don't forget where you put it!

07 Edit cmdline.txt

Find the file cmdline.txt and open it in your Linux desktop text editor. Add the following to the end of the last line of the file:

```
init=/bin/sh
```

As the Raspberry Pi boots, this command will be read, enabling us to access a screen to reset the password. Save and eject the card.

08 Change the lost password

Unfortunately you won't be able to use SSH to recover the password, so instead connect a monitor and keyboard to your Raspberry Pi. Boot the Pi and wait for the prompt, at which point you should enter:

```
passwd username
```

Type the password, hit Enter and type it again to confirm.

09 Initialise the Raspbian boot

Thanks to the added code, we have changed the standard Raspbian boot to display a new prompt that will let us change the password.

When this is done, enter the following command to put things back in order:

```
sync
exec /sbin/init
```

The Pi will now boot Raspbian normally, enabling you to sign in with the new password.

10 Revert cmdline.txt

We are not done yet though. Safely shutdown your Raspberry Pi with:

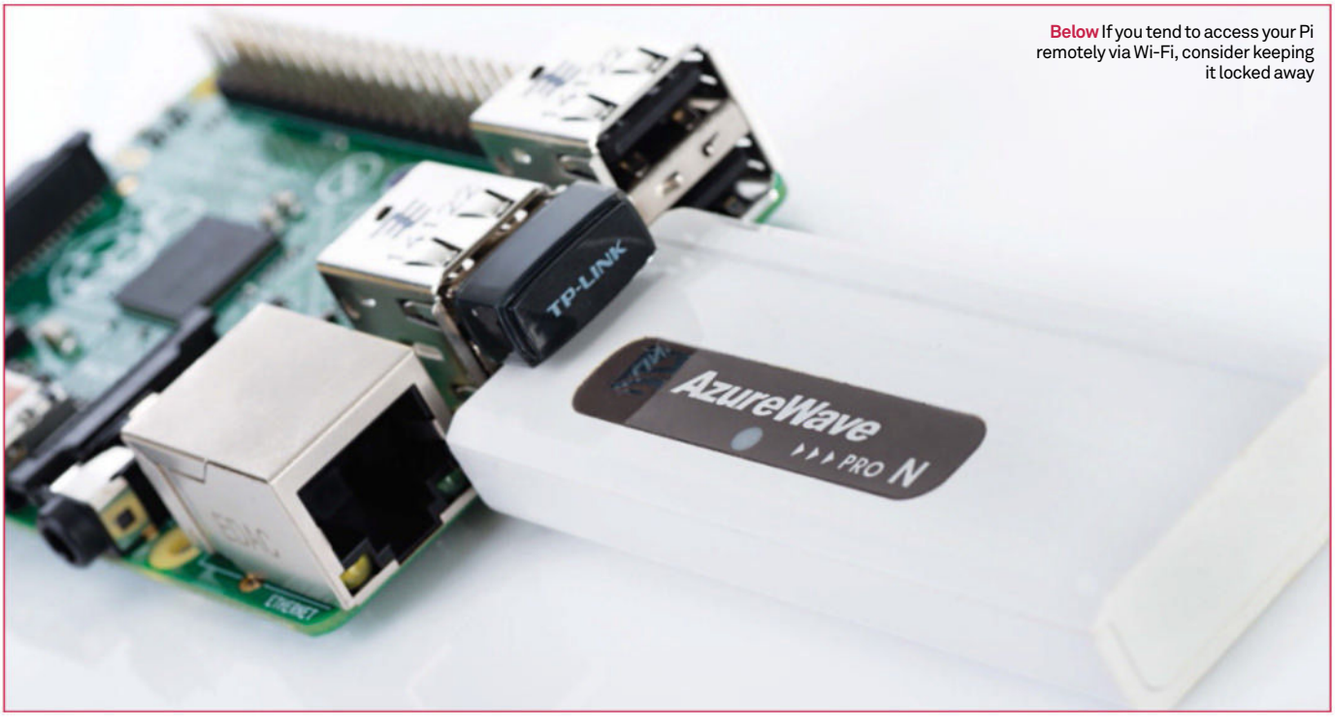
```
sudo shutdown -h now
```

With the Pi powered down, remove the SD card and insert it into the card reader again. Open cmdline.txt in your text editor once again and remove init=/bin/sh, then save and exit. This stops anyone else from resetting your password.

11 Physically secure your Raspberry Pi

Keeping digital intruders out of your Raspberry Pi with firewalls and secure account passwords is only part of the story. To fully protect your Pi you need to think outside of the box.

Barely larger than a credit card, the Raspberry Pi computer can easily be picked up and palmed. Physical security is paramount, but a genuinely secure Raspberry Pi case – for example, one compatible with Kensington locks – has yet to be released. However the ProtoArmour aluminium case from **www.mobileappsystems.com** can be screwed to a secure surface, which is great for more permanent project setups.



Below If you tend to access your Pi remotely via Wi-Fi, consider keeping it locked away

12 Lock it in a drawer

Probably the best way to keep your Raspberry Pi secure is to make sure you keep it locked in a drawer or cabinet – particularly useful if you use the device as part of a security cam system or as a cloud server storing valuable documents.

If no lockable storage is available and you're taking some time away from home where it isn't practical to take the Pi with you, another solution is needed. This might be to travel with your Pi's SD card in your wallet, perhaps leaving the computer attached to the back of a wardrobe with Velcro.

13 Add a firewall

Regardless of which operating system you're using, adding a firewall is a guaranteed way to improve your computer's security. While the Raspberry Pi has a built-in firewall, it is tricky to configure.

Thankfully, some other people have noticed this too and released fwbuilder, an interface to the otherwise complex iptables firewall that comes with Raspbian.

14 Install fwbuilder in Raspbian

Because iptables is a bit fiddly and errors can leave you with no network connection, fwbuilder has been developed to make firewall configuration quick and painless.

We'll use the **apt-get** command to first check for updates and then install fwbuilder:

```
sudo apt-get update
sudo apt-get install fwbuilder
```

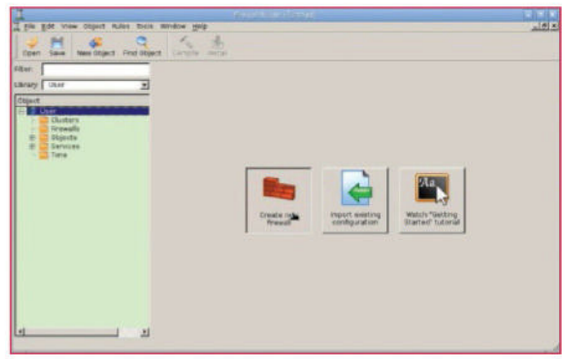
Follow the prompts to install and, once complete, switch to the Raspberry Pi GUI by entering:

```
startx
```

In the Pi's mouse-driven desktop, launch fwbuilder from the Internet menu. Upon launching fwbuilder, follow the given steps to set up your Raspeberry Pi firewall and save the resulting script.

We're nearly done but some adjustments are still required before your Pi fully connects to the network.

A firewall is guaranteed to improve your security



15 Complete firewall configuration

Launch the /etc/network/interfaces script in your text editor and complete configuration by adding

```
pre-up /home/pi/fwbuilder/firewall.fw
```

Next, find the section labelled "Epilog" and add

```
route add default gw [YOUR.ROUTER.IP.HERE] eth0
```

If you're using a wireless card, add the same line but switch the last characters to wlan0:

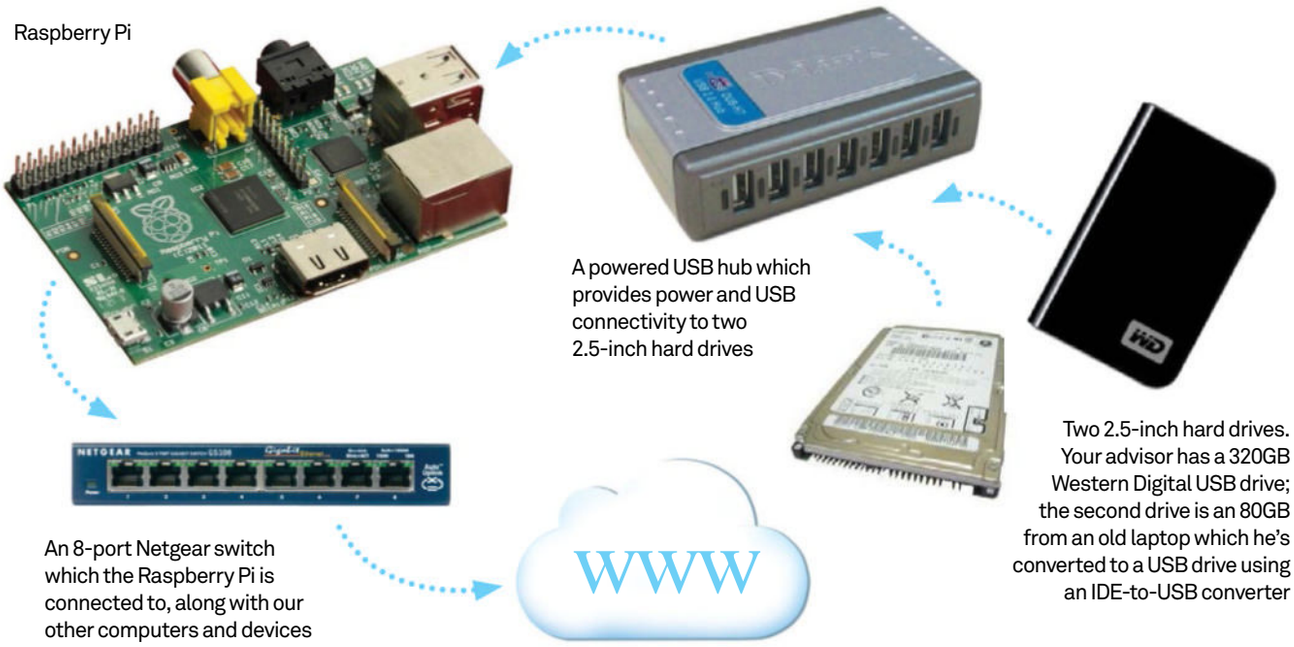
```
route add default gw [YOUR.ROUTER.IP.HERE] wlan0
```

16 Consider Raspberry Pi theft

While losing your Raspberry Pi or the data on it, might initially seem like a disaster, don't be disheartened. As long as you have taken steps to backup data or clone your SD card, you at least have continuity when you resume the project. You can also check our boxouts for methods to help you deal with physical theft.

Pocket your Pi

If you're still concerned with your Pi's safety, put yourself in the place of a potential thief. Where would you stash it? Probably in your pocket. The Raspberry Pi is small enough to take with you, so why leave it lying around? Any security questions relating to your Raspberry Pi can be addressed by keeping it close whenever you think it's necessary.



Build a file server with the Raspberry Pi

The Raspberry Pi is small, silent and energy efficient, so let's turn it into the ultimate file server!

What you'll need

- **Raspberry Pi** with all necessary peripherals
- **SD card** containing the latest Arch Linux image for RasPi: www.raspberrypi.org/downloads
- **Powered USB hub**
- **External hard drive or pen drive**
- **A computer running Linux** – it can be another Raspberry Pi

We'll be using Arch Linux as the operating system for our file server, because it is small, and has only the minimum packages required for a working system. This means that we can set up the file server without wasting resources on a graphical user interface and other unnecessary packages. Arch Linux comes with hardly any RAM allocated to the GPU by default, which is exactly how we want it for use as a headless server.

Our file server will be made up of the following software components:

- Base Arch Linux system
- SSH – will provide secure remote access to the Raspberry Pi and the files on it
- Samba – provides access to files on the server to a Windows, Mac or Linux client
- A dynamic DNS daemon (noip) – software that runs in the background and points a domain name to your router's IP address, meaning that you can access your Raspberry Pi from anywhere using an easy-to-remember web address
- Transmission daemon – a torrent client that runs in the background and can be accessed through a web browser

This tutorial assumes that you have flashed the latest Arch Linux ARM image to an SD card. If you haven't done this, the instructions for flashing an image can be found at **www.linuxuser.co.uk/tutorials/how-to-set-up-raspberry-pi/**.

You'll only need to go up to the step that involves writing the image to the SD card – or if you plan to use the SD card to store files, then you should follow the GParted steps also. Not that you'll also have to adapt the instructions slightly for using the Arch Linux image rather than the Debian one.

01 Log into Arch Linux

Connect the necessary cables to the Pi and wait for the Arch Linux login prompt. The login is root, and the password is also 'root'. We'll change the root password from the default later on.

02 Run a full system update

Arch Linux runs on a rolling release schedule, meaning that there are no version numbers and software is continually updated. Use the command 'pacman -Syu' to start a full system update. You'll be shown a prompt explaining that pacman needs to be updated first. Answer 'Y' to the prompt. You can now run 'pacman -Syu' again to start a full system update. There will be a lot of packages to update so it will probably take a while, especially because the Pi runs from an SD card.

03 Investigate your network

We highly recommend assigning a static IP to your Raspberry Pi rather than being handed one by your router because you'll always know where to find it on the network, which will be useful for accessing it remotely. You'll also need a static IP if you want to access the Raspberry Pi from the internet. We'll need to find out a couple of things about your current network setup before setting a static IP. You can use the commands 'ifconfig eth0' and 'ip route show' to do this.

```
interface=eth0
address=192.168.1.191
netmask=255.255.255.0
broadcast=192.168.1.255
gateway=192.168.1.254
```

04 Set up a static IP address

Now that we have found out things about your network, such as your current IP address, the network mask and so on, we can set up a static IP address. The majority of the Arch Linux configuration is done from a file called rc.conf, which is located in the /etc directory. You can open this file in the nano editor with the command 'nano /etc/rc.conf'. Scroll down using the arrow keys until you come to the networking section.

Begin to fill in the blank eth0 section. Our IP address was 192.168.1.215. When assigning an IP address, you'll only want to change the last number. We're going to change our address to 192.168.1.191. You'll probably want to use a number between 100 and 200. Set the netmask and broadcast to the values from 'ifconfig eth0' so that the interface is configured correctly for your home network. Set the gateway to the address in the line similar to default via '192.168.1.254 dev eth0 metric 202' from the output of 'ip route show'. Once you have done this, use the key combination Ctrl+O followed by the Enter key to save the changes. You can then use Ctrl+X to exit nano.

05 Log in with SSH

We'll now log into the Pi using SSH – but before that, we'll restart so that the static IP and any updates take place. Use the command 'init 6' to do this. Once the Pi has booted back up, open a terminal on your Linux computer and type 'ssh root@[ip of your pi]'. Answer yes, to say that you want to connect, and type in the root password, which will still be root. You are now logged in over SSH.

06 Set the default gateway

This step is really part of step 4 (set up a static IP address). The reason for doing this step after restarting, is that we found the changes were lost when we did it before a restart. This is probably due to DHCP cleaning up any settings it changes during shutdown. We will now set the IP of the DNS server, which will be used to resolve addresses such as google.co.uk to an IP address that your computer can connect to. Your DNS server will be provided by the same IP as your default gateway. You can set the DNS server using the following command:

```
echo 'nameserver [ip of default gateway]' > /etc/resolv.conf.
```

07 Change the root password

Since we might be exposing an SSH login to the internet, we need to change the password to a more secure one. Type 'passwd', then follow the on-screen instructions to change your password. Your SSH session will stay logged in, but you'll need to use the new password next time you log in.

08 Install the required packages

Use the command 'pacman -S samba noip transmission-cli' to install the required packages mentioned at the start of the article. Answer 'Y' to any prompts you may encounter.

09 Formatting your hard drive

Before continuing, note that formatting a disk **will remove all the data on it**. It's now time to connect your hard drive to the Pi. (We're using a pen drive, but the steps are exactly the same.) Use the command

```
fdisk -l | grep Disk
```

to get a list of disks attached to the system. You should be able to tell which disk is the one you intend to use to store files on by the size of the disk. For example, our pen drive is 16GB, so we know that the 16.1GB disk is ours. Run the following command:

```
(echo o; echo n; echo p; echo 1; echo ; echo; echo w) | fdisk [path to your disk]
```

to create a partition that will be whole size of the disk. Fdisk is an interactive program, so this command simply inputs the keys that you would press in a specific order to create a partition that will take up the whole size of the disk.

```
[root@alarmpi ~]# fdisk -l | grep Disk
Disk /dev/mmcblk0: 7948 MB, 7948206080 bytes
Disk identifier: 0x000c21e5
Disk /dev/sda: 16.1 GB, 16064184320 bytes
Disk identifier: 0x7ccab1c6
[root@alarmpi ~]# (echo o; echo n; echo p; echo 1; echo ; echo; echo w) | fdisk /dev/sda
Welcome to fdisk (util-linux 2.21.2).

Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): Building a new DOS disklabel with disk identifier 0x96692914.

Command (m for help): Partition type:
   p   primary (0 primary, 0 extended, 4 free)
   e   extended
Select (default p): Partition number (1-4, default 1): First sector (2048-31375359, defa
ult 2048): Using default value 2048
Last sector, +sectors or +size{K,M,G} (2048-31375359, default 31375359): Using default v
alue 31375359
Partition 1 of type Linux and of size 15 GiB is set

Command (m for help): The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@alarmpi ~]# mkfs.ext4 /dev/sda1
mke2fs 1.42.5 (29-Jul-2012)
Filesystem label=
OS type: Linux
Block size=4096 (log=2)
Fragment size=4096 (log=2)
Stride=0 blocks, Stripe width=0 blocks
981120 inodes, 3921664 blocks
196083 blocks (5.00%) reserved for the super user
First data block=0
Maximum filesystem blocks=4018143232
120 block groups
32768 blocks per group, 32768 fragments per group
8176 inodes per group
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208

Allocating group tables: done
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done

[root@alarmpi ~]# mkdir /mnt/data
```

10 Create a file system & mount point

Once we have a partition on the disk, we need to create a file system and a place to mount it. You can create an ext4 filesystem on the partition using the command

```
mkfs.ext4 [path to disk]1
```

You can make a directory to mount the drive in using the command

```
mkdir /mnt/data
```

11 Make the drive accessible to Linux

The fstab file on Linux system contains a list of storage devices on the system, and where to mount them. The file is read on boot, so any devices in the fstab file will be mounted automatically as long as it is connected during boot.

We'll edit the fstab in nano using the command 'nano /etc/fstab'. You want to add a line like the following:

```
[path to disk]1 /mnt/data ext4
defaults 0 1
```

Save the changes in the same way we did earlier. Once you have done this, you can use the command 'mount -a' to reread the fstab file and mount the new entry we just added.

12 Share the drive with network clients

We need to open an empty Samba configuration file in nano using the command

```
nano /etc/samba/smb.conf
```

Input the following information:

```
[global]
# workgroup = NT-Domain-Name or
Workgroup-Name, eg: MIDEARTH
  workgroup = WORKGROUP
  security = user
  load printers = no

# Some performance tuning
socket_options = TCP_NODELAY SO_
RCVBUF=65536 SO_SNDBUF=65536

[data]
   path = /mnt/data
   public = no
   writable = yes
```

Save the changes in the same way we did earlier.

13 Permit access to the shared drive

Set a password for your Samba user using the command 'smbpasswd -a' and then enter the password you want to use twice. Now that we've done that, we can start the Samba daemon using the command

```
/etc/rc.d/samba start
```

Note that the method of accessing a Samba share from each operating system will be different, so you may have to look it up. It should show up as 'ALARMPI' in the Network browser on most operating systems and user-friendly Linux distributions. Use the username 'root' and the password that you set with the smbpasswd command.

14 Configure the Transmission torrent daemon

We'll need to start the Transmission daemon because we'll need to edit some configuration files that it will only make on first execution. Start it using the command:

```
/etc/rc.d/transmissiond start
```

You'll then want to stop it using the command:

```
/etc/rc.d/transmissiond stop
```

so that we can edit the configuration file without Transmission interfering. Open the configuration file using the command:

```
nano /root/.config/transmission-
daemon/settings.json
```

You need to set rpc-whitelist-enabled from true to false, and also change the download-dir to /mnt/data/Downloads. You can then save the changes and make that directory using the command:

```
mkdir /mnt/data/Downloads
```

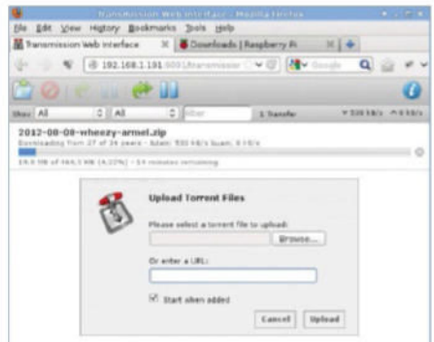


Fig 1 Testing out Transmission

15 The Transmission web interface

We can now start the Transmission daemon using the same start command from the previous step. Transmission can sometimes be a bit picky with the syntax of its configuration files, so now that you've started

> The Transmission web interface is straightforward to use

it, you'll want to check that your configuration changes are still there. If not, stop the Transmission daemon and try again.

You can go to the Transmission web interface by opening up a web browser and going to the IP address of your Pi, followed by :9091. This is needed because the web interface is served from port 9091. In our case, we used 192.168.1.191:9091. Click on the icon in the top-left corner of the interface to add a torrent file. You can either upload a file from your computer, or copy and paste a URL. As you can see from **Fig 1** (on preceding page), we have just added a Raspberry Pi image to test it out.

The Transmission web interface is really straightforward and easy to use, so you should be able to figure out anything else you want to do. There is also more documentation on the settings.json configuration file here: **https://trac.transmissionbt.com/wiki/EditConfigFiles**

16 Set up dynamic DNS

Head over to **www.no-ip.com/personal/** and sign up for the No-IP Free option. Once you have done that, don't bother downloading No-IP's client because we've already installed it. Go to your email Inbox and follow the activation link that was just sent to you by No-IP. You can now sign in to your account. Once you have logged in, select the 'Add a host' option. Choose a hostname and a domain to be part of from the drop-down list. Leave the Host Type as 'DNS Host' and then click the 'Create Host' button.

Your advisor used the hostname liam-ludtest with the domain **no-ip.org**, so would access that using **liam-ludtest.no-ip.org**.

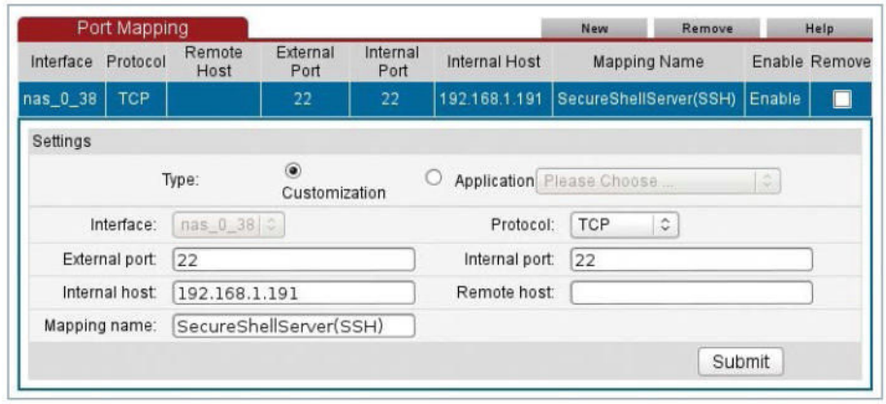
17 Configure No-IP

Run the command:

```
noip2 -C -Y
```

...to be taken through interactive configuration of the No-IP client. We left the update interval to the default of 30 minutes, meaning the client will check every 30 minutes for an IP address change. Once you've finished, start the daemon with the command '/etc/rc.d/noip start'.

Fig 2 Port mapping example



After a minute or two, your IP address will be accessible via your No-IP hostname. However, it's likely that trying it from inside your house will simply take you to your router's homepage.

18 NAT port forwarding

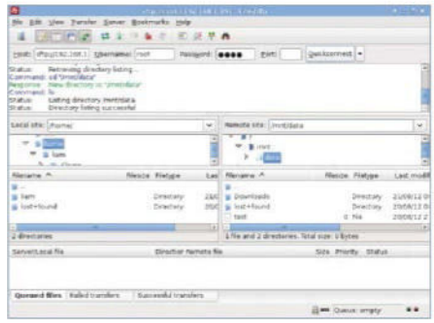
It is likely that there are multiple devices behind your router that all use the same external IP address. This is because of the shortage of IPv4 addresses, and also because it is more secure to segregate the internet from your internal home network. NAT (network address translation) forwards a port from the router's external IP address to a computer on the LAN (local area network). In this case, we'll want to forward any traffic for port 22 that comes to your router's external IP address to the IP address of your Raspberry Pi. Port 22 is the port used for SSH, which is the only port we'd recommend that you forward. SSH will provide access to your files, and also port forwarding, so you can access the Transmission web interface should you want to.

The configuration of port forwarding really depends on the router that you are using, so you may have to look up that information. The chances are that it will be hidden away in the 'advanced' section of your wireless router. You should be able to access your router by typing your No-IP hostname into your web browser. If not, it should be at the address of your default gateway that we used earlier on.

On his router, your advisor had to go to Advanced>NAT>Port Mapping and add a mapping that looks like that in **Fig 2**.

19 Use FileZilla for accessing files

We recommend that you use FileZilla, which you should be able to install with your



package manager, to access files via SSH. Set the host to the IP address of your Pi (or your No-Ip hostname if outside your LAN), the username to 'root', and the password to your password. Set the port to 22 and click 'Quickconnect'. Click OK to trust the host and connect to it. To access files on your external drive, change remote site from /root to /mnt/data.

20 Use SSH to port forward

Use the SSH command with the following option to forward any traffic from 127.0.0.1:9091 to 126.0.0.1:9091 on the Pi:

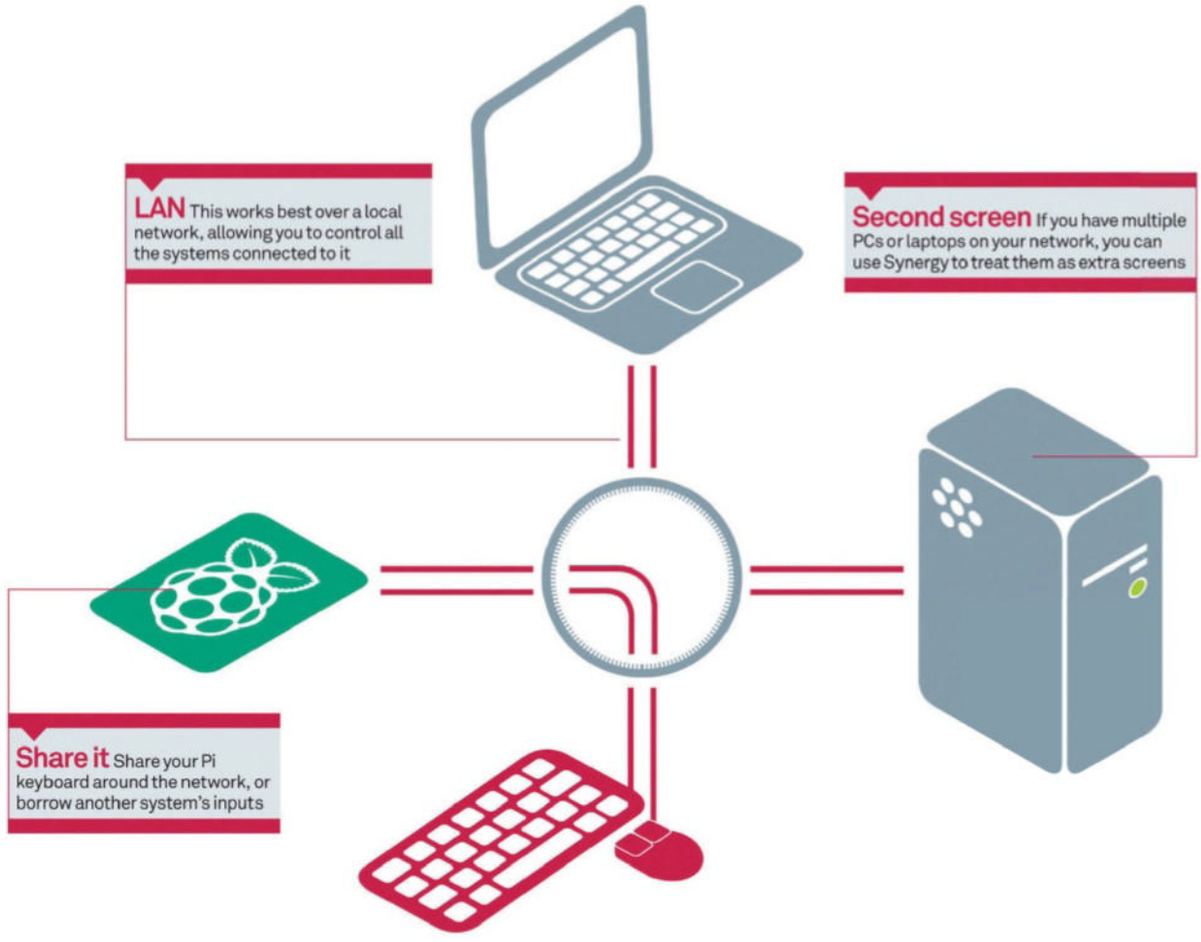
```
ssh -L 9091:127.0.0.1:9091
root@192.168.1.191
```

(You can replace the IP address of the Pi with your No-IP hostname if you are outside of your LAN.) 127.0.0.1 is a loopback address, which points back to 'this computer'.

Once you have run that command, you can then go to the web browser on your computer, type in 127.0.0.1:9091 and access the Transmission web interface as if it was on the LAN. Now, you are ready to enjoy your brand new file server!

Network and share your keyboard and mouse

Borrow a mouse and keyboard from another PC, using only your Raspberry Pi and Synergy



What you'll need

- Latest Raspbian Image
  raspberrypi.org/downloads
- Synergy
- Host computer

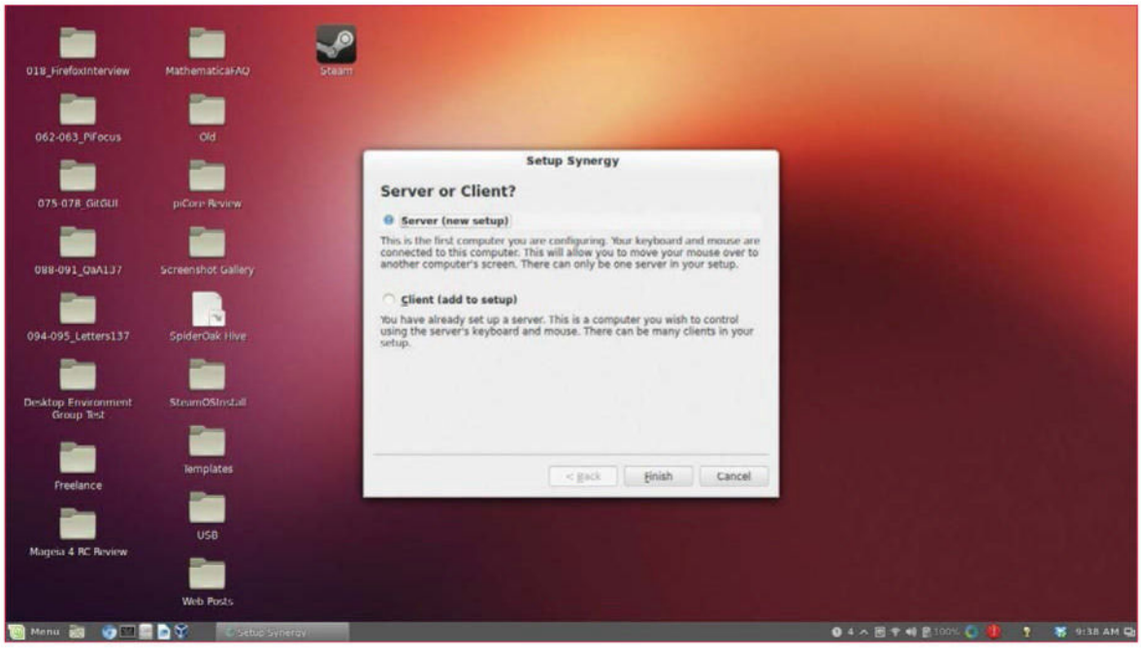
One issue we sometimes find with the Raspberry Pi is the lack of USB ports. We don't always have the luxury of using a powered USB hub, and it can become a bit of a hassle to juggle a mouse and keyboard with other devices. Instead of using a hardware solution for this, you can always try a software solution – one that opens up the uses of the Raspberry Pi as well. The Synergy program lets you share the mouse and keyboard of one system with other systems on the same network, acting as a virtual KVM. In this tutorial we'll learn how to use your main computer's input devices on your Raspberry Pi, as well as how you can look into making it a server.

01 Install Synergy

Synergy is available from the Raspbian repositories. We can install it by using the following:

```
$ sudo apt-get update
$ sudo apt-get install synergy
```

This will go through the basic installation process as normal and Synergy will be put in the Accessories folder.



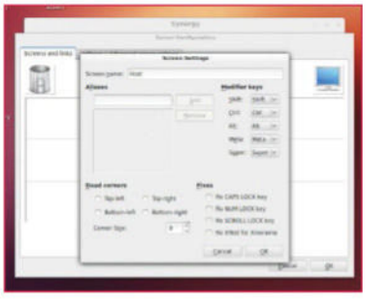
Left Select the Server option to use this machine's mouse and keyboard for the Pi

02 Start up Synergy

Start up Synergy on the host computer and choose the 'Server' option for the moment. We'll cover how to use it as a client later, and how to use the Raspberry Pi as a server for the mouse and keyboard.

03 Encryption and passwords

Here, you can set up whether or not the connection is encrypted. This is useful for stopping key loggers from being able to snoop on your information, or random clients from connecting and hijacking your mouse. Provide a password and then click Finish.



04 Server naming

Once the process has finished, go to Configure Server. Your host computer will be put virtually in the centre of your array of displays and you can drag and drop it around, along with any connected screens. Double-click on the server to change its name, making it easier to remember and find. Add a new screen and call it pi.

05 Starting and connecting

Once you're happy with the setup, click Start to be able to accept client connections. To connect from a Raspberry Pi, enter the following:

```
$ synergyc --name pi [IP Address of host]
```

It will be recognised as 'pi' on the host system.

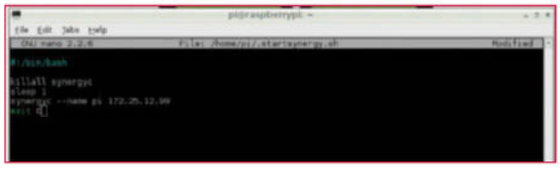
06 Autostart Synergy

To make sure it starts every time you turn on the Pi, we need to create an LXDE autostart file by using the following:

```
$ sudo mkdir -p ~/.config/lxsession/LXDE
$ sudo touch ~/.config/lxsession/LXDE/autostart
$ sudo nano ~/.config/lxsession/LXDE/autostart
```

And then add the following to autostart:

```
~/.startsynergy.sh
```



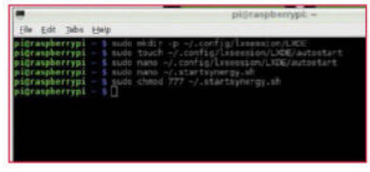
07 Start file

Open and populate the startsynergy file with:

```
$ sudo nano ~/.startsynergy.sh
```

```
#!/bin/bash

killall synergyc
sleep 1
synergyc --name pi [IP address of host]
exit 0
```

Synergy lets you share a mouse and keyboard



08 Permissions

Finally, to finish it off you'll need to run:

```
sudo chmod 777 ~/.startsynergy.sh
```

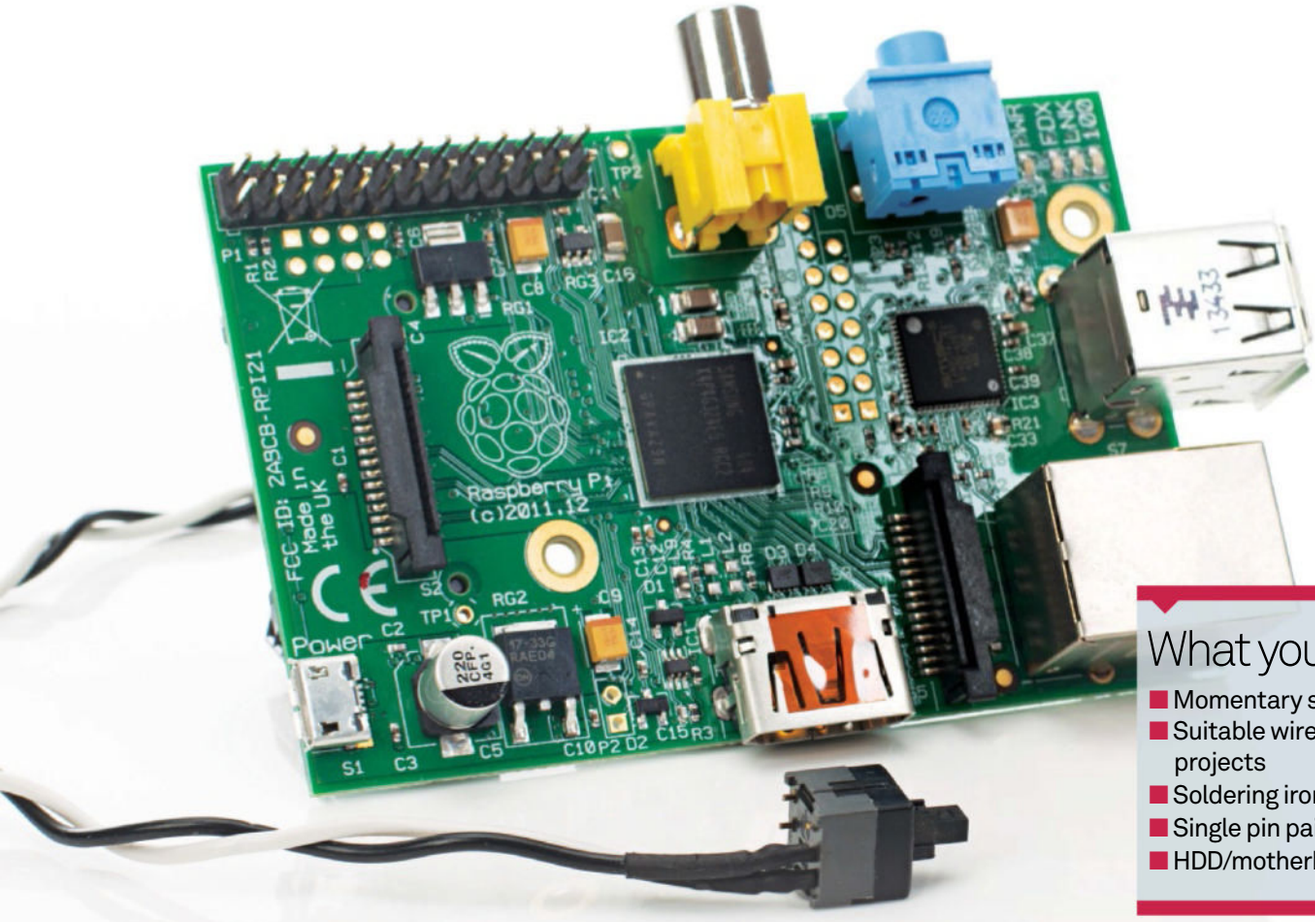
This will autostart, and hopefully autoconnect, Synergy whenever you turn it on. The Raspbian client is a little old, so if you get a problem you may need to compile the latest version from source.

09 Pi server

Setting up the Raspberry Pi as a server is a little more involved and uses the **synergys** command. It allows you to listen for clients on specific addresses. You then need to create a separate configuration file to arrange the displays – however, you can load one from a different computer and edit it.

Add a reset switch to your Raspberry Pi

Need to restart your Pi after a system lock-up? Ease strain on the mains connector – install a reset switch!



What you'll need

- Momentary switch
- Suitable wire for PCB projects
- Soldering iron and solder
- Single pin pair header
- HDD/motherboard jumper

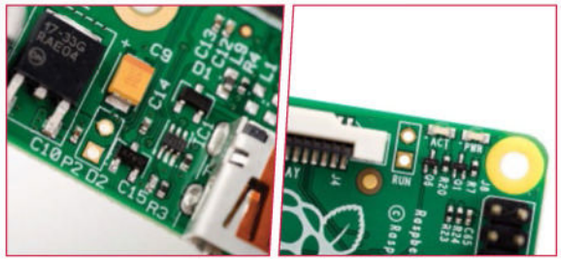
We all know that shutting down a Raspberry Pi by removing the power cable is risky. Data may be writing to the SD card, leading to corruption, while repeated removal of the power cable can cause problems with the connector port.

Clearly this can cause problems when faults cause the Raspberry Pi to hang, so the simple fix here is to add a simple reset function to the device. There are three ways this can be done: with a USB reset button, a motherboard jumper on the GPIO bus or with a momentary button connected to newly-soldered pins on the P6 header on the Model B Rev 2 and B+ (this is the most complicated option).

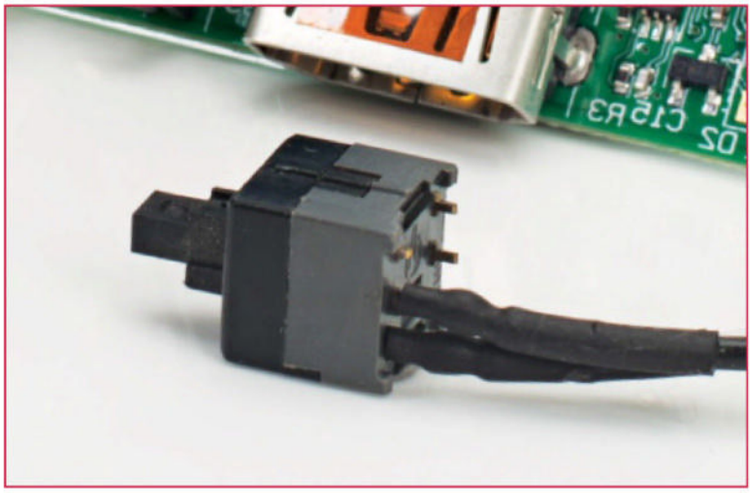
If you have an old PC lying around, retrieving the reset button and cable from this and even the connecting motherboard pins is achievable if you're handy with a soldering iron. Otherwise, we recommend purchasing the parts online, although be aware that you'll probably need to buy more pins than you'll need.

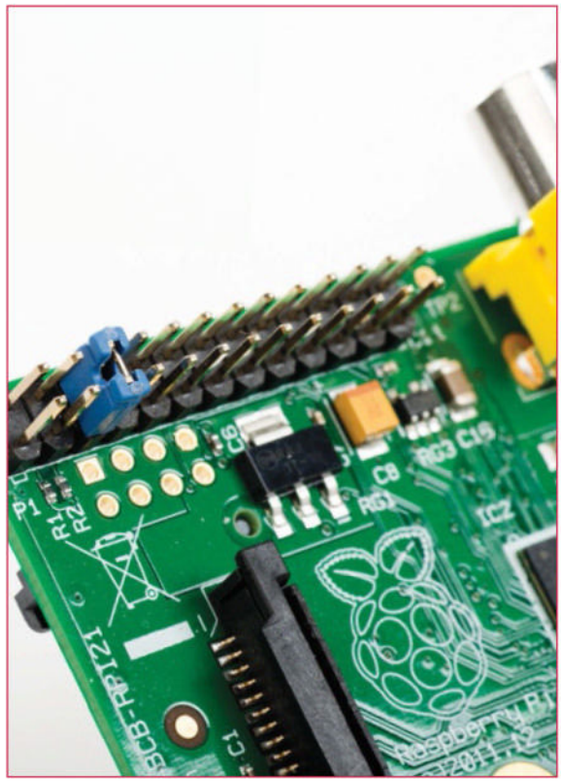
01 Check your Raspberry Pi model

Only two models feature the P6 header: the Raspberry Pi Model B Rev 2 (which you can find next to the HDMI port) and the B+ (to the left of the '© Raspberry Pi 2014' label). You will need to install the pins manually, however, as they are not preinstalled for this function.



Shutting down a Raspberry Pi by removing the power cable is risky





■ You should know your Pi inside and out, and learn how to identify GPIO pins

02 Find your components

Header pins can be purchased online, although this will invariably result in having to order more than you need.

Alternatively, if you have an old motherboard, remove a pair of pins with a soldering iron. Similarly, you might buy a new reset button, or use one from an old PC.

03 Solder pins to your Pi

To gain stability when soldering, place the Pi upside down on a layer of packaging foam, with the header slotted into the holes.

Using fine solder, secure the pins to the mainboard with your soldering iron. This will require a very steady hand, so get assistance if required.

04 Connect your reset switch

Leave the solder to cool for a few minutes before attaching the reset switch connector.

Some cases don't have space for the pins and/or the connector, however, so take the time to plan ahead and make sure everything fits. If not, you may need to make some adjustments to your case.

05 Reset Raspberry Pi following crashes

With the switch installed, you'll be able to reset the Raspberry Pi when required. Note, however, that this isn't an option to be used for whenever you feel like restarting. Rather, it should be done only when the system fails to respond within a reasonable time frame.

06 Reset with a HDD jumper

Not keen on soldering new pins to your Raspberry Pi? That is perfectly understandable, but it doesn't mean you cannot reset the computer. We have another solution for you.

Using a motherboard jumper, two GPIO pins and a script to initiate an ordered shutdown is a simple alternative that doesn't involve solder and potential PCB damage.

07 Identify the GPIO pins

This method works on most models. Each has a GPIO array, 26 pins on the A and B (Rev 2) and 40 on the A+ and B+. The jumper should be placed on GPIO3, pins 5 and 6 counting from the left with the board the right way around.

08 Detect jumper with a script

Use the script at **bit.ly/1Ge5n00** to detect the jumper, making it executable (`sudo chmod 755`) before running. Within a minute your Pi will shut down. Add this line to /etc/crontab to run the script whenever you boot up.

```
@reboot root /home/user/scripts/gpio_actions.sh
```

Remember to remove the jumper before booting up!

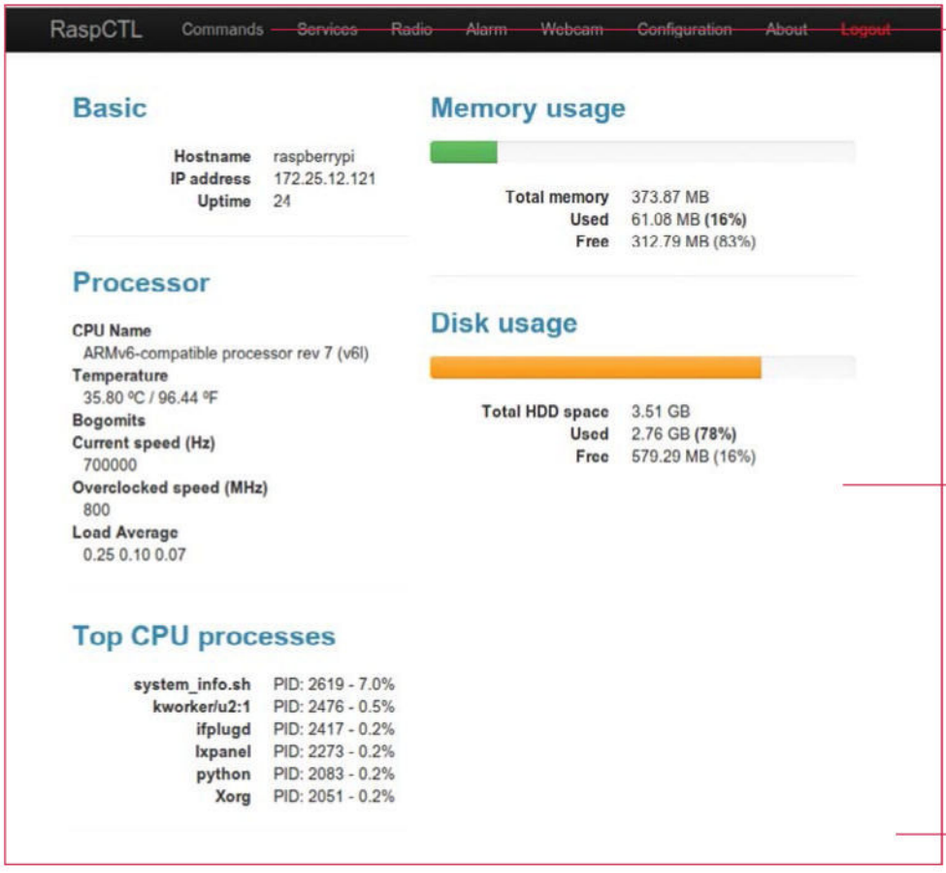
09 Try a USB reset button

Specialist online stores offer USB reset buttons that can be connected to your Pi for scenarios when the device needs to be rebooted.

If the idea of using the HDD jumper or doing some minor soldering doesn't suit you, then a USB reset switch might be your best option.

Remotely control your Raspberry Pi

Use a web interface to control your Pi and employ it as a fileserver or media centre from a remote location using any web-connected device



Commands Create custom commands for running your Raspberry Pi

Other utilities Seeing through your webcam and setting an alarm are just two additional things you can do with your Pi

Main window Get the full details of the currently running system from the web

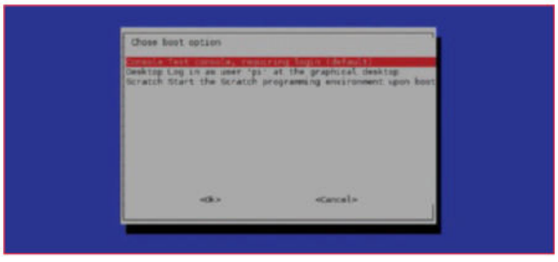
What you'll need

- Raspbian set to command line
- RaspCTL
- Internet connection

Not everyone uses the Raspberry Pi while it's hooked up to a monitor like a normal PC. Due to its size and portability, it can be located almost anywhere that it can be powered and it's widely used as a file server, media centre and for other nontraditional applications. Some of these uses won't easily allow access to a monitor for easy updates and maintenance. While you can always SSH in, it's a bit slower than a full web interface that allows for custom commands and a view of the Pi's performance. We're using software called RaspCTL, which is still in development, but works just fine for now.

01 Update your Pi!

To make sure the Raspberry Pi works as best it can, you'll need to update Raspbian. Do this with a `sudo apt-get update && apt-get upgrade`, followed by a firmware update with `sudo rpi-update`. Finally, if you're booting to LXDE, enter `raspi-config` and change it to boot to command line to save power.

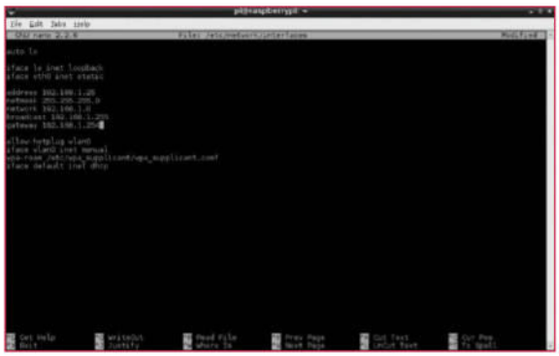


02 Edit the IP

For everything to work more easily, you should set the Raspberry Pi to have a static IP of your choice. To do this, edit the networking config by using:

```
$ sudo nano /etc/network/interfaces
```

...and change iface eth0 inet dhcp to iface eth0 inet static.



03 Set up a static IP

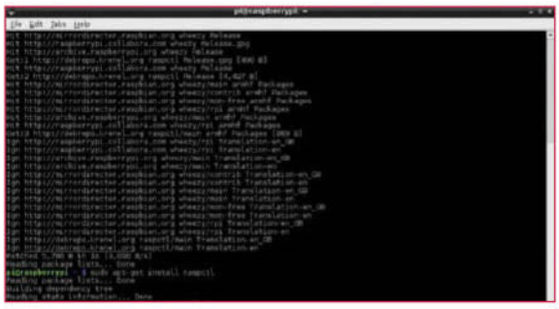
Add the following lines under the iface line with your relevant details:

```
address 192.168.1.[IP]
netmask 255.255.255.0
network 192.168.1.0
broadcast 192.168.1.255
gateway 192.168.1.[Router IP]
```

04 Ready to install

You'll need to grab the public keys for the software we're going to install by using the following commands. The first will take just a moment to download the software, while the other quickly installs it:

```
$ wget debrepo.krenel.org/raspctl.asc
$ cat raspctl.asc | sudo apt-key add -
```



05 Add the repository and install

Add the repository to the source's file with the following command:

```
$ echo "deb http://debrepo.krenel.org/ raspctl
main" | sudo tee /etc/apt/sources.list.d/raspctl.
list
```

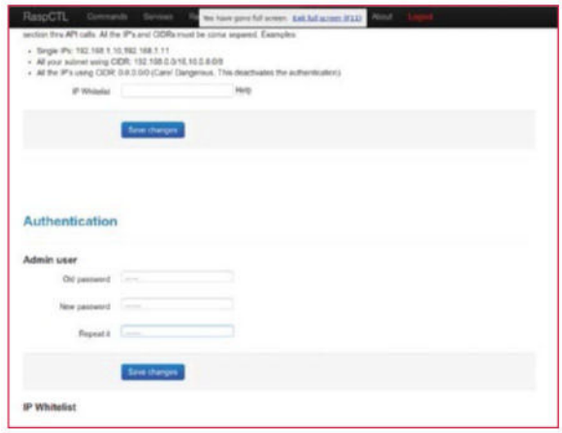
...and finally install the software with:

```
$ sudo apt-get update
$ sudo apt-get install raspctl
```

06 Access your Raspberry Pi

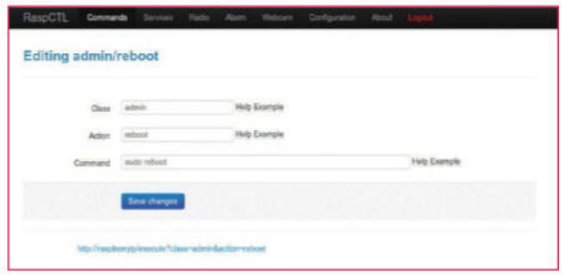
Now the software is installed you can start to access your Raspberry Pi from anywhere on your network. To do this type the following into your address bar, with the IP being the one we set up earlier:

```
http://[IP]:8086
```



07 Change your password

The default username and password is admin for both fields, and you should make sure to change that before doing anything else. Go to Configuration along the top bar and find the Authentication field at the bottom of the page. Input the original password (admin), followed by your new passwords. The username will remain as admin.



