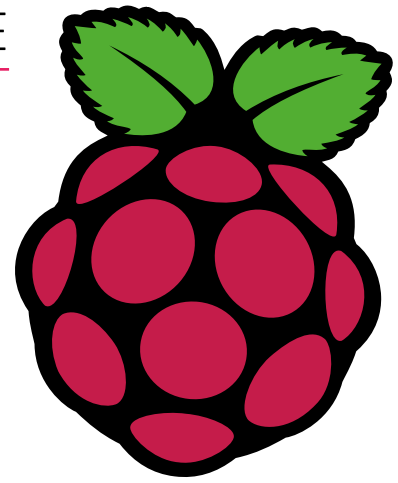




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# The MagPi



Issue 101 | January 2021 | [magpi.cc](http://magpi.cc)

The official Raspberry Pi magazine

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## RASPBERRY PI 400

# PROJECTS & GUIDES

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ARTS + CRAFTS

Get creative with Raspberry Pi

Raspberry Pi inside!

INCLUDES QUICKSTART GUIDE!



**WIN!** 5 RASPBERRY PI 400s UP FOR GRABS!

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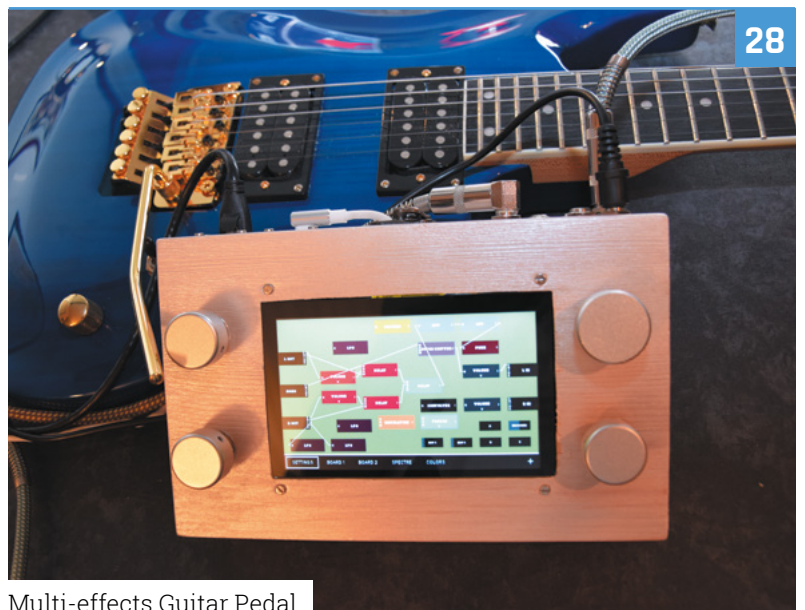
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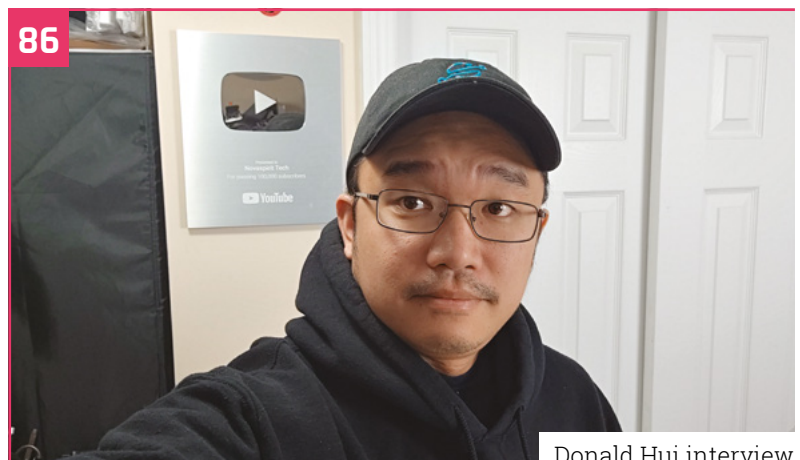
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# OnionBot Sous Chef

Too many cooks spoil the broth, but too few can mean culinary disaster. **Rosie Hattersley** hears how a Raspberry Pi bot provides a helping hand



**Ben Copley**

Design engineer Ben undertook this project for his master's thesis at Imperial College London. It's the most complex – and tastiest – of his many Raspberry Pi projects to date.