08 First command

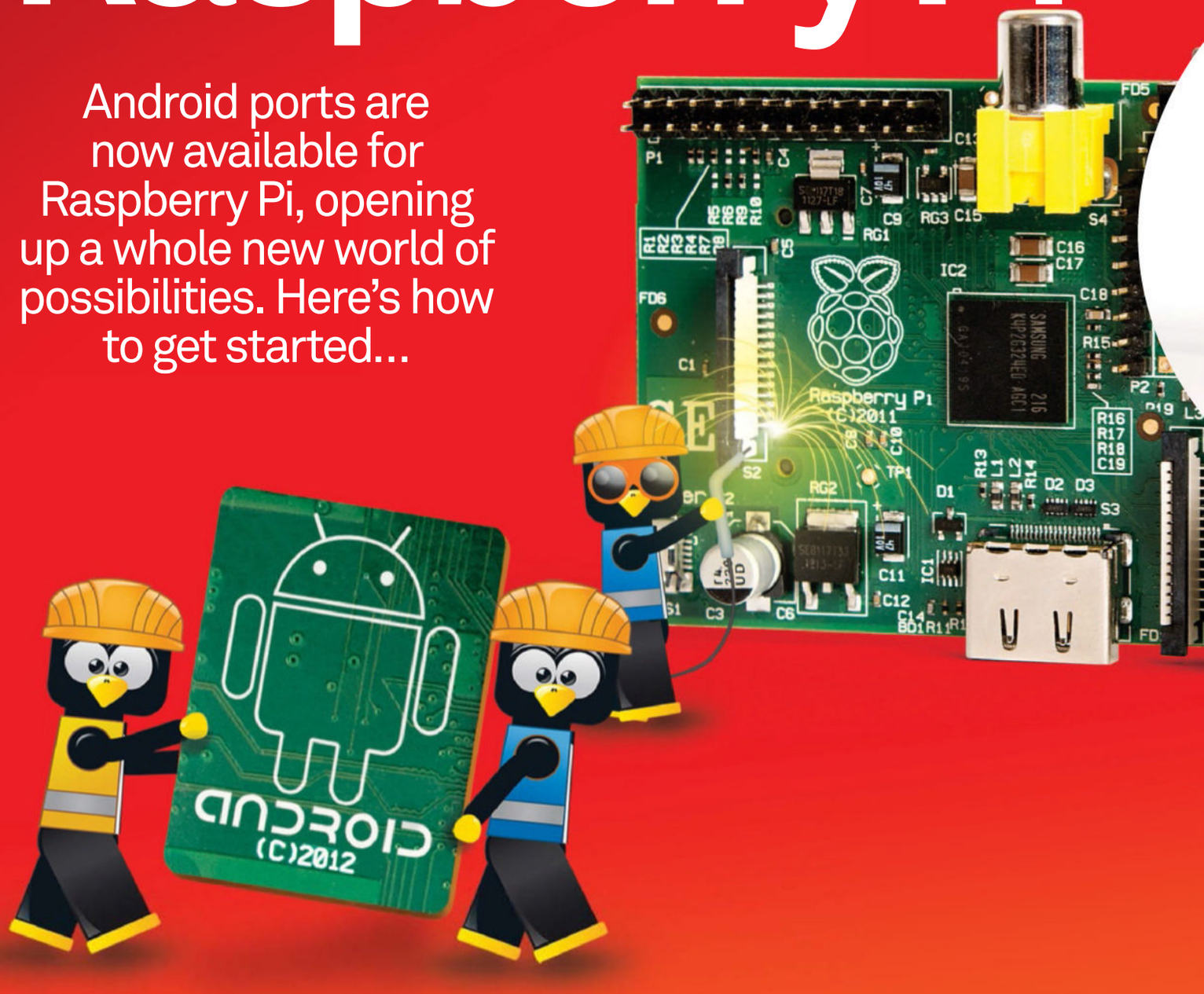
Go to Commands on the top bar to begin creating commands to run. Here you'll need to add a class – a user-defined way to filter your commands that won't affect the way it's run – a name for the command and the actual command itself. The commands won't necessarily run from the pi user unless you tweak the config files.

09 More functions

The web interface has a few extra functions apart from running commands, such as the ability to view the webcam and connect to radio services. Updating the software every so often will also allow you to make sure it keeps working. Play around with it and see what best suits you.

Install Android on your Raspberry Pi

Android ports are now available for Raspberry Pi, opening up a whole new world of possibilities. Here's how to get started...



While one of the main reasons for the creation of the Raspberry Pi was to offer a cheap way for people to get into programming and using Linux, there are plenty of people who see it being used as a replacement for other forms of computing tasks. With the Pi being so small, the concept of using it for purposes where space is a premium is definitely not too far-fetched. Its form factor, weight and low power requirements make it ideal for use in a number of situations; however, the software may not always be the best for the task. Where Linux may be lacking, though, Android is there to cover it.

Android ports to Raspberry Pi have been in the works for a little while now, but they've only just been made a usable reality thanks to the recent open-sourcing of the VideoCore GPU driver code. This allows for full hardware acceleration of Android, something that was previously having to be done purely by the CPU.

Android can offer a very different experience and interface than a standard Linux distribution, without having to obtain custom distros so it's optimised for a particular use. This means you can experiment with the sort of applications you'd want to use Android for without carrying around multiple SD cards in lieu of wiping them every time.

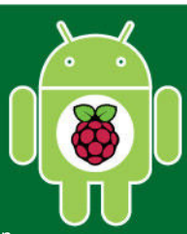
Thanks to an ever growing development community, Google recently announced that there had been 25 billion Android app downloads by the end of September, five billion up from the number at the end of July, from its 675,000-strong selection. With this rate of expansion, there are always a number of apps for pretty much anything you'd want an Android device to do. With access to this range of possibilities on the Raspberry Pi, you can create a system that has the advantages of using a mobile, user-friendly OS, with the price of the Pi. And the addition of more I/O ports from the Pi can make it fit in better than your standard Android smartphone.

There are three types of projects we're going to cover over the next few pages: a smart TV, a home automation remote and an in-car computer. While such distros like XBian and OpenELEC exist for media centres and home theatre PCs using the Raspberry Pi, the XBMC apps do not have the same kind of range as Android. With apps going outside the concept of plain media watching, and even the inclusion of Android games, there's a lot more you can do with an Android-run smart TV.

For home automation, there are very mature X10 and Z-Wave remote control apps available on Android that are optimised for the kind of interface you'd want to use for a remote control, unlike the mainly mouse-focused tweaking tools used on Linux distros. Finally, with in-car computers, the touch-screen optimisations and grid array for apps allow for easy navigation to music, podcast and other media apps, as well as plenty of fantastic GPS and satellite navigation applications native to Android.

Meet Razdroid

The team makes the first project to get Android on your Pi



Before the release of the VideoCore drivers, some community members decided they wanted to have a go at porting Android to Raspberry Pi, creating Razdroid. Based mainly on CyanogenMod, the project got far enough to have a couple of working ports, only limited by the lack of hardware acceleration. Since then, the Raspberry Pi Foundation has created its own ports, and eventually released the VideoCore driver to make ports of Android and other software a lot smoother.

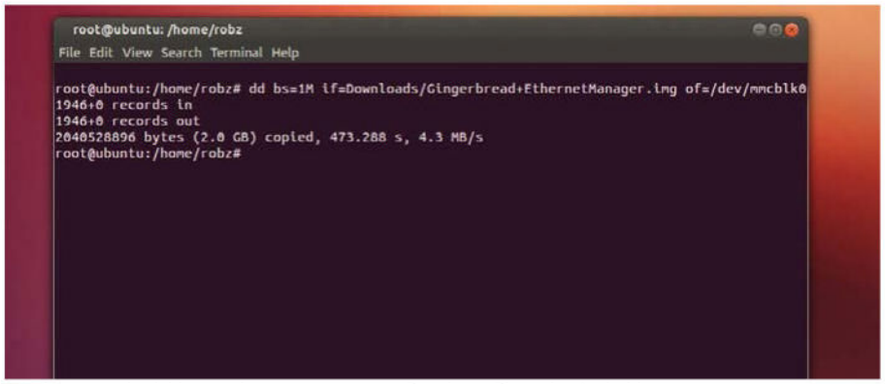
All you need is a Raspberry Pi set up and ready to go!

It's easy to install Android...

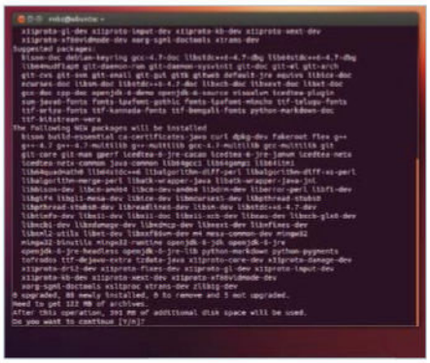
Follow our step-by-step guide to get up and running

You can put Android on your Raspberry Pi right now by visiting the Razdroid site at **www.razdroid.net**. There are currently a couple of images, based around both CyanogenMod 7.2 and 9, with different performance capabilities and app compatibility. The images can be put on an SD card using the same method as you would a Linux distro image, and will run from boot without any extra setup needed.

If you're feeling a little more adventurous, you can compile the images from source instead. You'll be able to make changes, updates and additions as well, if you want to improve the build. The steps on this page will guide you through a basic build of CyanogenMod 7.2, based on Android 2.3, for the Raspberry Pi, using the same files as the Razdroid image to get it working.



Using a standard dd operation, you can get your Raspberry Pi running Android



01 Install libraries

You'll need to get the necessary libraries for the build to work:

```
$ sudo apt-get install git-core gnupg flex bison gperf build-essential zip curl libc6-dev libncurses5-dev:i386 x11proto-core-dev libx11-dev:i386 libreadline6-dev:i386 libgl1-mesa-glx:i386 libgl1-mesa-dev g++-multilib mingw32 openjdk-6-jdk tofrodos python-markdown libxml2-utils xsltproc zlib1g-dev:i386
$ sudo ln -s /usr/lib/i386-linux-gnu/mesa/libGL.so.1 /usr/lib/i386-linux-gnu/libGL.so
```

CC: Jim Killock

Eben Upton speaks

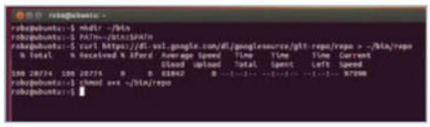
The co-founder of the Raspberry Pi Foundation

Without Eben Upton, the Raspberry Pi would not have been possible. Coming from a background of computing and teaching, Upton is currently a technical director at Broadcom and is responsible for the overall software and hardware architecture on the Raspberry Pi.

When the Raspberry Pi was first created, there were some very specific goals in mind for the finished product. Thanks to the way it met these goals, it has blown up as the darling of hobbyists and other tech enthusiasts for all manner of projects. To further understand the relationship between the original goals and this new concept of putting Android on the Raspberry Pi, we spoke to the co-creator of the Raspberry Pi himself, Eben Upton.

Upton told us that there had never really been any plans originally for Android to be supported by the Raspberry Pi. However, developments in recent times had changed the view of the Foundation: "A significant minority of our customers want to see it, so that makes it important to us."

When the Foundation originally announced it was working on Android compatibility, it already had a working prototype. "This implementation uses a different kernel and VideoCore binary image from the one available on GitHub," explained Upton, "which is why we've been keeping quiet about it so far." This was in late July, and it took the Foundation a further three months to finally get the VideoCore drivers open-sourced. Upton told us shortly before its release why it had been delayed so long: "The issue around releasing the Broadcom Android version is that we'd need a separate microcode image for the GPU, and we really don't want to fork the community."



02 Working directory

We need to download the source to a folder that we can make executable. First create the directory:

```
$ mkdir ~/bin
```

Then add it to your path:

```
$ PATH=~/bin:$PATH
```

And finally, download and chmod:

```
$ curl https://dl-ssl.google.com/dl/googlesource/git-repo/repo > ~/bin/repo
$ chmod a+x ~/bin/repo
```

03 Build environment

Now we'll make a directory for the build environment and initialise it for the repo sync. First:

```
$ mkdir ~/android_pi
```

Then move to it and initialise:

```
$ cd ~/android_pi
$ repo init -u git://github.com/CyanogenMod/android.git -b gingerbread
```

And finally sync:

```
$ repo sync -j16
```

04 Device tree

After the sync has finished, create a new directory and download the device tree for your build:

```
$ mkdir -p ~/android_pi/device/rpi
$ cd ~/android_pi/device/rpi/
$ git clone https://github.com/Mathijsz/device_rpi.git
$ mv device_rpi rpi
```

05 Initial setup

Before we do the actual build, we need to run a little script to properly prepare the source code:

```
$ cd ~/gingerbread_pi/device/rpi/rpi
$ ./initial_setup.sh
$ cd ~/gingerbread_pi
```

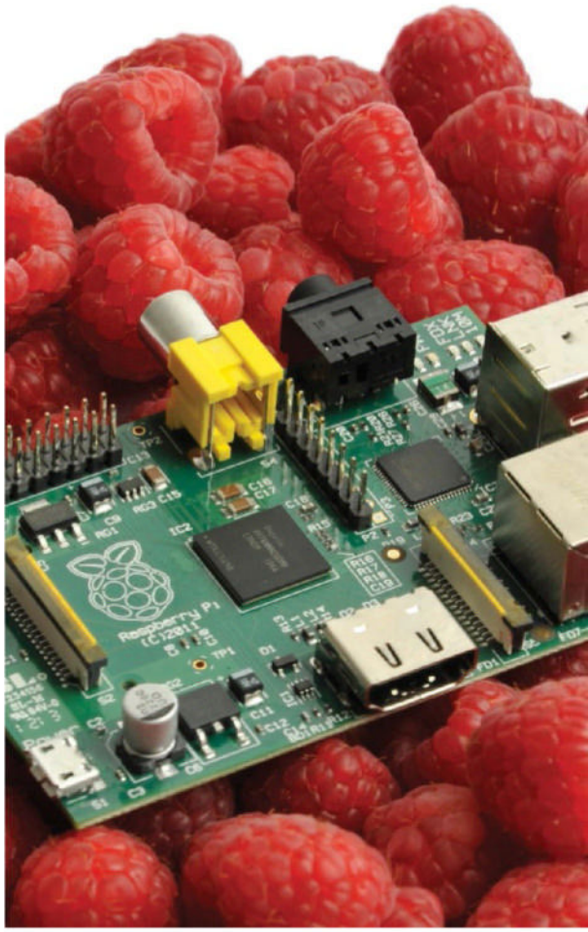
This will automatically make the changes.

06 The build

We're now ready to build our Razdroid image. Make sure to do following to start the build:

```
$ source build/envsetup.sh
$ lunch
$ make -j4
```

Be aware that this may take a while.

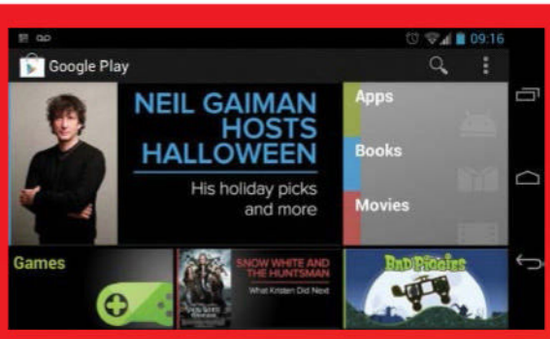


Now the source code has been released, via the ARM Userland on GitHub, and marks the first time a full ARM-based, multimedia SoC has received vendor-provided open-sourced drivers, and Broadcom is the first company to open up its mobile GPU drivers in this way. With it, people can get down to finishing Android ports and starting new ones.

Android is well known as being used on touch-screen interfaces, but earlier devices included keyboards and trackballs. While this has gone out of vogue for smartphones and other handheld devices, for testing out your Android-powered Pi it would be useful to have this option. Is it available now, though?

"I'm not aware of any significant challenges in this area." Upton told us when we asked about traditional inputs. "We expect most people would use Android with a mouse and keyboard, and this seems to be a well-supported option from ICS (Android 4.0) onward."

So with this native mouse and keyboard support, you're going to be able to find a lot more applications for a Raspberry Pi running Android than you could do with even an Android smartphone. On top of that, you will likely get the same kind of performance as a Linux distro according to Upton: "I would expect them to be very close in terms of performance. There may be more UI acceleration in Android, though, which we hope to bring into Linux."



The Play Store will initially be missing from any ports

Finally, one of the main reasons to use Android would be to access the huge array of apps. We asked Upton about the issue with Google Play – those into the Android scene might know that CyanogenMod had to remove this from the standard build for legal reasons. Upton told us there were currently no plans to obtain a licence for the store; however, Android allows you install the APK files without the store, and these are usually very easy to obtain.

The concept of the Raspberry Pi is a spiritual successor to the BBC Micro

Smart TV

Use your Raspberry Pi to make any TV 'smart'

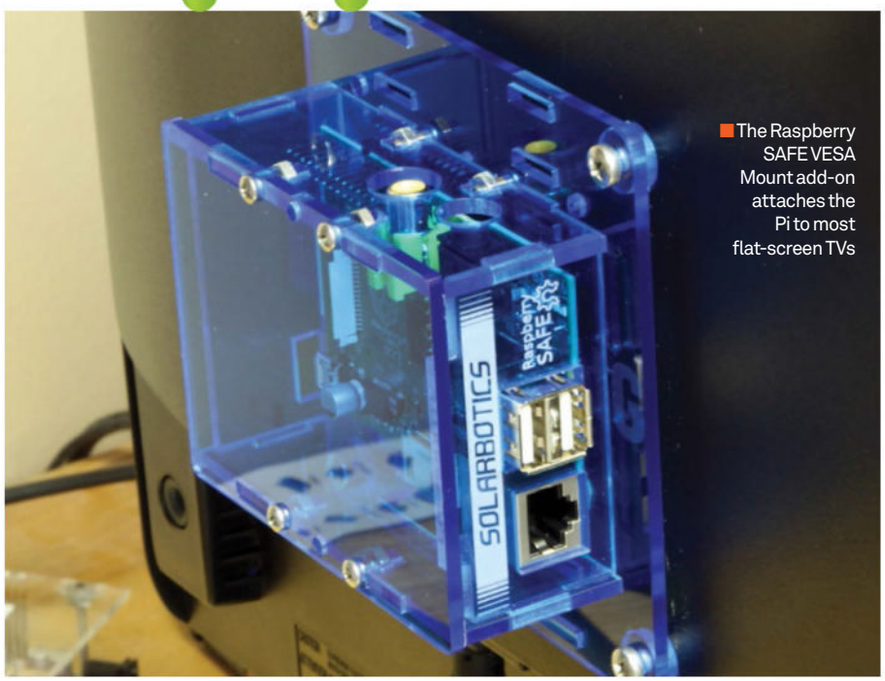
Smart TV is a very recent and popular buzzword for a more advanced media PC running inside your TV, which add a whole host of different apps as well as being able to stream your content from around a network. Android itself does not need any specific apps or skinning to turn it into a functional smart TV – the display is already configured for easy access to all the installed software, and using home replacement apps such as Launcher Pro will allow you to increase the number of on-screen apps if the stock launcher displays too few for you.

This usage for Android has not gone unnoticed by other people, with a few companies already on board. Recently, a high-profile Kickstarter project was successfully funded, called Pocket TV by Infinitec, which while definitely not the first Android-powered smart TV device, is notable for running off a USB stick. Like the Pocket TV, the Raspberry Pi is capable of running 1080p video without an issue. The benefits of Android even go beyond the TV, as Ahmad Zahran, founder of Infinitec, explains:

"[You] get access to all your information, games, TV streaming channels, work documents and your entire digital life. You'll have all the benefits that you get from carrying your smartphone but with the ability to display it on a much bigger screen. Imagine walking into a meeting and doing a presentation without a laptop."

As well as having access to simple information apps such as the Weather and Stocks, you can also use Android widgets to add a news feed or social network streams, and you can even connect to streaming websites like Netflix or the BBC iPlayer, as well as browsing the web.

Once you've got your Raspberry Pi set up as an Android smart TV, you may be wondering where to put it. Well luckily, there are a few cases out there that support VESA mounts, the standard used to attach flat-screen TVs to brackets and walls. The Raspberry SAFE case by Solarbotics is just the tool to tuck it out the way.



The Raspberry SAFE VESA Mount add-on attaches the Pi to most flat-screen TVs

Game on!

Why not turn your smart TV into a games console?

If the buzz around the Ouya is anything to go by, a lot of people are interested in how to turn Android into a games console. With a Raspberry Pi running Android, you're already part way there. While you could use a mouse and keyboard for some games, others will probably work better with a joypad, and this is where the MOGA controller comes in. It connects via Bluetooth to Android and is able to control a number of Android games.

Get OnLive

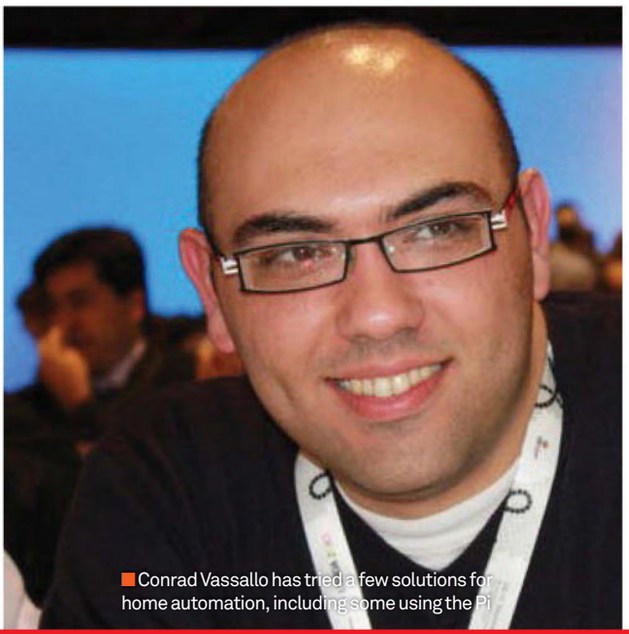
If Android games don't really do it for you, how about full-blown PC games? The OnLive streaming service allows you to buy and rent games and play them anywhere, thanks to all the legwork being done in the cloud. Using the OnLive Android app, you can access these games from your Android-powered Raspberry Pi and play them directly on your television without the need for a bulky PC in your living room. And it also works out much cheaper than the official OnLive console.

The MOGA can also cradle Android phones, hence the square shape

Home automation

There's no need for costly official controllers

Using home automation can be fairly simple. There are a number of different standards used for achieving it, such as powerline-based X10, or the RF-controlled Z-Wave products. These are usually controlled by very expensive remotes and wall screens, vastly increasing the price over the hardware you'd need in the first place.



Conrad Vassallo has tried a few solutions for home automation, including some using the Pi

There's also a problem with running on open source operating systems. We spoke to an open source home automator, Conrad Vassallo, about the problems he faced even getting it started:

"I did some research on systems that provided home automation and concluded that Z-Wave was the best option for me... soon I could control the lights in my living room with the touch of a button on a remote control. However, this was not enough: I wanted to have the system controlled by timed events and so the quest for a Z-Wave computer interface was on. First I bought a ControlThink USB stick, which did work fine for my needs; however, my home server runs on CentOS and the ControlThink USB stick was only supported under Windows. So I had to run the system on a virtual machine, which was not the best option on an Intel Atom PC."

Luckily he was able to get a setup running using code from the Open Z-Wave project, creating his own controller out of it – you can obtain the source code from here: **code.google.com/p/open-zwave-controller/source/checkout**.

The benefit of running these Z-Wave systems is that you can control them using Android apps. A Raspberry Pi and a small screen to connect it to cost a lot less than the officially made products and generally work better for the purpose, as you can always use the extra Android apps on the device anyway, whether it's mounted on a wall or a small box on your coffee table.

Kitchen computer

The size of a Raspberry Pi allows it to fit in a lot of spaces – add a touch screen and it takes up very little room. Putting it in a discreet location like the corner of a kitchen worktop gives you instant access to the internet and your home network for

looking up information, such as recipes via the Epicurious app, or using it to stream music from your file server while you cook.

Home automation controller

Using your Android-powered Pi to control the house is fairly simple once you have it up and running. However, you can make it completely customisable using software like Open Z-Wave to set up timed events and remote access using your Raspberry Pi as the controller.

"When I got my first Raspberry Pi, I thought it would make the project more interesting to have a dedicated appliance to control my lights," explained Conrad Vassallo, who already had a fully working solution. "So the next step was to install SSH, Apache, PHP and MySQL and my code on the Raspberry Pi. Now my system was consuming very little power and performed flawless!"

The system created by Conrad also supports Android input. "The Raspberry Pi is an excellent piece of hardware to 'embed' systems into. First, it is very small, silent, green and provides the services offered by larger, more expensive PCs."

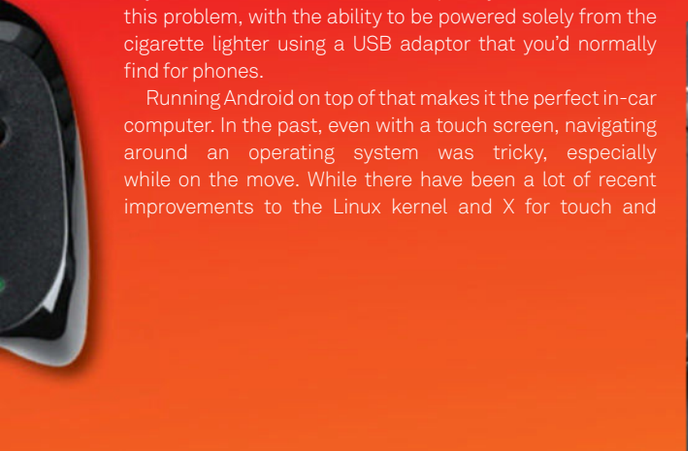
In-car computer

Fit a Raspberry Pi in your car

The main issues usually associated with carputers are finding a small enough computer with enough power to do the tasks you'd want it to do, and then making sure you have a proper way to actually power the system once it's in place in your vehicle. On its own, the Raspberry Pi is a solution to this problem, with the ability to be powered solely from the cigarette lighter using a USB adaptor that you'd normally find for phones.

Running Android on top of that makes it the perfect in-car computer. In the past, even with a touch screen, navigating around an operating system was tricky, especially while on the move. While there have been a lot of recent improvements to the Linux kernel and X for touch and multi-touch inputs, the desktop environments themselves are optimised for mouse and keyboard – at least, the lightweight ones like LXDE that would run on a carputer.

With Android, that is no longer an issue. As well as a fantastic selection of apps for music and podcast playback, you also have the fairly advanced satnav apps like Waze and even the native Navigation software. To top it off, there's also a customisable car dock mode that gives you bigger buttons and default access to car-friendly apps.



The making of Razdroid

Razdroid was developed by a small team of like-minded people, eager to test out the Raspberry Pi's limits. We spoke to three members of the team, Viktor Warg, Les de Ridder and Mathijs de Jager, about their involvement

The team want to get Roku-style streaming on the Raspberry Pi

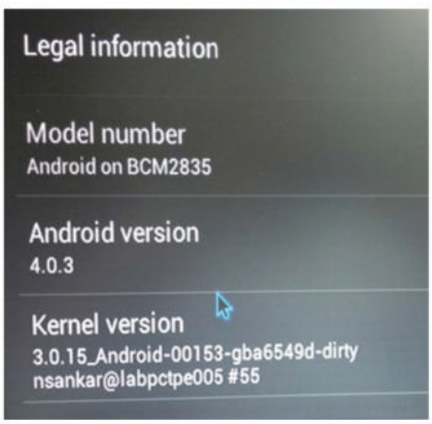
What caused you guys to start the project in the first place?

Viktor Warg: Well, I had just gotten my Raspberry Pi and instead of just loading up Debian as suggested, I started browsing the forums for something more, well, fun, to run on it. Stumbled upon the Android thread and knew instantly that I wanted Android on my Pi. Started collaborating with Mathijs and Les and one thing led to another, and here we are!

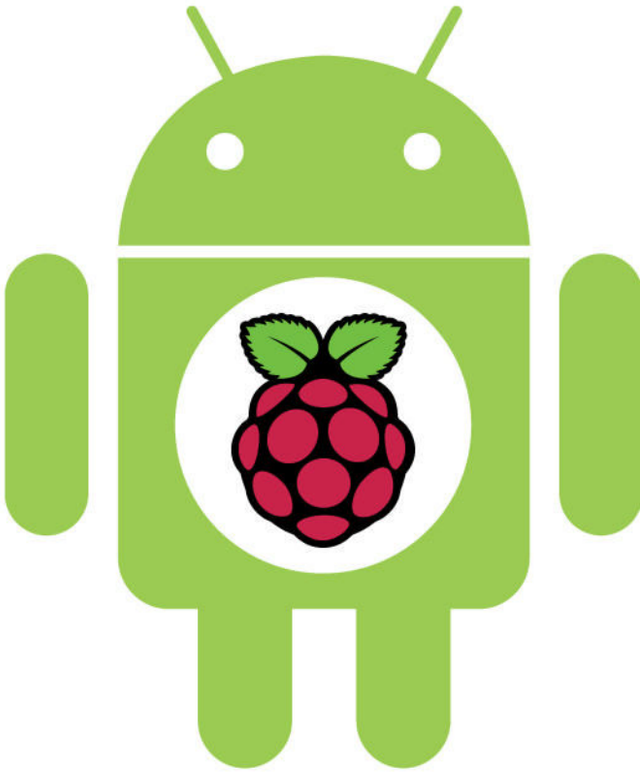
Les de Ridder: The only real reason I was interested in doing it was because it hadn't been done before. I thought it would be really nice to be part of something like this, as I had never done any porting or even embedded projects before.

What limitations did you experience with the Raspberry Pi?

VW: The main limitation was the lack of open source libraries for the VideoCore IV (the Pi's GPU) which had put the project in somewhat of a slumber for a few months. This led to the fact that we had a fully functional Android system but lacked the appropriate graphics libraries to make it hardware accelerated and thus the response times for the UI were sluggish at best.



The Raspberry Pi Foundation's successful attempt at running Android on a Raspberry Pi



LdR: Well, mostly Android compatibility issues. First of all, support for the Pi's relatively old CPU was pretty much broken in the then-available Android sources; Mathijs luckily managed to fix this. Other limitations were obviously the RAM: with 256MB, Gingerbread works, but Ice Cream Sandwich runs... well... much slower to say the least. This is not only caused by the RAM, but also by the lack of hardware graphics acceleration. Android requires people to build custom accelerated drivers for its libraries (eg Bionic). We couldn't do this at the time when we first built ICS for the Pi and still cannot, because the drivers' sources are sadly closed source.

How challenging was it to build Android for the Raspberry Pi?

VW: It was quite a challenge at first, seeing as none of us (as far as I know) had been involved in similar projects at all. As we progressed (or didn't, in some cases), things fell into place, though. Eventually, I'd venture as far as to saying that all three of us knew what most of the issues we faced stemmed from and how to solve them. One issue we had quite early was that the Raspberry Pi kernel wasn't compatible with some of the patches Android needed, mainly the IPC-Binder that it relies on heavily. If I recall correctly, that was solved by our main kernel guy (Mathijs) after a few days of brainstorming.

Mathijs de Jager: Another issue was a strange problem with executables crashing all the time ('segfaulting'). After some help from the #cyanogenmod-dev channel, it turned out to be a bug regarding the ageing ARMv6

architecture in the CyanogenMod sources we used. Additional build flags, almost specific to the Pi, were needed too. This had us stuck for quite a while.

What project ideas do you guys have for a finished product?

LdR: I personally would like to make a build that anyone who owns a Pi can use, whether it's a Model A with limited peripheral support or a new fancy Model B with 512MB RAM. This might mean that we would have to remove some features, but I think that we will be able to find a good configuration that works for the largest part of the people who are interested in running Android on their Pi, suiting as many people as possible. For people who are interested in making their own builds, we will supply patches so they can make their own configuration but still use our patches for the Pi. I don't really have any personal projects, but using it as a Google TV-like internet player would be nice.

What had you been using the Raspberry Pi for before Razdroid?

MdJ: Mine had been running as a local web server for testing.

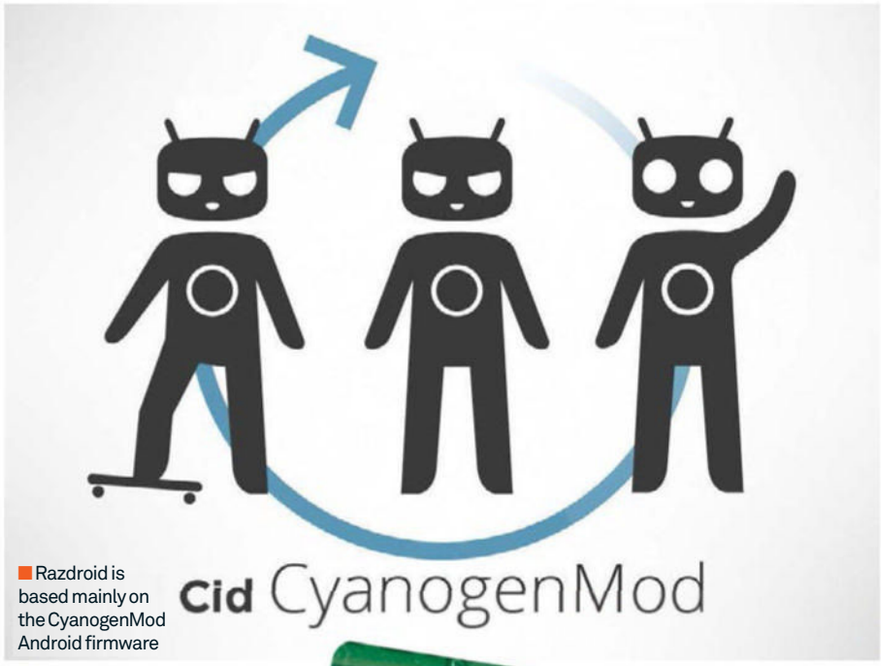
VW: Nothing at all. I had just gotten my Pi when I started helping the Razdroid project.

LdR: Not much to be honest. I only had just received my Pi when I started working on Razdroid. I was still waiting for my Pi electronics starter kit to arrive back then, which I later used for learning some basic electronics, like using resistors, LEDs, transistors etc.

"The Pi kernel wasn't compatible with some patches Android needed"

Any future plans for ports or development on the Pi?

MdJ: Netflix on Android on the Pi seems attractive and I can imagine a lot of people would want that, but I heard some DRM module is needed. The Broadcom CPU seems to have it (for example the Roku 2 has Netflix and has the same Broadcom CPU), but needs to have it enabled. Maybe the Pi Foundation can eventually get a licensing thing going, just like the MPEG2-decoding licence.



Razdroid is based mainly on the CyanogenMod Android firmware

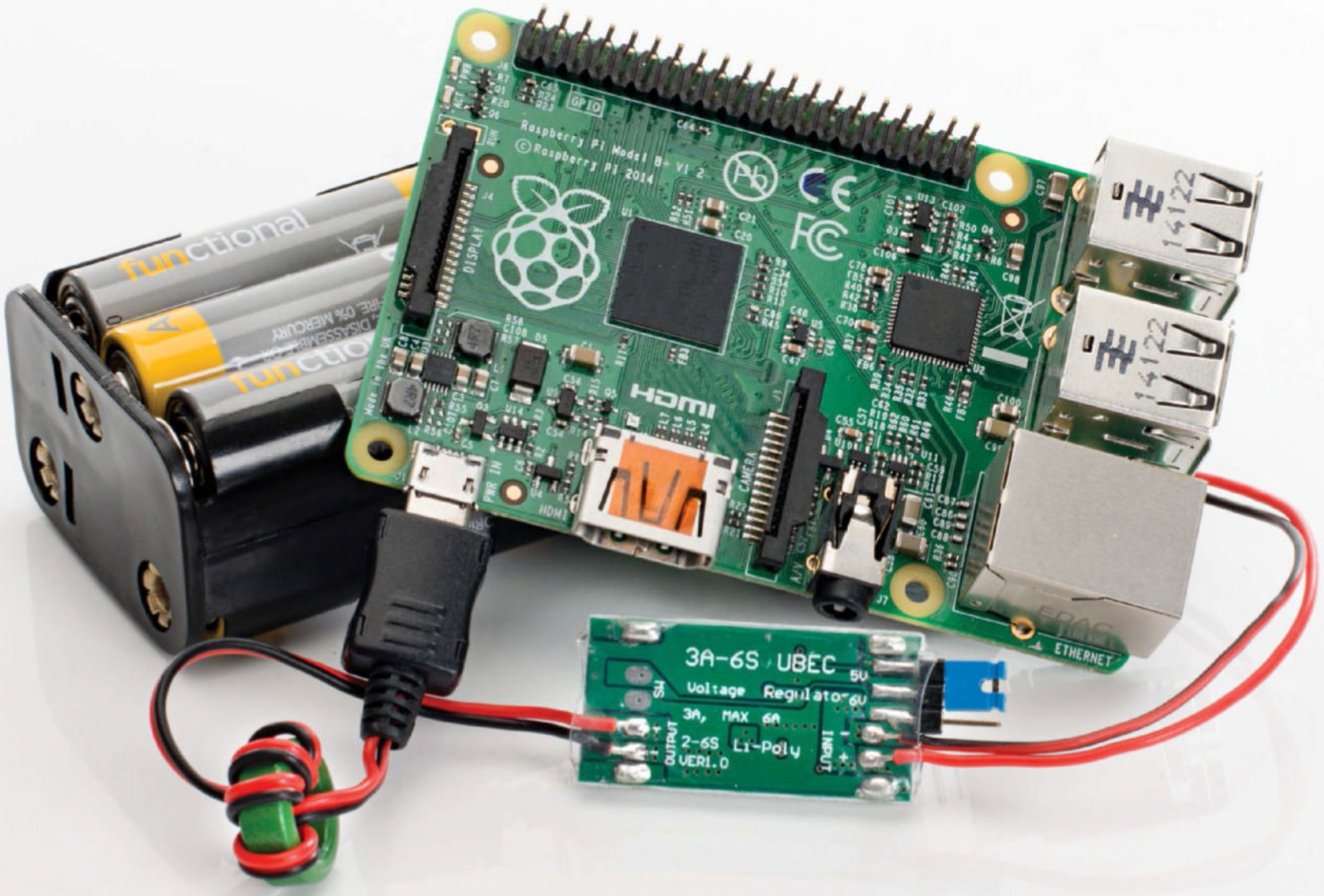
Contribute to Razdroid

Here's some ways you can help port Android

As Eben Upton said, the Raspberry Pi is about content creation, and what better way to do this than by getting in on a project and helping out with the Android port? Razdroid's Viktor Warg tells us that the drivers are a good start, but they need a little more: "We've analysed the libraries and figured out that we need to implement our own userland gralloc-module, and none of us have even the slightest idea on where to start on that."

The best place to start is to visit the Razdroid wiki, **www.razdroid.net**, and check on the current progress. There's also an IRC channel, #razdroid on Freenode, where the developers regularly talk about their current work, and the entire project is maintained on GitHub.

Of course you can always start your own project, either by using the official Android source from the AOSP, modding CyanogenMod, or forking Razdroid. Happy hacking!



Add a battery pack to your Raspberry Pi

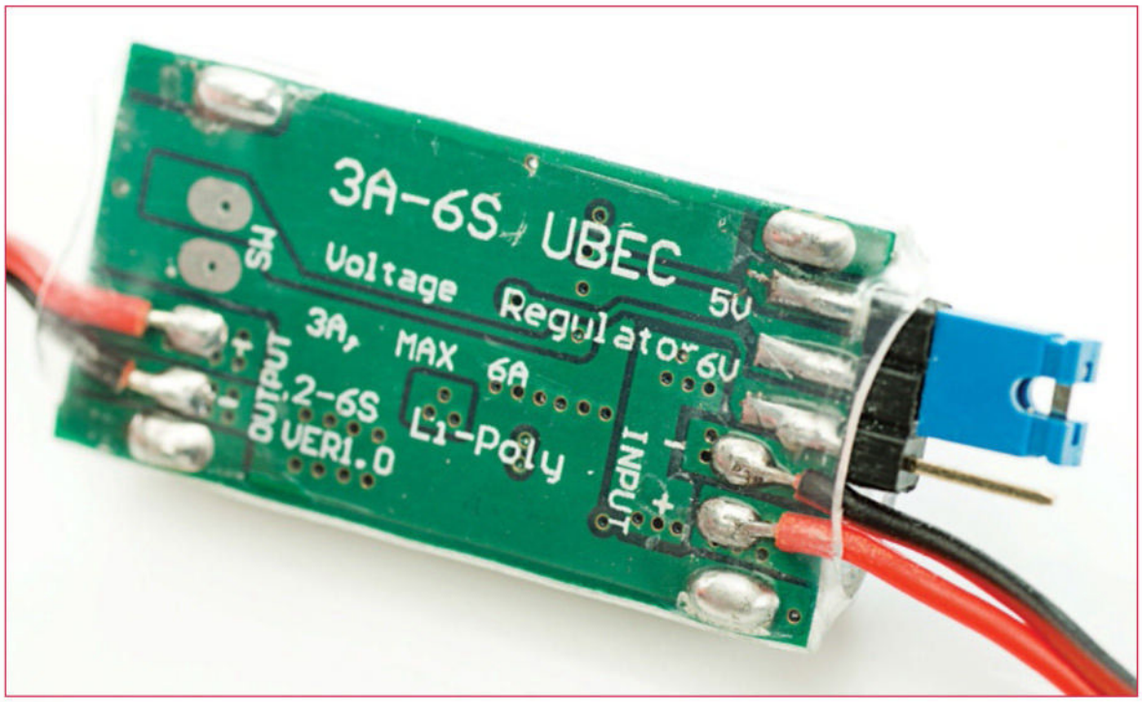
Don't leave your Raspberry Pi behind – incorporate it into mobile projects by powering it with AA batteries

Your Raspberry Pi's mobility is usually restricted by the length of the power lead. Rather than limiting it to your desk or living room, however, you can use it for mobile projects as diverse as launching it into near-Earth orbit or monitoring and automating your garden.

Of course, to do this you will need batteries, but adding battery power to your Raspberry Pi is simpler than you might have imagined. All that is required are six rechargeable AA batteries (or single-charge alkaline), a battery box with space for the batteries and a UBEC. The latter is a Universal Battery Elimination Circuit, a voltage regulator that will regulate the power supply and prevent damage to the Raspberry Pi, and can be bought for under £10.

What you'll need

- AA battery box
  bit.ly/1FDiJGa
- 3-Amp UBEC
  bit.ly/1HLKih7
- 3-Amp terminal strip
- 6x AA rechargeable batteries



Left You can also use a UBEC to charge your smartphone from a battery pack

01 Order your components

If you're buying your components online, you should be able to get them all within five days. However, if you're ordering offline (specifically the UBEC), you should avoid traditional electronics stores and instead visit a model enthusiast store, as these circuits are regularly used in RC devices.

02 Check your UBEC

Two types of UBEC are available. If you used the store that we suggest in the resources box to the left, you'll receive one with a micro USB power connector for easy connection to your Raspberry Pi. However, if you bought one from eBay then there is a strong chance that you will receive one with a 3-pin connector.

03 Change the UBEC connector pins

To use the UBEC with a 3-pin connector, alter the position of the pins so that they occupy the two outer slots.

Use a small jeweller's screwdriver to lever up the small plastic catch and remove the red wire from the central slot, before sliding into the unoccupied outer slot.

04 Connect the UBEC to the battery box

With five batteries in the battery box, connect it to the UBEC: red-to-red, black-to-black. You might do this by twisting the wires or soldering, or employ a 3-amp terminal strip, cut down to two pairs. The terminal strip can be cut to size using a modelling knife.

05 Add a battery to boot

With your Pi ready to use and your Wi-Fi dongle plugged in, connect the UBEC to the micro USB port and insert the sixth battery into the battery box. The Pi's power and status lights should indicate that the computer is booting up, which gives you a fully portable computer.

06 Connect the 3-pin UBEC

If you purchased the UBEC with the now-modified 3-pin connector, you'll need to connect this to the Raspberry Pi's GPIO header. Specifically, connect the positive +5V (red) connector to Pin 2 and the negative 0V connector to Pin 6. Once again, check the status lights to ensure the Pi is booting.

07 Measure uptime

You should have already set up your Pi for SSH use, so connect to the device via Putty after giving it time to boot fully (at least 60 seconds). In the terminal, enter:

```
watch -n 60 uptime
```

This command will display the system uptime and also keep the Wi-Fi connection active.

08 Judge your uptime results

Uptime results depend upon the type of battery you use and the Raspberry Pi model. Single-charge batteries will last a little bit longer, but this is a more expensive option. Meanwhile, newer models have greater power requirements but run for less time. For more power, add more batteries!

09 Power extreme!

More batteries added in parallel should result in almost double the uptime (at least 16 hours on a 256MB Raspberry Pi Model A), but instead of alkaline or rechargeable batteries you might consider a modern lithium-based AA cell, which will last considerably longer than alkaline batteries.

Use a UBEC

It is possible to power your Raspberry Pi directly from four or more batteries, but without the safety that the UBEC provides you're likely to burn out the computer. Unregulated power can cause considerable damage to your Raspberry Pi, and as you increase the current with more batteries, the risk also increases. Unless you are planning to learn the hard way and you have plenty of cash to burn, always use a UBEC!

Tricks

80 10 Inspiring Pi Projects

- Retro arcade cabinet
- Audiobook reader
- Web radio
- Media caster
- Portable Wi-Fi signal repeater
- Secure Tor web station
- Private cloud storage
- AirPi
- Dusklights
- Outdoor time-lapse camera

96 Set up the PiTFT touch screen

98 Calibrate a touch screen interface

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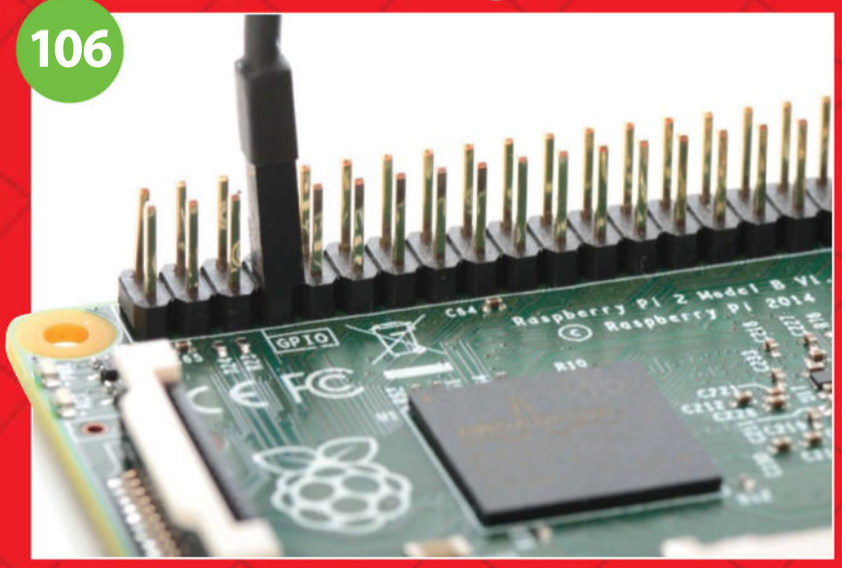
116 Add gesture control to your Pi

120 Make a digital photo frame

124 Pygame Zero



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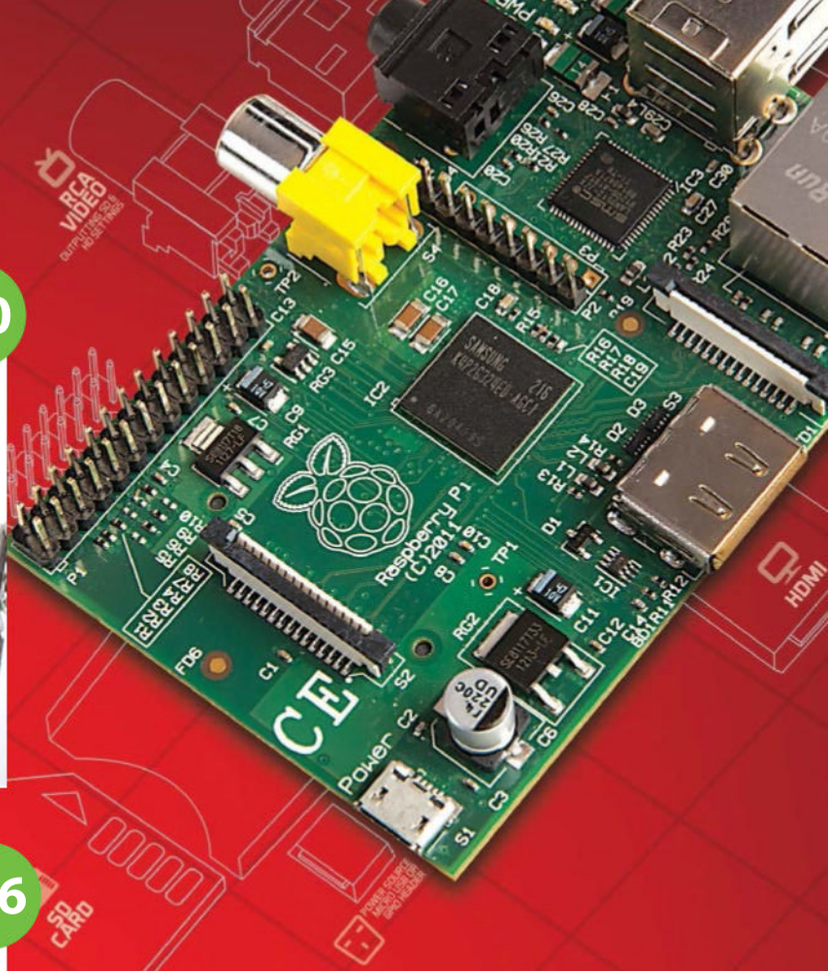

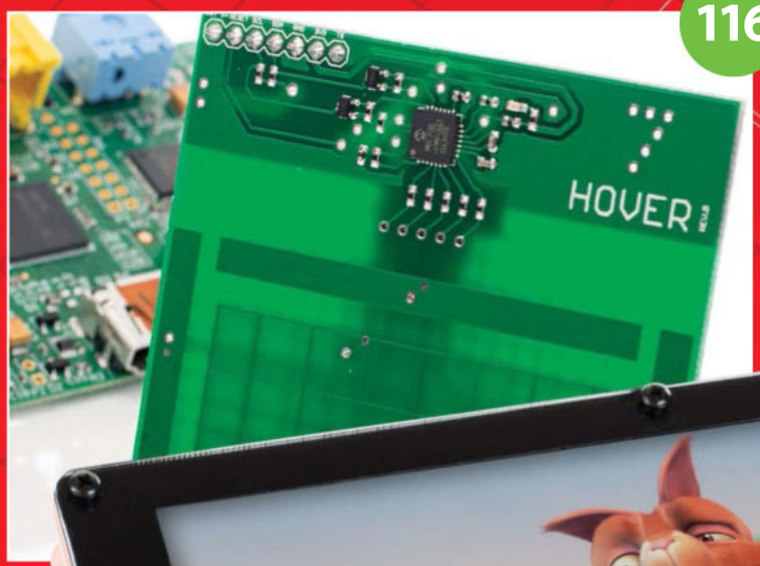

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"Fire up your imagination and test your Python skills"

120

120

10 Inspiring Pi projects

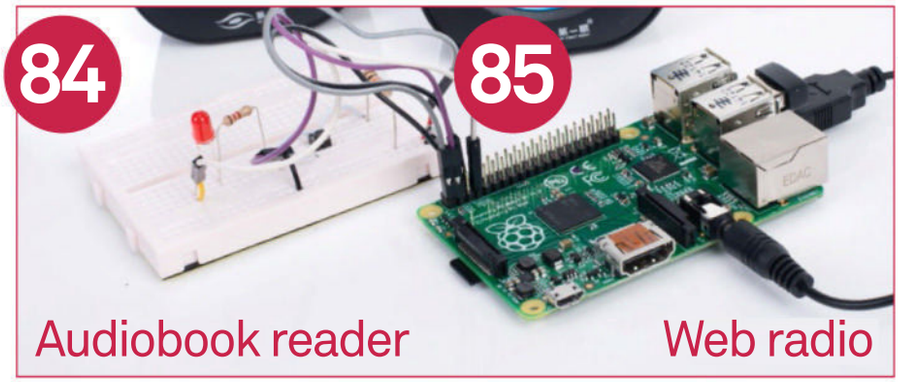
Fire up your imagination and test your Python skills

The Raspberry Pi has come a long way over the last couple of years, and it's all down to the creativity and imagination of a burgeoning community that's bought over three million of these single-board computers. They've powered quadcopters and coffee makers, self-sailing boats and even touched the edge of space, but the one thing that's still as much in demand as it was on launch day is an idea.

Our Raspberry Pi community works so well because we all share our work with each other. We can all see what everyone else is up to and, if we see something that we like, we can have a go at making it ourselves – and then changing it, so we can share a different version. It's all about inspiration.

So for this feature we made ten inspiring projects for you to try – and we encourage you to deviate from the steps when a new idea takes hold and let us know where your project leads you! There's a range of different projects here for you to try, covering media and entertainment, networks, security and more. All the components you'll need for each one are listed on the page – we've tried to keep the cost down as much as possible by using widely and cheaply available parts – and each project is simple enough for you to work through in a single sitting.

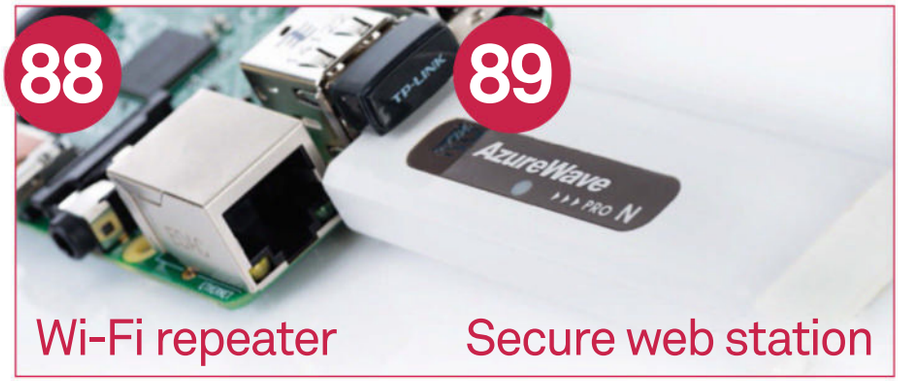
One more thing to mention – some of our Raspberry Pi creations are designed to be combined, to give you a great starting point when you begin adapting these projects to the way you want them. If you come up with any combinations we've missed, be sure to tweet us a photo (we are @Books_Imagine) – and have fun making them!



84 Audiobook reader

85 Web radio

86 Media caster

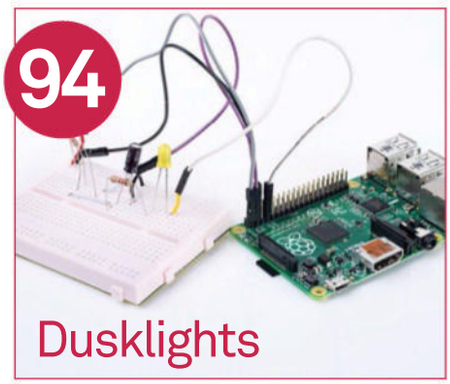


88 Wi-Fi repeater

89 Secure web station

90 Private cloud

92 AirPi



94 Dusklights

95 Time-lapse camera

82

Retro arcade cabinet

Create a tiny arcade machine and learn how to expand it into a fully-stocked games cabinet

We are very big fans of retro gaming, and when the Raspberry Pi was released a couple of years ago we immediately recognised its potential as an excellent device to power a homemade, MAME-using arcade machine. Maybe one day we could use a Raspberry Pi or another Linux-powered machine to run a cabinet in the future.

We weren't the only ones that realised how well a Pi would fit in an arcade machine; many projects have been completed since then with impressive results. If you don't fancy carving out custom pieces of wood just yet then you can always start small with the Cupcade kit from Adafruit. The kit is composed of laser-cut plastic panels, a PiTFT screen and a selection of buttons, custom boards and a special joystick that can be assembled into a miniature MAME arcade cabinet.

Unfortunately, for the moment, the Cupcade only supports the original Model B. However, we like to think of it as a great excuse to test out whether or not your Model B is up to the task of powering an arcade machine in case you want to expand. If not, that means you'll need another Raspberry Pi to replace the arcade one, in which case you can always upgrade to a Model B+ or the more recently released Model A+.

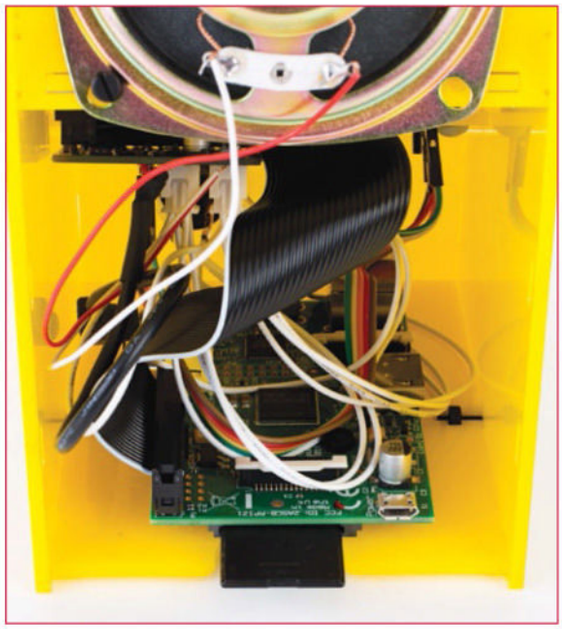
When you get the kit in, you'll need to assemble the components step-by-step. It's a long process which we don't quite have room for in this issue, so instead we're going to point you towards the excellent Adafruit instructions for constructing your Cupcade: **https://learn.adafruit.com/cupcade-raspberry-pi-micro-mini-arcade-game-cabinet/**.

A brief word of warning: it will take you a few hours to complete, so make sure you have some time clear to do so. It's quite fiddly in places as well, so it might be worth getting a second pair of hands to help you. When attaching the side panel to the screen, speaker and

What you'll need

- Raspberry Pi Model B
- Adafruit Cupcade
  adafruit.com/product/1783
- 1.5 A power supply
- Soldering iron
- Wire strippers
- A short length of audio wire

Left It's a bit tricky to get across the size of the Cupcade in this picture. Imagine the joystick is the same size as the analogue stick on a console controller



Top left You can always reverse the button mapping for traditional NES-style control

Top right The Raspberry Pi sits snugly below a great bale of wires

Bottom Upgrading to a full-size arcade cabinet is easily done, as the principles are the same as with the Cupcade build

buttons, we suggest ignoring the instruction to carefully lift the panel off your work desk. Instead, try sliding it slightly off the desk itself so that you can access each screw one at a time without having to precariously balance the sections at an angle.

Once completed, it's time to test it out. Adafruit has a pre-rolled image you can write to an SD card which can be downloaded with:

```
$ wget http://adafruit-download.s3.amazonaws.com/
cupcade-5-13-2014.img.zip
```

Write it to a 4 GB card (your Cupcade comes with one), download the free, non-commercial ROMs they provide to test the setup and power it up with a proper plug adapter. The components are running directly off the Pi and can be quite power-hungry, so it's imperative that you properly power it.

The image we've written has a full MAME arcade emulator in it, and a NES emulator. They're both configured to use the buttons you've installed on the case by default; this means that because the NES emulator directly maps the cabinet's A and B buttons to its own A and B, the layout is the reverse of the NES controller, which had A on the right and B on the left. Depending on what you plan to use the cabinet for, you can either swap over the buttons or just get used to a slightly altered control scheme.

How can we expand the Raspberry Pi from here to create a full-sized cabinet? The good news is that the emulators will still work when you use the HDMI port for output instead, allowing you to hook it up to a normal TV. The buttons and speakers will still work as well and they can be plugged straight into the Raspberry Pi's GPIO port via a connecting ribbon, like we used with the board to the screen.

However, this does leave you with only four buttons and the small joystick; luckily there are plenty of USB arcade sticks and components out there that can be connected via USB, and with the right configuring you can get them working on the emulators just fine.

There's a lot more you can do with the Pi once you've got it set up in a cabinet, such as letting it connect to the network so you can remotely maintain it without having to disassemble the entire thing to retrieve an SD card. Make sure you do your research on specific parts and look out for any community forums that will definitely have helpful advice on what to buy.

The emulators will still work when you use the HDMI port to hook it up to a normal TV

Be inspired

One of the best arcade cabinet projects we've seen has been featured on the Raspberry Pi blog: **bit.ly/1pWjQWE**

Using an old arcade cabinet for parts, the maker managed to modify the inputs to be read by the Pi and got the coin slot to work. You don't need to go this far by getting a CRT monitor or even an old busted cabinet, but it certainly adds a flair of authenticity to a project like this.

Audiobook reader

Create an audiobook player that works at the touch of a button

What you'll need

- Speakers
- LED
- 1.2 k resistor
- 10 k resistor
- Push-button switch
- Breadboard and wires

Audiobooks and podcasts are becoming more and more prevalent in a society where we've learned to multi-task thanks to all our modern devices. Whether out and about or doing some chores, it can be nice to have some extra sensory input when you're not using your full concentration. Enter, like always, the Raspberry Pi. With only a small selection of components and a pair of earphones or portable speakers, you can take your Raspberry Pi with you and have it play audio books.

First, you need to get the Raspberry Pi ready. Do your usual apt-get update and apt-get upgrade in the terminal before you start, although there isn't really much preparation involved. Once that's done, all we need to do is install VLC, which is done with:

```
$ sudo apt-get install vlc
```

Once that's done, turn off your Pi, disconnect the power and begin hooking up your circuit as according to the Fritzing diagram below. It's a fairly simple setup – we're going to use the button to activate the playing of the audiobook and the LED will turn on while this is happening.

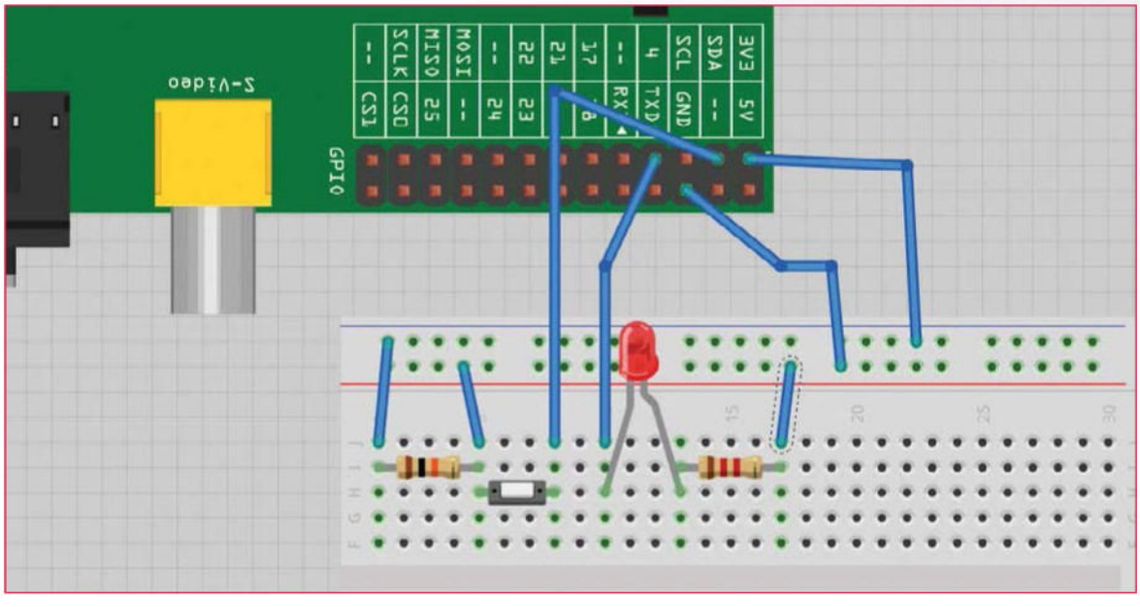
Once you're confident with the circuit, turn your Raspberry Pi back on and open up the terminal. Type in the following to download the Python code for this project:

```
$ wget http://www.linuxuser.co.uk/wp-content/uploads/2014/08/audiobook.zip
```

There are a couple things we need to note about the code: it first of all assumes you have your audiobook located in a directory known as audiobook within your home folder. It also looks for a file called audiobook.mp3 to play; you can easily change this by editing the path but you'll need to be consistent with the name of the file you have on your Pi. You could always have it point to a specific location on a USB stick, swapping out the files on another computer and renaming them appropriately once you've finished with previous book.

Test it out by running the code – one press of the button will start the process while another press will stop playing the book. If you find the button press too sensitive or not sensitive enough, edit the delay in time.sleep which is currently set at a default of 0.2 seconds.

Right The synergy between these two projects means you can use the same setup for both



Below This circuit will work on both the Model B and Model B+ – the pins begin at the same end of each board

Web radio

A portable radio that streams web content wherever you are

Our Raspberry Pi web radio is a true companion piece to the audiobook over the page, and we'll get into why as we go through this tutorial. Like the audiobook, we're taking full advantage of the Raspberry Pi to help aid you in a real-life situation. As standard radio methods begin to die out, the established web-streaming platforms will become more and more popular, and you can get in on those straight away using this project. The circuit for this is also the exact same one as the audiobook, so if you've already had a crack at that, then you'll just need to grab the code for this tutorial.

Before you wire it up, it's time to prepare your Raspberry Pi. Open the terminal and do an apt-get update and apt-get upgrade to make sure everything is up to date, followed up by installing VLC using:

```
$ sudo apt-get install vlc
```

When it's finished installing, you will need to turn off your Raspberry Pi. Disconnect the USB cable, break out the breadboard and components and follow the wiring diagram. It's not a complicated circuit at all, and revolves around sensing a button being pressed and lighting an LED on command. Double check all your connections on the breadboard and then plug your Pi back in.

Open the terminal and use it to download our Python script for playing internet radio:

```
$ wget http://www.linuxuser.co.uk/wp-content/
uploads/2014/08/webradio.zip
```

Unzip the file and put it wherever you want; it doesn't require any special placement in your Pi's file structure. You will likely want to change the radio station that the code is currently tuned to, and this can be found in the subprocess.Popen line in the code. Find an m3u URL for your favourite radio station and replace the URL already in that code to get it to play.

There may be a short delay between pressing the button and the music starting as VLC launches and gets the stream buffered. We've made it so the light comes on straight away, though, so at least you'll know the process has started. Pressing the button again will kill VLC and stop the radio stream. If you feel the button is too sensitive or not sensitive enough, look for the time.delay setting and change the amount of time it requires the button to be pressed.

Put 'em together

You can easily put both projects together and have an all-in-one radio and audiobook. Wire up a second button that will play the audio book instead and maybe even add extra buttons if you like for different radio stations.

Media caster

Cast your content over the local network to receive it from multiple clients so you don't lose your place

What you'll need

- Raspberry Pi Model B
- XBMC
  http://xbmc.org
- Portable hard drive

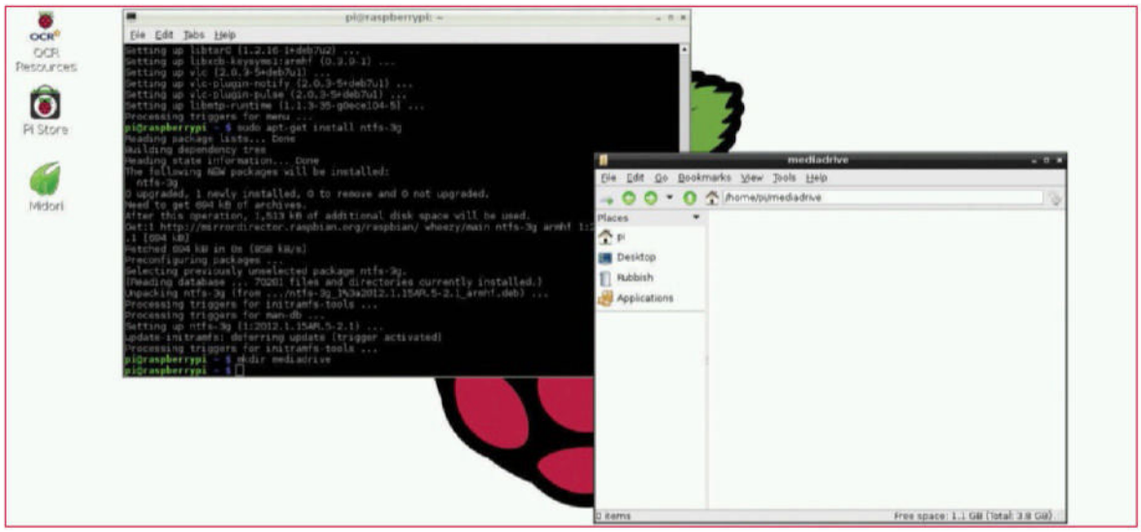
Have you ever wanted to move between rooms while watching or listening to the same film or song? We often find ourselves switching from a phone or tablet to the desktop. There are some complicated setups you can use for this involving MythTV and various custom-built servers and receivers, but you can also do it with just one Raspberry Pi server and then many XBMC receivers with a lot less hassle.

Broadcasting your media over your network so that the clients can pick up the stream means that you can easily pick up where you left off in your track or film wherever you move to, without having to make a note of the track position and find the file again. Here's how to get set up.

01 Install storage drivers

You'll likely be using a portable NTFS hard drive if you want to store a lot of media on your Raspberry Pi caster. This means you need to install the NTFS libraries on the Pi, which requires you to open the terminal and type:

```
$ sudo apt-get install ntfs-3g
```



Left Media stored on your portable hard drive will show up in a dedicated folder

02 Create mounting folder

We're going to have the Raspberry Pi automatically mount the hard drive for us whenever it boots up, and in order to do this it first needs to have a place where the files will be accessible. Let's create a directory called mediadrive inside the Home folder. Keep the directory name to just one word to make your life easier later.

```
$ mkdir mediadrive
```

03 Boot-time mount parameters

Your hard drive will likely be mounted as /dev/sda1, but do a fdisk -l if you want to double check. To make sure it mounts at boot, go to fstab with sudo nano /etc/fstab and write the following line below, with a tab between each bit of information:

```
/dev/sda1      /home/pi/mediadrive      ntfs-3g
defaults,noatime      0      0
```

04 Install VLC on Pi

So all our media is now accessible, and now we need a way to broadcast it. For this we'll use multi-functional media player VLC, which was originally designed to be the client for a casting server. You can install it with:

```
$ sudo apt-get install vlc
```

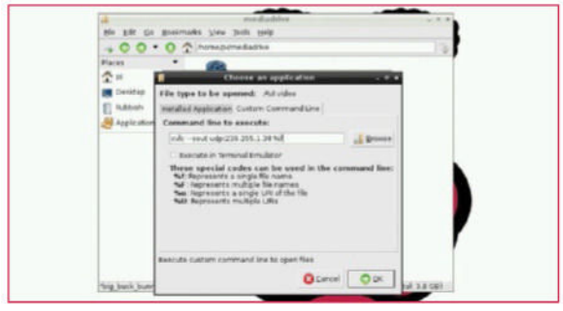
SSH into your Pi from another computer or an Android device

05 XBMC stream receiver

This bit is dead simple – on any computer you can easily get files off of, create a file called Stream.strm, and add this line to it, with IP as the last two sets of Pi's IP address:

```
udp://239.255.[IP].[IP]:1234
```

Save it and move it to your XBMC clients that you want to receive the cast from.



06 Custom VLC command

Here's the really fun part. Go back to your Pi and right click on one of the files you'd like to play, go to Properties and click the down arrow next to Open with. Go to Customise and then Custom Command Line and type in the following, with IP as the last two sets on your IP address:

```
cvlc --sout udp:239.255.[IP].[IP] %f
```

07 Test out casting

Here's the big test: boot up XBMC, open your media on the Raspberry Pi and use the Stream file on XBMC to receive the cast. It might take a moment to load but it will start playing via XBMC in short time.

08 Command line alternative

Your setup may not always be convenient for you to go to the Pi and start launching files from the desktop. You can always SSH into your Pi from another computer or an Android device and run the file using a similar custom command to the one we used earlier:

```
$ cvlc --sout udp:239.255.[IP].[IP] [file location]
```

Be inspired

Why not add a web interface to your Pi so that you can browse from your laptop or smartphone? Have it run the multicast code when clicking on files it's scraped from the media drive to make the process much easier. You can also fuse the project with our cloud server in a few pages time.

Portable Wi-Fi signal repeater

Boost your signal using a Raspberry Pi and two USB Wi-Fi dongles

What you'll need

- 2 USB Wi-Fi adaptors
- Raspberry Pi case
- Portable power pack

What we like about the Raspberry Pi for this project is that it's very low maintenance and extremely easy to put in an appropriate location. All you need for this project are two USB wireless adaptors, a nice little case and a way to power it. Once you've set it up, you can basically leave it to its own devices, checking in over SSH every now and then to do some updates.

Set this up on a monitor with a keyboard, using a fresh image of Raspbian and with your Wi-Fi dongles plugged in. On first boot keep it as CLI and after doing the usual apt-get updates and upgrades, type startx to get to the desktop. Configure the wireless for wlan0 to connect to your home network and make sure it has a fixed IP address, then reboot to make sure it all works from the command line by using ping www.google.com. Now you need to install your first bit of software using:

```
$ sudo apt-get install hostapd iw
```

After it's installed, you'll want to download and save the file we've created directly to config by entering the following two commands:

Right One Wi-Fi adaptor picks up your main Wi-Fi network, while the other one broadcasts a new signal

Above As well as from the main Tor website, you can also download Tor from this issue's DVD

```
$ wget http://www.linuxuser.co.uk/wp-content/uploads/2014/08/repeater.zip
$ cp LUDRepeater.conf /etc/hostapd/hostapd.conf
```

Do a reboot and test the configuration file with:

```
$ hostapd -dd /etc/hostapd/hostapd.conf
```

If there are no errors, open the file using nano /etc/hostapd/hostapd.conf and then add the following to the file:

```
DAEMON_CONF="/etc/hostapd/hostapd.conf"
RUN_DAEMON=yes
```

Also change the SSID to be the same one for your network in the ssid field. Once that's done, you'll need to install the bridge utilities with apt-get install bridge-utils. Then configure it with the following four commands:

```
brctl addbr bridge0
brctl addif bridge0 wlan0
brctl addif bridge0 wlan1
ifconfig bridge0 up
```

Test it out to make sure it works and then place it around the house to extend your wireless signal!

Secure Tor web station

Stay private online by routing all your web traffic through Tor on your Raspberry Pi

In a much more privacy-focused world, being able to browse securely online is an important freedom for many people. With the use of Tor and a few tweaks to the Raspberry Pi, you can make sure all your internet traffic is kept private.

First of all, you'll need to make sure to install Tor from the repos. Open up the LXTerminal and simply type:

```
$ sudo apt-get install tor
```

Once that's done, edit the torrc file by using sudo nano /etc/tor/torrc and add this to the top of the file:

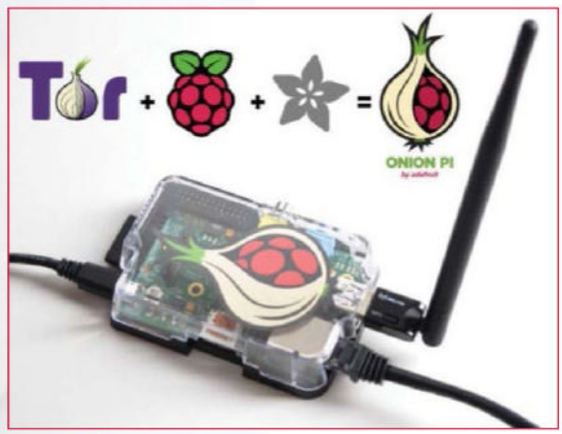
```
VirtualAddrNetworkIPv4 10.192.0.0/10
AutomapHostsOnResolve 1
TransPort 9040
DNSPort 53
```

Save this and then open the next file with sudo nano /etc/resolv.conf file and modify it:

```
nameserver 127.0.0.1
```

Finally, you need to change the iptables ruleset, but before you do this, use top to confirm the uid of Tor and make a note of it. Now open up a new file with nano /etc/init.d/iptables and enter the code found at: **http://www.linuxuser.co.uk/wp-content/uploads/2014/08/tor.zip**. Now save it and enter:

```
$ chmod 755 /etc/init.d/iptables
$ update-rc.d iptables defaults 12
```



Right Adafruit's Onion Pi Pack contains all the components you need to set up a secure connection

Put 'em together

A secure wireless connection can be created using the Raspberry Pi by looking at the Onion Pi project from Adafruit: **learn.adafruit.com/onion-pi/overview**

This creates a wireless access point connected to the internet that anonymises all web traffic by directing it through the Tor network.

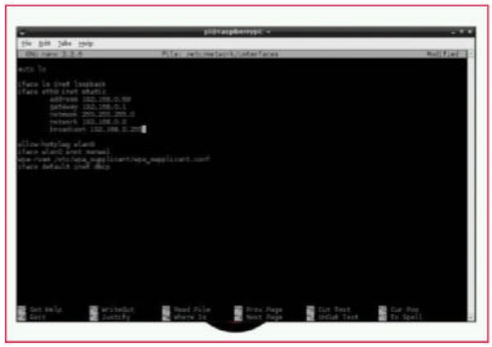
This means all your home computers and smart devices can be connected to Tor and not just the Raspberry Pi itself. You can also apply some of the lessons learnt in the Wi-Fi repeater tutorial to unshackle it from the ethernet cable, although that will reduce slightly its overall security.

Private cloud storage

Turn the Pi into your own personal Dropbox using ownCloud and an internet connection

The themes of a lot of our Raspberry Pi guides revolve around the size and portability of the Pi itself, lending it to tasks you may have used a full-sized or small computer for in the past that the Pi can now take over. Having your own private cloud is another excellent use of the Raspberry Pi's capabilities, because you can store it hidden away somewhere and it will require very little day-to-day maintenance.

Make sure you invest in some decent, portable USB storage such as an external HDD, and also get a case for your Pi in the process.



01 Set a static IP

After setting up your wired or wireless internet connection, you need to make it static. Use sudo nano /etc/network/interfaces to open up the network settings file. Fine the iface eth0 line so you can change and add to it:

```
iface eth0 inet static
      address 192.168.0.50
      gateway 192.168.0.1
      netmask 255.255.255.0
      network 192.168.0.0
      broadcast 192.168.0.255
```

What you'll need

- External storage
- Constant internet connection

Left Rather than store all your media and files on a cloud server in an unknown location, you can keep a cloud in your own home

02 Install a lot of software

You'll want Apache software and PHP for this. Install everything you need with:

```
$ sudo apt-get install apache2 php5 php5-json php5-gd php5-sqlite curl libcurl3 libcurl4-openssl-dev php5-curl php5-gd php5-cgi php-pear php5-dev build-essential libpcre3-dev libapache2-mod-php5 php-apc
```

03 Set up PHP accelerator

Install your accelerator with sudo pecl install apc and create an ini file for it. To do this, use sudo nano /etc/php5/cgi/conf.d/apc.ini and then add this to the file:

```
extension=apc.so
apc.enabled=1
apc.shm_size=30
```

04 Configure file limits

Go into the Apache config file with sudo nano /etc/php5/apache2/php.ini. It's a big file, but there are two filesize options you need to find, and a third extension option you need to add as below:

```
upload_max_filesize = 2048M

post_max_size = 2200M

extension = apc.so
```

05 Set up SSL

First of all, you need to enable SSL in Apache; do this by using sudo nano /etc/apache2/sites-enabled/000-default and change 'None' to 'All' in the AllowOverride option. Follow this up with the following two commands:

```
$ sudo a2enmod rewrite
$ sudo a2enmod headers
```

06 Finish up with Apache

You now need to do two sets of commands: a big one which requires some info and then a restart:

```
$ sudo openssl genrsa -des3 -out server.key 1024
$ sudo openssl rsa -in server.key -out server.key.insecure
$ sudo openssl req -new -key server.key -out server.csr
$ sudo openssl x509 -req -days 365 -in server.csr -signkey server.key -out server.crt
$ sudo cp server.crt /etc/ssl/certs;sudo cp server.key /etc/ssl/private;sudo a2enmod ssl
$ sudo a2ensite default-ssl

$ sudo service apache2 restart
```

07 Download and install ownCloud

Here you have a series of commands to run that will download, unzip and install ownCloud to the right place:

```
$ wget https://download.owncloud.org/community/owncloud-7.0.0.tar.bz2
$ sudo tar -xjf owncloud-7.0.0.tar.bz2
$ sudo cp -r owncloud /var/www
```

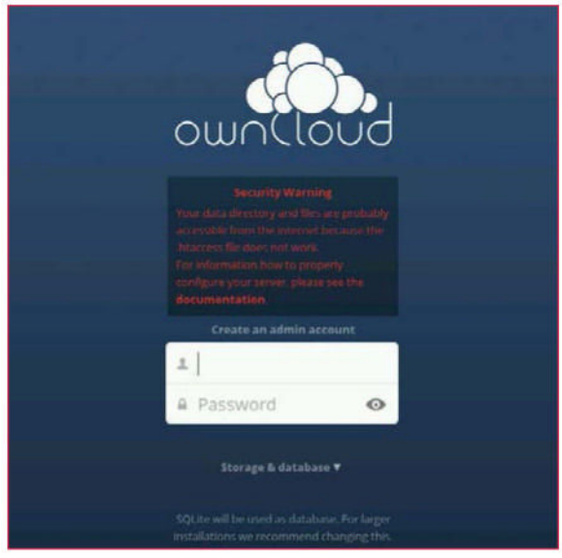
08 ownCloud permissions

Make sure your hard drive is connected and mounted as you want it. First, give webserver permission to use ownCloud:

```
$ sudo chown -R www-data:www-data /var/www/owncloud/
```

Next, use sudo nano /var/www/owncloud/.htaccess and make the same changes you did in the php.ini file above. Finally, give permissions to the location you mounted the hard drive to with:

```
$ sudo chown -R www-data:www-data [mount]
```



09 Set up ownCloud

Open Midori and navigate to https://[ipaddress]/owncloud to begin the ownCloud setup process. The first thing you'll need to do is change the data location to the mount point of your external drive, which can be found in the advanced options. And you're done!

Be inspired

Need an idea of what your next step could be? Check out our media caster tutorial and maybe you can fuse the two concepts together. Upload videos to your cloud and get them to play over your network.

AirPi

Predict the weather using your own sensor station

The AirPi has a pedigree that aligns perfectly with the mission of the Raspberry Pi Foundation. Created by two teens in sixth form to measure various forms of pollution, the project's popularity exploded with thanks to some highlighting by the Raspberry Pi Foundation and it's now the premier way to create a weather station on the Raspberry Pi.

The AirPi kit comes with a small selection of sensors by default that can be upgraded and improved upon with extra breakout boards and modules. Included with the kit is a barometric pressure sensor, a humidity and temperature sensor, an ultraviolet radiation sensor and a microphone for noise pollution.

The first thing you'll need to do is assemble the kit, for which you'll require a soldering iron and a steady hand. There are some basic instructions that come with the kit you can follow but it doesn't hurt to have a look at some of the online images to figure out exactly where everything goes. Be careful when soldering all the resistors to make sure you don't melt the 26-pin connector on the underside otherwise it won't go on your Pi.

Once that's done you need to start setting up your Raspberry Pi. Open up a terminal and get some of the Python tools you'll need to use:

```
$ sudo apt-get install git-core python-dev
python-pip python-smbus
```

Download and install the python-eeml package:

```
$ sudo apt-get install libxml2-dev libxslt1-dev
python-lxml
$ git clone https://github.com/petervizi/
python-eeml.git
$ cd python-eeml
$ sudo python setup.py install
```

You need to install i2c support for the pressure sensor, so first use sudo nano /etc/modprobe.d/raspi-blacklist.conf and remove the comment from the blacklist i2c-bcm2708 line. Next, open up the modules file with sudo nano /etc/modules and add i2c-dev to the bottom of the file. Save that and install:

```
$ sudo apt-get install i2c-tools
```

Add your Pi to the i2c user group with:

```
$ sudo adduser pi i2c
```

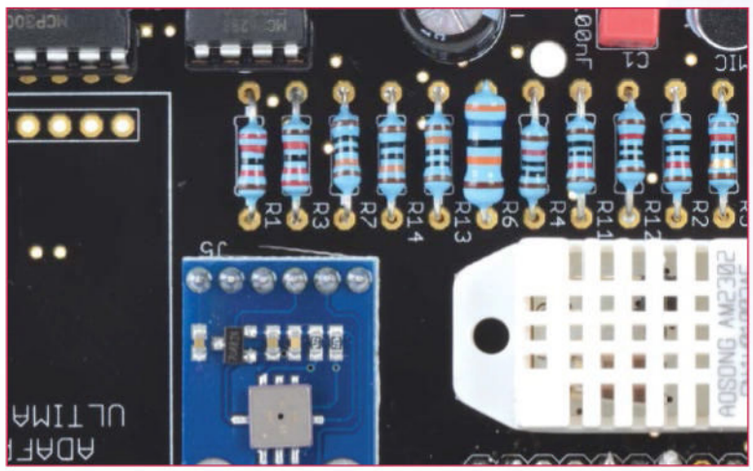
Now reboot your Raspberry Pi before continuing. Finally, install the final Python module with:

```
$ sudo apt-get install python-smbus
```

Now we can install the AirPi code. Still in the terminal, use:

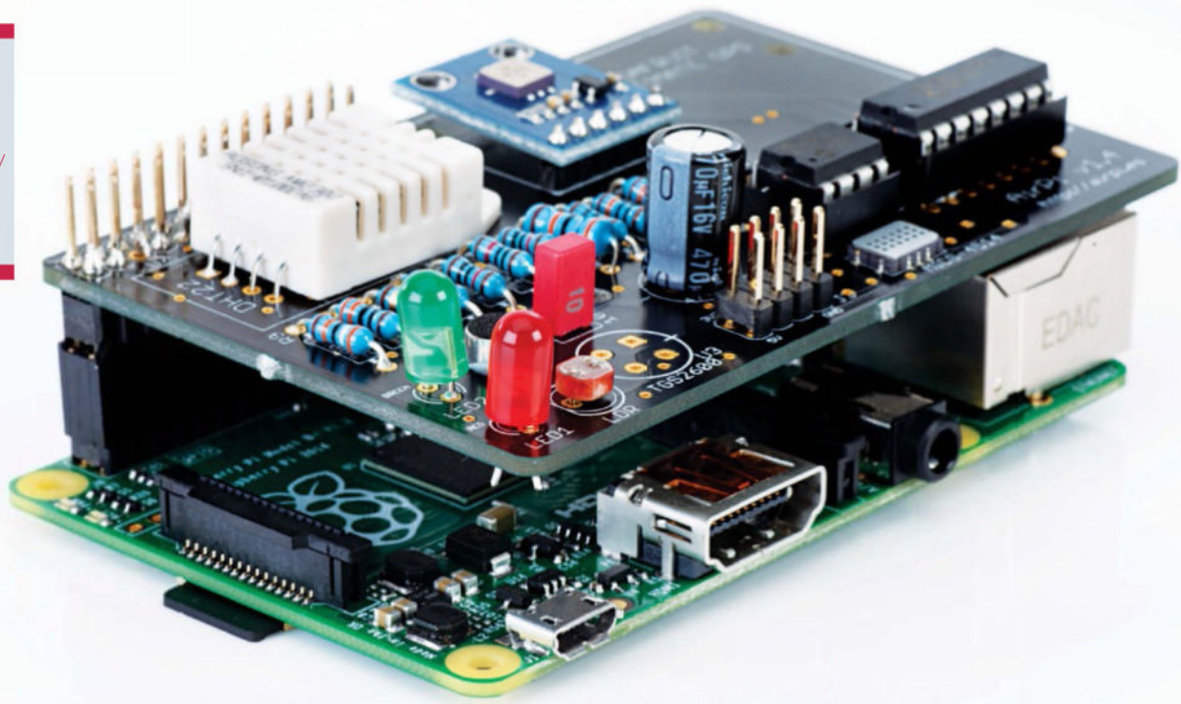
```
$ git clone -b non-modular https://github.com/
tomhartley/AirPi.git
```

If you're using a revision 2 Model B or a B+, use sudo nano AirPi/AirPi.cfg to edit the config file. Change I2CBus = 0 to I2CBus = 1 and alter the next line to read LCD = False. Create a Xively account, add the API and ID keys to the config file and save it. You can now start taking measurements by running Upload.py.



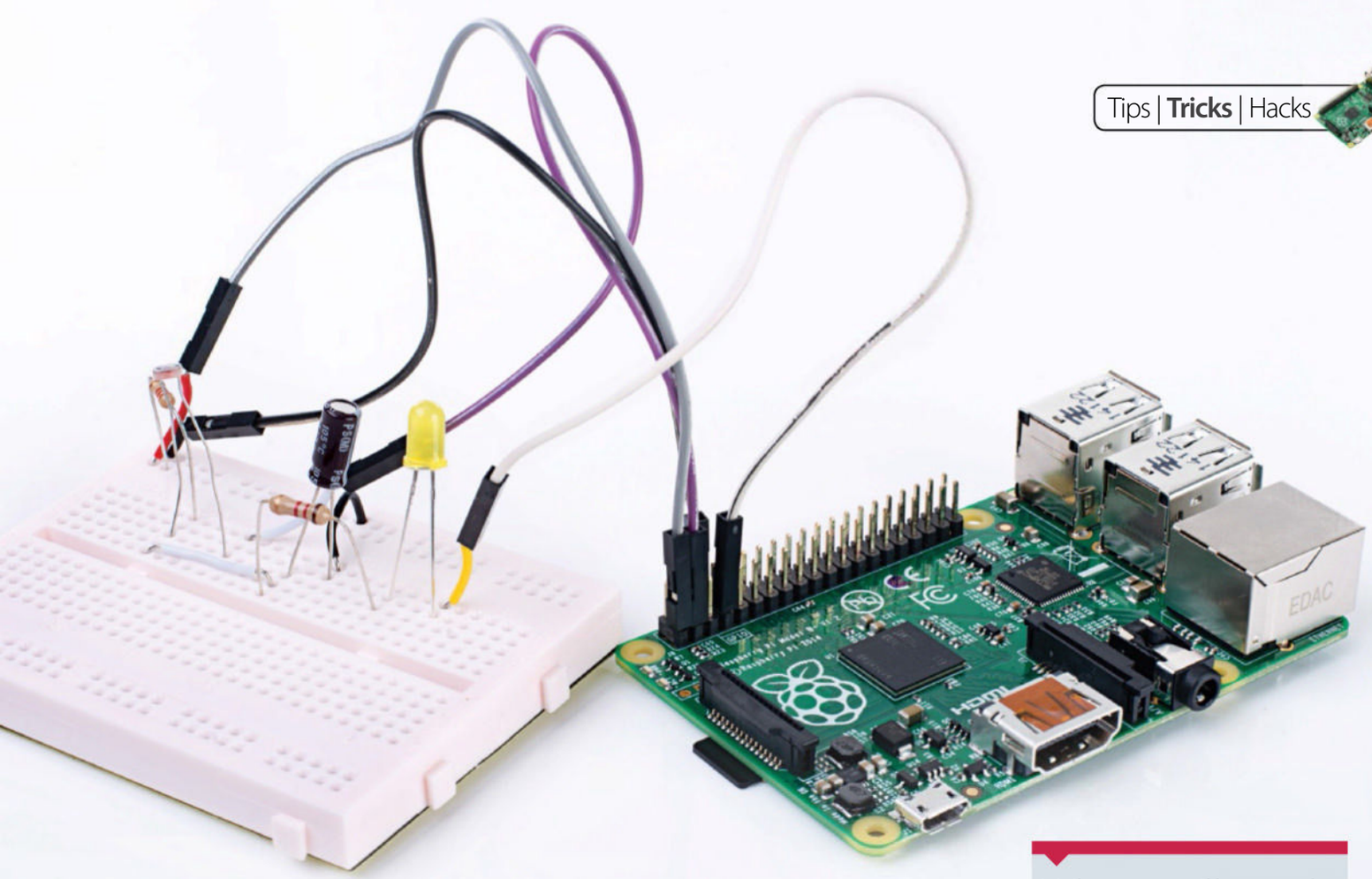
What you'll need

- AirPi
  tindie.com/products/tmhrtly/airpi-kit/
- Soldering iron
- Solder



Top right Measure your surroundings with AirPi and share your data with the scientific community

Bottom right The AirPi perfectly fits the Raspberry Pi, so you can easily enclose your device in a small weatherproof box



Dusklights

Use your Raspberry Pi to control outdoor lights that automatically come on when it's dark

What you'll need

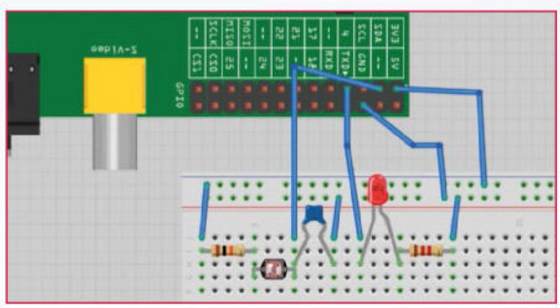
- 1.2 k resistor
- 2.2 k resistor
- Light dependent resistor
- 1 µF capacitor
- Breadboard and wires

You've probably all seen those cheap, solar-powered lamps that you can stick into your garden to try and give it a classy bit of illumination during the night. If you've actually got one then you may have found out that they don't shine very brightly and the plastic stakes can be very flimsy. So why not make your own version? What we'll show you on this page is the beginning of an array of light-sensitive LEDs using a single LED, so that you can understand how the system works. We'll use a special resistor called a light dependant resistor (LDR) or photoresistor that changes its resistance based on the levels of light it's receiving.

There's no extra software you'll need for this, so just make sure your Pi is up to date with an apt-get update and apt-get upgrade. Turn it off, unplug it from the power source and get to work wiring up the circuit as shown in the Fritzing diagram. Take special note of the placement of the components, especially the LDR and the capacitor. What you'll need to do is measure the time it takes for the capacitor to fully charge between pin three of the GPIO ports and ground. Also, make sure the negative end of the capacitor is hooked to the ground side of the circuit.

Once that's done, turn your Raspberry Pi back on and download the code we've created for this project using:

```
$ wget http://www.linuxuser.co.uk/wp-content/
uploads/2014/08/dusklight.zip
```

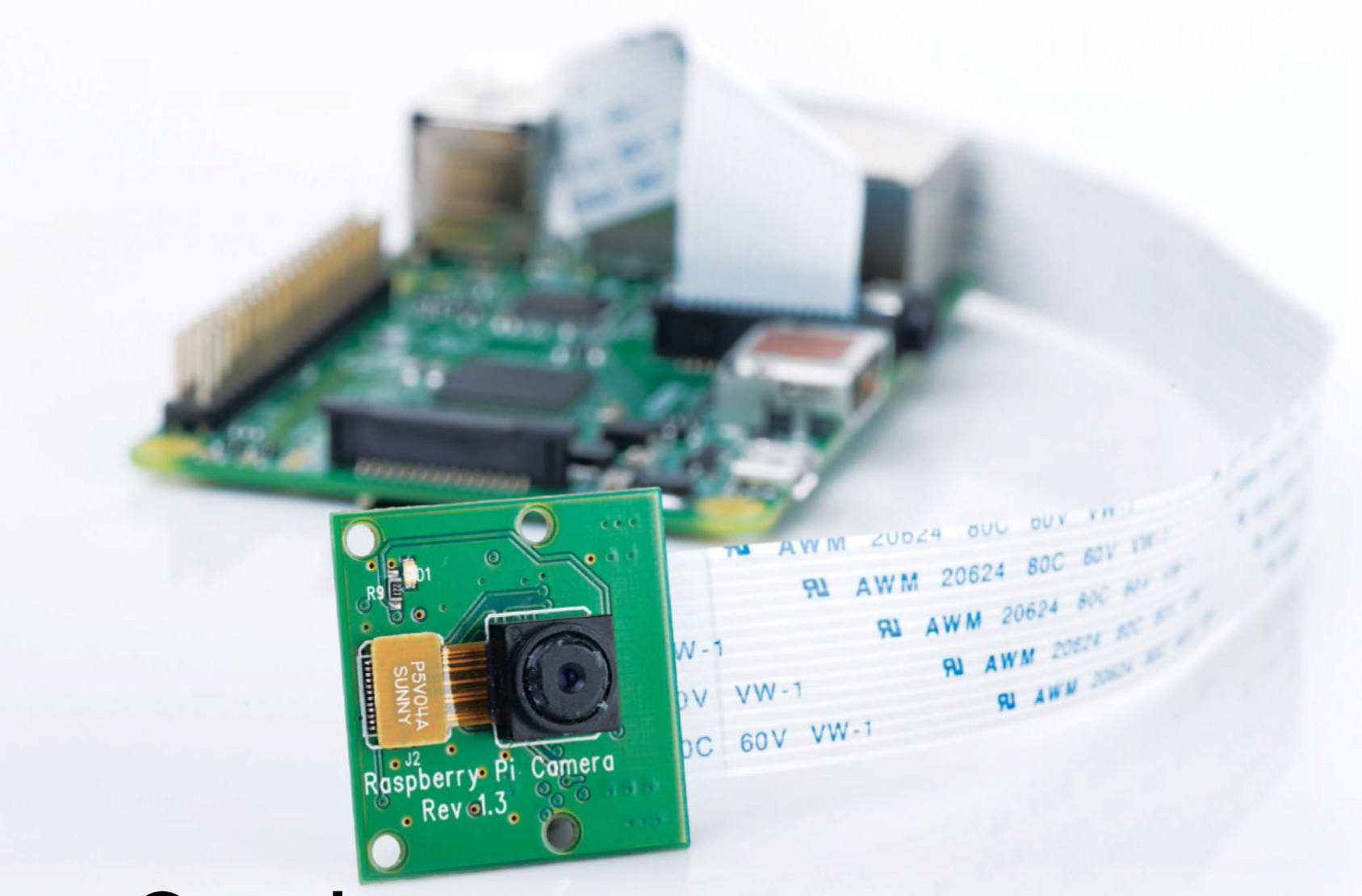


Unzip it and run it. We've made it so the Python shell will print out the values that the circuit returns, with a higher number meaning it's darker and the capacitor takes longer to charge. See how the circuits react to you covering the LDR with a finger or shining a torch on it in order to get an idea of how your version will work.

To get this working for outdoor use it will require a bit of trial and error. The easiest way is to set it up when it's getting to about the level of darkness you'd want the light to turn on and record the output from the sensor. Change the if statement so that it activates the LED over a certain number and you'll be set. With some external power and more LEDs you can have a Raspberry Pi power an entire array of shining lights around your garden.

Put 'em together

Linking up the AirPi with your dusklights allows you to have the ultimate outdoor Raspberry Pi device, allowing you to predict the weather and control your outdoor lighting with more precision. The humidity and pressure sensors will be able to tell if it's foggy or not, giving you more control over when your lights turn on.



Outdoor time-lapse camera

Get beautiful views of the sunset using your Raspberry Pi, a Pi camera and a small Python script

What you'll need

- Pi camera module
- A weatherproof case, such as a PICE+

We love the Raspberry Pi camera. It's a lovely little piece of kit that is as versatile as the Pi and it doesn't even take up any of the USB slots. We've done a bit of time-lapse photography in the past but that was using a proper camera attached to the Pi – now we're doing it with just the Pi camera and a lot less code thanks to the picamera Python module.

We need to set up our Pi with a few things before we start with the code, though. We'll start off with assuming you've got a freshly installed Raspbian SD card, so the first thing to do is an apt-get update followed by an apt-get upgrade to make sure your files are up to date. Follow this with an rpi-update to make sure your firmware is also up to date – this step is very important because if you're using an outdated firmware then the camera won't work.

The next step is to get the camera enabled. Open up the terminal if you're on the desktop, or simply write into the command line:

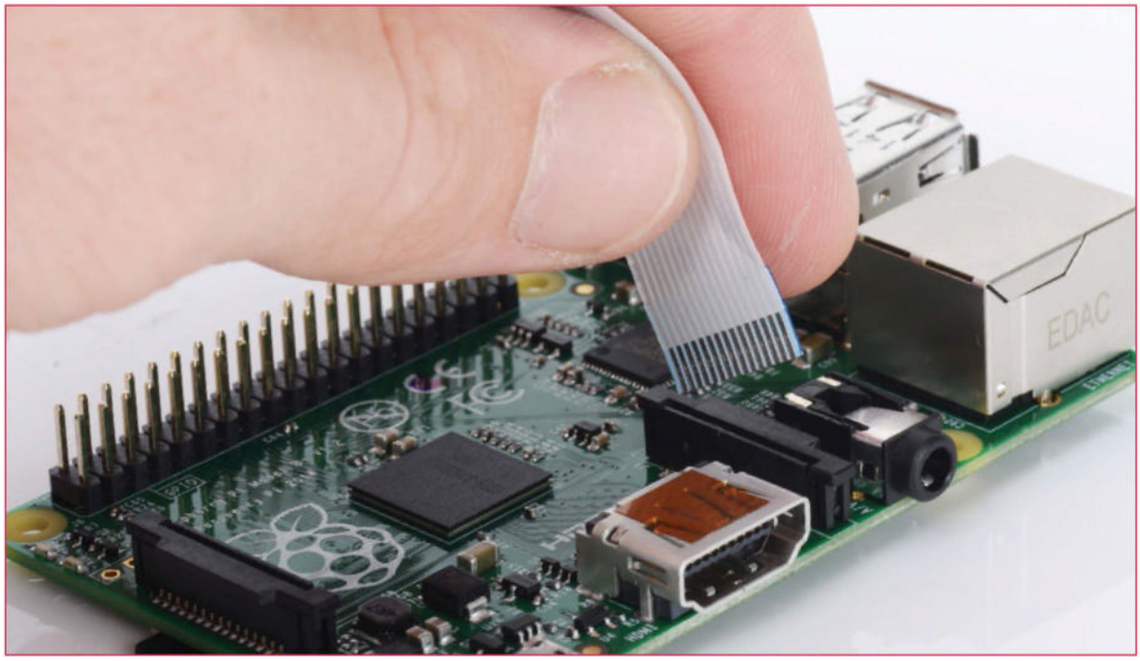
```
$ sudo raspi-config
```

Find the Enable Camera option. Press Enter and key over to Enable. Go to Finish but don't restart straight away as you have some more commands to get through. Install your picamera module using this:

```
$ sudo apt-get install python-picamera
```

You also need to install the software that you're going to use for compiling your images into the finished time-lapse video. We're using gstreamer to compile the video as it works well with the Raspberry Pi GPU. To get it installed, first add the repo to the sources list with:

```
$ sudo sh -c 'echo deb http://vontaene.de/raspbian-updates/ . main >> /etc/apt/sources.list'
```



Left Ground yourself and carefully insert your Pi camera while the Raspberry Pi is unplugged

Below The PICE+ case is currently being Kickstarted, so it wasn't available at the time of writing, but look out for it by the end of the year

Do an apt-get update and then install a huge selection of packages with the following:

```
$ sudo apt-get install libgstreamer1.0-0 liborc-0.4-0
gir1.2-gst-plugins-base-1.0 gir1.2-gstreamer-1.0
gstreamer1.0-alsa gstreamer1.0-omx gstreamer1.0-
plugins-bad gstreamer1.0-plugins-base gstreamer1.0-
plugins-base-apps gstreamer1.0-plugins-good
gstreamer1.0-plugins-ugly gstreamer1.0-pulseaudio
gstreamer1.0-tools gstreamer1.0-x libgstreamer-
plugins-bad1.0-0 libgstreamer-plugins-base1.0-0.
```

Once that's done, shut down the Raspberry Pi. Unplug the USB cable and locate the special DSI port for the camera, next to the HDMI port. Gently pull on the edges to lift the fastener and slot in your Raspberry Pi camera ribbon – make sure the silver connectors are facing the HDMI port. Turn your Raspberry Pi back on and get back into Raspbian. Everything should be about ready now, so give the camera a test by opening up the terminal and using:

```
$ raspistill -o test.jpeg
```

It will show the preview screen and then take a photo after five seconds; if it does so, you're ready to get set up with our code.

Our preferred method for doing this is to first create a folder called timelapse in your home directory; you can do this simply by opening the terminal and typing:

```
$ mkdir timelapse
```

If you haven't made any changes to your username and such, this should create the directory with the full path /home/pi/timelapse. Keep this in mind and we'll explain its importance in a bit. Now in the terminal we'll download the Python code we've created for this project:

```
$ wget http://www.linuxuser.co.uk/wp-content/
uploads/2014/08/timelapse.zip
```

Unzip it and have a quick look through it using IDLE. There are a couple of things to note in the code in case you wish to modify it. The photos variable is set to 500 and that's the number of shots it will take before compiling the video. In reality it will actually do one more due to the mathematical quirks of Python but that shouldn't matter. The delay parameter is in seconds and using a bit of Google Fu you can figure out that 500 shots at 30-second intervals will take about four hours to complete.

The large subprocess.call line is used to compile the images into an AVI file at 24 frames per second. It uses the full path to the directory that we mentioned previously, so if yours is slightly different make sure you change it now.

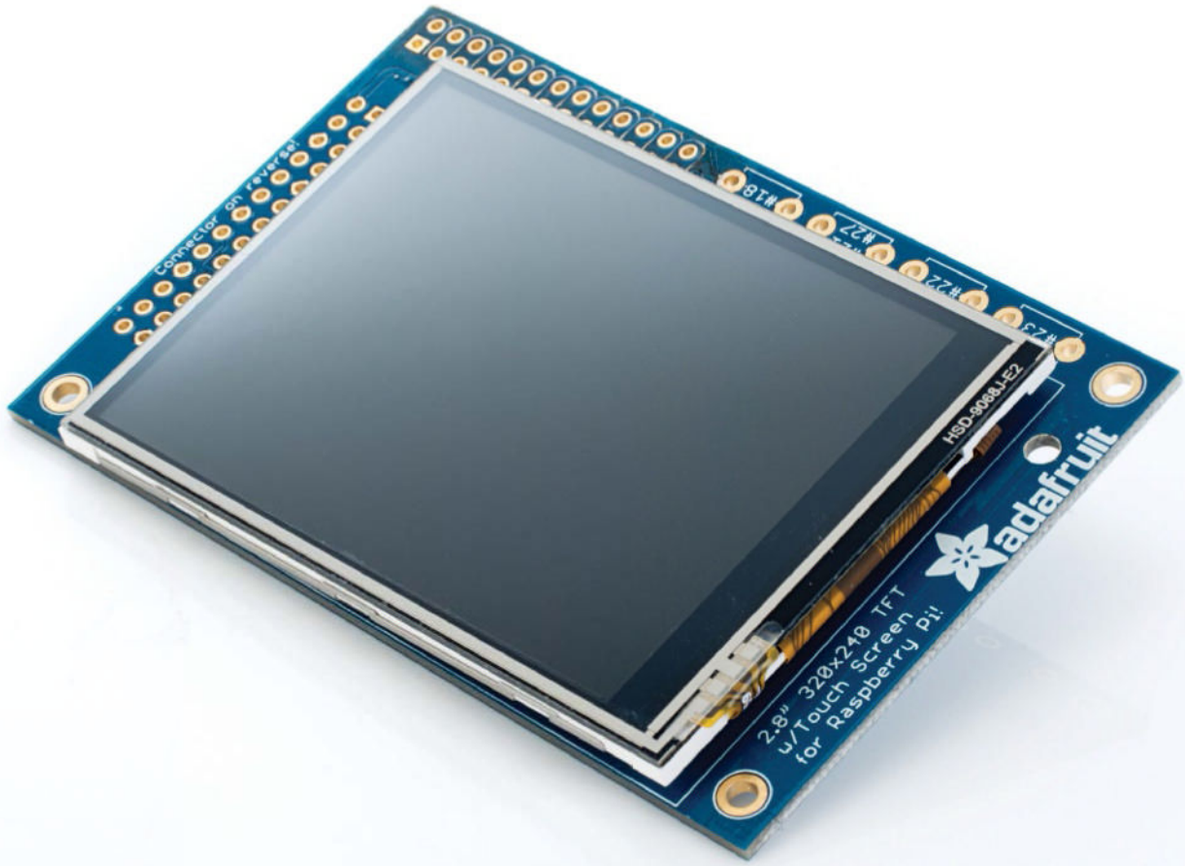
There are a number of ways you can use it to get a time-lapse of the outdoors; the easiest and safest way is to locate a window with the view you wish to use. This may not always be easy, though, in which case we suggest trying out the PICE or PICE+ case. It's a durable and waterproof case that is designed to house the Pi and a Pi camera. Once it's in place, all you'll need to do is hook it up to power, preferably with a long cable, and run the code. Once it's finished, retrieve the Pi and the AVI file.

Be inspired

With some modifications to the code and the Pi, you can make it a lot more automated, running the Python script after boot and uploading it to the cloud storage we set up earlier. You can also use it as a CCTV camera thanks to an additional hood that comes with the PICE

Set up the PiTFT touch screen

This simple little touch screen takes a bit more than just plugging it in, as we show in the first of our hand-held Raspberry Pi video player tutorials



What you'll need

- SD card with up-to-date version of Raspbian
- PiTFT, fully assembled
  bit.ly/1jHEJT4

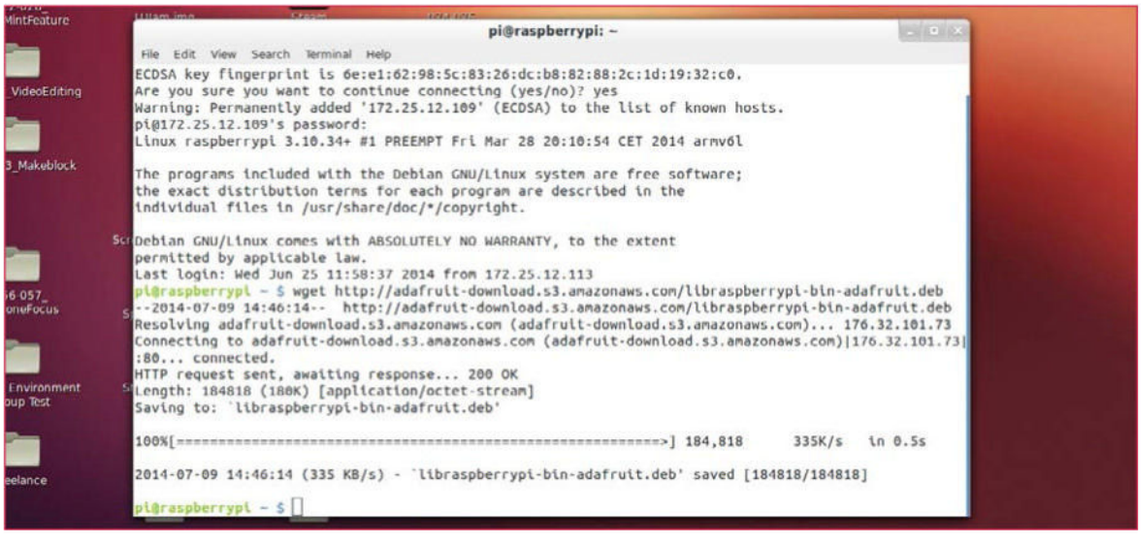
We've spoken a lot about about how portable the Raspberry Pi is, but one of the minor issues associated with this portability is the lack of a display. Carrying around a monitor is hardly practical and connecting via a phone with SSH takes some interesting trickery to get right. The PiTFT screen removes all these issues by requiring no extra power and being the size of the Raspberry Pi itself.

While Adafruit does supply a preconfigured Raspbian image for the screen, you'll need to add some extras to get it working on your current install, which is exactly what we're going to cover in this tutorial.

01 Adafruit kernel files

The first thing we need to do is download and install the necessary kernel files. Open up a terminal or SSH in and do the following:

```
$ wget http://adafruit-download.s3.amazonaws.com/libraspberrypi-bin-adafruit.deb
$ wget http://adafruit-download.s3.amazonaws.com/libraspberrypi-dev-adafruit.deb
$ wget http://adafruit-download.s3.amazonaws.com/libraspberrypi-doc-adafruit.deb
$ wget http://adafruit-download.s3.amazonaws.com/libraspberrypi0-adafruit.deb
$ wget http://adafruit-download.s3.amazonaws.com/raspberrypi-bootloader-adafruit-112613.deb

$ sudo dpkg -i -B *.deb
```



Left Get the neccessary files from the Adafruit website and download them to your Pi

02 Attach the screen

If you're using Raspbian from an image after September 2013, turn off the accelerated framebuffer using:

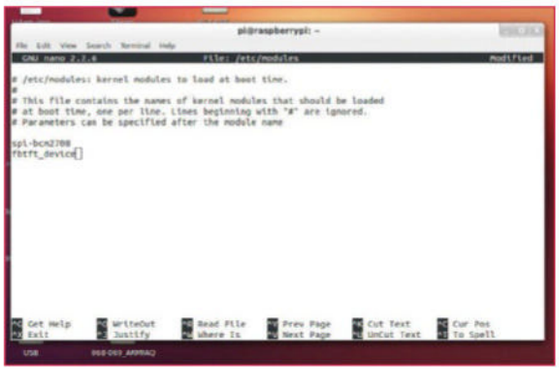
```
$ sudo mv /usr/share/X11/xorg.conf.d/99-fbturbo.conf ~
```

After that's done, shut down the Raspberry Pi completely and plug the screen into the GPIO pins if you haven't already done so.

03 Install the screen driver

We can do a test to make sure that the screen works at this point. This will turn on the screen but it won't work after reboot:

```
$sudo modprobe spi-bcm2708
$sudo modprobe fbtft_device name=adafruitts rotate=90
$export FRAMEBUFFER=/dev/fb1
$startx
```



04 Add the modules

There are two modules we need to get to auto-load at boot time, including the actual PiTFT driver. Open up the modules file with the first command and add the second two lines to the list:

```
$ sudo nano /etc/modules
```

```
spi-bcm2708
fbtft_device
```

05 Edit configuration files

We need to create/modify the necessary configuration file so that the screen can turn on properly. The first line opens the file, while the second line needs to be added to this file:

```
$ sudo nano /etc/modprobe.d/adafruit.conf
```

```
options fbtft_device name=adafruitts rotate=90
frequency=32000000
```

06 The options

You may have noticed the specific wording on these options: **rotate** allows you to have it at 0, 90, 180 or 270 degrees. A **frequency** of 32MHz gives you about 20fps on screen; but if the screen is playing up, take it down to 16MHz. Now reboot the Pi.

07 Install touch screen

Once back in, we need to create a new config file and populate it as shown below:

```
$ sudo mkdir /etc/X11/xorg.conf.d
$ sudo nano /etc/X11/xorg.conf.d/99-calibration.conf
```

```
Section "InputClass"
        Identifier      "calibration"
        MatchProduct    "stmpe-ts"
        Option  "Calibration"   "3800 200 200 3800"
        Option  "SwapAxes"      "1"
EndSection
```

08 Testing touch

Once that's all done you can restart X with:

```
$ FRAMEBUFFER=/dev/fb1 startx
```

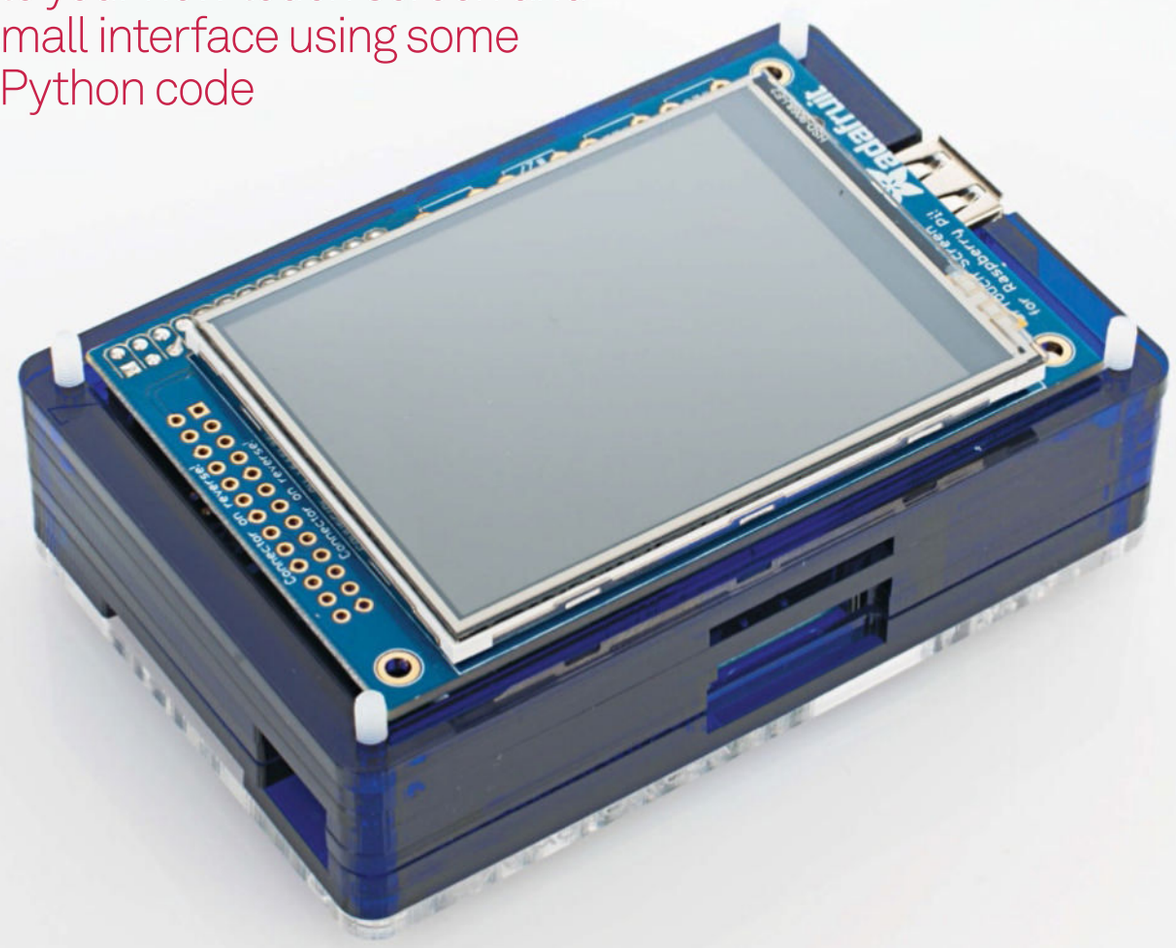
You can make it so you just need to type `startx` by adding the following to **~/.profile**:

```
export FRAMEBUFFER=/dev/fb1
```

You can also go into **raspi-config** to have the desktop load by default. That's it – you're now ready to start calibrating the display for your portable video player.

Calibrate a touch screen interface

Calibrate your new touch screen and add a small interface using some simple Python code



What you'll need

- SD card with up-to-date version of Raspbian
- PiTFT, fully assembled
  bit.ly/1jHEJT4

We've got a screen with basic touch functionality but where do we go from there? Our first step is to actually make the touch screen usable; it's resistant-style touch, so you can use your finger or a stylus with it, and this will affect the calibration of the screen once we get to it. Don't worry – if you calibrate with one method, you can always go back and recalibrate with another.

Once you've completed the tutorial on the previous two pages, be sure to give this one a try. Here we're going to properly set up the touch screen so you can continue to use the Raspberry Pi on the go without any other devices or within range of a decent power socket.

01 New rules

To make things easier for ourselves we're going to create a little rule so that we don't lose track of what the touch screen is called in the command line. SSH in, run the next command and copy the following text into it:

```
$ sudo nano /etc/udev/rules.d/95-stmpe.rules
SUBSYSTEM=="input", ATTRS{name}=="stmpe-ts", ENV{DEVNAME}=="*event*", SYMLINK+="input/touchscreen"
```

02 Reinstall the touch screen

We'll need to undo what we did at the end of the last tutorial to make sure we can get the touch part working properly, by removing and then reinstalling the support for it:

```
sudo rmmod stmpe_ts; sudo modprobe stmpe_ts
```

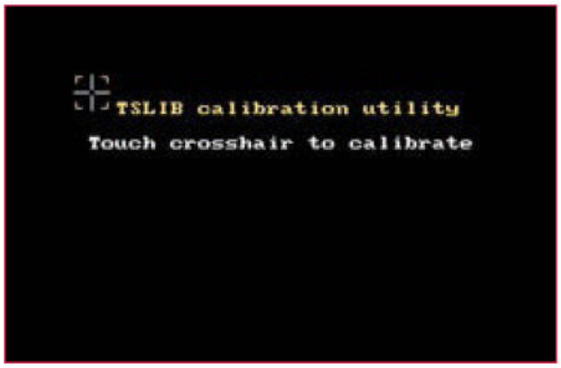
03 Main event

Find out what event the touch screen is known by with the following:

```
$ ls -l /dev/input/touchscreen
```

We can install tools now to calibrate and debug the touch screen. Install and test them with:

```
$ sudo apt-get install evtest tslib libts-bin
$ sudo evtest /dev/input/touchscreen
```



04 Touch calibration

Now we can finally begin the calibration process. Enter the following so that the Pi can learn roughly where the positions are on the screen:

```
$ sudo TSLIB_FBDEVICE=/dev/fb1 TSLIB_TSDEVICE=/dev/
input/touchscreen ts_calibrate
```

05 Draw calibration

Once you've done the previous calibration, you can try out a drawing test to see how the screen reacts. Do this with the following:

```
$ sudo TSLIB_FBDEVICE=/dev/fb1 TSLIB_TSDEVICE=/
dev/input/touchscreen ts_test
```

If it's not working quite to your liking, you can try the previous step again.

> Once you've done the calibration, you can try out a drawing test to see how the screen reacts

06 Install X calibrator

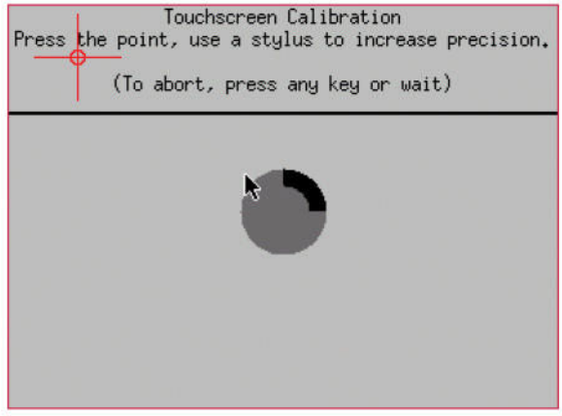
Now we need to calibrate the touch screen in X, which first means installing the correct tools. Use the following two commands to download and install the tool:

```
$ wget http://adafruit-download.s3.amazonaws.com/
xinput-calibrator_0.7.5-1_armhf.deb
```

```
$ sudo dpkg -i -B xinput-calibrator_0.7.5-1_armhf.deb
```

Follow this up quickly by deleting irrelevant calibration data with the following:

```
$ sudo rm /etc/X11/xorg.conf.d/99-calibration.conf
```



07 X-calibrate

From your SSH shell, run `startx` for the screen to turn on. From here you can either try to get `xinput_calibrator` typed into the terminal or type the following from the SSH session if it's easier:

```
FRAMEBUFFER=/dev/fb1 startx & DISPLAY=:0.0 xinput_
calibrator
```

08 Save calibration

Having completed calibration, you'll get an output starting with **Section "InputClass"**. Open up the following file and copy the output from **Section** to **EndSection** into there:

```
$ sudo nano /etc/X11/xorg.conf.d/99-calibration.conf
```

09 Play around

Your new touch screen is now properly set up! We'll go over more ways to make it easier to use in the following tutorial, but it's basically portable now and ready to have other projects, such as the PiPhone or PiCam, loaded onto it.

Portable Pi video player

Need a better way to watch video on the go? Let your newly powered-up touch-screen Pi play your favourite films and shows

What you'll need

- SD card with up-to-date version of Raspbian
- PiTFT, fully assembled
  bit.ly/1jHEJT4

We've got a Raspberry Pi that we can make portable now – but how can you use it? The easiest thing to do with it is use it as a portable video player. It has a far superior battery to your phone and has the added bonus of being easily plugged into a TV once you reach your destination.

Before we can use it to play the videos, though, we need to make it a bit more friendly to transport and get it to play videos in a particular way. So we've recommended some excellent accessories and extras you can take advantage of to achieve this.

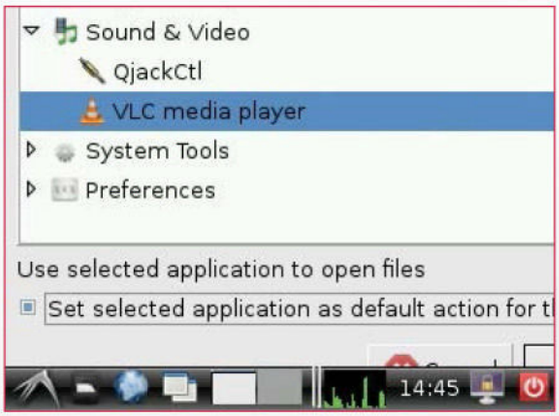
01 Install VLC

Go to your SSH terminal and install VLC media player. It's a lightweight, highly customisable media player that is able to play just about anything you throw at it. Do this with:

```
$ sudo apt-get install vlc
```

02 Default settings

Here's where it gets a bit tricky, as you'll need to perform this step via the screen. Hook the Pi up to a display, mouse and keyboard or just use the mouse and keyboard on the small screen. Go to an AVI or MP4 file and right-click on it, go to **Properties>Open with...** and choose **Customise** for the next step.



03 Set the default

Go to **Sound & Video** to select VLC from the menu. Click the checkbox to set it as the default app and then press **Enter** to save the changes. Now when you double-click or tap on the video, it will automatically play in VLC.

04 VLC options

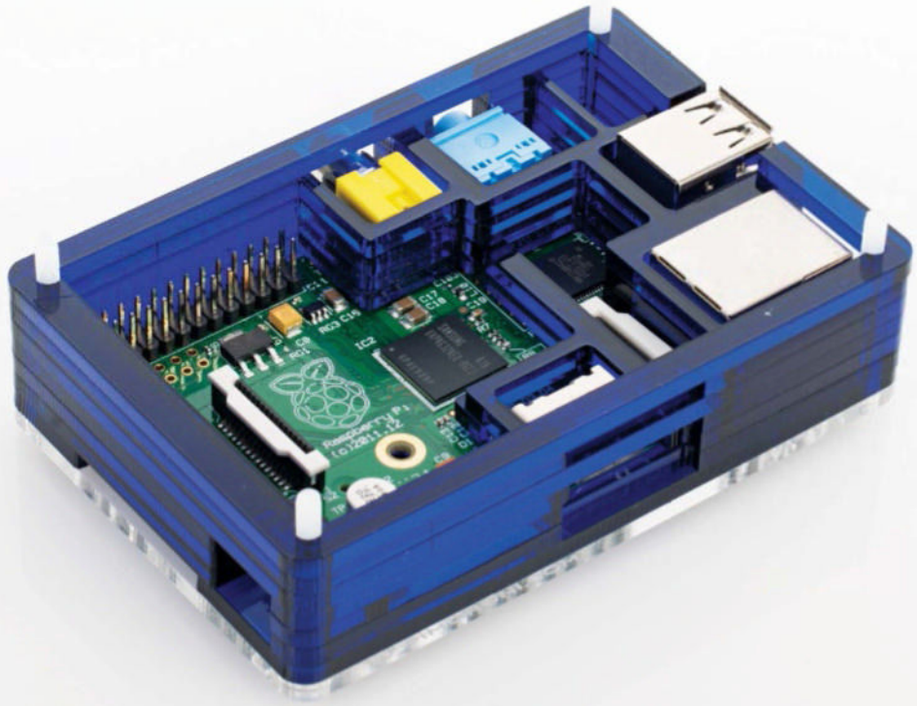
Open up VLC from the menu and right-click anywhere in the player space to open the **Context** menu. From here, go to **Tools** and then **Preferences**. Scroll down to click on 'Allow only one instance' and then go to the **Video** tab and click on the **Fullscreen** checkbox. Press **Enter** to save.

05 Play videos

You're done! It will play videos at the size of your Raspberry Pi screen and only one player will exist at a time. You may have better luck if you convert videos to 320x240, but it should play much larger videos just fine.

06 USB storage

A lot of Raspberry Pi SD cards have limited space, so it makes sense to keep your videos separate. Make sure to use storage that does not require any extra power, like a USB stick or portable hard drive. Access the storage from the **File Manager**, as no other mounting is required.



07 Get some protection

The PiTFT PiBow case from Pimoroni is one of the few cases – if not the only case – that houses the Raspberry Pi with the PiTFT screen. It's assembled in layers and only works with the revision 2 Raspberry Pi (the newer one with 512MB of RAM); this one won't have the pins between the yellow video port and headphone port.

08 Independently powered

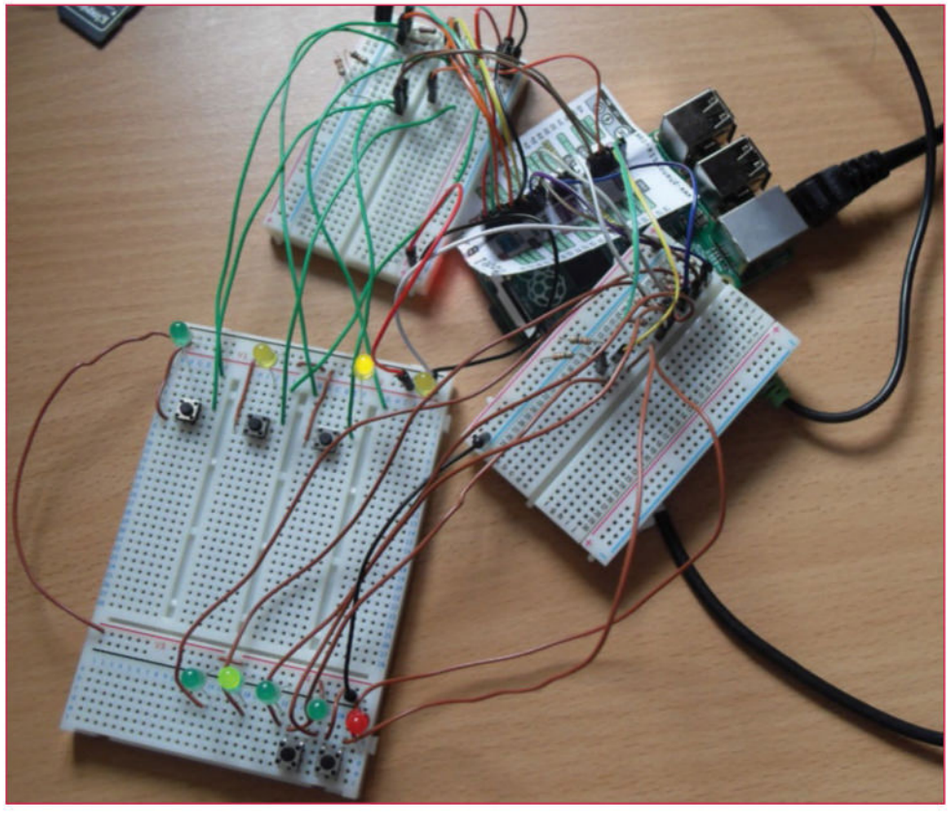
To have it working on the go, you'll need to have it set up so that you can remove it from a tethered power source. Portable, USB batteries are quite common these days, but there are certain things you need to look out for, such as high capacity and higher amp output.

09 Next time...

Now we have our portable Raspberry Pi video player! Use it as you wish and learn the ins and outs of the touch screen in the process. Next month we'll demonstrate how you can change the setup from watching video to capturing video with our RasPi Camera.

Make a Raspberry Pi sampler

Build your own looping drum machine with only 200 lines of code!



Left Extra breadboards are used here to keep the main breadboard as free from wires as possible

What you'll need

- Latest Raspbian image raspberrypi.org/downloads
- At least one breadboard
- Push buttons
- LEDs
- Female-to-male GPIO jumper cables
- Male-to-male GPIO jumper cables

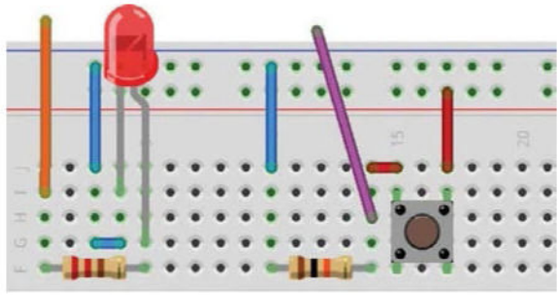
In this tutorial we combine electronics, music and programming knowledge to create a simple sampler with looping capabilities. The implementation used in this article has three drum sounds as the samples, but it is trivial to add more until you run out of GPIO pins.

Before we start, let's cover some basic musical terms. Music is split into bars. There are a certain number of beats in a bar. This sampler uses the 4/4 time signature, which means there are 4 beats in each bar. Tempo is the speed at which music is played, and it is measured in beats per minute (bpm). A metronome is an audible tone that is heard at the start of every beat.

Quantization is the process of aligning notes to beats, or exact fractions of a beat, and a quantization value is usually given in the form 1/8. This means that there are eight possible places in a bar where a note can be played. When the sampler is recording and a sample button is pressed, we store the sample at the current position in the bar with the accuracy of the quantize value. There's a lot to cover, so let's get started.

01 Connect LEDs

The circuit diagram is an LED that can be turned on and off with a GPIO output. The orange wire is the connection from the GPIO output. This then goes through a 220Ω resistor to limit the current draw to a safe level. This current flows through the positive leg of the LED and then back to ground. We need nine LEDs for this project.



02 Wire up buttons

The second circuit we need is a push button. The purple wire goes to a GPIO input. There is a 10KΩ pull down resistor to ground, which represents a logical 0. When the push button is pressed, the 3.3V supply representing a logical 1 is connected to the purple wire. The electricity takes this path because it has less resistance than the path to ground. We need two buttons for record and undo, and then as many buttons as you like for samples (three drum samples are provided).

03 Download samples

Create a few folder for the project called pisampler. Then download and unzip the sounds:

```
mkdir pisampler
cd pisampler
wget http://liamfraser.co.uk/lud/pisampler/sounds.zip
unzip sounds.zip
```

There will now be a folder called sounds with some samples in. The file format for samples is .wav audio, Microsoft PCM, 16 bit, stereo 44100 Hz. Mono will work too. Any samples can be converted to this format with Audacity by exporting them as a .wav file.

04 Import required libraries

Create a file called pisampler.py in your favourite editor. The first thing we need to do is import the required libraries and set some configuration values. A key option is debounce: the time to wait before a button can be pressed again to stop accidental presses from contact bounce.

05 Create a sample class

We're going to use a class to represent each sample. It's going to need a few things: the pin that the sample button is connected to, the name of the sound file, and a reference to the instance of the sampler class. We haven't created the sampler class yet, but the sample will need to be able to tell if the sampler is recording or not, and have access to the data structure that recordings are stored in to add itself to it if necessary.

The other thing that we need to do is set the GPIO pin to an input, and add an event listener for when the button is pressed. We set callback (the function to be executed when the button is pressed) to a function called self.play_btn, which

Full code listing (Cont. on next page)

Step 04

```
import RPi.GPIO as GPIO
import time
import pygame
import os

beat_leds = [2, 3, 4, 17]
bar_leds = [27, 22, 10, 9]
record_led = 11
record = 19
undo = 26
debounce = 200 # ms
```

Step 05

```
class Sample(object):
    def __init__(self, pin, sound, sampler):
        self.sampler = sampler
        self.name = sound
        self.sound = pygame.mixer.Sound(os.path.join('sounds', sound))
        self.pin = pin
        GPIO.setup(pin, GPIO.IN)
        GPIO.add_event_detect(self.pin, GPIO.RISING, callback=self.play_btn,
                              bouncetime=debounce)

    def play_btn(self, channel):
        self.sound.play()
        s = self.sampler
        if s.recording:
            s.recording_data[s.bar_n][s.quantize_n].append({'loop' : s.loop_count,
                                                            'sample' : self})
```

Step 06

```
class PiSampler(object):
    def __init__(self, tempo=80, quantize=64):
        pygame.mixer.pre_init(44100, -16, 1, 512)
        pygame.init()

        self.quantize = quantize
        self.tempo = tempo
        self.recording = False
        self.record_next = False

        self.metronome = False
        self.met_low = pygame.mixer.Sound(os.path.join('sounds', 'met_low.wav'))
        self.met_high = pygame.mixer.Sound(os.path.join('sounds', 'met_high.wav'))
        self.met_low.set_volume(0.4)
        self.met_high.set_volume(0.4)

        self.samples = []

        self.recording_data = []
        for i in range(0, 4):
            bar_arr = []
            for i in range(0, quantize):
                bar_arr.append([])

            self.recording_data.append(bar_arr)

        GPIO.setmode(GPIO.BCM)
        for pin in beat_leds + bar_leds + [record_led]:
            GPIO.setup(pin, GPIO.OUT)

        GPIO.setup(record, GPIO.IN)
        GPIO.add_event_detect(record, GPIO.RISING,
                              callback=self.record_next_loop,
                              bouncetime=debounce)
```

Full code listing (Cont.)

Step 06

```
        GPIO.setup(undo, GPIO.IN)
        GPIO.add_event_detect(undo, GPIO.RISING,
                              callback=self.undo_previous_loop,
                              bouncetime=debounce)
```

Step 07

```
    @property
    def tempo(self):
        return self._tempo

    @tempo.setter
    def tempo(self, tempo):
        self._tempo = tempo
        self.seconds_per_beat = 60.0 / tempo

        self.quantize_per_beat = self.quantize / 4
        self.quantize_seconds = self.seconds_per_beat / self.quantize_
per_beat
```

Step 08

```
    def add(self, sample):
        self.samples.append(sample)

    @property
    def recording(self):
        return self._recording

    @recording.setter
    def recording(self, value):
        self._recording = value
        GPIO.output(record_led, value)

    def record_next_loop(self, channel):
        self.record_next = True
```

Step 13

```
    def play_recording(self):
        for sample_dict in self.recording_data[self.bar_n][self.
quantize_n]:
            if sample_dict['loop'] != self.loop_count:
                sample_dict['sample'].sound.play()

    def undo_previous_loop(self, channel):
        if len(self.last_recorded_loop) == 0:
            print "No previous loop to undo"
            return

        print "Undoing previous loop"

        loop = self.last_recorded_loop.pop()

        for bar in self.recording_data:
            for quantize in bar:
                removes = []
                for sample in quantize:
                    if sample['loop'] == loop:
                        removes.append(sample)

                for sample in removes:
                    quantize.remove(sample)
```

Step 11

```
    def do_leds(self, leds, n):
        count = 0
        for led in leds:
            if count == n:
                GPIO.output(led, True)
            else:
```

will play a sound and add it to the recording data if we are recording. It will become clear how this works once we've written the sampler class. Note that the GPIO event handler passes the pin that the event handler was triggered on, hence the channel variable that is present but never used.

06 The sampler init method

Here's the start of the sampler class. The last value in the Pygame mixer init is the buffer size. You might need to increase this to 1024 or higher if you have audio dropouts. We create some variables to store recording state. Metronome sounds are then added and their volume lowered. We also create a list to hold our samples in.

We create nested arrays to represent recorded sample presses. There is an array for each bar. Each bar has an array for each possible quantize value. The default value of 64 gives us 64 possible places to store a sample hit per bar.

Finally, we set up the LED pins, and the pins for the record and undo buttons.

07 The tempo property

The tempo variable is actually a property with a custom setter. This means when a value is assigned, it does a custom action. In our case, we need to calculate how often we need to check for recorded notes to play in the main loop that we'll write later.

08 Helper functions

There are a few helper functions in the class. One of them simply adds a sample to the list of samples. Another sets a variable to trigger recording at the start of the next loop. There is also a function which turns the red LED on when the recording variable is set to true. Now we'll jump forward and take care of the main loop towards the end of the full code listing.

09 Start the main loop

The main loop doesn't actually have to do any work at all to play sounds, as that's done by the GPIO event handlers. The main loop is used to play the metronome, update the state about which bar/beat/quantize we are currently on, update the LEDs and deal with recording if necessary.

Before the loop, we create variables to track the state. The last recorded loop is a list that we will use as a stack. A stack is a last in/first out data structure, allowing us to undo recordings multiple times by removing each sample that was recorded when the loop count was the value on the top of the stack.

If we're at the start of a new beat then we use a function called do_leds that we haven't created yet. As the LEDs work in the same way (a block of four LEDs where only one is turned on), we can use the same function twice and just pass a different set of pins, and the index of the LED we want to turn on. We then call the do_metronome function which will play the appropriate metronome sound.

We then do some recording logic which starts recording if we should be recording, and stops recording if we have just been recording, adding the

loop number to the last_recorded_loop stack. We increment the loop count after doing this.

10 Main loop continued

This code is at the indentation level after the "while True:" statement. After dealing with the recording logic, we need to play any notes that have been previously recorded. We'll work out how to do that later on. After that, we can sleep until the next quantize change is due. Once this happens, we have to do logic that deals with the quantize and any related variables such as the beat or bar if necessary, either incrementing them or resetting them if necessary.

11 Lighting LEDs

The LED code is simple. It simply goes through each pin in the list you provide it with and lights up the appropriate LED, ensuring that all of the others are turned off.

12 The metronome

The metronome simply plays a high tone on the first beat or a lower tone on the remaining beats if the metronome variable is set to true.

13 The recording code

Looking back at the sample class we created at the start, you can see that if recording is enabled, and a note is pressed, then we add a dictionary to the list of samples for the current bar at the current quantize point. The dictionary contains a reference to the sample so that it can be played, and also the loop that it was added on so that it can be removed if necessary. The code for playing and undoing recordings can be seen below.

Note that we directly play the sound rather than using the btn_play function so that we don't trigger the recording logic when playing recorded sounds.

The pop function in undo_previous_loop removes the last thing that was added to the stack, which will be the loop count. We then go through every possible recording data point and remove anything recorded on the loop we want to remove.

14 Finishing it off

To finish it off, we need to add a main function where we load some samples in and then start the main loop. Remember that you need to run the code with sudo python2 pisampler.py because we need sudo to access the GPIO. Happy jamming!

15 Possible improvements

There are a number of improvements that could be made to the sampler. Here are a few to get you started:

- A button to turn the metronome on and off
- The ability to time stretch samples (such as chords) to fit with the tempo
- The ability to pitch shift samples on the fly
- Using a shift register to use less pins when lighting the LEDs, allowing more inputs
- The ability to save recorded beats so that they can be loaded and played back

Full code listing (Cont.)

Step 11

```
                GPIO.output(led, False)

            count += 1
```

Step 12

```
    def do_metronome(self):
        if not self.metronome:
            return

        if self.beat_n == 0:
            self.met_high.play()
        else:
            self.met_low.play()
```

Step 09

```
    def run(self):
        self.loop_count = 0
        self.last_recorded_loop = []
        self.bar_n = 0
        self.beat_n = 0
        self.quantize_beat_n = 0
        self.quantize_n = 0

        while True:
            if self.quantize_beat_n == 0:
                self.do_leds(beat_leds, self.beat_n)
                self.do_leds(bar_leds, self.bar_n)
                self.do_metronome()

                if self.quantize_n == 0 and self.bar_n == 0:
                    if self.record_next:
                        self.recording = True
                        self.record_next = False
                    elif self.recording:
                        self.recording = False
                        self.last_recorded_loop.append(self.loop_count)

                    self.loop_count += 1
```

Step 10

```
            self.play_recording()
            time.sleep(self.quantize_seconds)

            if self.quantize_beat_n == self.quantize_per_beat - 1:
                self.quantize_beat_n = 0
                self.beat_n += 1
            else:
                self.quantize_beat_n += 1

            if self.quantize_n == self.quantize - 1:
                self.quantize_n = 0
            else:
                self.quantize_n += 1

            if self.beat_n == 4:
                self.beat_n = 0
                self.bar_n += 1
                if self.bar_n == 4:
                    self.bar_n = 0
```

Step 14

```
if __name__ == "__main__":
    sampler = PiSampler(tempo=140)
    sampler.add(Sample(05, 'kick01.wav', sampler))
    sampler.add(Sample(06, 'snare01.wav', sampler))
    sampler.add(Sample(13, 'clhat01.wav', sampler))
    sampler.metronome = True
    sampler.run()
```

Build a radio transmitter

Take advantage of the interference-blocking feature and make your mark on the airwaves

Back in the 1960s, offshore boats were used to broadcast what was then known as 'pirate' radio: unlicensed broadcasts that provided an alternative to the BBC's light program (as the most populist radio station was then known). Pirate radio was a revolution that inspired Radio 1 and commercial broadcasting, but these days you don't need a boat to pursue your radio DJ dream – just a Raspberry Pi.

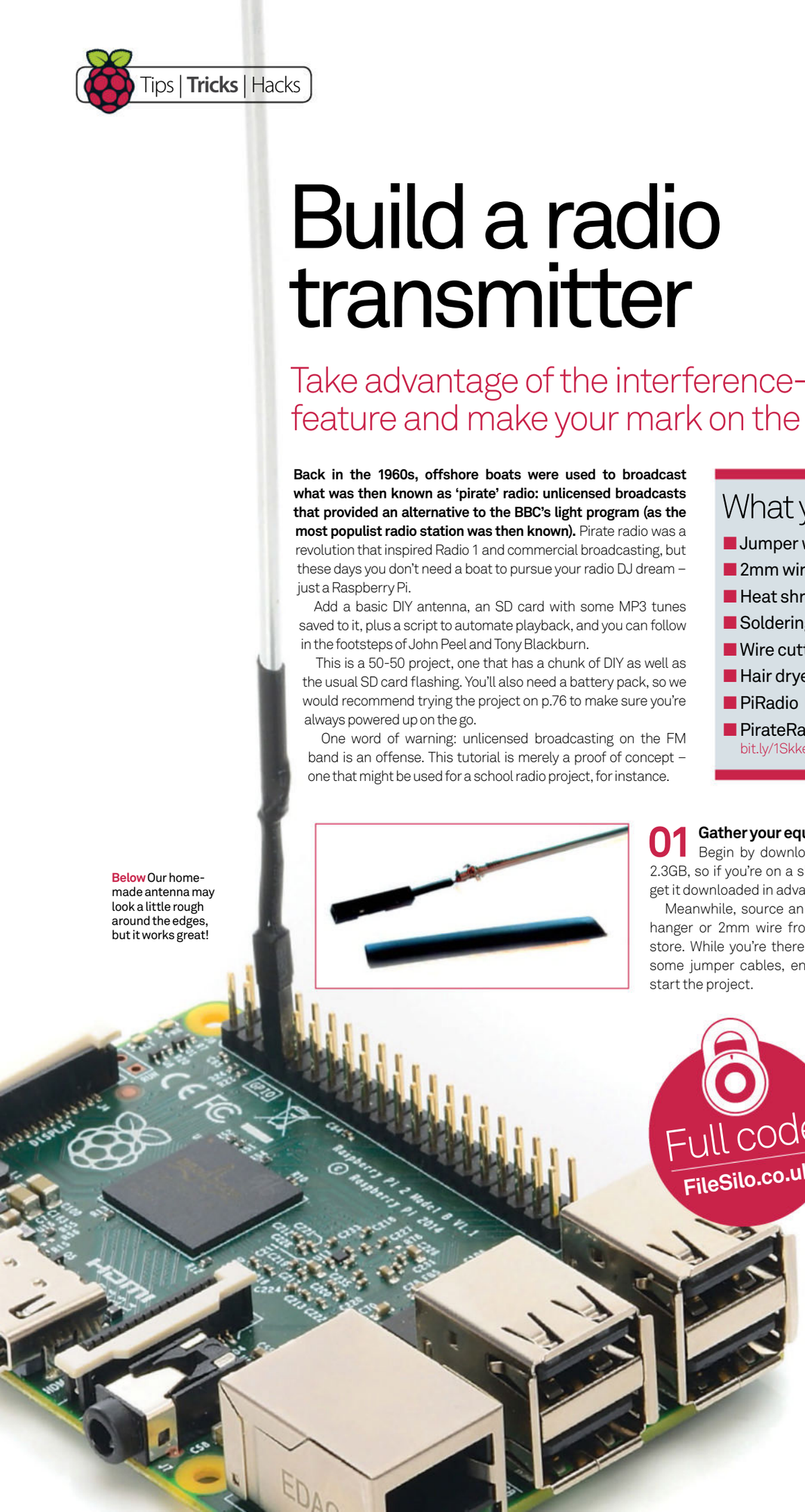
Add a basic DIY antenna, an SD card with some MP3 tunes saved to it, plus a script to automate playback, and you can follow in the footsteps of John Peel and Tony Blackburn.

This is a 50-50 project, one that has a chunk of DIY as well as the usual SD card flashing. You'll also need a battery pack, so we would recommend trying the project on p.76 to make sure you're always powered up on the go.

One word of warning: unlicensed broadcasting on the FM band is an offense. This tutorial is merely a proof of concept – one that might be used for a school radio project, for instance.

What you'll need

- Jumper wire
- 2mm wire
- Heat shrink tubing
- Soldering iron
- Wire cutters/strippers
- Hair dryer/heat gun
- PiRadio bit.ly/1MWkxwp
- PirateRadio.py script bit.ly/1SkkeCh



Below Our home-made antenna may look a little rough around the edges, but it works great!

01 Gather your equipment

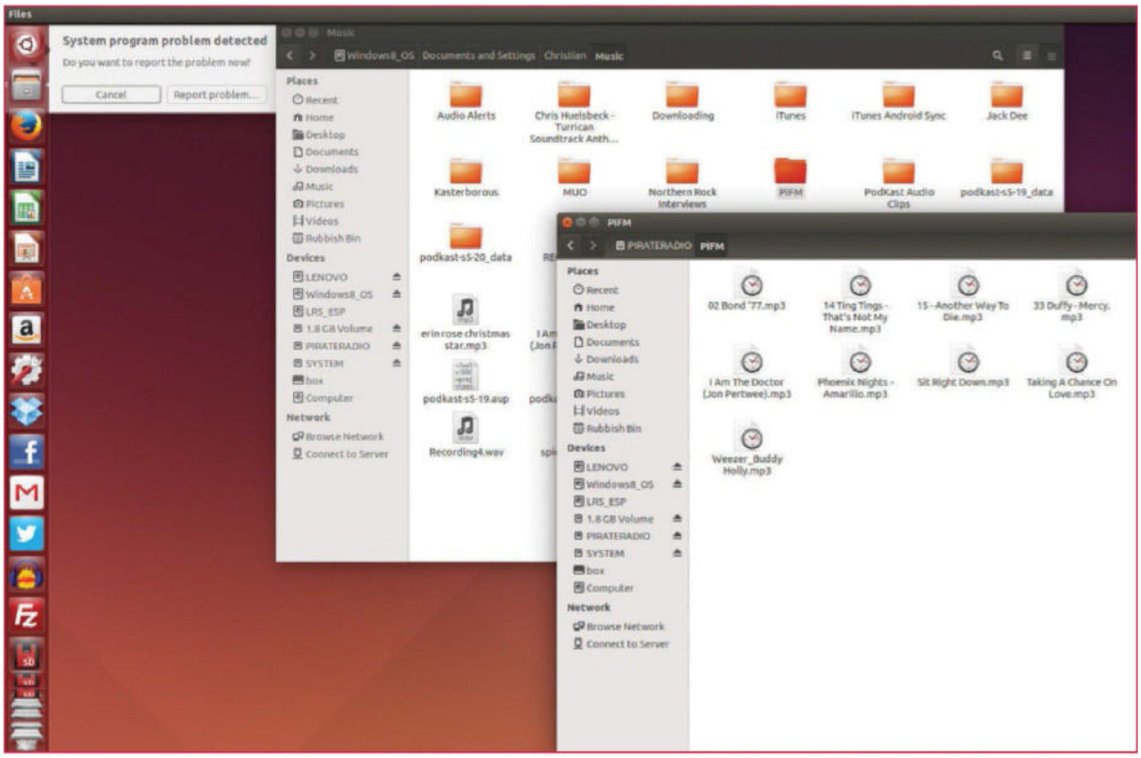
Begin by downloading the PiFM image. This is over 2.3GB, so if you're on a slower connection then you'll need to get it downloaded in advance.

Meanwhile, source an antenna. This might be a wire coat hanger or 2mm wire from your local electronic component store. While you're there, grab some heat shrink tubing and some jumper cables, ensuring that you're well prepared to start the project.

Full code FileSilo.co.uk

Build a case

Okay, so you've already got a suitable case for your Raspberry Pi, but why not go all-out and put together a new case for this project? One idea is to take inspiration from the broadcast motif and design an old-style antenna case, with the Pi and the genuine antenna cleverly hidden inside it. Alternatively, a Mason jar (or other suitably wide-necked jar) will also make a great home for the PiFM – just drill a hole in the lid for the antenna!

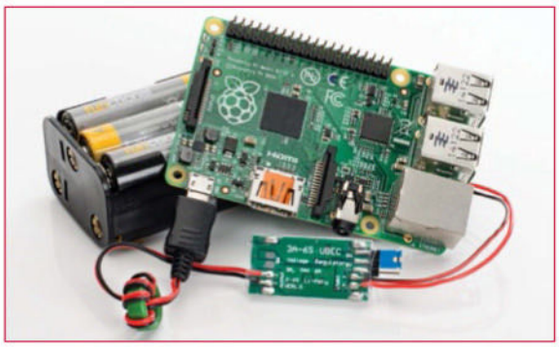


Left Prepare MP3 files in advance or make your own using Audacity, or a similar open source audio production tool

02 Prepare MP3 files in advance

There's no facility for live broadcast. Instead, you will need to arrange your MP3 files in advance. These will be played using a script and transmitted to the nearest radio.

Planning on some DJ-ing? All is not lost, as you can produce your own MP3 files using Audacity or similar open source audio production tools. To get the files to play in a particular order, number them, or the folders, sequentially.



03 Power your Raspberry Pi radio

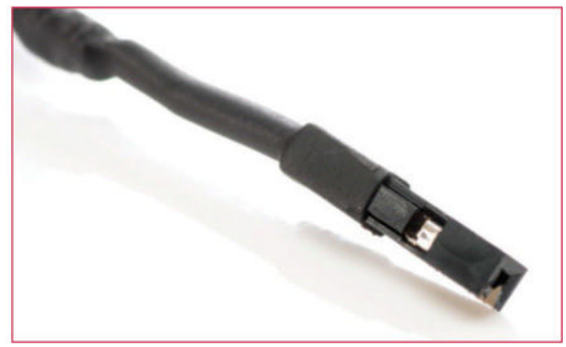
Planning to try this out in a remote area? You'll need a battery pack to power your Raspberry Pi, or else run it from your car's cigarette lighter. For flexibility, you may also need a mobile device with SSH software to wirelessly connect to your Raspberry Pi pirate radio in headless mode.

Of course, the project doesn't have to be portable and you can power your Raspberry Pi as usual.

04 Prepare your broadcast antenna

To broadcast from your Raspberry Pi, you'll need a suitable antenna. Electronic retailers stock copper wire that's around 2mm in diameter, but this is usually only available in bulk. As you only need a single 200-250mm length, the best option is to use a handheld rotary blade (or hacksaw) to cut the length from a wire coat hanger.

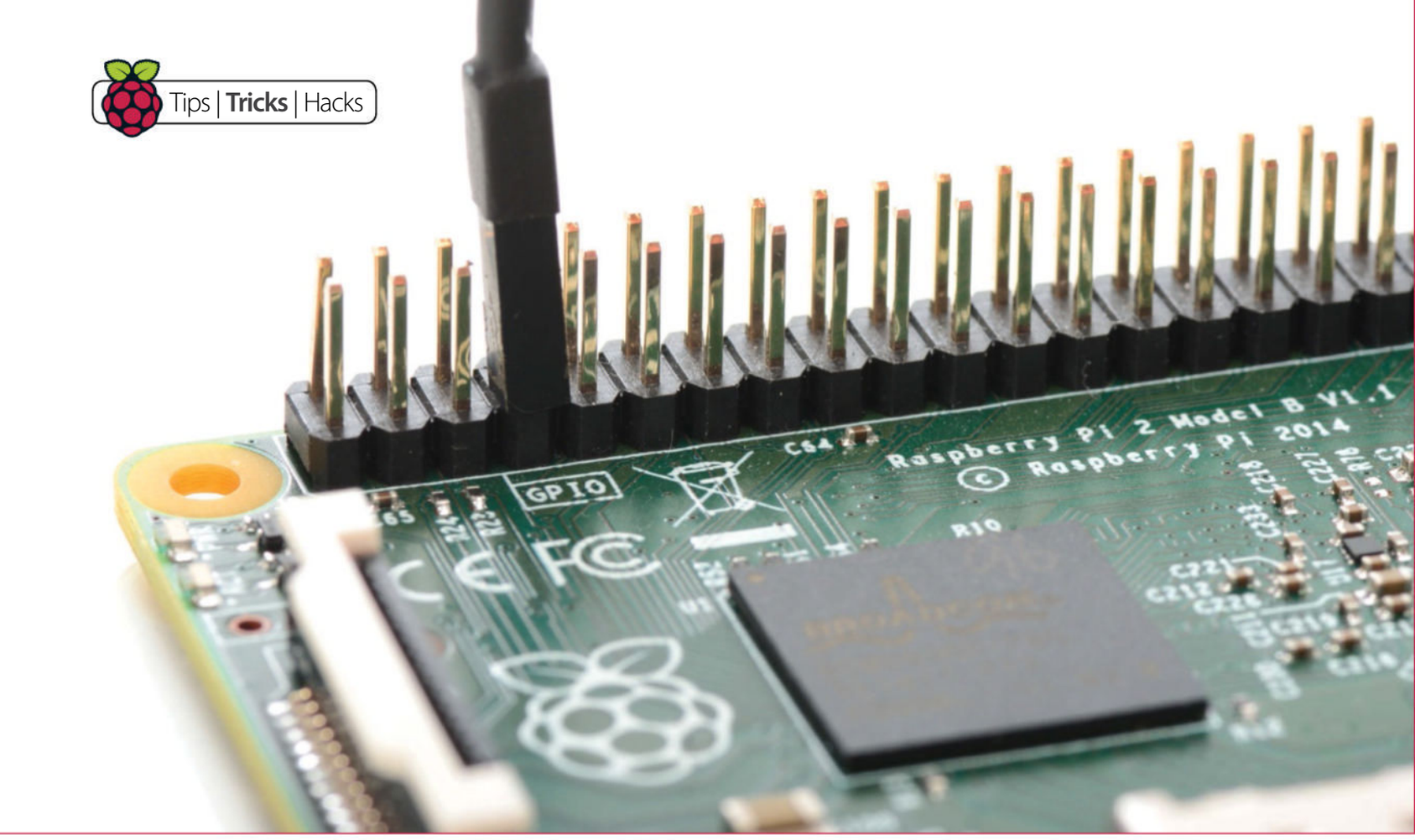
> Unlicensed broadcasting on the FM band is an offence. This tutorial is merely a proof of concept – one that might be used for a school radio project, for instance



05 Connect the jumper

Strip the wire from a female jumper, leaving enough to solder the 2mm wire to.

Once cooled, add a 50mm length of heat shrink tubing to the top of the jumper and the lower portion of the antenna to insulate the connection. This will tighten as you apply heat from a hairdryer or heat gun. Be careful when heating, as the antenna will warm up and can burn your fingers.



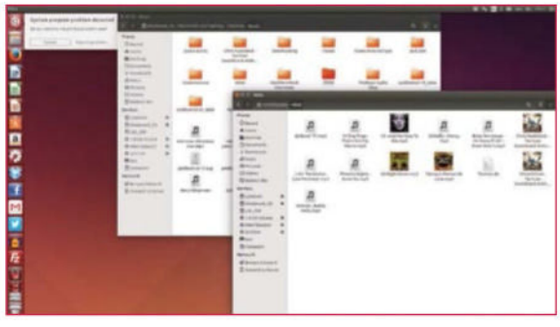
Above The original GPIO 4 hack was discovered by two students at Imperial College London

06 Connect the antenna

The antenna is connected to pin 4 on your Raspberry Pi's GPIO. Before you do this, check that your Raspberry Pi case is suitable for high profile GPIO connections. If not, consider connecting it to a short length of wire and mounting it on top of your case with an adhesive like Sugru, or perhaps just tape it to the side of your case. As long as the antenna has a connection to pin 4, you're good to go.

07 Prepare your SD card

As with all Raspberry Pi projects, it's good to start with a freshly flashed SD card. To get started quickly, use the disk image linked in the kit list, extract the ISO file and flash. However, if you would rather spend some time tweaking the script, flash Raspbian Wheezy and install PirateRadio.py from GitHub.



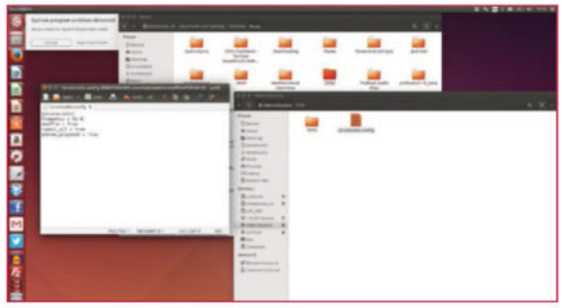
08 Copy your MP3 files to SD

You cannot simply dump your MP3 files on the SD card. With your flashed SD card still inserted into your PC card reader, browse to the /Pirate Radio partition of the card and paste your copied files.

Beyond simply pasting in numbered MP3s, you can also drop in named folders from your music collection containing entire albums or artist catalogues.

Multiple audio formats

Throughout the tutorial, we've talked about audio files as MP3s, but one of the many beauties of the PiFM project is that it supports other formats. These are re-encoded as required in time for broadcast, based on a playlist created when the Python code scans the SD card for audio files. In addition to MP3s, you can cue up and broadcast files in FLAC, WAV, M4A, AAC and WMA.



09 Configure the Pirate Radio

With the SD card still inserted into your PC, open the pirateradio.config file in a text editor. Look for the frequency setting and adjust this as necessary. You'll need to set this to a frequency that is currently unoccupied, so switch on your FM radio, find some free space and change the pirateradio.config file as necessary. Save and exit the file when you're done.

10 Random and continuous music

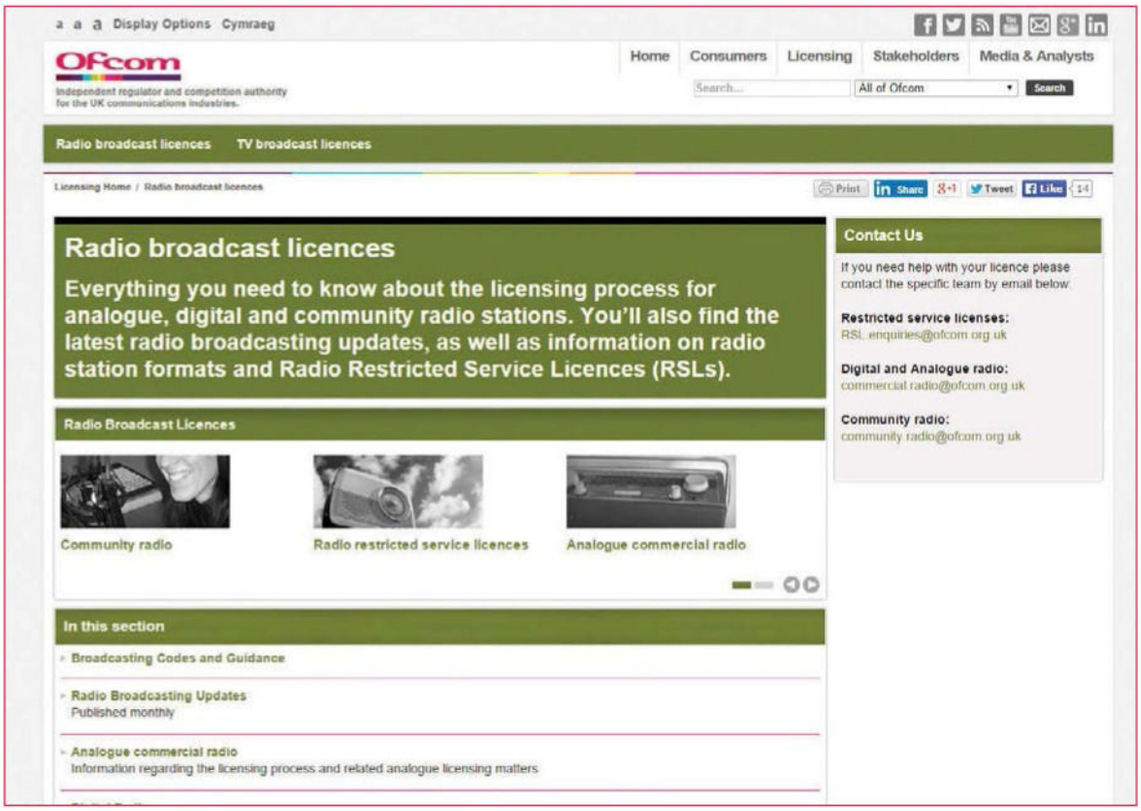
Should you plan to add a lot of music to your SD card for playback on your pirate radio project, you may want to use the **shuffle** and **repeat_all** settings in the pirateradio.config file. By default these are set to true, but to disable, you simply need to change true to false.

Save when you're done, and remember to unmount the SD card before removing it from your computer.

11 Stereo or mono?

The pirateradio.config file offers you the choice of setting a true or false value to the **stereo_playback** value. You should consider this carefully, as it will determine quality and range for your broadcast.

Set to true, the broadcast will be of superior audio quality. However, the range will be reduced as additional power is



How does the Pi broadcast?

Spread-spectrum clock signals on the GPIO pins are the secret power behind the Raspberry Pi's surprising hidden ability to broadcast on the FM band. By utilising this energy with an antenna on pin 4, you can turn a method employed to reduce electrical interference with other devices connected to and situated near your Raspberry Pi into a tool for radio communication.

Left Check out Ofcom's radio broadcasting licenses for more details on the law regarding broadcasting music

required. So setting **stereo_playback** to false will increase your broadcast's range. However, due to the scale of the transmitter, this is only a matter of 20 feet!

12 Appreciate the law

It's all too easy to get into trouble with this project, so before you start broadcasting make sure you're familiar with the law and licensing requirement for broadcasting on the FM band. This project is perfect for short range use, such as playing your MP3s on an old car radio, although you'll have to modify the length of the antenna for this. Schools may also benefit from a Raspberry Pi radio station.

13 Take to the airwaves!

Insert your SD card into the Raspberry Pi and plug the device in. Meanwhile, step away from the device and head into the next room with your FM radio and tune into the specified frequency. Once the Raspberry Pi has booted you should find that the MP3 files are being broadcast!

14 Troubleshooting bad broadcasts

Problems with your broadcast? Check the FM radio is capable of picking up other stations. If you're in the UK, look for Radio 2 on 88-91 FM, which can be received virtually anywhere.

You should also check the frequency setting in the pirateradio.config file. Remember that the band is accessible in the UK from 87.5-108 FM. As such, you cannot access frequencies beyond these points on an FM radio.

15 Check your antenna for problems

Reception issues may be traced back to the antenna. Double-check the soldering is secure and confirm that the wire is connected to GPIO 4. Using the wrong pin won't harm your Raspberry Pi, but equally it won't result in audio being broadcast to your FM radio!

> This project is perfect for short range use, such as playing your MP3s on an old car radio, although you'll have to modify the length of the antenna for this

Interference in the broadcast may be due to wireless routers and microwave ovens. Your Raspberry Pi's power source may also cause problems.

16 Elevate your broadcast

You can improve the range by positioning your Raspberry Pi and the PiFM antenna in an elevated position. You might, for instance, place it by an upstairs window.

Even better results can be achieved by broadcasting from up a tree or on a hillside – but keep in mind that an unlicensed project really needs to maintain a short range.

17 Curb your piracy

You've built a compact, potentially portable radio transmitter, but remember that it isn't the 1960s and you're not a revolutionary. Consider the approved uses for the project and stick to these, rather than using it to cause mischief and get a criminal record. You could make an FM repeater, for example, or create a wireless mic. If you really want to get on the radio, consider volunteering with your local community station.

Tether your Raspberry Pi to an Android device

Need the internet on your Pi on the go? Try out a physical tether to your Android device for instant online access

The portability of the Raspberry Pi is one of its most lauded features and you can get many different accessories to help aid this portability. Mini screens, mini wireless keyboard and mouse combos, portable batteries and more can get you out and about, but the Internet is a stumbling block that you can't easily fix with an accessory. What you do also usually have with you is an Internet-connected magic pocket box called a smartphone that, with a bit of know-how, you can connect the Pi to and steal some Internet from. Over the next two pages we will impart this know-how to get you using your Raspberry Pi on the Internet when you're on the go.

01 The easy way

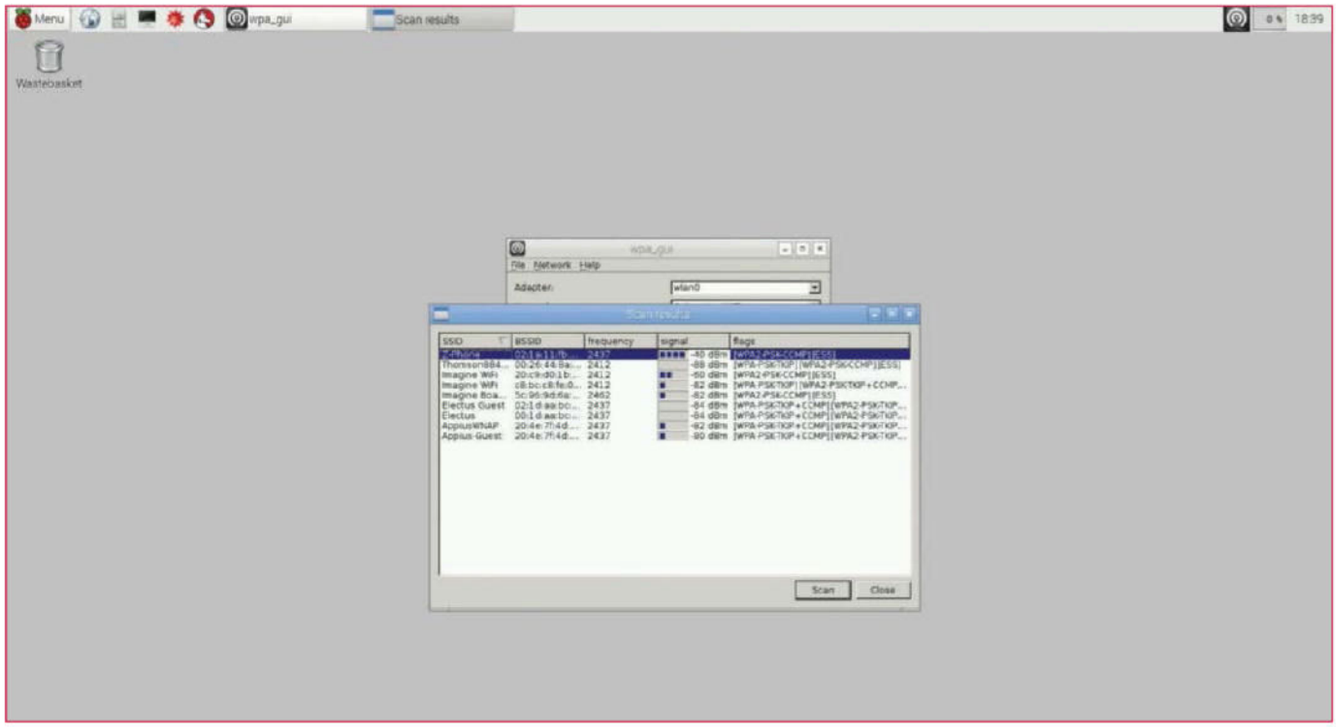
A lot of smartphones now have a Wi-Fi hotspot feature, which the Raspberry Pi can easily attach to. First of all, turn the hotspot on and then boot into the Pi. Connect a wireless dongle and open up the wpa_gui in Preferences>Wi-Fi Configuration.

02 Scan for device

Click Scan to open up the scan window and then select Scan again from inside there. It should pick up your device – connect it as you would to any Wi-Fi network and the Pi will remember it for when it needs it next.

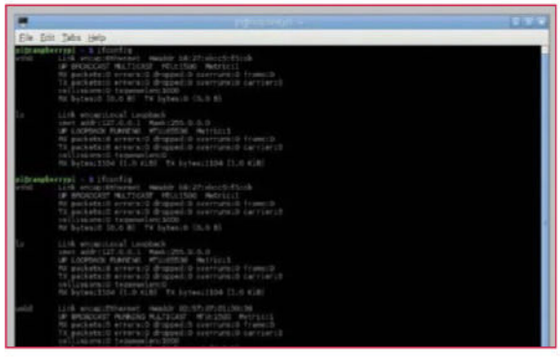
What you'll need

- Android device
- USB cable



03 Set up tether

First connect your phone to your Raspberry Pi via a USB cable – depending on the amount of power your Pi has, it might have trouble charging your phone but it will still let you tether. In the tethering menu you can now activate USB tethering.



04 Check connection

Your Android device will create an interface known as eth0 on the Raspberry Pi. You can check to make sure this is happening, and that it will let you tether, by opening up a terminal and typing the following:

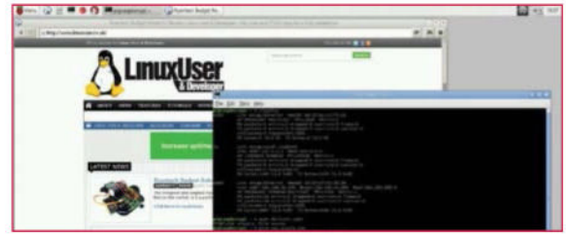
```
$ ifconfig
```

05 Quick connect

You can connect from the terminal right now to access the Internet. You should be able to do this by typing the following into the terminal:

```
$ sudo dhclient usb0
```

This will automatically grab any available IP address that your phone will give to it.



Above It's usually easy to figure out which device is your phone – set it right next to the Pi and it will be the one with the best signal!

06 Test connection

There's a few ways to test your connection. We'd usually stay in the terminal and ping **www.google.com**, which you can do, or you can click on the browser and see if it loads the page.

07 Save the settings

Once you reboot your Pi, it won't remember to automatically connect to the phone's tether. However, we can add an entry to its config so that it will try and do this in the future. From the terminal use:

```
$ sudo nano /etc/network/interfaces
```

08 Interface settings

Here you'll find all the current network settings – yours might look different from ours depending on if you have added any fixed wireless settings or passthroughs. Using the same syntax as the eth0 line, add:

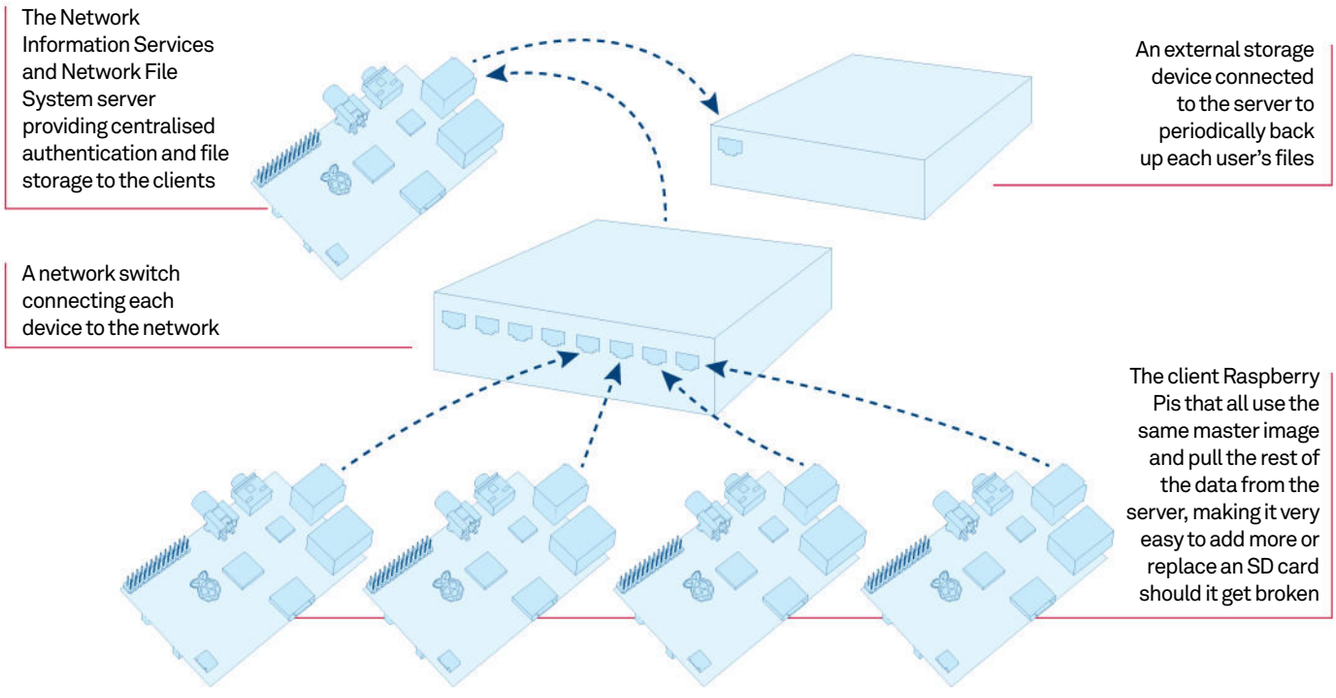
```
iface usb0 inet dhcp
```

09 Tether on the go

After a save and reboot, your Pi should now automatically connect to your phone, whether it's via Wi-Fi hotspot or a physical connection. It may draw a little more charge than usual while tethering, so be sure to keep an eye on your battery level.

Mobile data

Using your Pi on your mobile phone will eat up data much faster than browsing on your phone normally is. We suggest not doing a full software, distribution or firmware update if you don't want to spend a fortune on data. You can also set limits on the amount of data used on your phone to save yourself any problems, and a physical tether will allow you to connect via the phone's Wi-Fi if that's an option.



Build a network of Raspberry Pis

Learn how to set up a network of Raspberry Pis with centralised authentication and file storage

Resources

At least 2 Raspberry Pis
with appropriate peripherals
(Note that the server Raspberry Pi will only need a power and Ethernet cable connected once configured)

SD card

Computer

Network switch

Ethernet cable

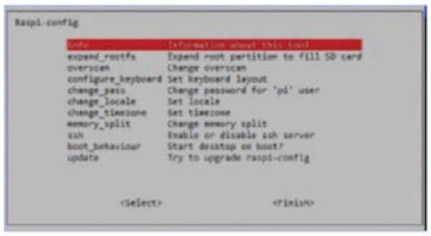
Storage device

In this tutorial, we'll learn to set up a Network Information Services server on a Raspberry Pi that centralises some of the configuration of Linux systems. This includes user accounts. This means that we can set up users on the Raspberry Pi server and have them available on each client Raspberry Pi. This arrangement would be useful in a classroom situation where there were a number of Raspberry Pis shared between classes. Each child would have a username and password, and they would have access to all of their files from any Raspberry Pi once they have logged in. One big advantage of this is that each user's files can be backed up from a single place. We'll also be giving some examples of software that could be used in a classroom on the Raspberry Pi.

We'll be using the latest Raspbian image as the operating system for both our Raspberry Pi server and Raspberry Pi clients, so we'll need to start by writing that to two SD cards. Note that we'll be making a master SD card for the clients which can then be written to the rest of the SD cards, so only write the image to two of them.

The instructions for flashing an image to an SD card can be found at **www.linuxuser.co.uk/tutorials/how-to-set-up-raspberry-pi/**. You will only need to go up to the step where you write the image to the SD card. Note that you will have to adapt the instructions slightly for using the latest Raspbian image rather than the Debian one. The image that we used was 2012-09-18-wheezy-raspbian.zip.

We are going to assume that you are plugging the Raspberry Pis into an existing network with DHCP, a protocol for handing out network settings to devices that connect to said network. This way, they can get access to the internet for installing packages and other useful things such as teaching resources.



01 Initial configuration of the server Raspberry Pi

Connect a keyboard, mouse, Ethernet cable, monitor and, lastly, power to your server Raspberry Pi. Raspbian will boot and a configuration menu will be displayed. You need to select the option to expand_rootfs to make sure that you're using the entire space of the SD card. You should definitely change the password for the pi user so that no one can log into your server with the standard credentials of Username: pi and Password: raspberry. Then change the memory split to 240MiB for ARM and 16MiB for the VideoCore. Finally, enable SSH, then select 'Finish'. Select 'Yes' to reboot now.

02 Fire up your Linux computer

Now that we have enabled SSH on the server Raspberry Pi, we can configure it remotely using SSH as long as your Linux computer is on the same network (if not, connect it now). We might as well make sure that SSH works now for when a monitor is no longer needed. During the boot process of Raspbian, a message will be displayed with the current IP address of the Pi. Open up a terminal on your Linux computer and type 'ssh pi@[your Pi's IP address]'. Type 'yes' when asked if you want to connect and then enter the new password that you set. You are now logged into your server Pi.

03 Setting up a static IP address

We highly recommend assigning a static IP to your server Raspberry Pi because you, and more importantly the client Raspberry Pis, will always know where to find it on the network. We'll need to find out a couple of things about your current network setup before setting a static IP. You can use the commands 'ifconfig eth0' and 'ip route show' to do this. We've included the important output from our commands below so that you can see what to do with each value. Now that we have found out things about your network, such as your current IP address, the network mask and so on, we can set up a static IP address.

Use the command:

```
sudo nano /etc/network/interfaces
```

...to edit the networking configuration file. Use the arrows to navigate and start by deleting the line 'iface eth0 inet dhcp'. Then replace it with lines similar to the following:

```
iface eth0 inet static
address 172.17.173.249
netmask 255.255.255.0
gateway 172.17.173.1
```

Make sure that the IP address you assign to your Raspberry Pi server isn't taken. You'll want to discuss this with your network administrator if you have one, but it's usually safe to assume that the address the device had already won't be taken. You'll also want to note down that IP address for future usage.

Save the changes in nano using the key combination Ctrl+O followed by Enter. You can exit nano using Ctrl+X.

You might notice that we haven't done anything about the DNS server. DNS is used to resolve hostnames such as google.co.uk to an IP address. The IP address of the DNS server is stored in /etc/resolv.conf and will not change value after changing to a static IP address.

```
pi@raspberrypi ~ $ ifconfig eth0
eth0      Link encap:Ethernet
HWaddr xx:xx:xx:xx:xx:xx
          inet addr:172.17.173.249
Bcast:172.17.173.255
Mask:255.255.255.0
pi@raspberrypi ~ $ ip route show
default via 172.17.173.1 dev eth0
172.17.173.0/24 dev eth0
proto kernel  scope link  src
172.17.173.249
```

04 Restart the server Pi

Restart the server Pi so that the networking changes we just made can take place. Log back in using SSH and the new IP address that you chose.

05 Installing the required packages for an NFS server

NFS stands for Network File System, and is what we'll use to share each user's home directory. Run the command:

```
sudo apt-get update
```

.....to update the package lists on the device, followed by :

```
sudo apt-get install nfs-kernel-server nfs-common rpcbind
```

...to install the packages required for an NFS server. You'll probably get a message like '[warn] Not starting NFS kernel daemon: no exports.... (warning)'. This is just telling us that the NFS server hasn't started because we haven't set it up to share (export) any directories yet.

06 Exporting directories

Add the line:

```
/home *(rw,sync)
```

...to the end of /etc/exports using nano. The line means share the /home directory with everyone, permitting read and write access. Although this sounds insecure, other users will only get read access to directories that aren't their own and therefore won't be able to delete or change files. NFS requires rpcbind, so you need to start that before NFS. Rpcbind doesn't start on boot by default on Raspbian, but we want it to. You can do this using the command 'sudo update-rc.d rpcbind enable'. You can start them both immediately using the following commands:

```
sudo /etc/init.d/rpcbind start
sudo /etc/init.d/nfs-kernel-server start
```

07 Installing NIS

NIS stands for Network Information Services and used to be called Yellow Pages, or yp for short. Many of the services and directories still have 'yp' in the name. Use the command 'sudo apt-get install nis' to install Network Information Services. Accept any extra packages that may be required. You will now be taken to the package configuration screen for NIS. It will start by asking you to enter an NIS domain. This can be anything you like, but we're calling ours raspberrypi. Once you have set that, NIS will continue to install and then the NIS services will attempt to start. This will take a few minutes and fail, so don't worry when that happens. We need to do more configuration before it will work.

08 Configuring NIS

We need to do a few things before our NIS server will work. The first thing we need to do is open up /etc/default/nis with nano as we do in the usual way. Make sure you prefix the nano command with sudo because we need root privileges to edit each of these files. You need to change the line:

```
NISSERVER=false
```

...to...

```
NISSERVER=master
```

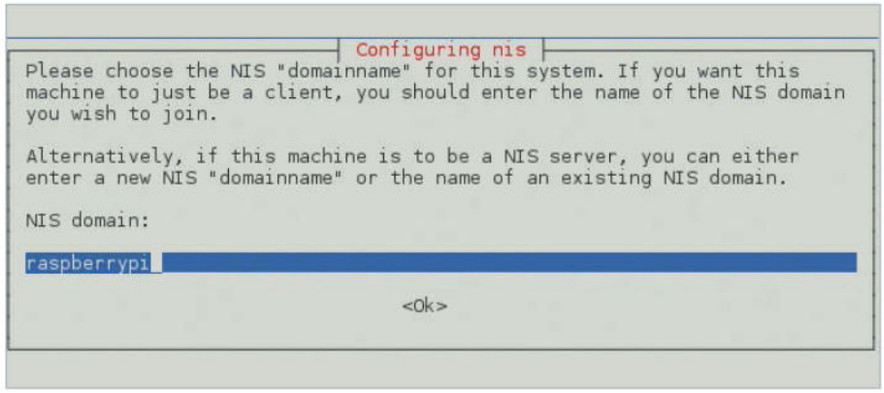
...and also change the line...

```
NISCLIENT=true
```

...to...

```
NISCLIENT=false
```

Save the changes and then exit nano. We then need to edit:



`/var/yp/Makefile`

...and change the line...

```
ALL = passwd group hosts rpc
services netid protocols netgrp
```

...to...

```
ALL = passwd shadow group hosts
rpc services netid protocols
netgrp
```

The password file on Linux contains a list of users and information like their home directory and the User & Group IDs. We need to add the shadow file as that file stores password hashes for users. We also need to change the line:

`MINGID=1000` to `MINGID=0`

...because we'll be adding our NIS users to system groups such as audio so that they can play sound. The next step is to change the server's hostname by editing the /etc/hostname file. We're going to change our hostname from raspberrypi to nismaster. We then need to change /etc/hosts to complete the hostname change, as well as add an extra line. We need to do this because servers running NIS are added by name rather than their IP address. You'll see this shortly. Plus, we should be able to differentiate the NIS server from all of the other Raspberry Pis anyway. Change the line:

`127.0.1.1 raspberrypi`

...to...

`127.0.1.1 [your new hostname]`

You'll also need to add a new line for the IP address of the NIS server in the form:

```
[IP address] [hostname].[NIS
domain] [hostname]
```

09 Initialising the NIS master database

Before anything else, restart the Pi using sudo init 6 to let the hostname change take place. Reconnect once the Pi has booted back up. Run the command:

```
sudo /usr/lib/yp/ypinit -m
```

and then press Ctrl + D followed by Enter. We can now start the NIS server using the command:

```
sudo /etc/init.d/nis start
```

10 Adding a new user

All users are added on the NIS server. You can use the command 'sudo adduser [username]' to do this, and then fill in the extra information required interactively. The NIS databases are updated automatically after adding a new user. We now need to add the new user to some groups so they can do things like play audio and so on. You can do this with the command 'sudo usermod -a -G audio,video,plugdev,games,users,netdev, input [username]'. We have now made more changes to the user and will have to rebuild the NIS database manually using:

```
cd /var/yp
sudo make
```

You can use the command 'sudo passwd [username]' on the NIS server as the pi user to change the password of a user. You will have to rebuild the database again after doing this.

11 Preparing the client

We're pretty much done with the NIS server for now, so it's time to start working on a client image. Connect up the second Raspberry Pi and insert the SD card with the fresh Raspbian image on. Raspi-config will show as it did when we configured the server. The only option you need to use is the one to expand_rootfs and then select 'Finish'. Select 'Yes' to reboot now.

12 Logging in and installing required packages

Log in with the standard credentials of Username: pi and Password: raspberry and then run the command 'sudo apt-get update' to update the package list on the device. Install the required packages for NFS and NIS clients using the command 'sudo apt-get install nis rpcbind nfs-common'. The NIS domain configuration screen will show as before, so just set this to whatever you set it to the first time. As before, the system will fail to start the NIS because we need to do extra configuration, including setting rpcbind to start at boot using the command 'sudo update-rc.d rpcbind enable'. We're going to need rpcbind shortly so we might as well start it now using 'sudo /etc/init.d/rpcbind start'.

13 Mounting the server's home directory

It's now time to mount the server's home directory as our own. We want to do this at every boot, so we'll put an entry in /etc/fstab to make it permanent. Open /etc/fstab in nano and add a line in the following format to the end of the file:

```
[server ip]:/home /home nfs
defaults 0 0
```

You can now save the changes and use the command 'sudo mount -a' to mount each entry in the /etc/fstab file, therefore mounting the servers home directory as the clients. If you run 'ls /home' you'll see the home directory of the test user we created before and also the pi user on the server.

```
pi@raspberrypi /home $ cat /etc/
fstab
proc            /proc
proc    defaults          0
0
/dev/mmcblk0p1  /boot
vfat    defaults          0
2
/dev/mmcblk0p2  /
ext4    defaults,noatime  0
1
# a swapfile is not a swap
partition, so no using swapon|off
from here on, use dphys-swapfile
swap[on|off]  for that
172.17.173.249:/home /home nfs
defaults 0 0
pi@raspberrypi /home $ ls /home
pi testuser1
```

14 Becoming an NIS client

You need to open up /etc/yp.conf in nano (remember to use sudo) and add the lines:

```
ypserver [server ip address]
domain [nis domain] server [server
hostname]
```

You also need to edit the /etc/nsswitch.conf file to look like ours. Once you've done that, you can reboot the client using the command 'sudo init 6'.

Linux has lots of educational software, ideal for the classroom

15 Log in with a user from the NIS server

Wait for the client to boot up and then try to log in with the pi user. Remember we didn't change the password of the pi user when we set up the client? We are now going to be logging in with the pi user from the server, so the password will be different.

The nice thing about this is that the Pi is still operable with the standard credentials when there is no network cable connected or the server is down. However, it will complain a lot during the boot process and still won't be able to access the home directory on the server.

16 Installing packages on the client

Linux has a bunch of fantastic educational software that would be ideal for use in a classroom. We're going to recommend a few programs that would be good to include on the master client image. There is already a pretty good collection that comes with the base Raspbian image, but we can definitely add more.

We're going to install the following software:

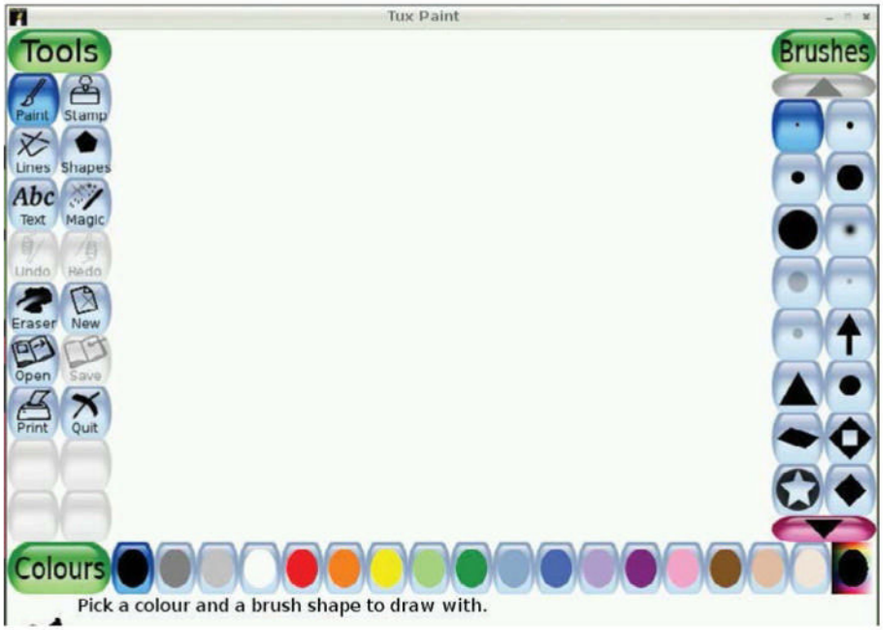
AbiWord – A basic word processor
Gnumeric – A basic spreadsheet program
GCompris – Bundle of children's educational software packages
Galculator – Scientific calculator
TuxMath – Maths tutor for kids
Tux Paint – Children's drawing program

You can install all of this software at once using 'sudo apt-get install abiword gnumeric gcompris galculator tuxmath tuxpaint'. This may take a while. Once it's finished, you can type 'startx' to load the LXDE desktop environment and have a play around everything on there.

Have a go at logging in as the test user also. One problem will be that there are no desktop icons because they are only set for the pi user. The programs will still be there in the start menu anyway. When logging out, the users need to log out of LXDE so that they go back to the console and then type 'logout'.

17 Duplicating the card

Before continuing, shut down the client Pi by switching to the pi user using 'su pi' and then typing 'sudo init 0'. Everything on Linux is seen as a file. Because of this, we can simply use a combination of the cat command and pipes to duplicate the SD card. Switch to the root user on your Linux computer using the command 'su root'. Use the output of 'fdisk -l | grep Disk' to find the path of the SD card. Ours is /dev/mmcblk0. You can back up the card using the command 'cat /dev/mmcblk0 > nisclient.img' and restore the backup to a different card using 'cat nisclient.img > /dev/mmcblk0' once you have taken the original card out.



18 Preparing a disk to be used as a backup area

The instructions for preparing an external disk to be used as a backup area can be found here: **www.linuxuser.co.uk/features/build-a-file-server-with-the-raspberry-pi**. Use steps 09 to 11 to do this.

19 Backing up the server

One of the main advantages to having central file storage is that everything can be backed up from one place. More importantly, files that are deleted can be restored. We'll be using rsync to perform the backups, so you'll need to install that using the command 'sudo apt-get install rsync'. We're going to assume that you've set up your backup area in /mnt/data. We'll be using the command

```
sudo rsync -avP /home /mnt/data
```

to perform the backups. The switches mean the following:

a – preserve the permissions and other properties of the file
v – show verbose output
P – show progress

This command syncs any changes from /home to /mnt/data, but will not get rid of any files that are deleted from the /home directory. Rsync is very efficient: only the changes made to a file are copied over, rather than a new file. We want to run this command regularly, say once an hour or so, so we'll add it to cron. Cron is a daemon that runs commands at specific intervals according to each user's crontab. You can edit the pi user's crontab using the command 'crontab -e'. Add the following line to the end of the crontab file:

```
0 * * * * 'sudo rsync -avP /home /mnt/data'
```

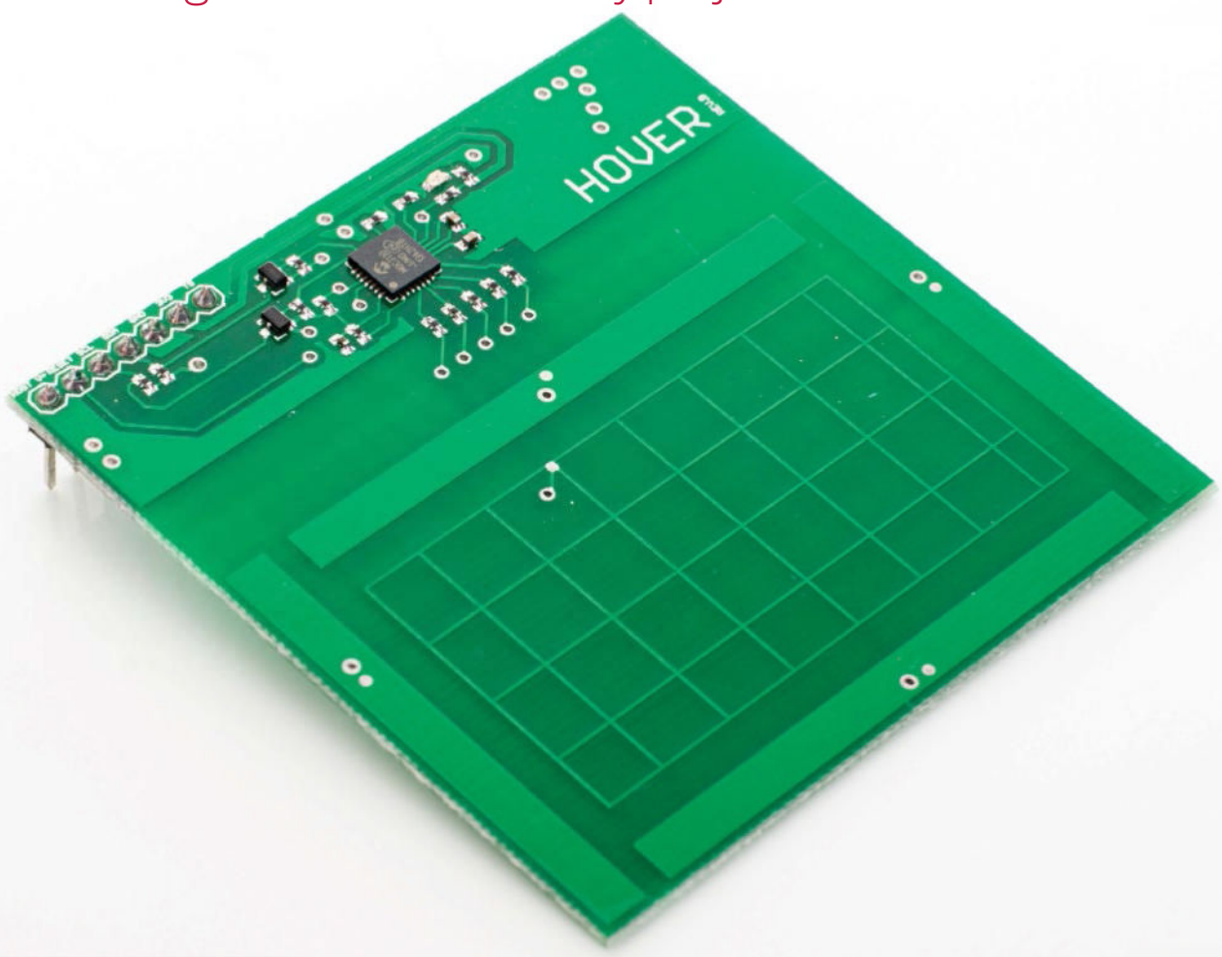
The crontab file takes lines in the format: minutes hours day-of-month month day-of-week. The above line tells the cron daemon to run the command in at the start of each hour. Save the changes as you usually would in nano.

20 That's it!

With the project complete, you now have a central authentication and file storage area that gets backed up, as well as a master image for the client Raspberry Pis that is filled with useful software. Now you can start enjoying your network of Raspberry Pis!!

Add gesture control to your Raspberry Pi

Hover is an impressive add-on board for your Raspberry Pi that allows you to easily add touch and gesture control to any project

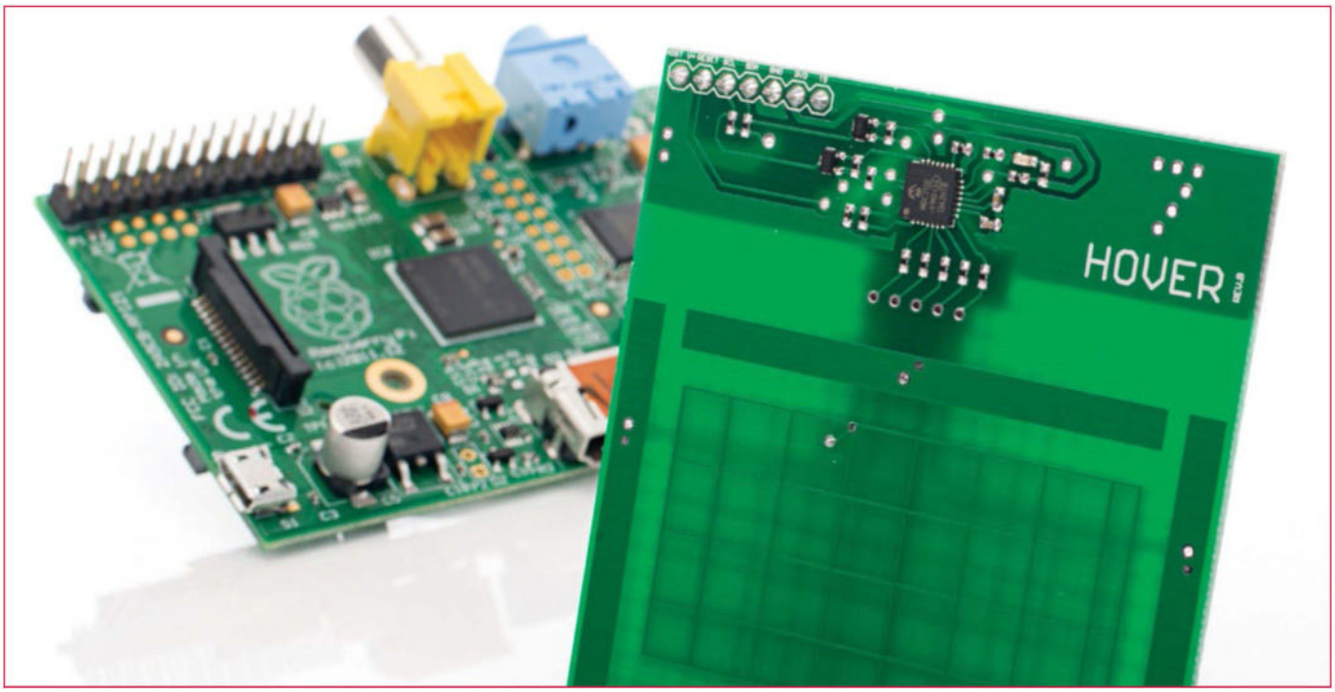


What you'll need

- Raspberry Pi
- Hover
- Breadboard
- Male to female jumper cables
- Speaker or headphones

People often ask what the best way is for them to get started with Raspberry Pi. Obviously this does depend on the individual user and what they want to achieve and get out of any project, but in a more general sense it's often the hardware projects that win out for getting to grips with it. They teach a variety of skills (including programming, circuit building, soldering, hardware design and much more) and are also varied enough to both keep beginners interested and allow them to work out for themselves exactly what aspect they love best. Even a seasoned professional will get a serious kick out of a bit of physical computing and automation! This is one of the unique features of the Pi compared to traditional "black box" computers; you can break out of the usual boundaries and interface with everyday objects like never before.

One of the most important aspects of a hardware project is often the user input mechanism, and as technology is refined we see new and more intuitive ways to accomplish this task. Gesture and touch control is now present in a large number of consumer devices and even the biggest technophobes are starting to embrace the ease of this technology. It is time to bring your Raspberry Pi projects into the 21st century with Hover!



The physical pins you should be using on the Raspberry Pi are 1, 3, 5, 6, 16 and 18

01 Get the gear!

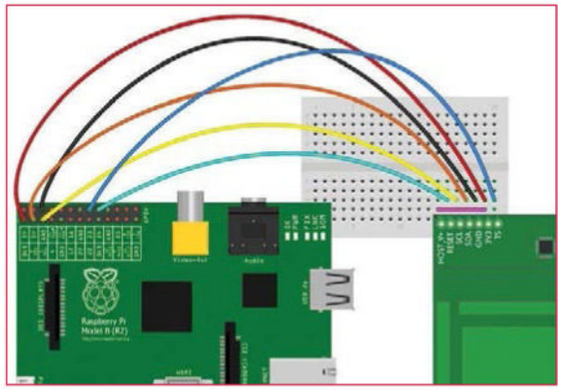
The Hover add on board is available to purchase direct from Hover (**http://www.hoverlabs.co/#shop**) for $39 (£25), however this will ship from Northern America and therefore if you are based in the UK or Europe it will likely be quicker and cheaper to order from one of the other retailers listed via the above link. The added benefit of ordering from a retailer is that if you need any of the other items you can likely get those at the same time!

Hover will work perfectly with any Raspberry Pi, including both the new plus versions and the older models – just make sure your system is fully up to date with:

```
sudo apt-get update
sudo apt-get upgrade
```

02 Update GPIO and I2C

When making use of GPIO and I2C (or any other interfacing technique on the Raspberry Pi) it is always good practice to update to the very latest software versions possible. Newer versions typically have bug fixes and additional futures which can come in very handy. GPIO and the RPi.GPIO Python library are installed by default on Raspbian, but you may need to enable I2C if you haven't already. This is a fairly standard process and has been covered many times so we won't go into it here. We would, however, highly recommend the brilliant I2C setup tutorial from Adafruit (**https://learn.adafruit.com/adafruits-raspberry-pi-lesson-4-gpio-setup/configuring-i2c**).



03 Set up the hardware

Make sure your Raspberry Pi is powered down and not connected to power before starting this step, to avoid any unnecessary damage to your Raspberry Pi. Pick up your Hover, breadboard and wires and connect the as shown in the Fritzing diagram. The physical pins you should be using on the Raspberry Pi are 1, 3, 5, 6, 16 and 18. Whilst a Model B Pi is shown, this will be the same connection on a Model A, B, A+ or B+ of any revision. Once completely set up like the image, reconnect the power cord and open an LXTerminal session.

04 Check the connection

Hover connects to the Raspberry Pi through the I2C interface located on the main 26 or 40 pin GPIO bank (depending on which version of the Raspberry Pi you are using). There is a very easy way to check if your Raspberry Pi is correctly connected to Hover using the simple command line I2C tools. Issue the following command:

```
sudo i2cdetect -y 1
```

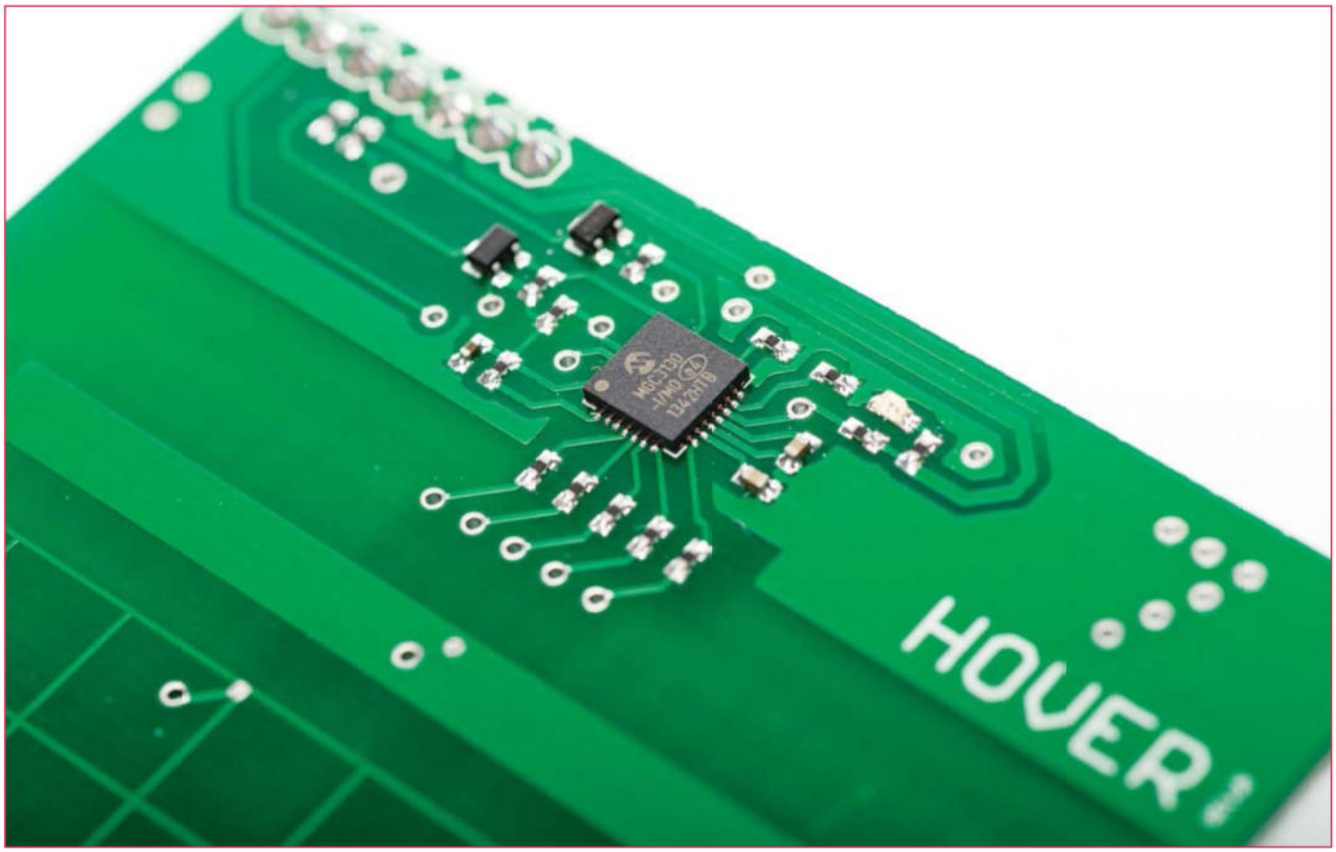
If you see 42 in the response then you are successfully connected to Hover!

Above You can tap the Hover or swipe in four directions just above it

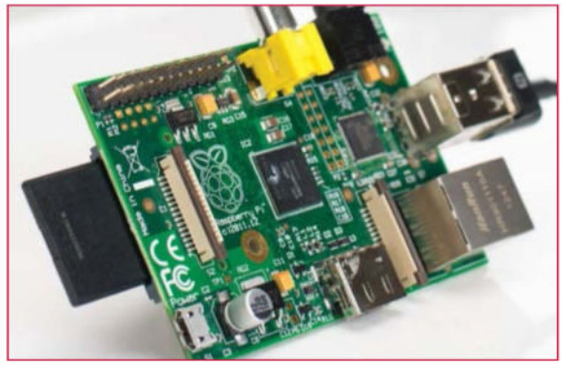
Plenty of platforms

The Hover board has intelligent on-board level shifting, meaning that it can be used with either 3.3V or 5V logic levels which means it can be used with pretty much any microcontroller your heart desires. There are connection examples and code snippets available for Arduino, Sparkcore and PCduino on the Hover website (**hoverlabs.com**) and these can also be adapted to suit other devices fairly easily.

If you decide to create your own example with another device then why not submit a pull request to the Hover GitHub (**github.com/jonco91**) if you are happy to share!



Above This MGC3130 chip works as the 3D tracking and gesture controller



Why Python?

Python is extremely useful for beginners due to its easy-to-understand syntax, fairly prose-like formation and the flexibility and ease of acquiring existing software libraries to help your projects. It is also the official programming language of the Raspberry Pi and is therefore very well supported within the community. That is not to say that Hover will not work with other programming languages; simply that the creators of Hover have not yet released any code libraries in other languages.

05 Using a Rev 1 Pi?

In the code, we have passed an option "-y 1" which tells the operating system which I2C bus to look at (there are two on the BCM2835 processor on the Pi). The first revision Raspberry Pi (the one that initially launched in February 2012 with 256MB of RAM) made use of I2C bus 0, whereas all other versions of the Raspberry Pi since have used I2C bus 1. So the above code would change to:

```
sudo i2cdetect -y 0
```

And you should expect the same output (42) as in step 7. Additionally you will need to edit line 27 of the Hover_library.py file, changing bus = smbus.SMBus(1) to bus = smbus.SMBus(0). A patch that automatically detects the Raspberry Pi version and makes this change for you has been submitted, but not yet accepted into the master branch so this may not be necessary in future versions.

06 Download the sample code

Now you have everything hooked up correctly and your Raspberry Pi is fully up to date, it is time to get the Hover Python library, which makes using the board from Python scripts extremely easy. You can get this using the following command:

```
git clone https://github.com/jonco91/hover_
raspberrypi.git
```

This should download a folder called hover_raspberrypi to your /home/pi directory containing all of the files needed for this article. Alternatively you can download the zip file from **https://github.com/jonco91/hover_raspberrypi/archive/master.zip**.

07 Run the example file

The current Hover library is simply a Python file with all of the necessary functions included within it, rather than an installable package (however, this may change in the future). In order to use the functions contained within the Hover_library.py script discussed above, it is therefore necessary to make sure that the Hover_library.py script is located in the same folder as any script you have written that makes use of any of the Hover functions. In a terminal session, navigate to the folder containing the Hover_example.py file and run it using:

```
sudo python Hover_example.py
```

The Hover board will initialise and you will then see a message "Hover is ready", meaning you are good to go.

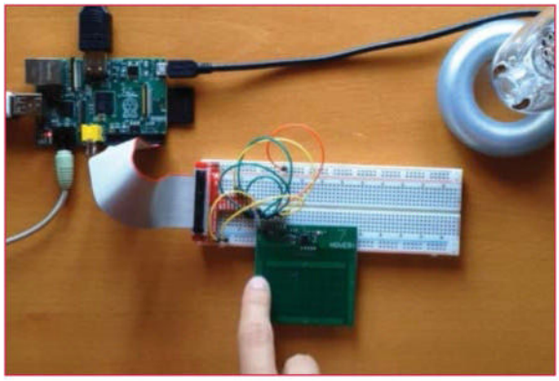
08 Investigate the output

Once you have completed step 7, if you touch the Hover board or make gestures above it you will begin to see output in the terminal which is a bunch of 0s and 1s and then a description of what it has seen – right swipe, north tap, etc. The way the Hover works is that it can sense any one of nine different actions and these are sent to the Raspberry Pi over I2C as an 8-bit binary value. The first three bits describe whether it was a touch or gesture event and the remaining five bits describe the specific type or direction of the event. The exact breakdown can be seen in the code listing to the right.

09 Enable 3.5mm audio

Grab your speakers and plug them in to the 3.5mm jack plug on the Raspberry Pi. You will then need to route audio to the 3.5mm jack using the following command (you can skip this step if you are using an HDMI display, which has in-built audio):

```
sudo amixer cset numid=3 1
```



10 Make a drum machine

In the hover_raspberrypi folder is another folder called examples that contains code and sounds to turn Hover into a drum machine! Navigate to the hover_raspberrypi directory and then copy the Hover_library.py file into the examples folder by using:

```
cp Hover_library.py examples
```

You can then move into the examples folder and run the Hover_drum.py file using:

```
cd examples
sudo python Hover_drum.py
```

Make some gestures and taps on and around Hover and you will have your own basic drum machine!

11 Create your own responses

The great thing about having a Python library available is that it is easy to integrate this device into any of your existing or future projects. The code shown is all you need to get started with Hover. You will see that on line 15 and onwards there are comments saying "code for ... goes here". Essentially all you need to do is insert the actions you want to occur on the particular event mentioned in the comment and you will be up and running... it really is that easy!

Full code listing

```
import time
from Hover_library import Hover

hover = Hover(address=0x42, ts=23, reset=24)

try:
  while True:

    # Check if hover is ready to send gesture
    # or touch events
    if (hover.getStatus() == 0):
      # Read i2c data and print the type of
      # gesture or touch event
      message = hover.getEvent()
      type(message)
      if (message == "01000010"):
        # code for west touch goes here
      elif (message == "01010000"):
        # code for centre touch goes here
      elif (message == "01001000"):
        # code for east touch goes here
      elif (message == "01000001"):
        # code for south touch goes here
      elif (message == "01000100"):
        # code for north touch goes here
      elif (message == "00100010"):
        # code for swipe right goes here
      elif (message == "00100100"):
        # code for swipe left goes here
      elif (message == "00110000"):
        # code for swipe down goes here
      elif (message == "00101000"):
        # code for swipe up goes here

      # Release the ts pin until Hover is
      # ready to send the next event
      hover.setRelease()
    time.sleep(0.0008)   #sleep for 1ms

except KeyboardInterrupt:
  print "Exiting..."
  hover.end()

except:
  print "Something has gone wrong..."
  hover.end()
```

12 Other project ideas

Most of you are probably now wracking your brains for projects you could use Hover in, but let's face it – pretty much any project that requires physical interaction would be made better with touch and gesture control. If you think it is cool but are lacking inspiration, we recommend looking at the projects section of the Hover website at **http://www.hoverlabs.co/projects**, where there are projects by the creators and community alike. If you make something cool, be sure to send us the pictures!

Where are the hoverboards?

Did you come here looking for information on how to build your space age transportation device? We can't help you with that, but we don't want to leave you disappointed! Hoverboards were first popularised as a fictional personal transportation method in the 1989 film *Back To The Future Part II* and took the appearance of a levitating skateboard with no wheels. 25 years later and it seems we might be getting close to turning this dream into a reality. Hendo Hoverboards have created a $10,000 hoverboard which uses a principle similar to that of maglev trains to generate lift (**kck.st/ZMd9AA**), and more recently Ryan Craven has created a much cheaper alternative using four leaf blowers and some other cheap parts (**mrhoverboard.com/about**).

Make a digital photo frame

Take your Raspberry Pi, HDMIPi and Screenly and turn them into a beautiful digital photo frame

What you'll need

- Raspberry Pi Model B
- HDMIPi kit
- Class 10 SD Card
- 5.25V Micro USB power supply
- USB keyboard
- Wi-Fi dongle
- Internet connection

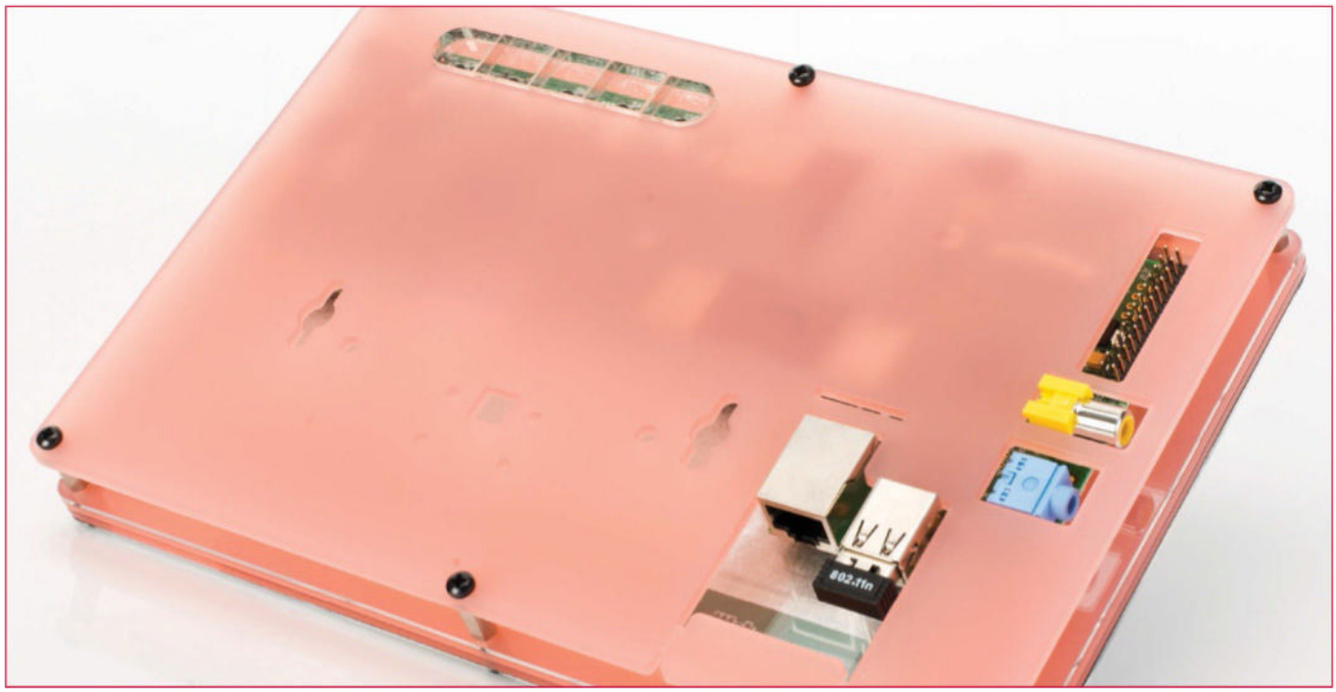
Digital signage is a huge market in modern times, and increasingly we are seeing digital advertising in the public space – be it on street billboards, shopping centres and even in some city taxis. Screenly is an exciting piece of software from Wireload Inc that has set out to reduce the barriers to entry of the digital signage market by employing a Raspberry Pi as its main hardware component for the individual signage nodes. With the powerful VideoCore IV graphics processor at the heart of the Pi and its low electrical power consumption, using it as a digital signage platform is a no-brainer.

Our expert has been using Screenly a lot recently for some projects and it truly is a really great piece of software. He was also one of the first backers of HDMIPi on Kickstarter, and when his reward arrived recently it occurred to him that, together with Screenly, it would make the perfect home-brew digital photo frame and another great Raspberry Pi-based hardware project. In this tutorial, we will show you how to assemble this powerful hardware/software combination for yourself.

01 Order your items

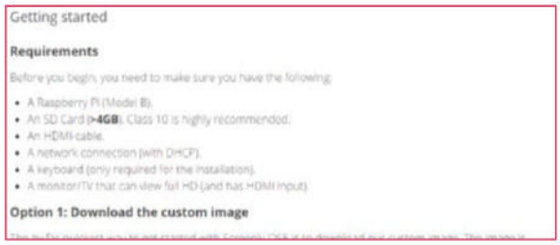
If you haven't already got them in your Raspberry Pi collection, you will need to order all of the items from the "What you'll need" list. The HDMIPi is currently only compatible with Model B of the Raspberry Pi, although a Model B+ version is in the works (the B+ does actually work with HDMIPi, but unfortunately cannot fit into the case). Pretty much any USB keyboard will work with Screenly, including wireless ones, so you do not need to worry about a mouse for this tutorial as it will all be done from the command line.

Finally, a speaker is only necessary if you intend to play videos from the display with sound as well.



02 Assemble your HDMIPi

The HDMIPi comes as a do-it-yourself kit rather than a polished product. Not only does this make it cheaper for you to buy, but it also gives it a more hack-like feel in its Pibow-esque acrylic layer case. It is not hard to assemble, but in case you get stuck there is a fantastic assembly video here: http://hdmipi.com/instructions.



03 Download Screenly OSE

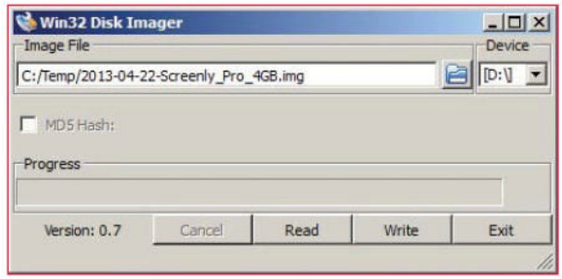
Now that you have the hardware all ready to go we need to download the Screenly OSE SD card image. This is only a 3.7GB image file, however it may not fit on some 4GB SD cards so we would recommend a minimum of 8GB, for extra space for all your pictures and videos. Visit **bit.ly/1wLKIRQ** and download the ZIP file from one of the mirrors under the "Getting started" heading.

04 Flash image to SD Card (Linux)

It's worth noting the value of having a Linux machine at your disposal (or a spare Raspberry Pi and SD card reader) to download the ZIP file in Step 03. This is typically the easiest way to unzip the file and copy the image across to your SD card. Assuming the disk isn't mounted, open a terminal session and type:

```
unzip -p /path/to/screenly_image.zip | sudo dd
bs=1M of=/dev/sdX
```

Make sure that you replace /path/to/screenly_image.zip with the actual path.



05 Flash image to SD Card (Other OS)

If you do not have another Linux machine handy, or a card reader for your Raspberry Pi, you can still do this from other popular operating systems. On Windows you should use Win32 Disk Imager and follow the easy to use GUI. From Mac OS X you have the options of using the GUI-based software packages PiWriter and Pi Filler, or running some code from the command line. Visit **www.screenlyapp.com/setup.html** for more info.

06 Insert SD card and peripherals

Once the Screenly image has been successfully transferred to your SD card, you will need to insert it into the Raspberry Pi within your HDMIPi casing.

It is a good idea to connect your Wi-Fi dongle and keyboard at this point. Take a look at the image at the top of this page to see where the slots are in relation to the casing. A wired network is also required for the initial setup and for configuring the Wi-Fi connection.

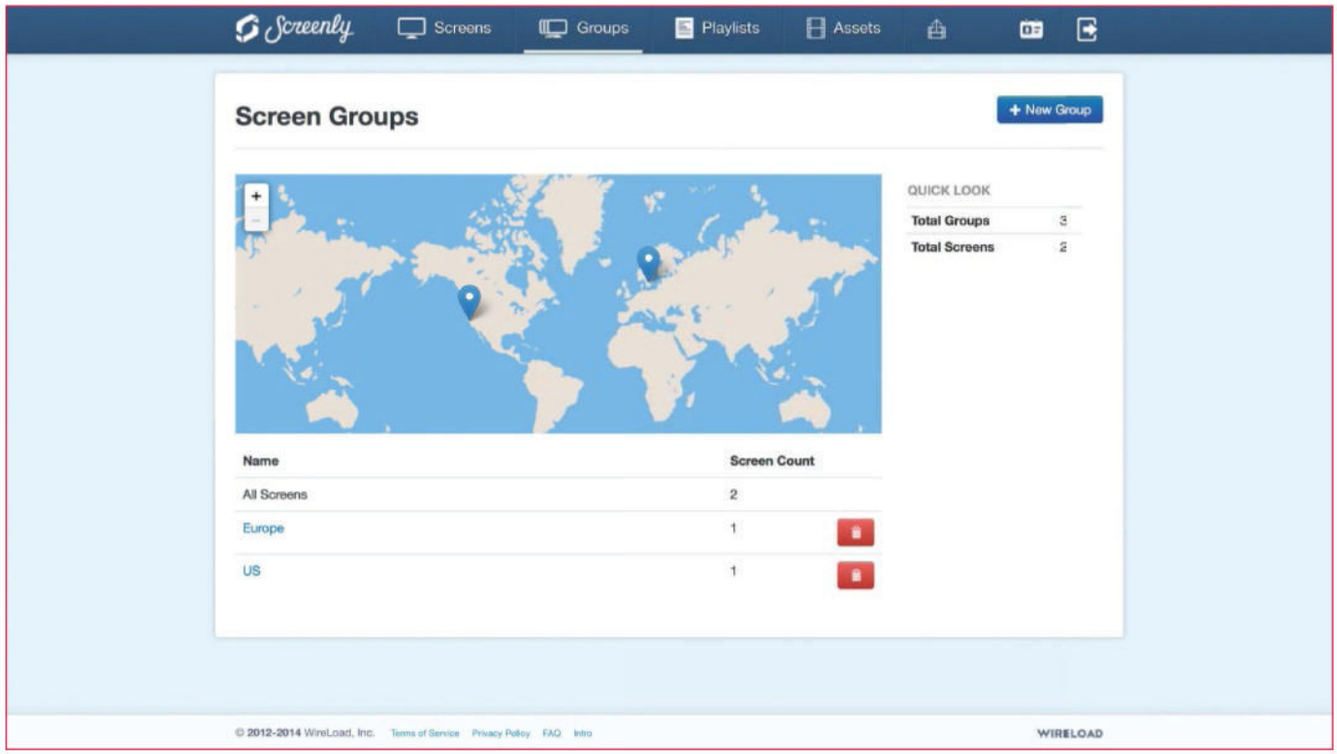
07 Boot up your Raspberry Pi

The HDMIPi driver board has a power output for the Raspberry Pi which means you only need one power supply for this setup. Plug it in and wait for it to boot into the Screenly splash screen. An IP address (of format http://aaa.bbb.ccc.ddd:8080) should be displayed here, which will allow you to gain access to the management dashboard.

Above The reverse view of HDMIPi, showing GPIO and connector cutouts

History of HDMIPi

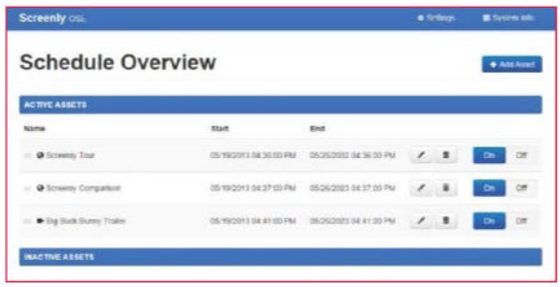
HDMIPi is a collaboration between Cyntech and Alex Eames from RasPi.TV. They wanted to bring a cheap HD resolution HDMI screen to the market that will reduce the cost of having a dedicated monitor for your Raspberry Pi. They took to Kickstarter to launch their idea (**kck.st/17zyaQg**) and there was a huge response to this project from both within and outside the Raspberry Pi community. Over 2,500 people from all over the world enabled them to smash their £55,000 target, and the campaign finished with over £260,000. UNICEF even thought they were good enough to use in their educational projects in Lebanon (**bit.ly/ZDpO8Z**).



Above Screenly Pro can manage multiple screens and has cloud storage too

Screenly Pro Edition

In this tutorial we have used the open source version of Screenly – Screenly OSE. This is a fantastic bit of software and a great addition to the open source ecosystem. At this point, some of you may be dreaming of huge remote-managed display screen networks and the good news is that this is entirely possible with Screenly Pro. This is completely free for a single display screen and 2GB of storage, and it has larger packages for purchase starting at two screens right up to 130+ screens. It also adds a lot of additional features not seen in Screenly OSE – find out more about those on the Screenly website (**bit.ly/1EXl92p**).



08 Disable Screenly video output

Load the IP displayed on the splash screen on the browser of a different computer (you won't be able to do it directly from the same Pi). The Screenly OSE dashboard should now load. Once inside the dashboard, move the slider for Big Buck Bunny to the OFF position or delete the asset entirely.

09 Enter the command line

Once you have disabled the Big Buck Bunny trailer from the web interface, you should now be able to enter the command line easily and you can do this by pressing Ctrl+Alt+F1 on the attached keyboard at any time. Alternatively, you can access the command line over SSH using the same IP address as shown previously on the splash screen.

10 Run the update script

The image file we downloaded from the website is actually just a snapshot release and does not necessarily include the latest Screenly OSE code, as the code updates are made more regularly than the image. It is therefore good practice to run an upgrade to the latest version using the built-in script. You can run the following command:

```
~/screenly/misc/run_upgrade.sh
```

11 Configure Raspberry Pi

Once you are successfully at the command line, you need to type `sudo raspi-config` to enter the settings and then select '1 Expand root file system' to make sure you have access to all of the space on the SD card. Then, change the time zone (option 4 and then 12) so that it is correct for your location. If your screen has black borders around the edge you may also need to disable overscan (option 8 and then A1). We would also recommend changing the default password to something other than raspberry to stop any would-be hackers from easily accessing the Raspberry Pi via SSH (option 2). Once complete, exit without restarting by selecting Finish and then No.

12 Enable and set up Wi-Fi

As Screenly runs on top of Raspbian, the Wi-Fi setup is essentially the same as the standard command line setup within the OS. In order to do this you need to edit the interfaces file using `sudo nano /etc/network/interfaces` and then type in the following code, replacing ssid and password with the actual values:

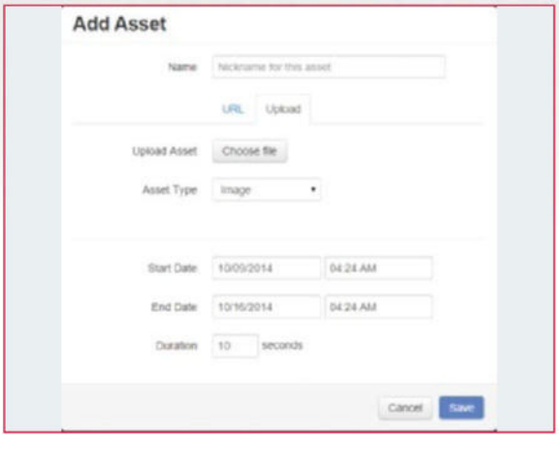
```
auto lo

iface lo inet loopback
iface eth0 inet dhcp

allow-hotplug wlan0
auto wlan0

iface wlan0 inet dhcp
        wpa-ssid "ssid"
        wpa-psk "password"

iface default inet dhcp
```

Then exit and save by hitting Ctrl+X, then Y and then Return.

Above Once fully configured, load your pictures and video to complete your digital photo frame!

13 Test the connection

The easiest way to test the Wi-Fi connection is to shut down the Raspberry Pi using `sudo shutdown -h now` and then remove the wired network connection and reboot the Raspberry Pi by removing and reattaching the microUSB power connector. If the Wi-Fi connection has worked, you should now see the splash screen with IP address again.



14 Upload pictures to Screenly

Once again, you will need to visit the Screenly OSE web interface by entering the IP address into another computer. Since you are now using a wireless connection, the IP address may be different to the previous one. You need to select the 'Add Asset' option at the top right-hand side, which should launch a pop-up options screen. Select Image from the drop-down box and you then have the option of either uploading the image or grabbing it from a URL using the corresponding tabs. Enter the start date and end date of when this image should appear, and how long it should appear on screen for, then press Save. Repeat this step for each of the pictures.

15 Test with video and more

Pictures are great, but Screenly also allows you to display videos (with audio if you wish) and web pages, which really is a huge benefit. This is perfect if you want to enhance your digital photo frame even further or perhaps display the local weather and news to keep yourself informed. Plug in your speaker – we would recommend The Pi Hut portable mini speaker (available from **bit.ly/1xEpBNZ**) or anything similar.

16 Place in situ and enjoy!

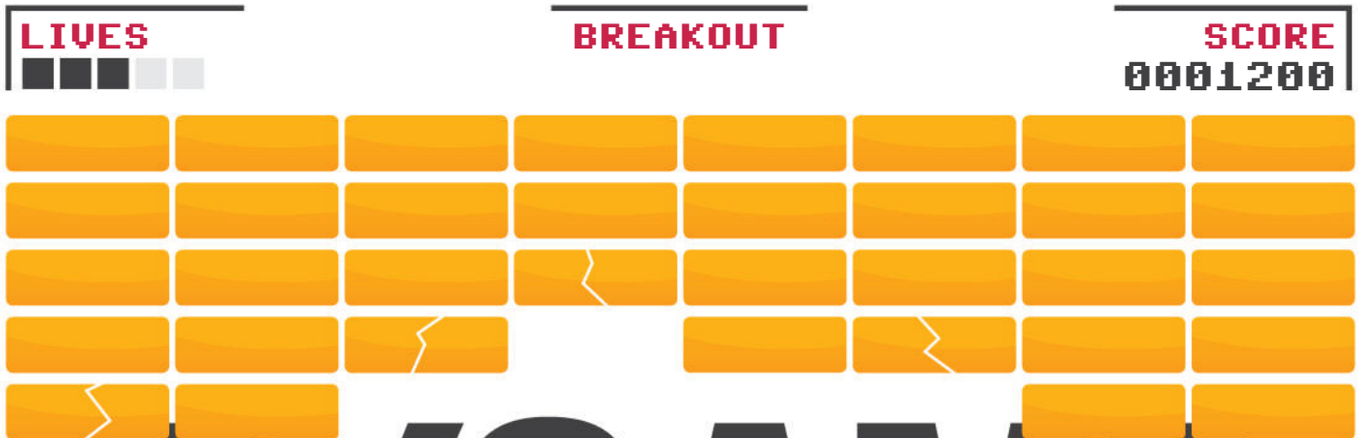
Once you have got Screenly all set up and loaded all of your favourite pictures and videos onto it via the web interface, it is now time to enjoy the fruits of your labour! Mould the spider stand (if you have one) into shape by taking the middle two legs at the top and bending them downwards and backwards. Then spread the front-middle legs a bit wider to give a good base and shape the outer legs at the top and bottom to support the screen. You are then ready to give it its permanent home – our expert's is on the mantelpiece over the fireplace!

17 Other project ideas

In this tutorial we have looked at just one fairly basic application of Screenly and the HDMIPi. You could use this powerful open source software to run your digital signage empire, share screens in schools and clubs, or as a personal dashboard using a suitable web page. Whatever you make, please don't forget to take pictures and send them to us!

Access Screenly from afar

The default Screenly image is essentially some additional software running on top of Raspbian OS. This means that SSH is enabled by default (it's why we changed the default password in Step 11) so it's now possible to access the command line, as well as the Screenly dashboard, from outside of your LAN. We recommend setting a static IP for your Screenly-powered Raspi from your router settings and then setting up SSH with keys on your Pi, and port forwarding on your router for ports 22 and 8080. The Screenly dashboard has no login so anyone can access it, but an authentication feature is imminent.



PYGAME ZERO

Pygame Zero cuts out the boilerplate to turn your ideas into games instantly, and we'll show you how

Games are a great way of understanding a language: you have a goal to work towards, and each feature you add brings more fun. However, games need libraries and modules for graphics and other essential games features. While the Pygame library made it relatively easy to make games in Python, it still brings in boilerplate code that you need before you get started – barriers to you or your kids getting started in coding.

Pygame Zero deals with all of this boilerplate code for you, aiming to get you coding games instantly. Pg0 (as we'll abbreviate it) makes sensible assumptions about what you'll need for a game – from the size of the window to importing the game library – so that you can get straight down to coding your ideas.

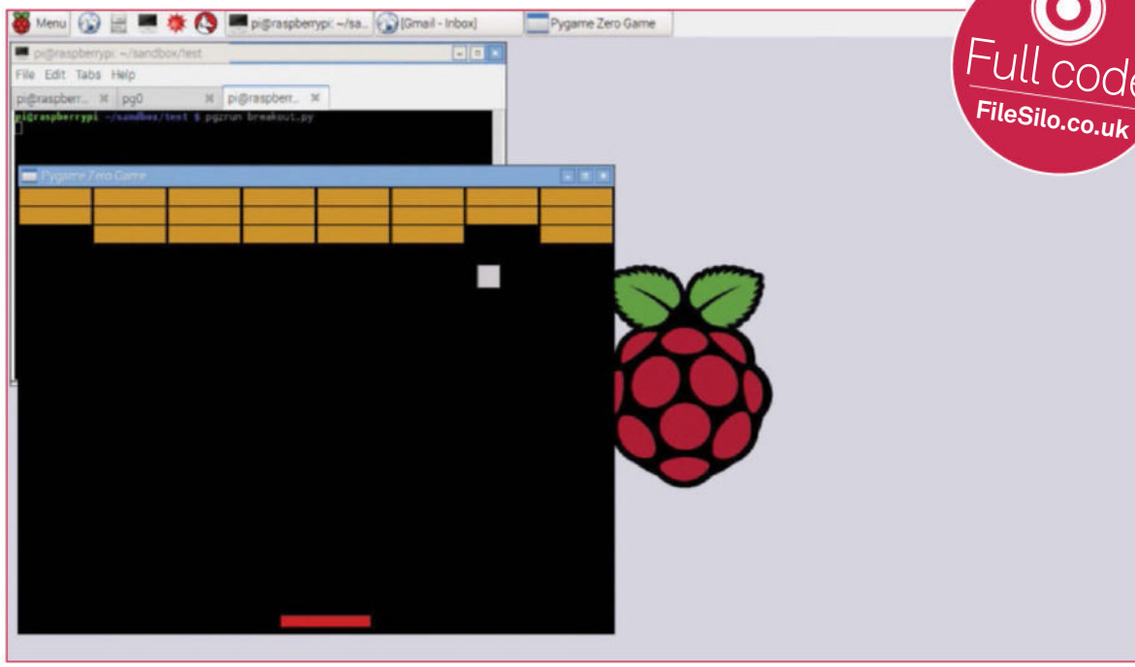
Pg0's creator, Daniel Pope, told us that the library "grew out of talking to teachers at Pycon UK's education track, and trying to understand that they need to get immediate results and break lessons into bite-size fragments, in order to keep a whole class up to speed."

To give you an idea of what's involved, we'll build up a simple game from a *Pong*-type bat and ball through to smashing blocks *Breakout*-style. The project will illustrate what can be done with very little effort. Pg0 is in early development but still offers a great start – and is now included on the Pi in the Raspbian Jessie image. We'll look at installation on other platforms, but first let's see what magic it can perform.

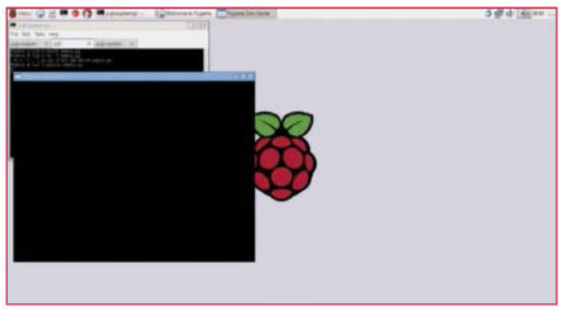
What you'll need

- Pygame Zero
  pygame-zero.readthedocs.org
- Pygame
  pygame.org
- Pip
  pip-installer.org
- Python 3.2 or later
  python.org

Full code
FileSilo.co.uk



Right *Breakout* is a classic arcade game that can be reimagined in Pygame Zero



Young and old

In situations where Pygame is used boilerplate and all with young people, great results can also be achieved (see Bryson Payne's book), but Pygame and Pg0, despite their use as powerful educational tools, are also good for creating games for coders no matter what stage of learning they are at.

Great games are all about the gameplay, driven by powerful imaginations generating images, animations, sounds and journeys through game worlds. Good frameworks open up this creative activity to people who are not traditional learners of programming, which is an area where Python has long excelled.

01 Zero effort

Although game writing is not easy, getting started certainly is. If you've got Raspbian Jessie installed on your Pi, you're ready to go. Open a terminal and type:

```
touch example.py
pgzrun example.py
```

And you'll see an empty game window open (Ctrl+Q will close the window). Yes, it's that easy to get started!

02 Python 3

If you haven't got Raspbian Jessie, chances are you'll have neither Pg0 nor Pygame installed. The Python's pip package installer will take care of grabbing Pg0 for you, but the preceding steps vary by distro. One thing you will need is Python 3.2 (or newer). If you've been sticking with Python 2.x in your coding (perhaps because it's used in a tutorial you're following), make Pg0 your chance for a gentle upgrade to Python 3.

03 Older Raspbian

If you're still running Raspbian Wheezy, you'll need to run the following steps to install Pygame Zero:

```
sudo apt-get update
sudo apt-get install python3-setuptools python3-pip
sudo pip-3.2 install pgzero
```

Pygame Zero deals with all of this boilerplate code for you, aiming to get you coding games instantly

04 No Pi?

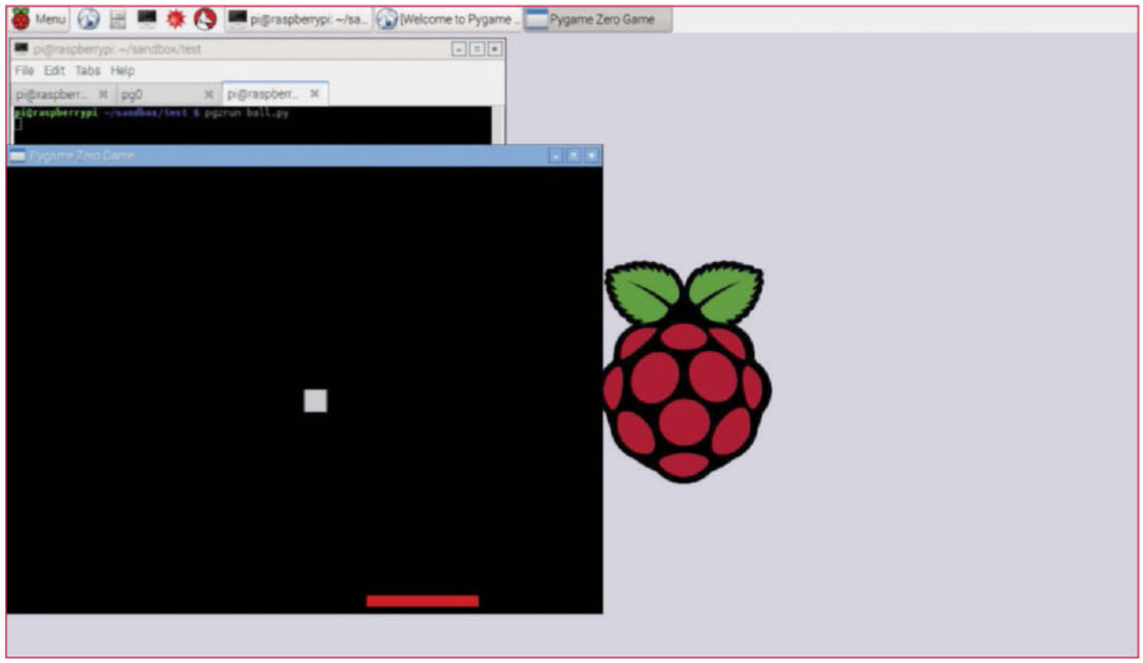
You don't even need a Raspberry Pi to install Pygame Zero – just install the Pygame library, then use pip to install Pygame Zero. Instructions vary by distro, but a good place to start is the documentation: **bit.ly/1GYznUB**.

05 Intro.py

That default black square of 800 by 600 pixels we saw in Step 1 can be overridden manually. For example, we can replace it with an oversized gold brick, in a nod to *Breakout*:

```
WIDTH = 1000
HEIGHT = 100
def draw():
    screen.fill((205, 130, 0))
```

That colour tuple takes RGB values, so you can quickly get colours off a cheatsheet; **screen** is built into Pg0 for the window display, with methods available for all sorts of different sprites...



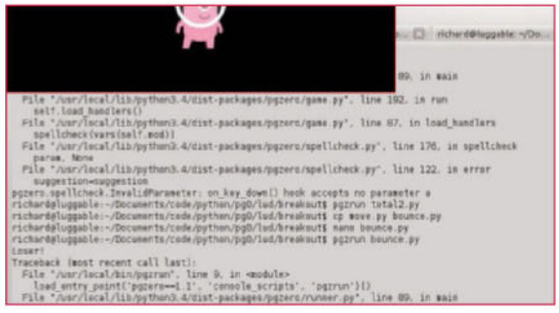
Right The bat and ball come first – they're the cornerstones of *Pong* and *Breakout*

Object orientation

David Ames, who uses Pg0 to teach younger children to code at events across the UK, told us: "One thing to avoid when it comes to teaching kids is Object Orientation." OOP (object-oriented programming) is partly abstracted away by Pg0, but it can't be ignored.

Perhaps the best approach is using Pg0 and some simple code to start, then dropping in a piece of OO when it's needed to solve a particular problem.

With the Code Club age group – about eight to eleven – feeding information to solve practical problems works well. It can work with adults, too – but there's always someone who's read ahead and has a few tricky questions.



06 Sprite

The intro example from the Pg0 docs expands on that with the **Actor** class, which will automatically load the named sprite (Pg0 will hunt around for a .jpg or .png in a subdirectory called images).

```
alien = Actor('alien')
alien.pos = 100, 56
WIDTH = 500
HEIGHT = alien.height + 20
def draw():
    screen.clear()
    alien.draw()
```

You can download the alien from the Pg0 documentation (**bit.ly/1Sm5lM7**) and try out the animation shown there, but we're taking a different approach in our game.

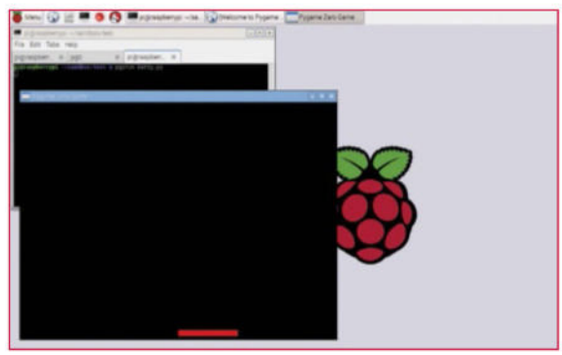
07 Breakout via Pong

While the Pi is something of a tribute to 1980s 8-bit computers, *Breakout* comes from the 1970s and is a direct descendant of the early arcade classic *Pong*. We'll follow the route from *Pong* to *Breakout* (which historically involved Apple founders Steve Wozniak and Steve Jobs) in the steps to creating our code, leaving you with the option of developing the *Pong* elements into a proper game, as well as refining the finished *Breakout* clone.

08 Batty

You can think of *Breakout* as essentially being a moving bat – that is, you're hitting a moving ball in order to knock out blocks. The bat is a rectangle, and Pygame's **Rect** objects store and manipulate rectangular areas – we use **Rect((left, top), (width, height))**, before which we define the bat colour and then call upon the **draw** function to put the bat on the screen, using the **screen** function.

```
W = 800
H = 600
RED = 200, 0, 0
bat = Rect((W/2, 0.96 * H), (150, 15))
def draw():
    screen.clear()
    screen.draw.filled_rect(bat, RED)
```



09 Mouse move

We want to move the bat, and the mouse is closer to an arcade paddle than the arrow keys. Add the following:

```
def on_mouse_move(pos):
    x, y = pos
    bat.center = (x, bat.center[1])
```

Use **pgzrun** to test that you have a screen, bat and movement.

10 Square ball

In properly retro graphics-style, we define a square ball too – another rectangle, essentially, with the **(30, 30)** size making it that subset of rectangles that we call a square.

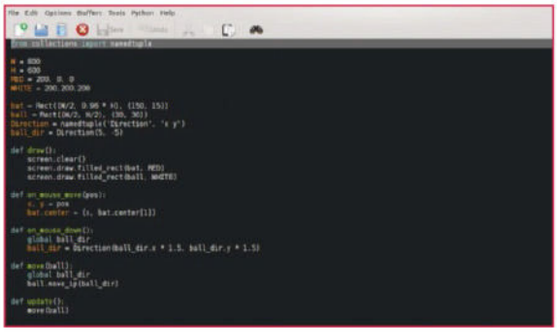
We're doing this because **Rect** is another built-in in Pg0. If we wanted a circular ball, we'd have to define a class and then use Pygame's **draw.filled_circle(pos, radius, (r, g, b))** - but **Rect** we can call directly. Simply add:

```
WHITE = 200,200,200
ball = Rect((W/2, H/2), (30, 30))
```

... to the initial variable assignments, and:

```
    screen.draw.filled_rect(ball, WHITE)
```

... to the **def draw()** block.



11 Action!

Now let's make the ball move. Download the tutorial resources in **FileSilo.co.uk** and then add the code inside the 'move.py' file to assign movement and velocity. Change the **5** in **ball_dir = Direction(5, -5)** if you want the ball slower or faster, as your processor (and dexterity) demands – but it's hard to tell now because the ball goes straight off the screen! Pg0 will call the **update()** function you define once per frame, giving the illusion of smooth(ish) scrolling if you're not running much else.

12 def move(ball)

To get the ball to move within the screen we need to define **move(ball)** for each case where the ball meets a wall. For this we use **if** statements to reverse the ball's direction at each of the boundaries. Refer to the full code listing on page 67.

Note the hardcoded value of 781 for the width of screen, minus the width of ball – it's okay to hardcode values in early versions of code, but it's the kind of thing that will need changing if your project expands. For example, a resizable screen would need a value of **W - 30**.

13 Absolute values

You might expect multiplying y by minus one to work for reversing the direction of the ball when it hits the bat:

```
ball_dir = Direction(ball_dir.x, -1 * ball_dir.y)
```

... but you actually need to use **abs**, which removes any minus signs, then minus:

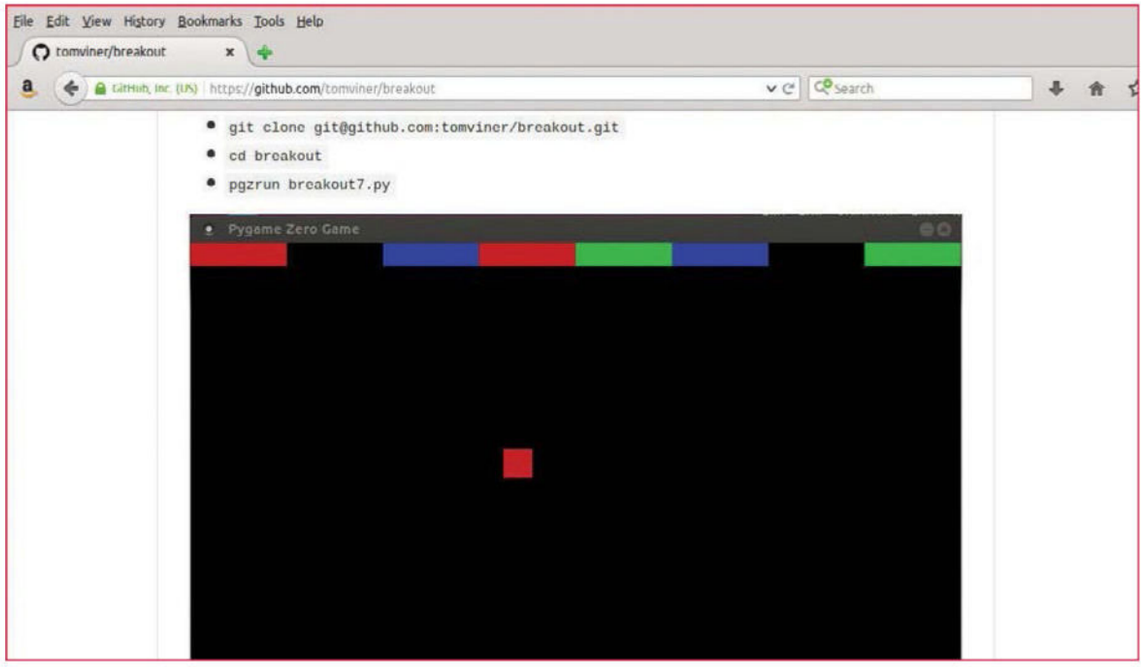
```
ball_dir = Direction(ball_dir.x, - abs(ball_dir.y))
```

Try it without in the finished code and see if you get some strange behaviour. Your homework is to work out why.

> To get the ball to move we need to define **move(ball)** for each case where the ball meets a wall

Full code listing

```
## Breakout type game to demonstrate Pygame Zero library
## Based originally upon Tim Viner's London Python Dojo
## demonstration
## Licensed under MIT License - see file COPYING

from collections import namedtuple
import pygame
import sys
import time

W = 804
H = 600
RED = 200, 0, 0
WHITE = 200,200,200
GOLD = 205,145,0

ball = Rect((W/2, H/2), (30, 30))
Direction = namedtuple('Direction', 'x y')
ball_dir = Direction(5, -5)

bat = Rect((W/2, 0.96 * H), (120, 15))

class Block(Rect):

    def __init__(self, colour, rect):
        Rect.__init__(self, rect)
        self.colour = colour

blocks = []
for n_block in range(24):
    block = Block(GOLD, ((((n_block % 8)* 100) + 2, ((n_block //
                    8) * 25) + 2), (96, 23)))
    blocks.append(block)

def draw_blocks():
    for block in blocks:
        screen.draw.filled_rect(block, block.colour)

def draw():
    screen.clear()
    screen.draw.filled_rect(ball, WHITE)
    screen.draw.filled_rect(bat, RED)
    draw_blocks()

def on_mouse_move(pos):
    x, y = pos
    bat.center = (x, bat.center[1])

def on_mouse_down():
    global ball_dir
    ball_dir = Direction(ball_dir.x * 1.5, ball_dir.y * 1.5)
```



Right Tom Viner's array of blocks negates the need for bordered rectangles

14 Sounds

Also upon bat collision, **sounds.blip.play()** looks in the sounds subdirectory for a sound file called blip. You can download the sounds (and finished code) from **FileSilo.co.uk**.

Actually, now we think about it, ignore the previous comment about homework – your real homework is to turn what we've written so far into a proper game of *Pong*! But first let's finish turning it into *Breakout*!

15 Blockhead!

If you're not very familiar with the ancient computer game *Breakout*, then:

```
apt-get install lbreakout2
```

... and have a play. Now, we haven't set our sights on building something quite so ambitious in just these six pages, but we do need blocks.

16 Building blocks

There are many ways of defining blocks and distributing them onto the screen. In Tom Viner's team's version, from the London Python Dojo – which was the code that originally inspired this author to give this a go – the blocks are sized in relation to number across the screen, thus:

```
N_BLOCKS = 8
BLOCK_W = W / N_BLOCKS
BLOCK_H = BLOCK_W / 4
BLOCK_COLOURS = RED, GREEN, BLUE
```

Using multicoloured blocks which are then built into an array means that blocks can join without needing a border. With its defining variables in terms of screen width, it's good sustainable code, which will be easy to amend for different screen sizes – see **github.com/tomviner/breakout**.

However, the array of colour bricks in a single row is not enough for a full game screen, so we're going to build our array from hard-coded values...

17 Going for gold

Create a Block class:

```
class Block(Rect):

    def __init__(self, colour, rect):
        Rect.__init__(self, rect)
        self.colour = colour
```

... and pick a nice colour for your blocks:

```
GOLD = 205,145,0
```

18 Line up the blocks

This builds an array of 24 blocks, three rows of eight:

```
blocks = []
for n_block in range(24):
    block = Block(GOLD, ((((n_block % 8)* 100) + 2,
                ((n_block // 8) * 25) + 2), (96, 23)))
    blocks.append(block)
```

19 Drawing blocks

Draw_blocks() is added to **def draw()** after defining:

```
def draw_blocks():
    for block in blocks:
        screen.draw.filled_rect(block, block.colour)
```

20 Block bashing

All that remains with the blocks is to expand **def move(ball)** – to destroy a block when the ball hits it.

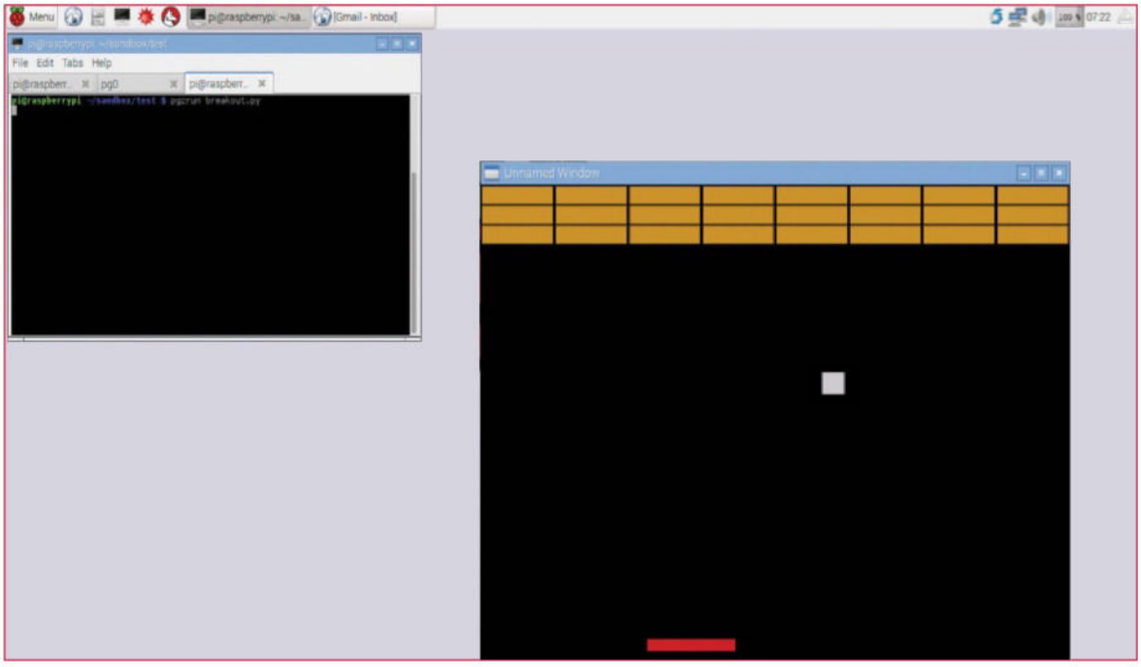
```
to_kill = ball.collidelist(blocks)

if to_kill >= 0:
    sounds.block.play()
    ball_dir = Direction(ball_dir.x, abs(ball_dir.y))
    blocks.pop(to_kill)
```

Pg0 +1

There's a new version of Pg0 in development – it may even be out as you read this. Pg0 creator Daniel Pope tells us "a tone generation API is in the works," and that at the Pg0 PyConUK sprint, "we finished Actor rotation."

Contributions are welcome – not only to the Pg0 code, but more examples are needed not just to show what can be done, but to give teachers tools to enthuse children about the creative act of programming.

Pg0 has also inspired GPIO Zero, to make GPIO programming easier on the Raspberry Pi, with rapid development occurring on this new library as we go to press.



Left Test your game once it's finished – then test other people's *Breakout* games to see how the code differs

21 Game over

Lastly, we need to allow for the possibility of successfully destroying all blocks.

```
if not blocks:
    sounds.win.play()
    sounds.win.play()
    print("Winner!")
    time.sleep(1)
    sys.exit()
```

22 Score draw

Taking advantage of some of Pygame Zero's quickstart features, we've a working game in around 60 lines of code. From here, there's more Pg0 to explore, but a look into Pygame unmediated by the Pg0 wrapper is your next step but one.

First refactor the code; there's plenty of room for improvement – see the example 'breakout-refactored.py' in your tutorial resources. Try adding scoring, the most significant absence in the game. You could try using a global variable and writing the score to the terminal with **print()**, or instead use **screen.blit** to put it on the game screen. Future versions of Pg0 might do more for easy score keeping.

23 Class of nine lives

For adding lives, more layers, and an easier life-keeping score, you may be better defining the class **GameClass** and enclosing much of the changes you wish to persist within it, such as **self.score** and **self.level**. You'll find a lot of Pygame code online doing this, but you can also find Pg0 examples, such as the excellent pi_lander example by Tim Martin: **github.com/timboe/pi_lander**.

24 Don't stop here

This piece is aimed at beginners, so don't expect to understand everything! Change the code and see what works, borrow code from elsewhere to add in, and read even more code. Keep doing that, then try a project of your own – and let us know how you get on.

Full code listing (cont.)

```
def move(ball):
    global ball_dir
    ball.move_ip(ball_dir)

    if ball.x > 781 or ball.x <= 0:
        ball_dir = Direction(-1 * ball_dir.x, ball_dir.y)
    if ball.y <= 0:
        ball_dir = Direction(ball_dir.x, abs(ball_dir.y))

    if ball.colliderect(bat):
        sounds.blip.play()
        ball_dir = Direction(ball_dir.x, - abs(ball_dir.y))

    to_kill = ball.collidelist(blocks)

    if to_kill >= 0:
        sounds.block.play()
        ball_dir = Direction(ball_dir.x, abs(ball_dir.y))
        blocks.pop(to_kill)

    if not blocks:
        sounds.win.play()
        sounds.win.play()
        print("Winner!")
        time.sleep(1)
        sys.exit()

    if ball.y > H:
        sounds.die.play()
        print("Loser!")
        time.sleep(1)
        sys.exit()

def update():
    move(ball)
```

Hacks

132 Build a Raspberry Pi-controlled car

138 Raspberry Pi car computer

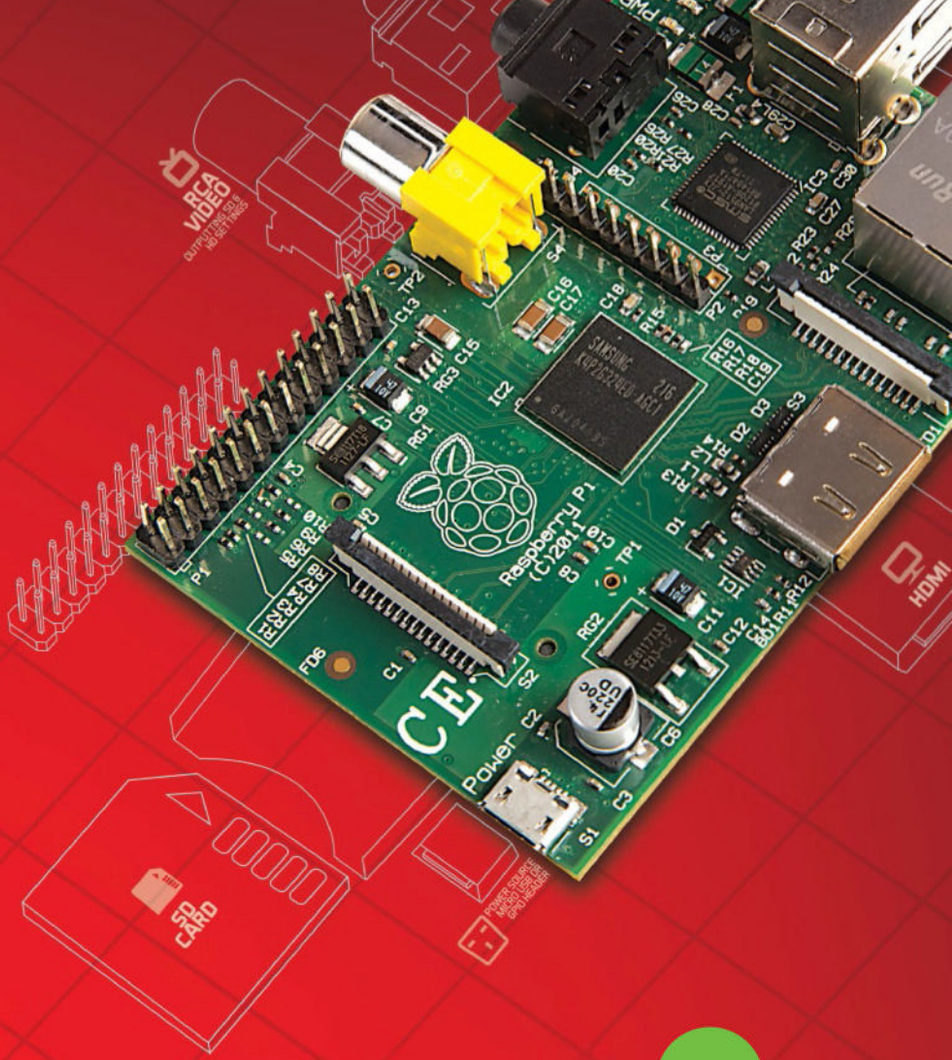
146 Build a Minecraft Power glove

150 Build a super Raspberry Pi

144

138

"Learn about the technologies that are starting to power the world's newest and biggest economy"



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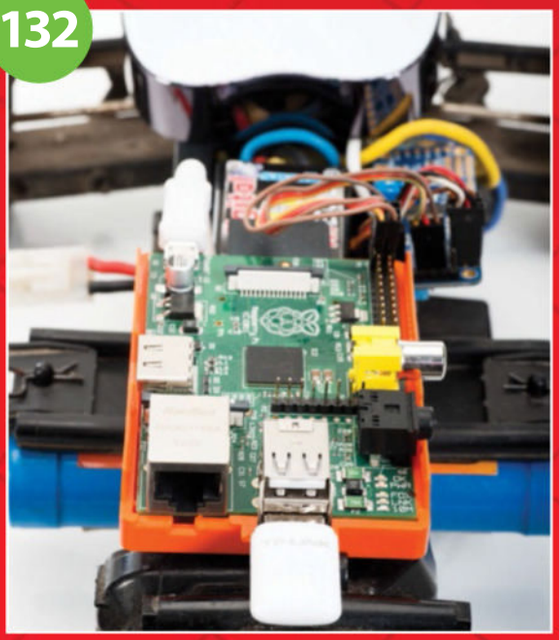
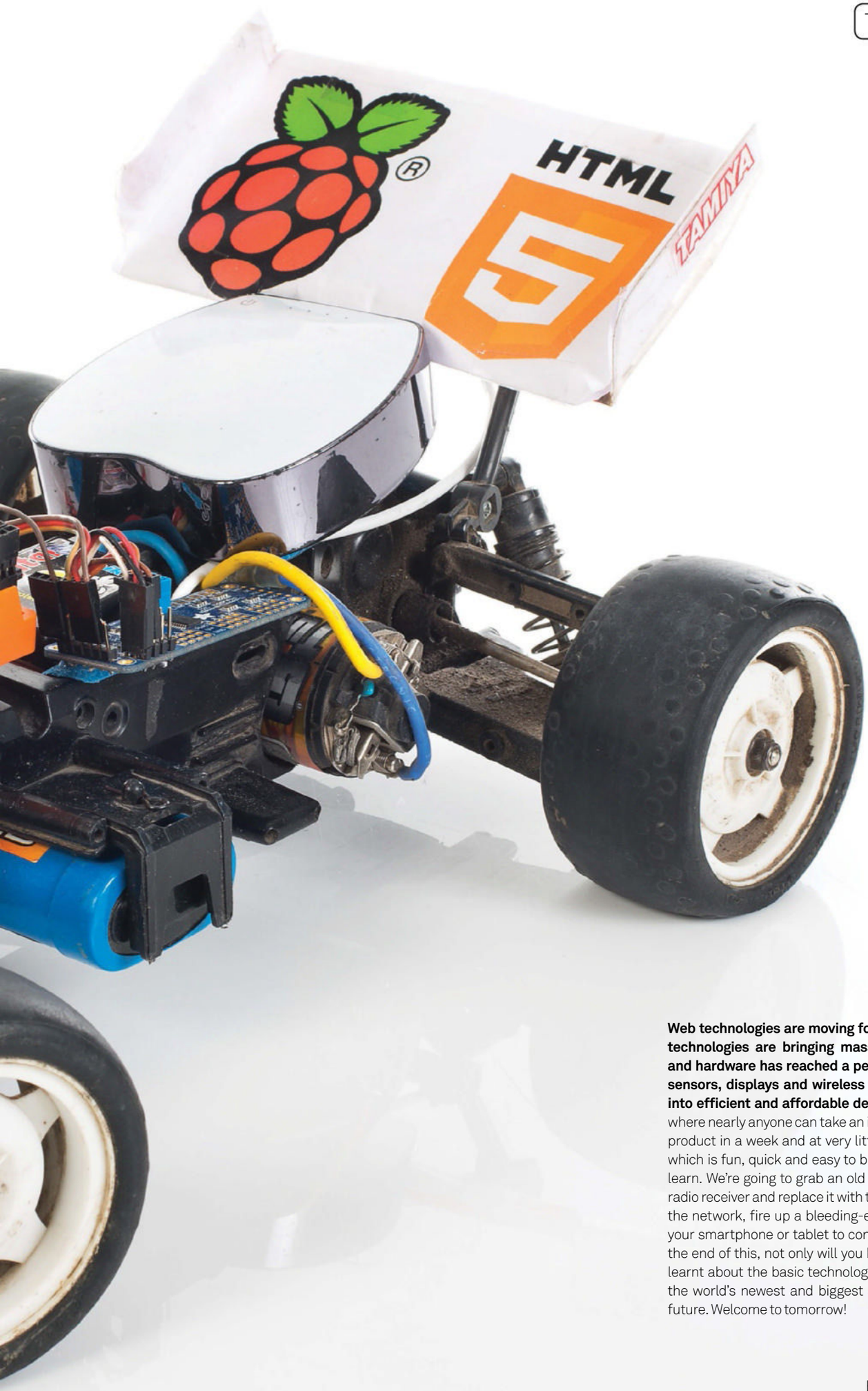


150

146

Build a Raspberry Pi-controlled car

Make use of cutting-edge web technologies to take control of a remote controlled car with a smartphone or tablet...



Web technologies are moving forward at a huge pace, cloud technologies are bringing mass computing to individuals, and hardware has reached a perfect moment in time where sensors, displays and wireless technology have all evolved into efficient and affordable devices. We truly are at a point where nearly anyone can take an idea from nothing to a working product in a week and at very little cost. Just like this project, which is fun, quick and easy to build on and a fantastic way to learn. We're going to grab an old remote-control car, rip off its radio receiver and replace it with the Raspberry Pi, hook it up on the network, fire up a bleeding-edge web server and then get your smartphone or tablet to control it by tilting the device. By the end of this, not only will you have a fun toy – you will have learnt about the basic technologies that are starting to power the world's newest and biggest economy for the foreseeable future. Welcome to tomorrow!

Raspberry Pi-controlled car build process

Components list

- A toy RC car with two channels (steering and drive)
- Adafruit PWM I2C servo driver
- Female-to-female jumper cables
- 5V battery power bank

Estimated cost: **£60 / $100**

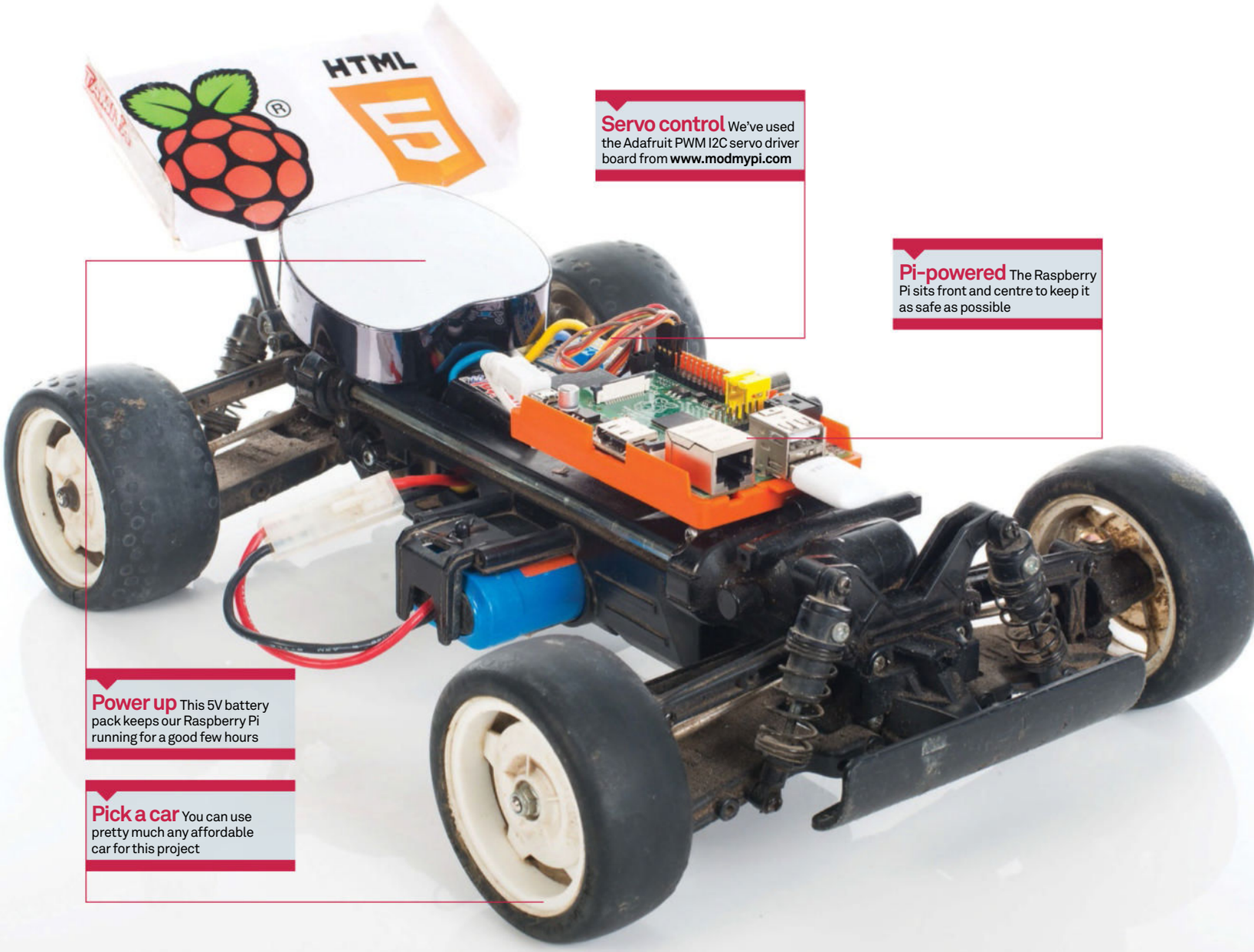
Components from www.modmypi.com

Before you can take control of your car with a smartphone, you'll need to make some significant changes to the chassis

To help our toy car come to life using the latest web technologies and our credit card-sized computer, we're going to need to make some pretty significant changes to its workings. Fortunately, the most complex aspects of the build can be accomplished with a couple of affordable purchases, namely a servo controller board to take care of the steering and throttle, and a 5V battery pack to keep the Raspberry Pi running smoothly.

01 Identify and remove old radio

This project is effectively replacing the car's normal transmitter and receiver. Notice the three sockets on the original receiver: one goes to the motor controller and one to the steering servo. Some remote-control cars also have separate battery for the electronics, but those (especially with an electronic speed controller with BEC) get their 5V power supply directly from the speed controller, saving on components. If you don't have a speed controller with 5V BEC, you'll need to get a 5V supply elsewhere. Many shops sell 5V battery power supplies – often as mobile phone emergency top-ups. **www.modmypi.com** sells a suitable 5V battery power bank for under £20.



Servo control We've used the Adafruit PWM I2C servo driver board from **www.modmypi.com**

Pi-powered The Raspberry Pi sits front and centre to keep it as safe as possible

Power up This 5V battery pack keeps our Raspberry Pi running for a good few hours

Pick a car You can use pretty much any affordable car for this project

We're using the Raspberry Pi's I2C bus to control the servo interface board

02 Attach the servo cables to the new controller

We soldered our 16-channel I2C servo controller board from **www.modmypi.com** as per its instructions and simply plugged channel 0 (steering) and channel 1 (motor) headers onto it. There are six cables in total: the bottom two are ground, the middle two are the power and the top two are the PWM (pulse-width modulation) signals. This is a good time to think of places to mount the extra components and the best fixing method seems to be sticky-back Velcro.

03 Connect the I2C bus to the Raspberry Pi

We're using the Raspberry Pi's I2C bus to control the servo interface board, which only needs four cables – they all go between the Raspberry Pi and the servo controller board as pictured. This month's accelerometer tutorial explains how to set up I2C on the Raspberry Pi.

From top to bottom we need to use the 1. GND, 2. SCL, 3. SDA and 4. VCC, which map directly to the same ports on the Raspberry Pi. Essentially this is power, ground and two communication channels – it's all pretty straightforward so far...

04 Hooking it up to the Raspberry Pi

On a Rev 1 Raspberry Pi, the cables look the same. Though the Rev boards have different labelling, the physical pins are in the same place. Bottom left (closest to the RasPi power connector) is the 3.3V power; next to that is the SDA header, which is the data channel. Next to that in the bottom right is the SCL channel, which controls the clock of the I2C devices. And finally – on the top-right port – is the Ground.

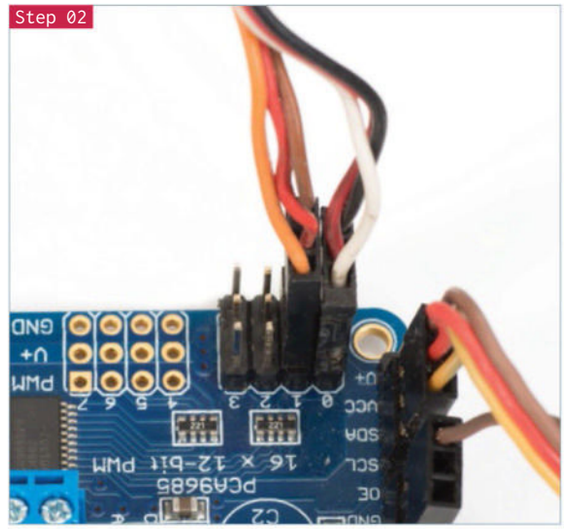
05 Overview of the main components

You should now have the servo board in the middle with the steering servo and speed controller on one side and the Raspberry Pi on the other. The motor is connected to the other end of the speed controller (that end should have much thicker wires); the speed controller also has two thick wires going to the main car's battery – in this case a 7.2V NiCad. We now have two very separate power systems with the high current motors on one side and the low current electronics on the other. Let's make sure it stays that way!

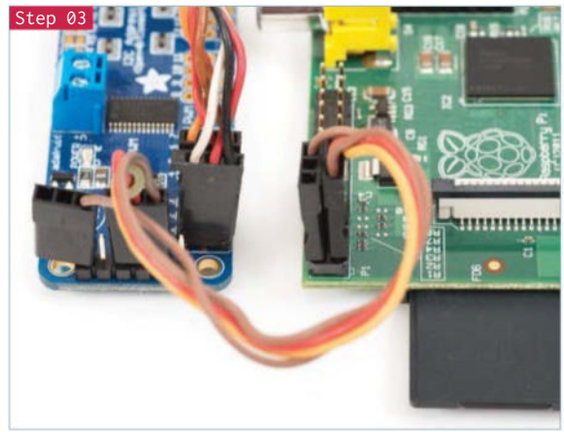
06 Find everything a home

Now it's time to find a home for the new components. Use plenty of sticky-back Velcro, tie wraps or elastic bands to keep everything secure and find spaces in the car's body to hide the wires where possible. While it is possible to stick or screw the Raspberry Pi directly to the car, we recommend to use at least the bottom half of a case for added protection and ease of access. Insert your SD card, network cable or Wi-Fi dongle (if programming from another machine) and power supply. Sit back and admire your hacking. Next we'll tackle the software side of the project...

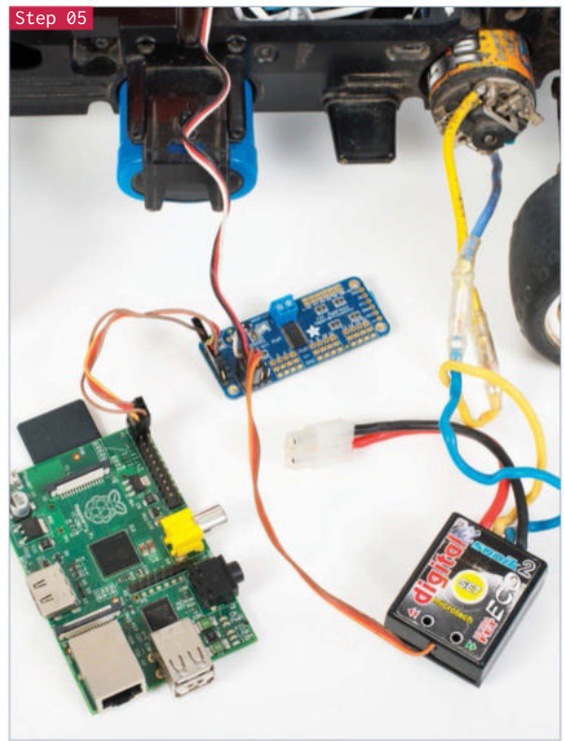
Step 02



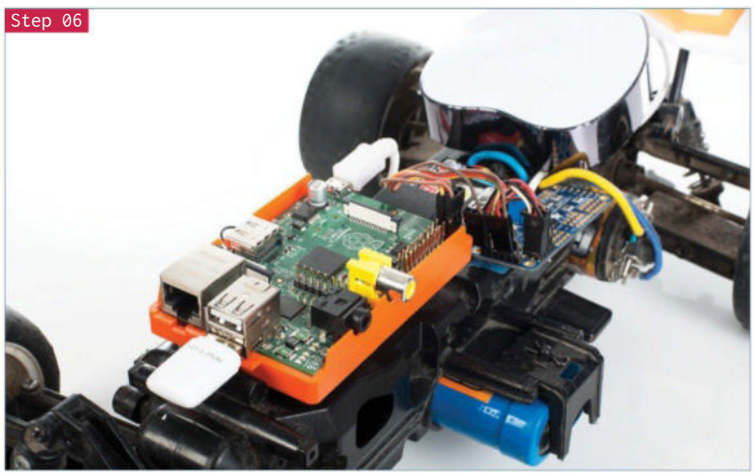
Step 03



Step 05



Step 06



Controlling your Raspberry Pi-powered car

Control a toy car with a smartphone and the latest web technologies

Now we have our fantastic Raspberry Pi-powered car all wired and charged, it's time to make it come alive. We're using the best web technologies that the JavaScript programming language offers, to harness the natural movement of your hand and wirelessly drive the vehicle. Each little movement will trigger an event that calculates what the car should do and then sends it over a socket connection up to 20 times a second.

What you'll need

- A RasPi car, ready to go
- An internet connection
- A reasonably modern smartphone/tablet
- Pi car source code
  github.com/shaunuk/picar

01 Download and install the software

To get the I2C connectivity working, you can follow the steps from pages 64-65. Next we'll need to find a home for our new project code – how about **/var/www/picar**? Type **sudo mkdir /var/www/picar** in the terminal to make the directory and then change into that directory: **cd /var/www/picar**.

Now, to download the project using Git, type **sudo git clone http://github.com/shaunuk/picar**. If you haven't got Git, install it with **sudo apt-get install git**.

This will download the custom software for driving the car, but we still need the web server and some other bits before we can start burning rubber...

02 Download and install Node.js

We now need to get the awesome Node.js and its package tool, the Node package manager (npm). Type **sudo wget http://nodejs.org/dist/v0.10.21/node-v0.10.21-linux-arm-pi.tar.gz**. This will download a fairly recent version of Node.js – the version Raspbian has in its repositories is way too old and just doesn't work with the new technologies we're about to use. Extract the node package by typing **sudo tar -xvzf node-v0.10.21-linux-arm-pi.tar.gz**.

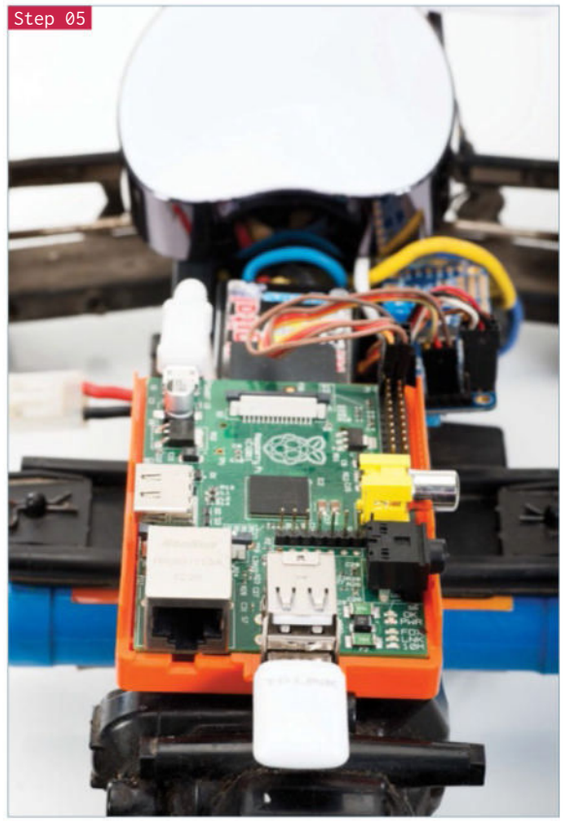
03 Configure Node.js

To make it easy to run from everywhere, we will create symbolic links for Node and npm binaries. In the terminal, type **sudo ln -s /var/www/node-v0.10.21-linux-arm-pi/bin/node /bin/node** and then **sudo ln -s /var/www/node-v0.10.21-linux-arm-pi/bin/npm /bin/npm**. Then, to get the extra modules, type **npm install socket.io node-static socket.io adafruit-i2c-pwm-driver sleep optimist**

04 Get to know the project

Now we have everything, you should see three files: the server (**app.js**), the client (**socket.html**) and the jQuery JavaScript library for the client. The server not only drives the servos, but it is a web server and sends the socket.html file and jQuery to the browser when requested – it's a really neat and simple setup and just right for what we're trying to achieve.

Step 05



Above You need to adjust some of the variables to control your particular remote controlled car set-up

05 Test the servos

Our handy little program (**app.js**) has a special mode just for testing. We use two keywords here: beta for servo 0 (steering) and gamma for servo 1 (motor control). Type **node app.js beta=300**. You should see the front wheels turn. Now the numbers need experimenting with. On our example, 340 was left, 400 was centre and 470 was right. Do the same for the motor by typing **node app.js gamma=400** and take note of the various limits of your car.

06 Configure sensible defaults

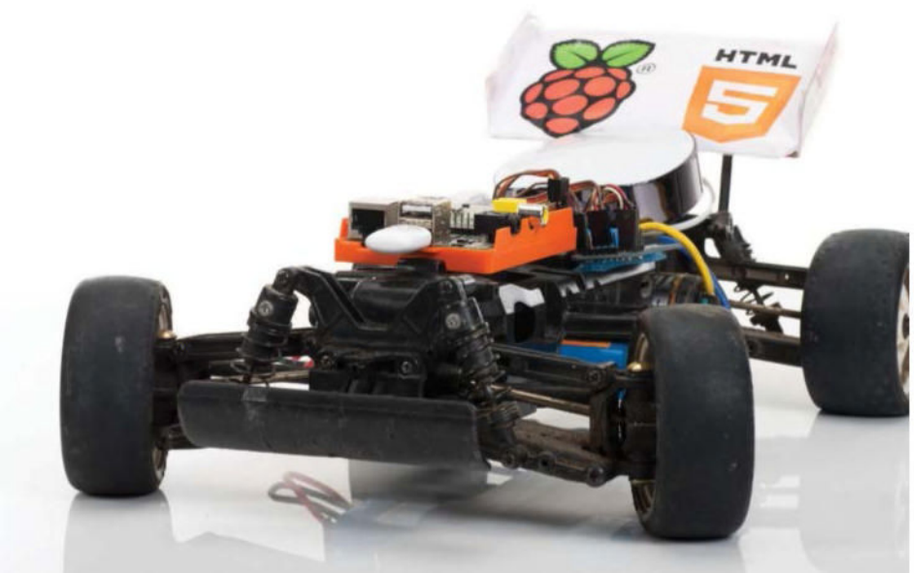
Now you know what your car is capable of, we can set the defaults in app.js and socket.html. Edit app.js and find the section that says 'function emergencyStop'. Adjust the two numbers to your car's rest values. Then open socket.html and adjust the predefined values under 'Define your variables here'.

07 Going for a spin

We're almost ready to try it out, but you need to know the IP address of your Pi car, so type **ifconfig** at the terminal. Then fire up the app by typing **node app.js**. Now grab the nearest smartphone or tablet, making sure it's on the same network as your Pi. Open the web browser and go to **http://[your IP address]:8080/socket.html**. You should get an alert message saying 'ready' and as soon as you hit OK, the gyro data from your phone will be sent to the car and you're off!

Step 07

Below All you need to finish off your project is access to a smartphone or tablet



We'll harness the natural movement of your hand and wirelessly drive the vehicle

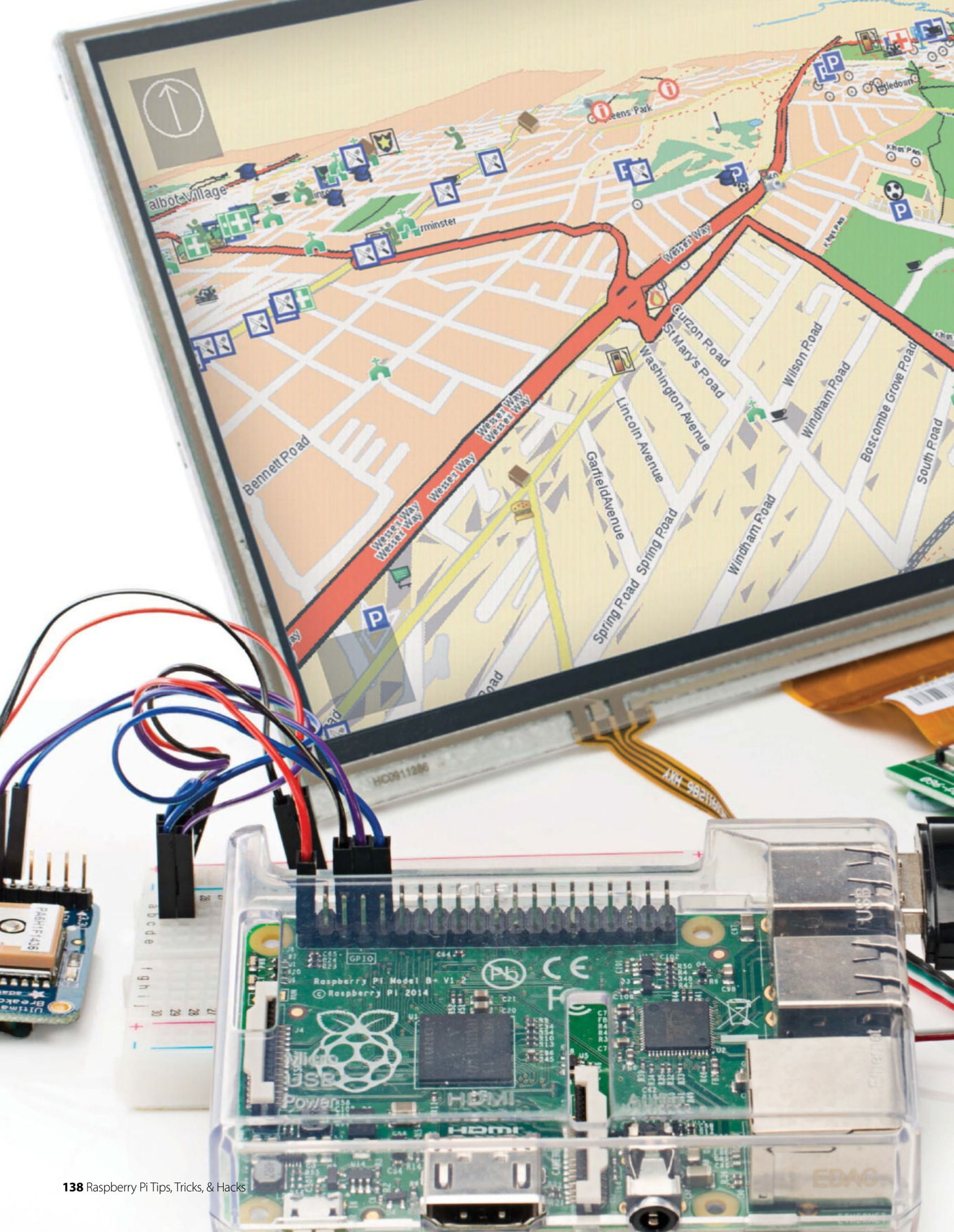
Full code listing

socket.html

```
<html>
<head>
<script src="jquery-2.0.3.min.js" language="javascript"></
script>
<script src="/socket.io/socket.io.js"></script>
<meta name="viewport" content="user-scalable=no, initial-
scale=1.0, maximum-scale=1.0;" />
<script>

//------ Define your variables here
var socket = io.connect(window.location.hostname+':8080');
var centerbeta = 400; //where is the middle?
var minbeta = '340'; //right limit
var maxbeta = '470'; //left limit
var multbeta = 3; //factor to multiply the raw gyro figure ↵
by to get the desired range of steering
var centergamma = 330;
var ajustmentgamma = 70; //what do we do to the angle to get
to 0?
var mingamma = 250; //backwards limit
var maxgamma = 400; //forward limit
var multgamma = 1; //factor to multiply the raw gyro figure ↵
by to get the desired rate of acceleration
window.lastbeta='0';
window.lastgamma='0';

$(function(){
  window.gyro = 'ready';
  alert('Ready -- Lets race !');
});
window.ondeviceorientation = function(event) {
  beta = centerbeta+(Math.round(event.beta*-1)*multbeta);
  if (beta >= maxbeta) {
    beta=maxbeta;
  }
  if (beta <= minbeta) {
    beta=minbeta;
  }
gamma = event.gamma;
  gamma = ((Math.round(event.gamma)+ajustmentgamma)* ↵
multgamma)+ centergamma;
//stop sending the same command more than once
send = 'N';
if (window.lastbeta != beta) { send = 'Y' }
if (window.lastgamma != gamma) { send = 'Y' }
window.lastbeta=beta;
window.lastgamma=gamma;
if (window.gyro == 'ready' && send=='Y')  { //don't send ↵
another command until ready...
  window.gyro = 'notready';
    socket.emit('fromclient', { beta: beta, gamma: gamma } );
    window.gyro = 'ready'; }}
```

app.js

```
//declare required modules
var app = require('http').createServer(handler)
  , io = require('socket.io').listen(app)
  , fs = require('fs')
  , static = require('node-static')
  , sys = require('sys')
  , PwmDriver = require('adafruit-i2c-pwm-driver')
  , sleep = require('sleep')
  , argv = require('optimist').argv;
  app.listen(8080);

//set the address and device name of the ↵
breakout board
pwm = new PwmDriver(0x40,'/dev/i2c-0');

//set pulse widths
setServoPulse = function(channel, pulse) {
  var pulseLength;
  pulseLength = 1000000;
  pulseLength /= 60;
  print("%d us per period" % pulseLength);
  pulseLength /= 4096;
  print("%d us per bit" % pulseLength);
  pulse *= 1000;
  pulse /= pulseLength;
  return pwm.setPWM(channel, 0, pulse);
};
//set pulse frequency
pwm.setPWMFreq(60);
//Make a web server on port 8080
var file = new(static.Server)();
function handler(request, response) {
  console.log('serving file',request.url)
  file.serve(request, response);
};
console.log('Pi Car we server listening on port 8080 visit ↵
http://ipaddress:8080/socket.html');
lastAction = "";
function emergencyStop(){
  pwm.setPWM(0, 0, 400); //center front wheels
  pwm.setPWM(1, 0, 330); //stop motor
  console.log('###EMERGENCY STOP - signal lost or shutting ↵
down');
}
if (argv.beta) {
  console.log("\nPerforming one off servo position move ↵
to: "+argv.beta);
  pwm.setPWM(0, 0, argv.beta); //using direct i2c pwm module
  pwm.stop();
  return process.exit();
}
if (argv.gamma) {
  console.log("\nPerforming one off servo position move ↵
to: "+argv.gamma);
  pwm.setPWM(1, 0, argv.gamma); //using direct i2c pwm module
  pwm.stop();
  return process.exit();
}
//fire up a web socket server
io.sockets.on('connection', function (socket) {
  socket.on('fromclient', function (data) {
  console.log("Beta: "+data.beta+" Gamma: "+data.gamma);
  //exec("echo 'sa "+data+"' > /dev/ttyAMA0", puts); //using ↵
http://electronics.chroma.se/rpisb.php
  //exec("picar.py 0 "+data.beta, puts); //using python ↵
adafruit module
  pwm.setPWM(0, 0, data.beta); //using direct i2c pwm module
  pwm.setPWM(1, 0, data.gamma); //using direct i2c pwm module
  clearInterval(lastAction); //stop emergency stop timer
  lastAction = setInterval(emergencyStop,1000); //set ↵
emergency stop timer for 1 second
  });
});
process.on('SIGINT', function() {
  emergencyStop();
  console.log("\nGracefully shutting down from SIGINT ↵
(Ctrl-C)");
  pwm.stop();
  return process.exit();
});
```


Bennett Road
Wesser Way
Wesser Way
Wesser Way
Wesser Way
Wesser Way
Garfield Avenue
Lincoln Avenue
Washington Avenue
St Mary's Road
Curzon Road
Wilson Road
Windham Road
Boscombe Grove Road
South Road
Spring Road
Spring Road
Windham Road
Raspberry Pi Model B+ V1.2
© Raspberry Pi 2014
GPIO
HDMI
USB
Power

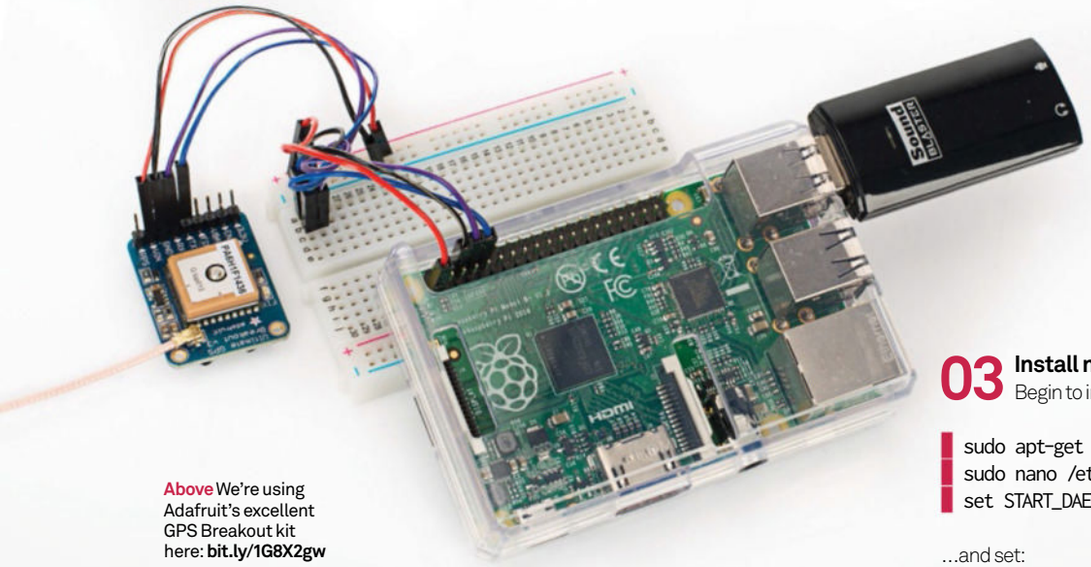
Raspberry Pi Car Computer

Make your own touchscreen navigation system that gives directions, local weather reports and plays music

Cars are getting clever. These days, with smart navigation interfaces built into new cars, you don't need to go out and buy yourself a TomTom to get help with directions. But if you've got a Raspberry Pi then you don't even need to buy that – let alone a new car!

In this project we will show you how to build your own car computer with your Pi, a quality touchscreen like the 9-inch model from SainSmart that we're using here, and a few other bits like a GPS module and USB 3G modem. Your CarPi will be able to use open source navigation software Navit to show your route map on screen, plus speech synthesis to read out directions, and it will also be able to check your location and give you weather reports. It'll work as a music player too, of course.

It's an ambitious project, but you will gain a solid understanding of custom-made interfaces, navigation software and geolocation data, touchscreen calibration, speech synthesis and more. While you don't have to use the same SainSmart screen as us, we do recommend it for this project as it is one of the few large touchscreens out there for the Pi. There are more improvements at the end too, so check the components list, make sure you've got everything and let's get started!

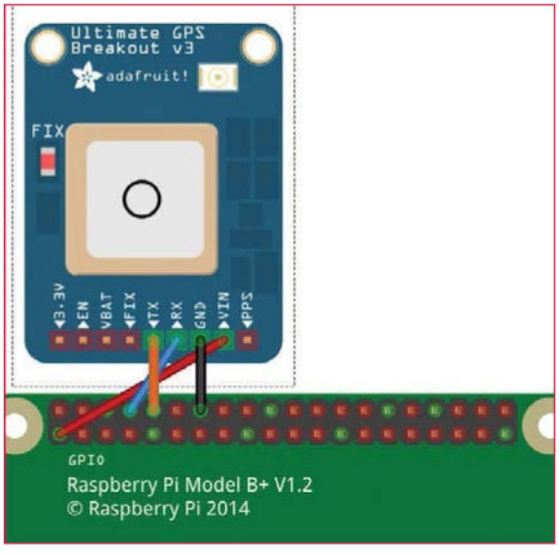


Above We're using Adafruit's excellent GPS Breakout kit here: **bit.ly/1G8X2gw**

01 Basic configuration

Boot up your Raspberry Pi and expand the filesystem using **raspi-config**. Go to Advanced Options and disable the Serial connection – you'll need this to talk to the GPS module later. In raspi-config, enable X at boot as the pi user. Say Yes to reboot. Once rebooted, ensure your packages are up to date with:

```
sudo apt-get update
sudo apt-get upgrade
```



02 Connect GPS module

Solder the pin headers onto the Adafruit GPS module. You can also solder the battery connector which is used to keep the device partially active, giving a faster fix. You only need to use 4 pins: 3.3V, ground, serial transmit and serial receive. Power the Pi off again before connecting anything.

As we are using GPS, the antenna will have to go outside or under a window to gain signal. Connect the antenna to the board and power everything back on. The light on the GPS module will flash frequently while finding a fix. Once it has one, it will blink every 15 seconds.

03 Install navigation software

Begin to install the Navit navigation software by entering:

```
sudo apt-get install navit gpsd gpsd-clients espeak
sudo nano /etc/default/gpsd
set START_DAEMON="true"
```

...and set:

```
DEVICES="/dev/ttyAMA0"
```

Start the GPS daemon with:

```
sudo /etc/init.d/gpsd start
```

You can check it's working by looking at the GPS data with:

```
cgps -s
```

04 Connect the screen

The SainSmart screen doesn't come with any written instructions. Instead there is a YouTube video on their website with details about how to put it together: **bit.ly/1DF6eJJ**. The important part is that the DC power supply should be 12V.

05 Set the screen resolution

We will have to force the correct resolution (1024x600) for the screen by editing /boot/config.txt with sudo. To do so, add the following options:

```
framebuffer_width=1024
framebuffer_height=600
hdmi_force_hotplug=1
hdmi_cvt=1024 600 60 3 0 0 0
hdmi_group=2
hdmi_mode=87
```

For the changes to properly take effect you will need to reboot with `sudo reboot`.

06 Download kernel source

To start the touchscreen, you need to compile an extra kernel module to support it. The program rpi-source (**github.com/notro/rpi-source/wiki**) will find the source of your kernel. Install rpi-source with:

```
sudo wget https://raw.githubusercontent.com/notro/
rpi-source/master/rpi-source -O usr/bin/rpi-source
&& sudo chmod +x /usr/bin/rpi-source && /usr/bin/
rpi-source -q -tag-update
```

Then run `rpi-source` to get the source of the running kernel.

07 Update GCC

Recent Raspberry Pi kernels are compiled with GCC 4.8. Raspbian only comes with 4.6 so you will have to install 4.8 to continue with the following steps. Do this by entering:

```
sudo apt-get install -y gcc-4.8 g++-4.8 ncurses-dev
```

Then you have to set GCC 4.8 as the default:

```
sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-4.6 20
sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-4.8 50
sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-4.6 20
sudo update-alternatives --install /usr/bin/g++ g++ /usr/bin/g++-4.8 50
```

08 Pick the module to compile

Rpi-source puts the kernel source in a folder called 'linux'. To choose the USB Touchscreen Driver, enter the following:

```
cd linux
make menuconfig
Device Drivers -> Input device support -> Generic input layer (needed for keyboard, mouse, ...) -> Touchscreens (press space to include) -> USB Touchscreen Driver (press M to make module)
```

Once you've done that, you then need to make sure you save your changes as '.config' and run scripts/diffconfig to see the differences.

09 Compile and install the module

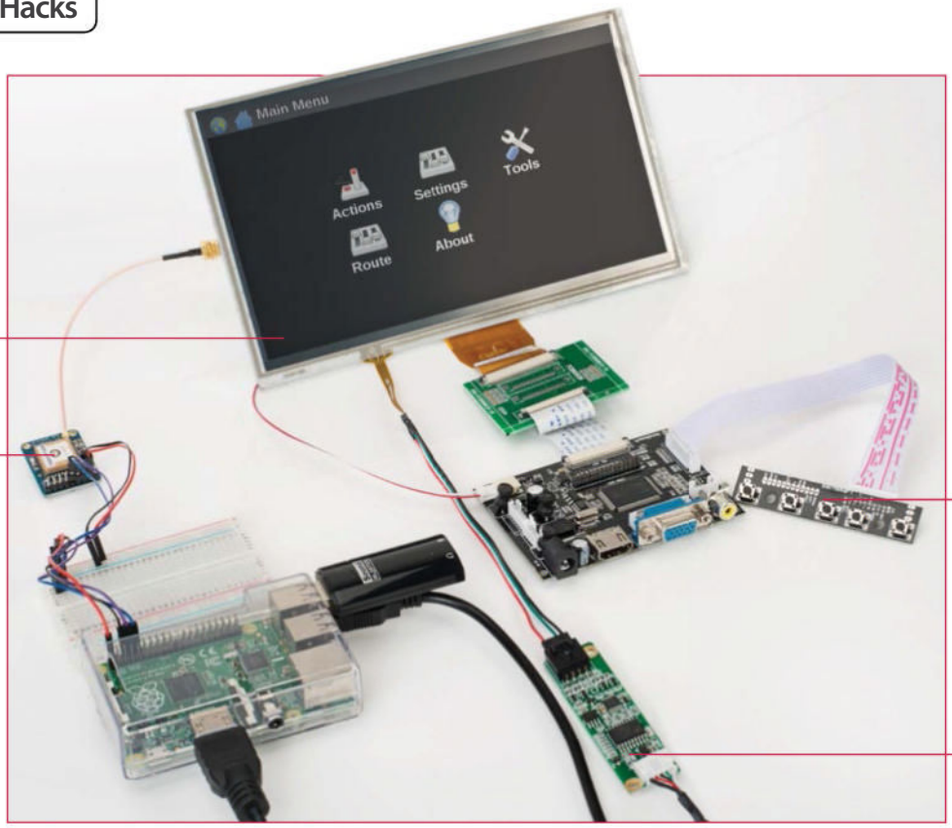
Now you need to compile and install the module. Do so by entering:

```
make prepare
make SUBDIRS=drivers/input/touchscreen modules
sudo make SUBDIRS=drivers/input/touchscreen modules_install
sudo depmod
```

If you unplug and reconnect the touchscreen, it should work fine but it will probably need calibrating.

Full code listing

```
#!/usr/bin/env python2

import os, sys, requests, pygame
from gps import *
from pygame.locals import *

class WeatherClient:
    apikey = "7232a1f6857090f33b9d1c7a74721"

    @staticmethod
    def latlon():
        gpsd = gps(mode=WATCH_ENABLE)

      # Needs better error handling
        try:
            while True:
                report = gpsd.next()
                if report['class'] == 'TPV':
                    gpsd.close()
                    return report['lat'], report['lon']
        except:
            return None, None

    @staticmethod
    def usefuldata(j):
        # Returns a string of useful weather data from a LOT of json
        d = j['data']['current_condition'][0]
        out = "Now - Temp: {0}C, Feels Like: {1}C, Description: {2}\n"\
              .format(d['temp_C'],
                      d['FeelsLikeC'],
                      d['weatherDesc'][0]['value'])

        hourly = j['data']['weather'][0]['hourly']
        hour_count = 1
        for h in hourly:
            out += ("+{0}hr - Temp: {1}C, Feels Like: {2}C, Chance of Rain:"
                    " {3}%, Description: {4}\n")\
                    .format(hour_count,
                            h['tempC'],
                            h['FeelsLikeC'],
                            h['chanceofrain'],
                            h['weatherDesc'][0]['value'])
        hour_count += 1

        # Rstrip removes trailing newline
        return out.rstrip()

    @staticmethod
    def update():
        errstr = "Error getting weather data"

        lat, lon = WeatherClient.latlon()
        if lat == None or lon == None:
            return errstr

        api_req = ("http://api.worldweatheronline.com/free/v2/weather.ashx"
        "?q={0}%2C{1}&format=json&key={2}").format(lat, lon,
                                                  WeatherClient.apikey)
        r = None
```



SainSmart's 9-inch HDMI/VGA touchscreen (**bit.ly/1Ciu4H9**) has a fantastic display and is perfect for all sorts of Pi projects

Adafruit's Ultimate GPS Breakout kit provides Navit and the weather function with the location data that they require

The screen control panel that comes with the SainSmart screen enables you to easily change the display settings (i.e. brightness, contrast, etc) as well as the input (i.e. HDMI, VGA, AV1, etc)

As well as the main controller board, the touch screen is connected to a four-line USB controller which then plugs into the Pi's USB port

10 Calibrate the touchscreen

At this point, you can easily calibrate the touchscreen by entering the following:

```
cd /etc/X11
sudo mkdir xorg.conf.d
cd xorg.conf.d
sudo nano 99-calibration.conf
```

...with the following content:

```
Section "InputClass"
    Identifier "calibration"
    MatchProduct "eGalax Inc. USB TouchController"
    Option    "SwapAxes"    "1"
    Option    "InvertX"     "1"
EndSection
```

Invert X actually inverts Y because the axes have been swapped around. Reboot again for these changes to occur. Now the calibration is roughly correct, download an input calibrator that Adafruit have packaged already.

```
wget http://adafruit-download.s3.amazonaws.com/
xinput-calibrator_0.7.5-1_armhf.deb
sudo dpkg -i xinput-calibrator_0.7.5-1_armhf.deb
DISPLAY=:0.0 xinput_calibrator
```

DISPLAY=:0.0 is useful because you can run the program from any terminal (including an SSH session) and have it appear on the touchscreen. Touch the points on the screen as prompted. Once the program is finished, you should get an output that is similar to the following:

```
Option    "Calibration"    "84 1957 270 1830"
```

Add it to the '99-calibration.conf' file that we created earlier just below the other Option entries.

11 Download maps

Navit needs maps; download them from **maps.navit-project.org**. You can either use the web browser on the Pi or download the map from another machine and copy it using **scp**. Use the predefined area option to select where you live. The smaller the area that you pick, the less data you will have to process. Here the UK has a map size of 608 MB. Now move the map to the navit folder:

```
mkdir -p /home/pi/.navit/maps
mv /home/pi/Downloads/$your_map /home/pi/.
navit/$country.bin
```

For example:

```
mv /home/pi/Downloads/osm_bbox_-9.7,49.6,2.2,61.2.bin
/home/pi/.navit/maps/UK.bin
```

12 Navit configuration

Sudo-edit /etc/navit/navit.xml with your favourite editor. Search for openstreetmaps. Now disable the sample map above, enable the openstreetmap mapset and set the data variable to where you just moved your map. In this case it looks like this:

```
<!-- Mapset template for openstreetmaps -->
<mapset enabled="yes">
<map type="binfile" enabled="yes" data="/home/
 pi/.navit/maps/UK.bin"/>
</mapset>
```

Then search for osd entries similar to:

```
<osd enabled="yes" type="compass"/>
```

...and enable the ones you want – we recommend enabling them all. You may want to zoom in closer than the default map layout. A zoom value of 64 is useful.

Embed the screen

We've looked at the PiTFT and the HDMIPi before, but the SainSmart touchscreen we're using here is uniquely suited to many embedded projects. It's larger than the PiTFT but also without the large bezels of the HDMIPi – and it's incredibly thin –so it's the kind of thing that is really useful for installation projects, whether that's something as simple as a photo slideshow in a real picture frame or a home automation control interface embedded into a cupboard door.

13 Sound configuration

Before configuring speech support for Navit, configure the external sound card. You have to stop the Broadcom module from loading and remove some Raspberry Pi-specific ALSA (Advanced Linux Sound Architecture). To do this, sudo-edit /etc/modprobe and comment out (i.e. prefix with a #):

```
snd-bcm2835
```

Then run:

```
sudo rm /etc/modprobe.d/alsa*
```

Reboot for the changes to take effect. Use alsamixer to set the volume on the if it's too quiet.

14 Download a voice

The speech synthesis software needs a voice and a proprietary binary. You can get both by completing the following steps:

```
sudo mkdir -p /usr/share/mbrola/voices/
wget http://www.tcts.fpms.ac.be/synthesis/mbrola/dba/en1/en1-980910.zip
unzip en1-980910.zip
sudo cp en1/en1 /usr/share/mbrola/voices
wget http://www.tcts.fpms.ac.be/synthesis/mbrola/bin/raspberri_pi/mbrola.tgz
tar zxvf mbrola.tgz
sudo mv mbrola /usr/local/bin/
```

15 Create speech script

Navit supports speech by running an external script and passing the text to speak as an argument. Create one using:

```
cd /home/pi/.navit
wget  http://liamfraser.co.uk/lud/carpi/chime.wav
touch speech.sh
chmod +x speech.sh
```

Now edit speech.sh:

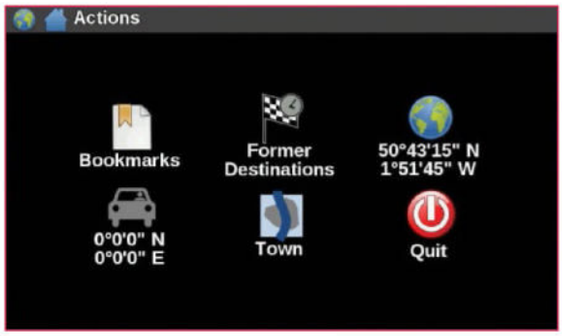
```
#!/bin/bash
aplay -r 44100 /home/pi/.navit/chime.wav
espeak -vmb-en1 -s 110 -a 150 -p 50 "$1"
```

Finally, test it with:

```
./speech.sh "Hello World"
```

Full code listing

```
        try:
            r = requests.get(api_req)
        except requests.exceptions.RequestException as e:
            return errstr

        return WeatherClient.usefuldata(r.json())

class CarLauncher:
    def __init__(self):
        pygame.init()
        pygame.mixer.quit() # Don't need sound
        screen_info = pygame.display.Info()
        self.screen = pygame.display.set_mode((screen_info.current_w,
                                               screen_info.current_h))
        pygame.display.set_caption('Car Launcher')
        self.titlefont = pygame.font.Font(None, 100)
        self.wfont = pygame.font.Font(None, 30)
        self.w_text = None # Weather text

    def clean_background(self):
        background = pygame.Surface(self.screen.get_size())
        self.background = background.convert()
        self.background.fill((0, 0, 0))

        # Render title centered
        text = self.titlefont.render("CarPi Launcher", 1, (255, 255, 255))
        textpos = text.get_rect()
        textpos.centerx = self.background.get_rect().centerx
        self.background.blit(text, textpos)

        self.screen.blit(self.background, (0,0))
        pygame.display.flip()

    def main_menu(self):
        # btns maps Text -> Rectangles we can do collision detection on
        self.btns = {'Music' : None, 'NAV' : None, 'Weather' : None}

        item_num = 1
        for key in self.btns:
            text = self.titlefont.render(key, 1, (255,255,255))
            textpos = text.get_rect()
            max_width = self.background.get_rect().width / len(self.btns)
            center_offset = max_width * 0.5
            # This y pos puts buttons just below title
            textpos.centery = self.background.get_rect().centery / 2
            textpos.centerx = (max_width * item_num) - center_offset
            self.btns[key] = textpos
            self.screen.blit(text, textpos)
            item_num += 1

        pygame.display.flip()

    def select_rect(self, rect, text):
        # Colour a rect the user has clicked in green
        surface = pygame.Surface((rect.w, rect.h))
        surface.fill((0, 255, 0))
        # Now we have to draw the text over it again
        t = self.titlefont.render(text, 1, (255,255,255))
        surface.blit(t, (0,0))
        self.screen.blit(surface, rect)
        pygame.display.flip()
```



Above The Navit software comes with a host of options built into its menu hierarchy

Above The pympdtouchgui front-end for the music player is surprisingly featureful

You will need to write your own launcher for CarPi

Make it mobile

It is definitely best to put this project together in a clean workspace so that you can clearly see what you're working with and ensure everything is correctly wired and soldered, but the point of the project is to make this setup portable so that you can put it in your car and use it on the road. You could install everything into a single, hand-made enclosure or customise a large bought one, or you could secure the various parts inside, for example, your glovebox or car doors. You'll also need to power both the screen and your Pi with a power pack and ensure that the GPS antenna is fastened into a good spot for signal.

16 Configure Navit for speech

The last part is simple. Edit the Navit config file again (/etc/navit/navit.xml) and replace the following line:

```
<speech type="cmdline" data="echo 'Fix the speech tag in navit.xml to let navit say:' '%s'" cps="15"/>
```

...with:

```
<speech type="cmdline" data="/home/pi/.navit/speech.sh %s" cps="10" />
```

Now you can run Navit with **DISPLAY=:0.0 navit** and have fun experimenting.

17 Install the music player

MPD is the music player back-end and pympdtouchgui is the front-end that needs installing manually:

```
sudo apt-get install mpd ncmpcpp
wget http://www.spida.net/projects/software/pympdtouchgui/pympdtouchgui-0.320.tgz
tar zxvf pympdtouchgui-0.320.tgz
cd pympdtouchgui-0.320/
sudo python setup.py install
# Fix hard coded path in software
sudo ln -s /usr/local/share/pympdtouchgui/ /usr/share/pympdtouchgui
```

18 Copy music

Scp (secure copy protocol) was used here to copy music. First get the Pi's IP address by running **ip addr**. Then run **sudo passwd** to set a password for root. From a computer with music on, run:

```
scp -r music_folder root@pi_ip_address:/var/lib/mpd/music/
```

Then on the Pi, change the ownership of the music that you just copied:

```
sudo chown -R mpd:audio /var/lib/mpd/music
```

19 Update mpd music library

Ncmpcpp is a command line client for mpd. Type **ncmpcpp** and press U to update the library. Press 3 to browse the library and check the music is there, and press Q to quit. Pressing 1 will select the help screen if you want to do more.

20 Install awesome window manager

Now you will need to write your own launcher for CarPi, which will run full-screen. To ensure every application is forced to full-screen, use awesome window manager in full-screen mode.

```
sudo apt-get install awesome
sudo rm /etc/alternatives/x-session-manager
sudo ln -s /usr/bin/awesome /etc/alternatives/x-session-manager
```

When changing the default x-session-manager, awesome will be auto-started at boot instead of LXDE. If you reboot the Pi, awesome should then load up automatically.

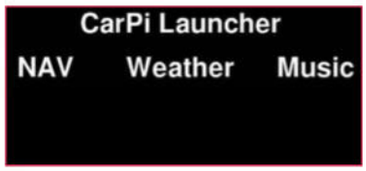
21 Install the requirements for your launcher

The launcher is going to use a weather API combined with location data from the GPS receiver to give weather updates when requested. The nicest HTTP API for Python is requests, which you can install by doing the following:

```
sudo apt-get install python-pip
sudo pip install requests
```

22 Write the launcher code

Creating the code itself is pretty self explanatory, but you can use our ready-made version by downloading the CarPi package from **FileSilo.co.uk** and extracting carlauncher/carlauncher.py.

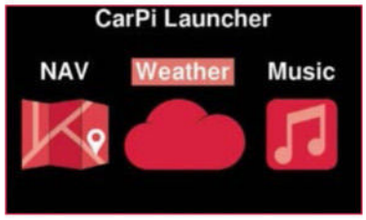


23 Start the launcher automatically

Sudo-edit /etc/xdg/awesome/rc.lua and move awful.layout.suit.max.fullscreen to the top of the layouts list. Add the following to the bottom of the file:

```
awful.util.spawn_with_shell("/home/pi/carlauncher/carlauncher.py")
```

Now reboot again and the launcher should come up automatically.



24 Future improvements

There are a number of improvements that could be made to the base project at this point:

- Make the launcher switch between applications rather than start them again each time
- Make the launcher look better aesthetically with icons
- Use Mopidy instead of MPD so you can use Spotify
- Further Navit configuration to make it more featureful
- An SSD or USB flash drive for storage to make things quicker

Full code listing

```
    def reset(self):
        self.clean_background()
        self.main_menu()
        self.render_weather()

    def execute(self, path):
        os.system(path)
        # os.system blocks so by the time we get here application
        # has finished
        self.reset()

    def render_weather(self):
        if self.w_text == None:
            return

        # Get y starting at the bottom of the nav button
        margin = 10
        y = self.btns['NAV'].bottomleft[1] + margin

        for t in self.w_text.split("\n"):
            line = self.wfont.render(t.rstrip(), 1, (255,255,255))
            line_rect = line.get_rect()
            line_rect.centerx = self.background.get_rect().centerx
            line_rect.y = y
            self.screen.blit(line, line_rect)
            y += margin + line_rect.height

        pygame.display.flip()

    def handle_events(self, events):
        for e in events:
            if e.type == QUIT:
                sys.exit()
            elif e.type == MOUSEBUTTONDOWN:
                pos = pygame.mouse.get_pos()
                # Check if it collides with any of the buttons
                for btn_text, rect in self.btns.iteritems():
                    if rect.collidepoint(pos):
                        self.select_rect(rect, btn_text)
                        if btn_text == "NAV":
                            self.execute("/usr/bin/navit")
                        elif btn_text == "Music":
                            self.execute("/usr/local/bin/pympdtouchgui")
                        elif btn_text == "Weather":
                            self.w_text = WeatherClient.update()
                            # Reset will render weather if string is populated
                            self.reset()

    def loop(self):
        clock = pygame.time.Clock()
        self.reset()

        while 1:
            self.handle_events(pygame.event.get())
            # 5 fps is plenty
            clock.tick(5)

if __name__ == "__main__":
    cl = CarLauncher()
    cl.loop()
```

Build a Minecraft power move glove

Create a piece of wearable tech with power moves assigned to each button to enhance your Minecraft game

Many of you will be avid fans of the game *Minecraft*. In schools it is fast becoming a motivational teaching and learning tool, useful in areas such as programming, creating logic gates and setting up a network.

This project is framed around creating a simple networked *Minecraft* game where one player chases the other and tries to hit the block they are standing on. The real hack is programming a 'power glove' that enables you to assign power moves to each button. These powers can then be deployed and used to slow down the other player and get yourself out of sticky situations – check out the video at bit.ly/1CQSmHS! The real beauty of this hack is that you can then create and customise your own power moves. The possibilities are endless, limited only by your imagination. If you're confident with GPIO pins and setting up buttons, jump straight to Step 8.

01 Update the Raspberry Pi

This project is designed for the Raspberry Pi 2 which requires the updated operating system, although it is compatible with the Raspberry Pi B+ too. First ensure that the software is up to date – open the LX Terminal type:

```
sudo apt-get update
sudo apt-get dist-upgrade
sudo apt-get install raspberrypi-ui-mods
```

02 Connect a button to the Raspberry Pi

Take one of the buttons and connect a wire to each contact, then take the other two ends and connect to the Pi. You may find this easier using a female-to-female connector. To set up a test button, use GPIO pin 17 – this is physical pin number 11 on the board. The other wire connects to a ground pin, shown by a minus sign (the pin above GPIO pin 17 is a ground pin).

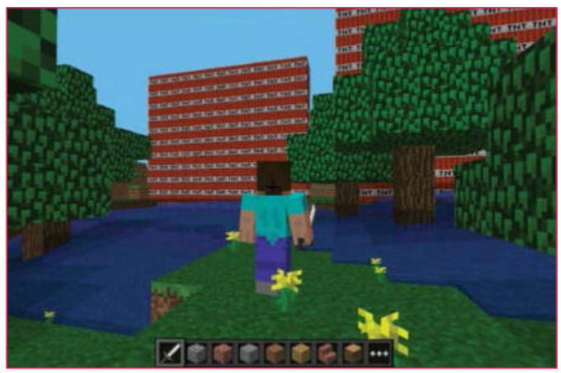
What you'll need

- Raspberry Pi 2
- 4 x 6mm tactile buttons
- Female-to-female jerky
- Terminal blocks
- A glove
- Router
- 2x CAT5 cables

03 Test that the button works

Use this test code to ensure the button is functioning correctly. Once it is, the same setup method can be used throughout this project. To ensure the buttons are responsive, use the pull-up resistor with the code GPIO.PUD_UP – this will ensure that multiple touches aren't registered on each button. Using Python 2.8, type in the code below, then save and run. If working correctly, it will return the message 'Button works'.

```
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)

GPIO.cleanup()
GPIO.setup(17, GPIO.IN, GPIO.PUD_UP)

while True:
    if GPIO.input(17) == 0:
        print "Button works"
```



04 Create a power move

Now to create your first power move. The glove and code are structured in such a way that once the basic code template is set up, you can create your own power moves and assign them to each button, keeping both your ideas and your gameplay fresh. The first power move you will program enables you to place a wall of TNT between you and the player trying to catch you. They have a choice to go around the wall or blow it up, but it will slow them down. In a new Python window, type the code below and save the program into the home folder:

```
import time
def Firewall():
    mc.postToChat("Firewall Placed")
    TNT = 46,1
    x, y, z = mc.player.getPos()
    mc.setBlocks(x-6, y, z+2, x+6, y+10, z+3, TNT)
    time.sleep(10)

while True:
    Firewall()
```

05 Open Minecraft

The updated version of the Raspbian OS comes with *Minecraft* pre-installed, it can be found under Menu>Games – so load it up. If you have used the *Minecraft: Pi Edition* before you will be aware that it runs better in a smaller-sized window, so don't make it full screen. You may prefer to adjust and arrange each window side-by-side to enable you to view both the Python code and the *Minecraft* game at the same time.

PiGlovePowerMoves.py

```
import time
from mcpi import minecraft

mc = minecraft.Minecraft.create("192.168.1.211")
#Replace with the other players IP address

import RPi.GPIO as GPIO

#Set up the GPIO Pins
GPIO.setmode(GPIO.BCM)

#Sets the pin to high
GPIO.cleanup()
GPIO.setup(17, GPIO.IN, GPIO.PUD_UP)
#11 on the BOARD GREEN Firewall
GPIO.setup(18, GPIO.IN, GPIO.PUD_UP)
#12 on the BOARD BROWN Lava
GPIO.setup(9, GPIO.IN, GPIO.PUD_UP)
#21 on the BOARD BLUE Mega Jump
GPIO.setup(4, GPIO.IN, GPIO.PUD_UP)
#7 on the BOARD ORANGE Puddle
GPIO.setwarnings(False)    #switch off other ports

#Builds a wall of TNT which if the player hits will explode
def Firewall():
    mc.postToChat("Firewall Placed")
    TNT = 46,1
    x, y, z = mc.player.getPos()
    mc.setBlocks(x-6, y, z+2, x+6, y+10, z+3, TNT)
    time.sleep(1)

#Lays Lava to slow down the other player
def Lay_Lava():
    Lava = 10
    check = 1
    mc.postToChat("Lava Deployed")
    while check == 1:
        time.sleep(0.2  )
        x, y, z = mc.player.getPos()
        mc.setBlock(x-1, y, z, Lava)
        check = 0

#Peforms a Mega Jump to lose players
def Mega_Jump():
    time.sleep(0.1)
    mc.postToChat("Mega-Jump")
    x, y, z = mc.player.getPos()
    mc.player.setPos(x, y+15, z)
    time.sleep(1)

#Creates a Puddle to slow down your player
def Mega_Water_Puddle():
    mc.postToChat("Mega Water Puddle")
    time.sleep(0.2)
    WATER = 9
    x, y, z = mc.player.getPos()
    mc.setBlocks(x-5, y, z-4, x-1, y, z+4, WATER)
    time.sleep(1)
```

GPIO pins

GPIO pins are a physical interface between the Pi and the outside world. At the simplest level, you can think of them as switches that you can turn on or off (input) or that the Pi can turn on or off (output). The GPIO. BCM option means that you are referring to the pins by the "Broadcom SOC channel" number. GPIO.BOARD specifies that you are referring to the pins by the number of the pin and the plug – the numbers printed on the board.

IP address

Most home networks will use IP addresses that start with 192.168.1 and then a number up to 255. An old router will assign these IP addresses automatically. If the router has Wi-Fi then players can also connect to multiplayer using a USB Wi-Fi dongle; you are setting up a LAN (Local Area Network).

06 Engage the firewall

Start a new *Minecraft* game, then go to the Python program and press F5 to run it. You may need to press the Tab key to release the mouse from the *Minecraft* window. The program will place a 12 x 10 wall of TNT behind the player every ten seconds – you can blow them up but the Pi might lag.

07 Assign the power move to the button

Now you have a working button and a power move, you can combine these two together. Basically, when you press the button the power move will deploy. Once this is working you can then set up the other three buttons with the same method. Open a new Python window and type in the code below – save the file in the home folder. Start a *Minecraft* game as shown in Step 6 and then run the new program. Every time you press the button you will place a TNT firewall.

```
import time
from mcpi import minecraft
mc = minecraft.Minecraft.create()
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)

GPIO.setup(17, GPIO.IN, GPIO.PUD_UP)
#11 on the BOARD

def Firewall():
    mc.postToChat("Firewall Placed")
    TNT = 46,1
    x, y, z = mc.player.getPos()
    mc.setBlocks(x-6, y, z-2, x+6, y+10, z-1, TNT)

while True:
        if GPIO.input(17) == 0:
            Firewall()
```

08 Set up further buttons

Once you have one button working the next step is to set up the other three using the same method from Step 2. Take the button and connect the two wires to either side. At this point you can add all three buttons and test them individually for connectivity. Connect each set of button wires to the GPIO 17 and run the firewall program. If the firewall power move builds on each click of the button, the connections and buttons are working and you're ready to attach the buttons to the glove.

Below If you want to get fancy, try using the popper buttons that Dan added to his Pi Glove 2 project

09 Create the glove

Take your glove and attach the four buttons to the fingers on the glove. There are a number of ways to do this: glue the button on, sew them in, stick them with double-sided tape – the choice is up to you. Wires can be hidden or on display, depending on your preferences and how you want the glove to look.

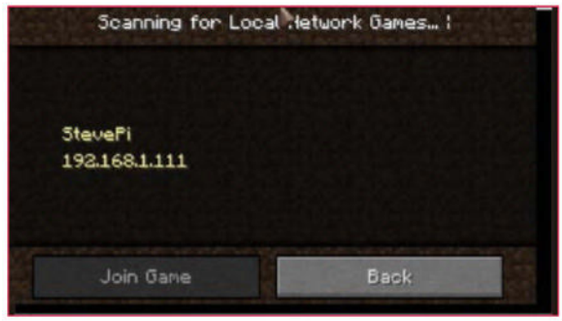
10 Connect the wires

Now you are ready to connect the wires to the Raspberry Pi to enable all four power moves to be used. Take one end of each wire and connect them to the respective pins, as shown below. The other end of the wire is placed into a ground pin. Note that the RPi.GPIO pin numbering system is used here rather than the physical pin number on the board – for example, GPIO pin 17 is physical pin number 11. The following pins are used:

```
GPIO 17, pin 11 on the board
GPIO 18, pin 12 on the board
GPIO 9, pin 21 on the board
GPIO 4, pin 7 on the board
```

11 Set the network up

To interact with other players in the *Minecraft* world you will need to set up a networked multiplayer game. This is simple and can be achieved using an old router. Connect each Raspberry Pi via an ethernet cable to the router and then back to the ethernet port on each Raspberry Pi. Turn on the router and wait about 30 seconds for the IP addresses to be assigned. Now load up *Minecraft* and one of the players will start a new game.



12 Run the game!

After the game has loaded, the other connected player will see an option to "connect to a multiplayer game", usually called Steve. The player selects this option and the networked game will begin. You will be able to see two 'Steves' and the *Minecraft* chat will inform you that 'Steve has joined the game'. Open Python and the glove code, press F5 to run and you will be able to see the power moves being deployed.

13 Interact in another player's world

You'll notice under the current setup that if the Pi Glove is connected to the game and you use one of your power moves, it will only appear in your *Minecraft* world and not in the other players. This isn't great, as the power move is supposed to stop the other player! To resolve this, find the IP address of the other

Raspberry Pi, then enter this IP address into this line of code: **mc = minecraft.Minecraft.create( )**. For example, **mc=minecraft.Minecraft.create("192.168.2.234")**, filling the empty brackets with the IP address of the other Raspberry Pi within your game. Remember that this is the IP address of the other player's Raspberry Pi and not your IP address.

14 Find your IP addresses

To find the IP address of a Raspberry Pi, load the LX terminal, type **ipconfig** and press Enter – the address will be displayed on the line that begins **int addr:**. This is the number that you enter into the **mc = minecraft.Minecraft.create("192.168.2.234")**. Remember on the Glove Raspberry Pi to enter the IP address of the other player's Raspberry Pi, not yours.

15 Run both programs

No game would be complete without some healthy competition and strategy. A second program is deployed by the other player on the network which tracks and registers if they catch or hit you. The program checks the block that they have hit and compares it to the player's location.

16 Test for hits

To check if the other player has hit you, run the second program on the Raspberry Pi of the player who is doing the chasing. The program basically finds the other 'glove' players current position and stores it in a variable. It then compares the position that you hit with your sword, recording and storing this too. The program then compares the values, if they match then you have hit the other player and have won the game. If not, get ready for a tirade of power moves. Note that in order to monitor where the other player is, you must set the code line **mc1 = minecraft.Minecraft.create( )** to the IP address of the Glove Raspberry Pi; for example, **mc1 = minecraft.Minecraft.create("192.168.1.251")**.

17 Game on

Now you are ready to play, check again that the IP addresses are set for the other Raspberry Pi and not your own. Build a new *Minecraft* world and start a new game on the Raspberry Pi with the player who is chasing. When loaded, the glove player joins the multiplayer game – this will be called Steve (see Step 11). When loaded, you should see both players in the world. Then run the 'Pi Glove power moves' program, and on the other Pi run the 'You hit me program'. Don't forget to set the IP addresses to each other Raspberry Pi.

Once set up, you can modify the power moves, use different blocks and add new moves. You could create a timer and a scoring system to track which player can survive the longest. If you are feeling adventurous, you may want to make another Power Glove, one for each player.

> The program compares the values, if they match then you have hit the other player and have won the game. If not, then get ready for a tirade of power moves

PiGlovePowerMoves.py (Cont.)

```
#Main code to run
try:
    lava_check = 0
    mc.postToChat("Minecraft Power Glove Enabled")
    while True:
        if GPIO.input(17) == 0:
            Firewall()
        if GPIO.input(18) == 0: #needs to stop
            Lay_Lava()

            #GPIO.output(18, GPIO.LOW)
        if GPIO.input(9) == 0:
            Mega_Jump()
        if GPIO.input(4) == 0:
            Mega_Water_Puddle()

except:
    print "Error"
```

YouWereHit.py

```
import time
from mcpi import minecraft

mc1 = minecraft.Minecraft.create("192.168.1.245")
#The other players IP address goes here

mc = minecraft.Minecraft.create()
mc.postToChat("###Here I come")
Hit = 1

while Hit == 1:

#Find the block stood on
  stood_x, stood_y, stood_z = mc1.player.getTilePos()
  time.sleep(3)

  blockHits = mc.events.pollBlockHits()
  if blockHits:
    for blockHit in blockHits:
      if stood_z == blockHit.pos.z and stood_y == blockHit.pos.y+1:
        mc.postToChat("I got you")
        time.sleep(2)
        mc.postToChat("###GAME OVER###")
        time.sleep(1)
        Hit = 0
        mc.postToChat("###Restart Hit Code")
```

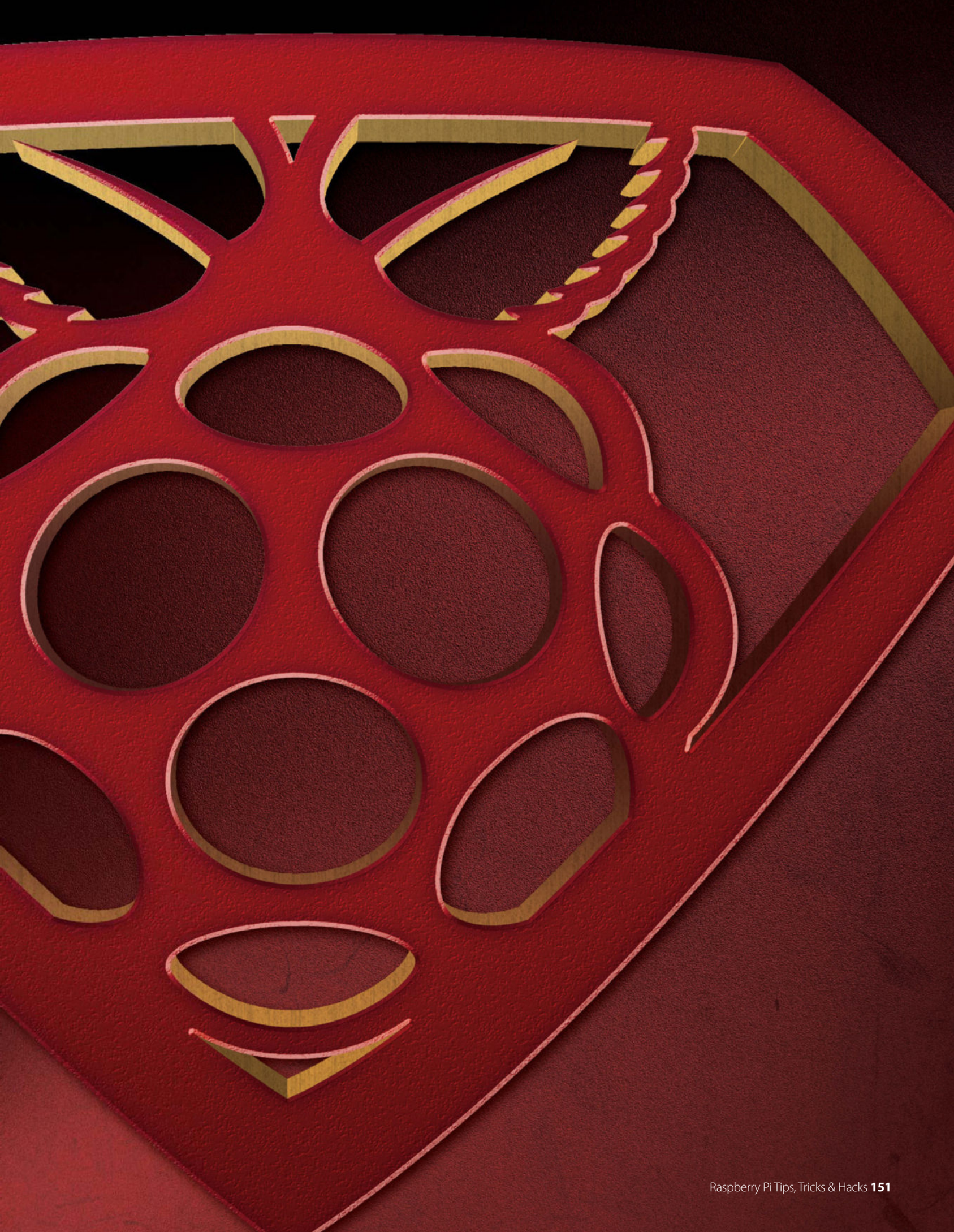
BUILD A SUPER RASPBERRY PI

Pool the resources of multiple Pis to create your own scalable Pi supercomputer

The Raspberry Pi is actually quite powerful for its price. On its own, though, you won't be doing any extraordinary calculations – or compiling or anything strenuous at all, for that matter. However, as it's readily available and fairly cheap, you can get twenty of them for the price of a new computer. Each of them on their own will be no different, but link them together over a network and you can have them share their power and vastly increase the amount they can process.

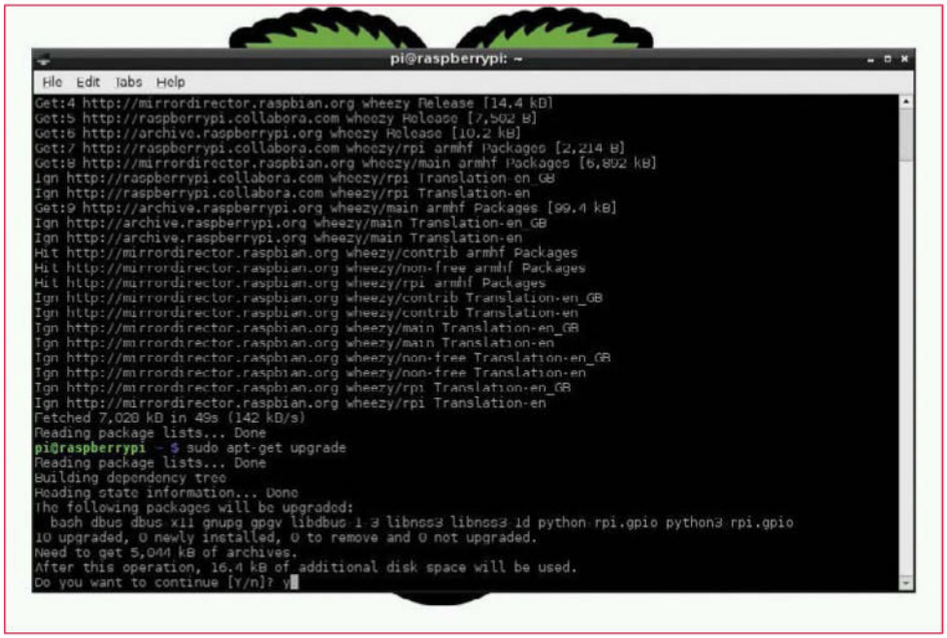
This kind of setup is generally known as a Beowulf cluster, so named for the eponymous hero of the epic poem in which Beowulf is described as having "thirty men's heft of grasp in the gripe of his hand". It's not ridiculously hard to achieve, either – all you need is a lot of Raspberry Pis, a bit of Python know-how and a reason to use it. This makes it a good project for things like classrooms, after-school Pi clubs and the like – really, anywhere there's a collection of Pis available for general use. The more Raspberry Pi nodes you add into the setup, the more powerful it will become, which means you can start with just two or three at home and then gradually add more and more to your cluster, if you want to. And because of the way it all works, you can hook in and control your SuperPi cluster from your main computer as well, making this as accessible at it is scalable.

Over the next few pages we'll show you how to get your Pis set up ready for use, including all the tools you'll need, how to get them all connected and then finally what you can do with all that processing power. We'd love to see your SuperPi once it's finished – drop us a tweet (@Books_Imagine)!



Programming your Pis

Get your Pis set up to talk to one other and share their processing power



Left If you want the SuperPi to become a reality then updating everything is crucial

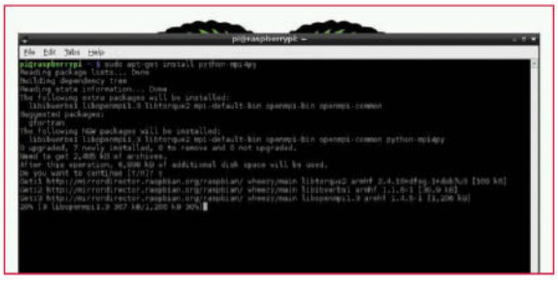
What you'll need

- As many Raspberry Pi computers as you want
- SD card with up-to-date version of Raspbian
- mpi4py MPI python module pypi.python.org/pypi/mpi4py
- Updated firmware on Raspberry Pi

01 Fully updated Pi

It's very important that your Raspberry Pi computers are fully updated for this, so make sure everything is compatible, including the firmware. This can be done with three commands in succession, and make sure you do it on every Pi in turn:

```
$ sudo apt-get update
$ sudo apt-get upgrade
$ sudo rpi-update
```

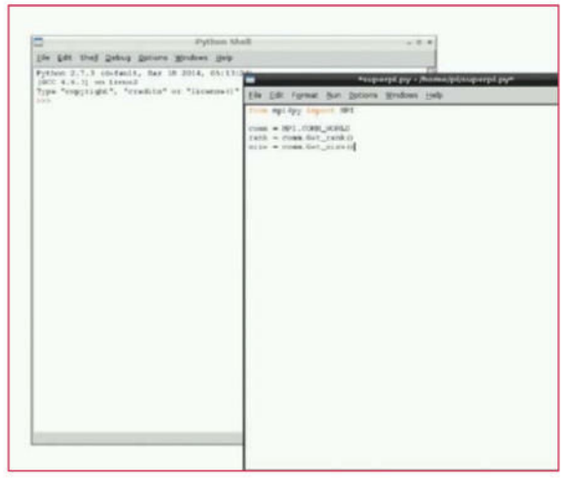


02 Get the MPI module

Install the mpi4py Python module in the terminal by using the following command (again, on every Pi):

```
$ sudo apt-get install python-mpi4py
```

The module will also work on Arch or other Raspberry Pi distros, although you'll need to add it manually or install it via pip.



03 Create your threads

To use MPI in Python, first import it with:

```
from mpi4py import MPI
```

The most important part of the code is telling MPI how to rank the threads and recognise their size. Do this with:

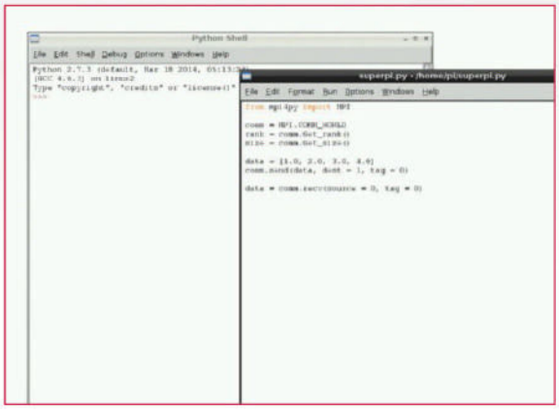
```
comm = MPI.COMM_WORLD
rank = comm.Get_rank()
size = comm.Get_size()
```

Other libraries

The mpi4py library can also be used with Numpy, the numerical and mathematics module for Python. This can be installed using sudo apt-get install python-numpy, and is very useful for doing the kind of large calculations that a cluster would be making. We'll be using it in our example over on the next page, so install it now.

Right You'll need to know the IP addresses of each Raspberry Pi, so be sure to note those all down now

Mpi4py will also work on Arch or other Raspberry Pi distros



04 Send and receive data

Sending data is quite easy: you need to give it a destination thread so MPI knows what it is when it returns, halting the original thread until it does:

```
data = [1.0, 2.0, 3.0, 4.0]
comm.send(data, dest=1, tag=0)

data = comm.recv(source=0, tag=0)
```

The tags allow you to parse what to do with some specific types of data.

05 Run the code

So that's the basics of how your code can be sent throughout a cluster. To actually activate the code and choose the Raspberry Pi recipients, you will need to write this in a terminal:

```
$ mpirun -host 192.168.1.20,192.168.1.21,192.168.1.22
python superpi.py
```

...with the IP addresses being the ones that are on the other Raspberry Pis.

06 Will it work?

What we've done above won't really do anything, but it at least illustrates how you can send code around the network. You can do it for any type of calculating but, due to some of the network lag, it's only worth it for large numbers and bigger data.

Full code listing

```
from __future__ import division

import numpy as np
from mpi4py import MPI

# Grab parutils from FileSilo.co.uk and put it in the same folder
as this. Use it to then print the number of cores used

from parutils import pprint

comm = MPI.COMM_WORLD

pprint("-"*78)
pprint(" Running on %d cores" % comm.size)
pprint("-"*78)

# Set up a ranking structure for the different nodes
my_N = 4
N = my_N * comm.size

if comm.rank == 0:
    A = np.arange(N, dtype=np.float64)
else:
    A = np.empty(N, dtype=np.float64)

my_A = np.empty(my_N, dtype=np.float64)

# Scatter data into my_A arrays
comm.Scatter( [A, MPI.DOUBLE], [my_A, MPI.DOUBLE] )

pprint("After Scatter:")
for r in xrange(comm.size):
    if comm.rank == r:
        print "[%d] %s" % (comm.rank, my_A)
    comm.Barrier()

# Everybody is multiplying by 2

my_A *= 2

# Allgather data into A again and print results
comm.Allgather( [my_A, MPI.DOUBLE], [A, MPI.DOUBLE] )

pprint("After Allgather:")
for r in xrange(comm.size):
    if comm.rank == r:
        print "[%d] %s" % (comm.rank, A)
    comm.Barrier()
```

Construct your SuperPi

Now you've programmed your Raspberry Pi units, it's time to link them together

Programming the Raspberry Pis is one part of constructing your supercomputer – properly housing them together is another problem. The very basic things you require to get them to work is power and a local network via a router and/or switches. This then extends to cases, SD cards and even Raspberry Pis themselves.

To make sure you get the most out of the system, you'll have to get the right selection of components to power and connect them.

> You won't need the maximum amount of power in a cluster, as you won't be powering a display or a camera off the GPIO ports

Power supply

A good power supply is extremely important when powering a Raspberry Pi, otherwise it will power on and run but you won't be able to get the most out of it. If you're using the Model B+ and notice a rainbow square in the corner, that's an indication you're not giving it enough power.

You won't need the maximum amount of power in your cluster, as you won't be powering a display or a camera or possibly anything off the GPIO ports, so the recommended two amps may be a little overpowered for your needs, even if you do push the processor to its limits. However, if you plan to do any overclocking then the two-amp power supply will become more and more necessary, and it's a lot better to be on the safe side.

As your cluster grows you'll also need to make sure you have plenty of surface protection as the Raspberry Pis can be extremely sensitive.

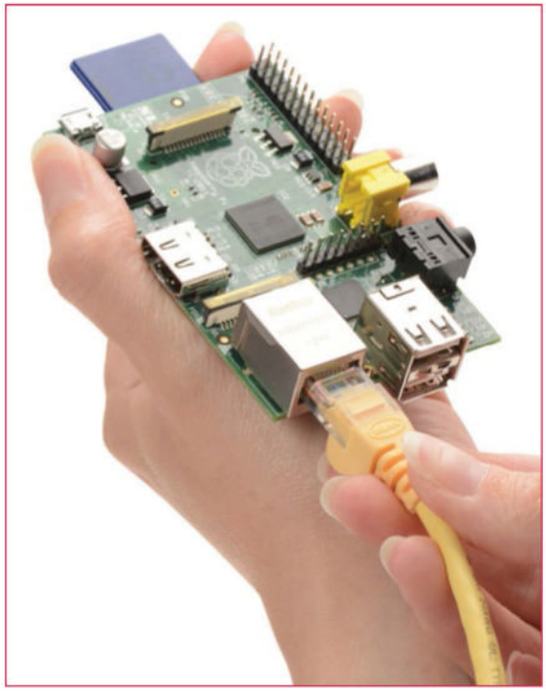
We recommend:

Raspberry Pi Universal Power Supply
pimoroni.com

Networking

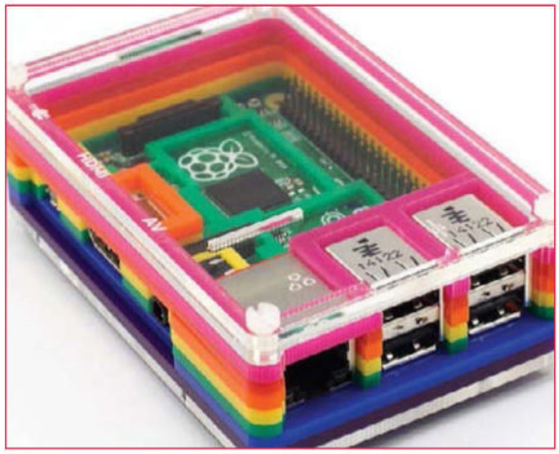
The more Raspberry Pis you plan to connect up, the more networking you will need to hook them together. The best method to do this is via cable, as it will carry any messages faster and with less latency than wireless – but creating the cluster isn't as easy as plugging it into a router, though. With more Pis you'll need more ports, and this can be accomplished by getting network switches. These are dumb connectors that contain no routing or address system, but allow you to connect more devices up to a central router.

Even though we recommend cabling, you can still use wireless to connect extra Pis. This also has the effect of cutting down on the amount of cabling and network switches you can use, but in general it's better to have a homogenous setup.



Overclock

If you find you still want a little extra power from your cluster, you could always try overclocking your Raspberry Pis. In Raspbian, you can do this from the config menu, accessible via sudo raspi-config. In the menu you will find an option to overclock with a few levels to select from. You can do this on separate Raspberry Pis or all of them, but be aware that doing so can shorten the lifespan of a Pi CPU, especially when set to the highest level.



Cases

There are many types of cases for a lot of Raspberry Pi uses: from simplistic plastic cases to protect the Pi from dust, to fully water- and weather-proof metal shells. One of the most versatile cases is the Pimoroni Pibow, which comes in a variety of sizes and configurations for all versions of the Raspberry Pi. The cases are all held together by screws that can easily be repurposed to help mount the Pis in a tower or other configuration so that they don't take up as much horizontal space.

They can be a little slower to get your Raspberry Pi into than some cases, but they're quite durable and easily customisable if you want to move them, or add a small touchscreen or scrolling LCD screen to the main Raspberry Pi to keep an eye on things without needing to SSH in.

We recommend:

Pimoroni PiBow
pimoroni.com

SD cards

SD card selection is a minor but still important factor when creating your cluster. Some Raspberry Pis come with an SD card which should be suitable enough, but others you'll need to buy some cards for. We recommend getting 4GB cards; while a 2GB card will do the job, 4GB allows you to use NOOBS if you have to and is also future-proof for larger distros and operating systems. As the Model B+ requires a micro SD card, make sure you have the right ratio of SD and micro SD cards.

When it comes to getting the SD cards all set up and homogenous, the easiest and quickest method is to first do all the installing and updating on one Raspberry Pi, minus the firmware update with rpi-update. Then create a copy of the disk by putting it into a Linux system, open up the terminal and use:

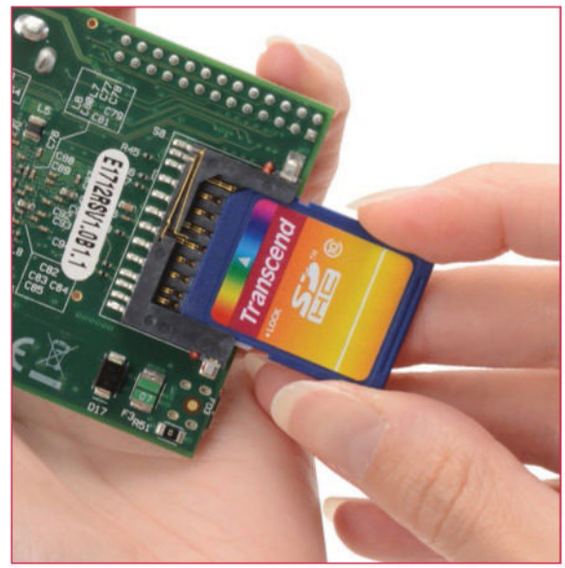
```
sudo dd bs=1M if=/dev/[SD card location] of=superpi.img
```

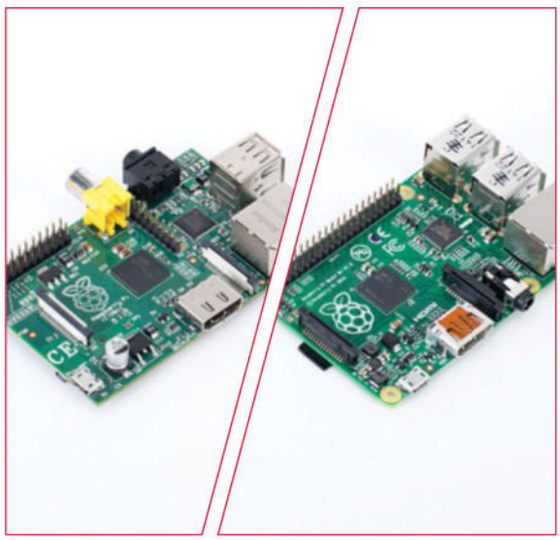
Once it's copied, you can write this to all the other cards using:

```
sudo dd bs=1M if=superpi.img of=/dev/[SD card location]
```

We recommend:

4GB
pimoroni.com





Raspberry Pis

It actually doesn't really matter what type of Raspberry Pi you use in your cluster – you could use a homogenous selection of the latest Model B+ or even have a mixture of the B+, B and Model As connected to each other. As long as you have them running the same software and possessing the relevant scripts, the system will work. The main differences you might encounter are the differing power draws between devices and that the Model As might be slightly slower for some calculations.

The Model A types do have a disadvantage in that they do not have an ethernet port built-in. However, they can still make use of a wireless dongle to connect to the overall network of Raspberry Pis.

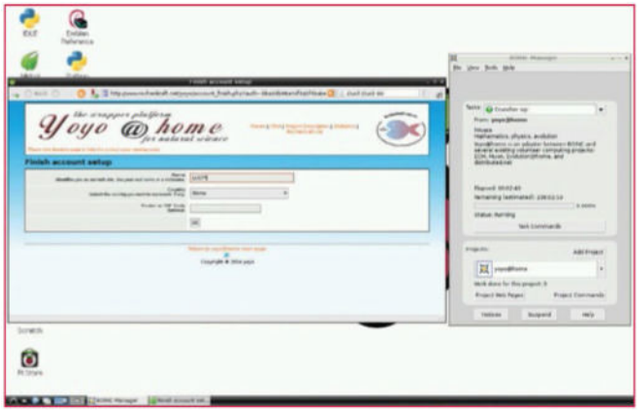
Make sure you set a static IP address for each Raspberry Pi with a specific range covering their location on the network. This is helpful for two main reasons, the first one being the ability to always be able to call the correct address when running MPI, and the second being that you can then SSH in and maintain your Pis from afar.

We recommend:

Model B+
element14.com

How to use your Super Raspberry Pi

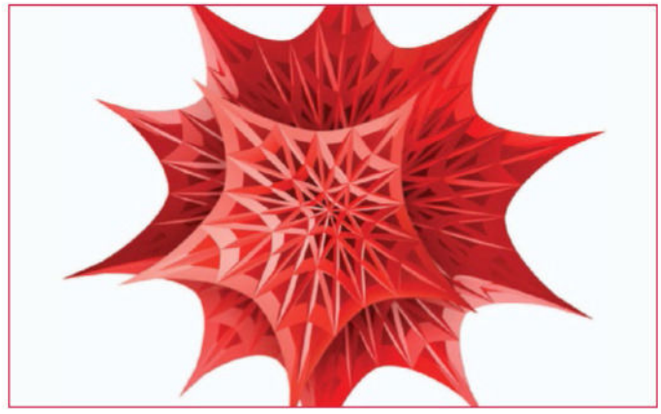
Your supercomputer is ready to crunch some code. What will you have it do?



Donate power with BOINC

BOINC is the computer network system that allows you to donate idle CPU power to crunch big data, such as folding proteins or analysing signals from the cosmos to look for alien life. There's a specific app add-on for BOINC that lets you spread the workload across the MPI network and treat them all as extra CPU threads rather than extra units. The app details can be found here: **bit.ly/1BBTS0W.**

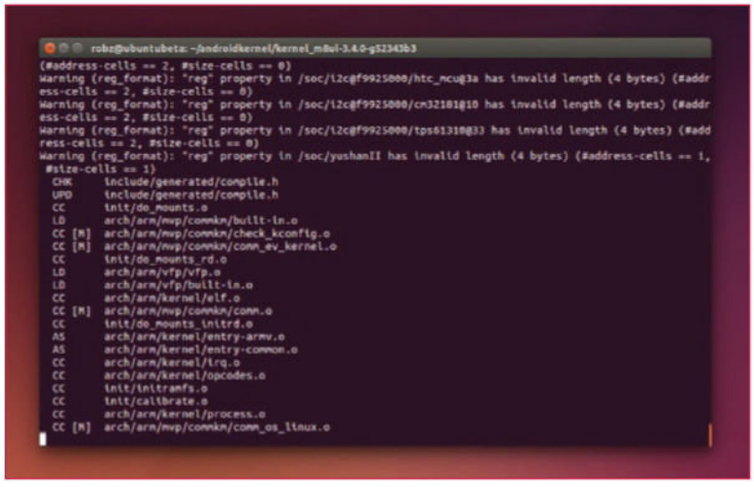
The Ras Pi on its own won't be able to add much to the pool, but linking several together can really boost the performance and create a powerful little node to help out with some projects. There are several you can donate processing power to involving science, medicine and maths. You can tweak BOINC to use more than just idling Pi power.



Modelling and simulations

Python and other languages can be used to create models of complex systems. Such models can include planetary orbits and objects interacting with them, huge mathematical equations and any resulting graphs for tides, the weather and much more. Many of these use a lot of calculations and can be slow even on a normal PC. Give them a lot more cores and you can get much faster, and sometimes more accurate, results.

Mathematica also contains some level of cluster support that works via Open MPI, the software we're using to link the Raspberry Pi network together. Wolfram has information on how it works and how to use it on their website (**bit.ly/1oEYVb8**), and it can really help with crunching the amount of data you can access and use in Mathematica.



Quick compiling

Now you have a lot more processing power at your disposal, you can try compiling Raspberry Pi programs on the cluster rather than just on the single Raspberry Pi. These will only really work on another Raspberry Pi, though, and compiling on a single Raspberry Pi can be extremely time-consuming compared to compiling on a proper PC or laptop.

There is, however, also a selection of MPI-only applications that can be built using your cluster to increase the functionality of cluster without relying on Python code. These must include specific MPI commands in the source code to make sure they run properly, which can be done a little differently than in our Python example. Look up the best practices for your programming language and if there are any extra modules or plugins you'll need for it. You can test the code in a similar way to how we tested the Python code.

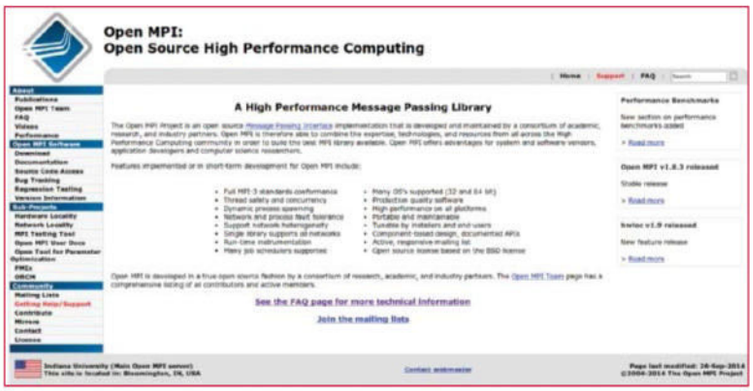
Resources

Find out more about MPI, Python and other ways to make use of your Super Pi

Open MPI

open-mpi.org

Open MPI (right) is the implementation of MPI that our Python module uses to send and receive data over the Raspberry Pi network. It supports all three major versions of MPI and, importantly, provides it in an open source format for everyone to use. There's full documentation for the extended library on the forums (**www.mpi-forum.org**) if you need to extend it past Python programs and take a little more control of what you're calculating and how.

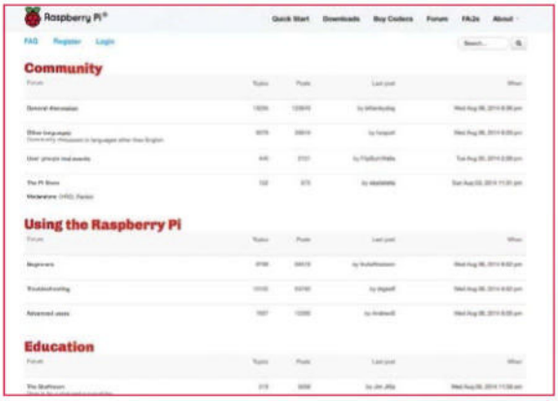


mpi4py documentation

pythonhosted.org//mpi4py/usrman/index.html

The Python module we're using has many more functions than the one we're using, and they're all contained in the documentation available on their website. You can learn how to do much more than just multiply numbers, as we showed you in our example, including the use of wrappers for other code, matrices of data and a couple other functions. It's very flexible and still in development so it's worth checking in on it and the change logs every now and then for new or different functions.

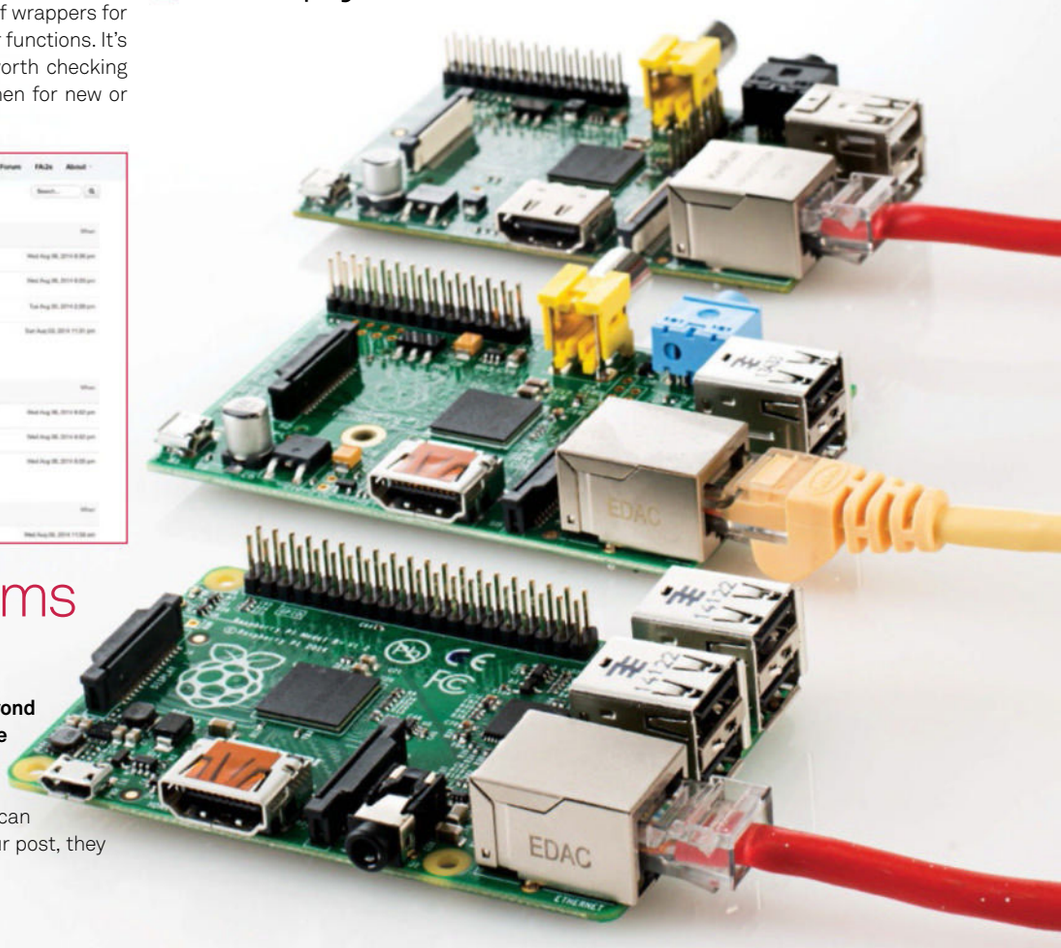
> You can learn how to do much more than just multiply numbers



Raspberry Pi forums

raspberrypi.org/forums

For anything going wrong with your Pi beyond MPI, your first port of call should always be the Raspberry Pi forums. The users are well experienced in using the Raspberry Pi and Linux, and will usually be able to help out. If you can give precise details and log files along with your post, they might be able to help you quicker.



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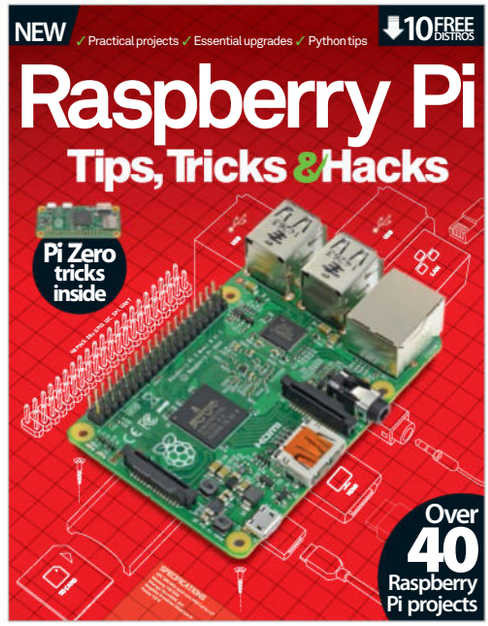

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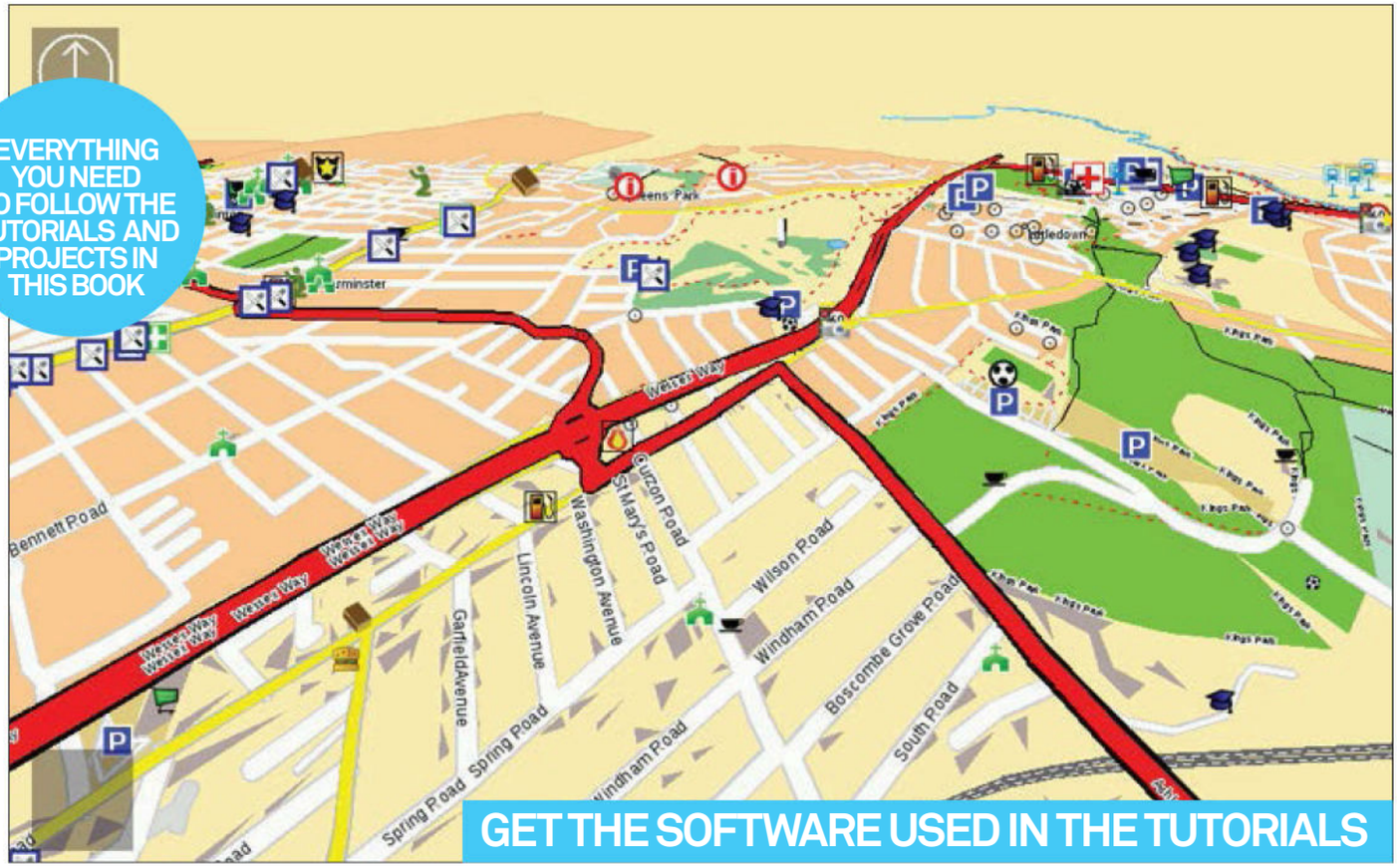

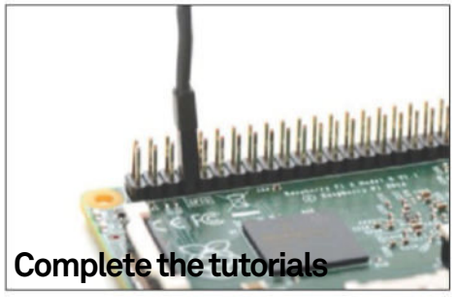

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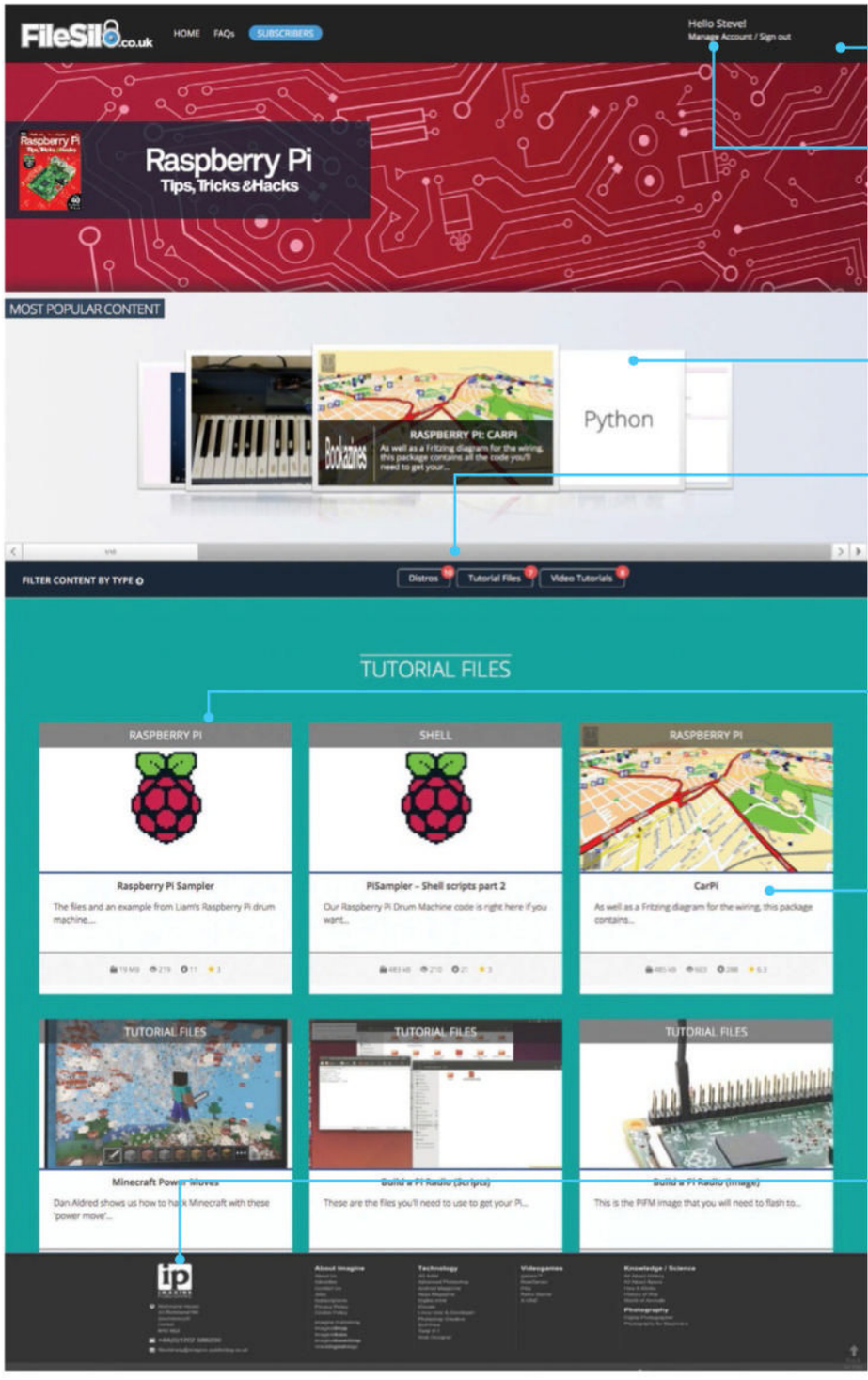

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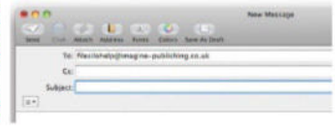

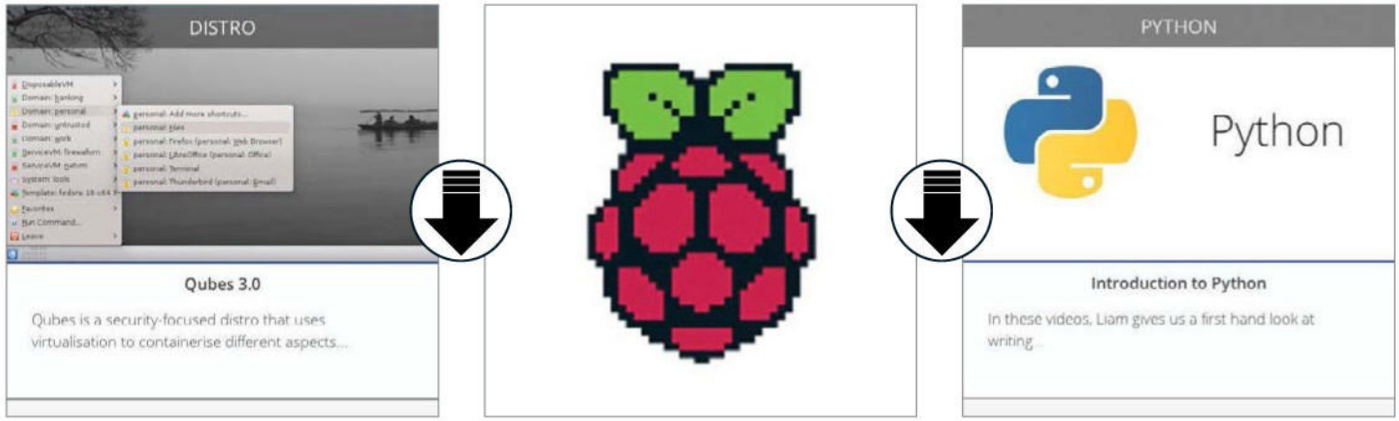

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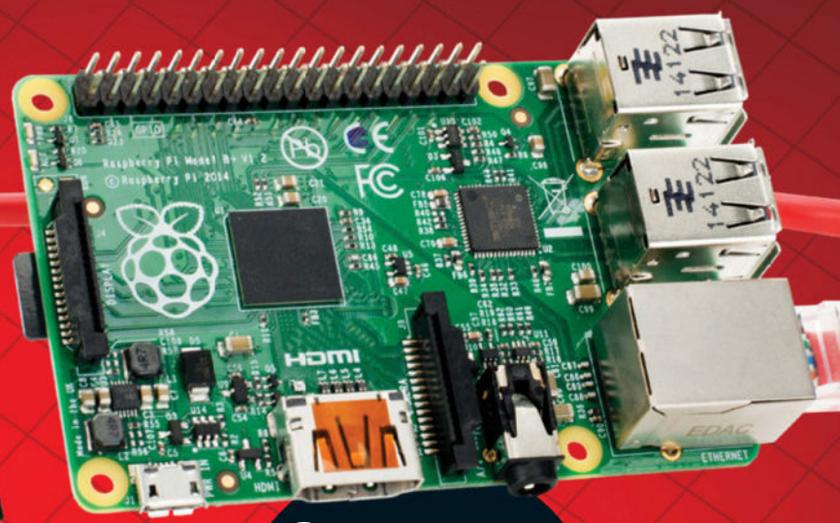

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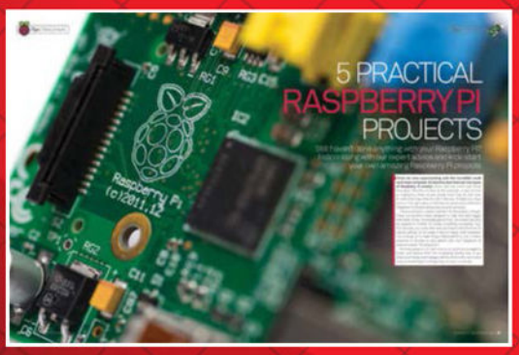

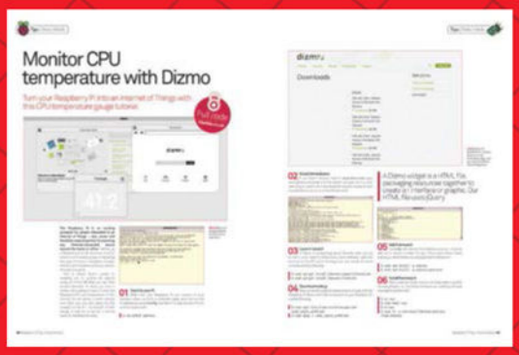

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