[magpi.cc/onionbotgit](http://magpi.cc/onionbotgit)

**S**tir-frying the onions, chopping the veg, adding seasoning, checking on what's roasting in the oven. These day-to-day cooking tasks are complex because they're performed simultaneously.

Keen cook Ben Copley found himself pondering how to automate such tasks when considering what he could usefully invent for his master's thesis at Imperial College London. His response was the OnionBot – “a Raspberry Pi 4-based sous-chef robot that supports me in the kitchen”.

Ben says he loves cooking, but never seems to have as much time as he'd like. “That got me thinking about how a robot might help take over some of the easy tasks.” He envisaged “a device that can automate the easier pan-cooking tasks so the head chef (me!) can focus on culinary creativity. Thus started my quest to completely over-engineer cooking a bowl of pasta.”

## Home cooks

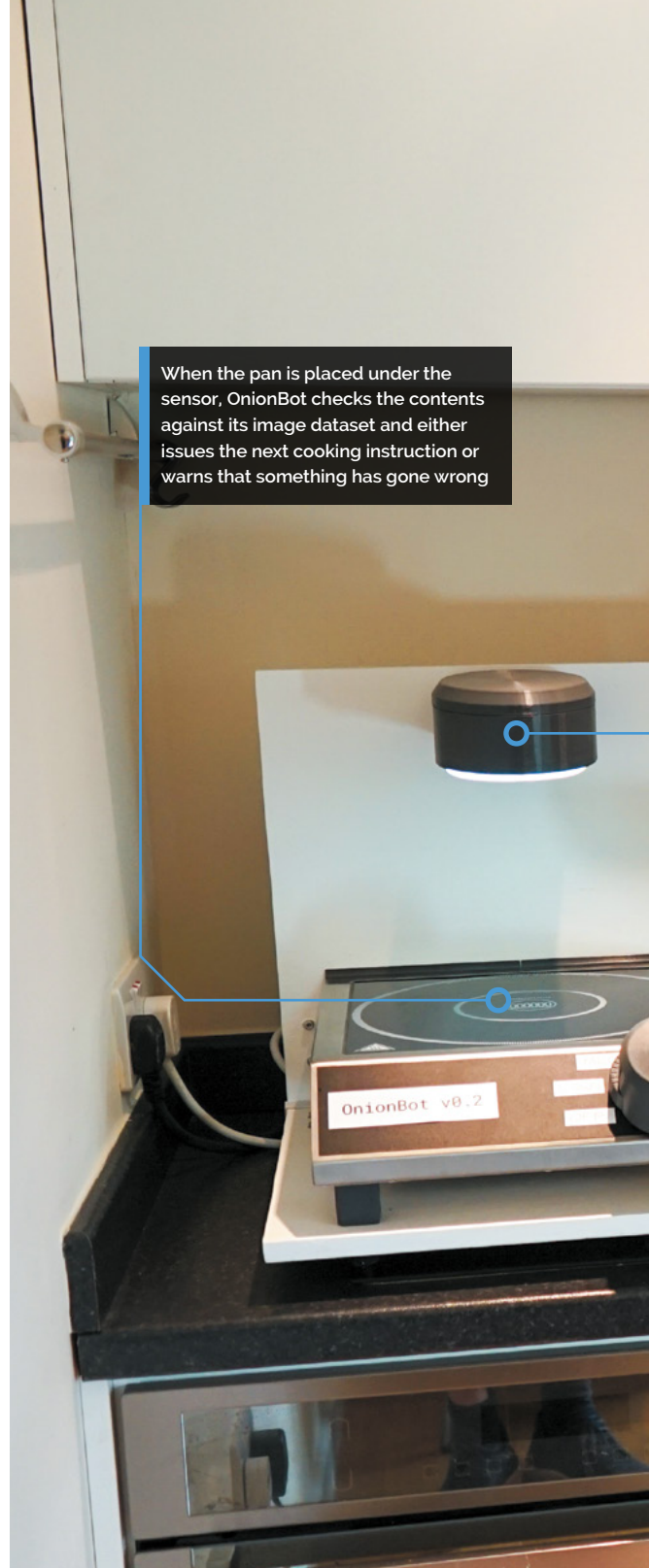
Ben wanted a counter-top device, ideally a robot with AI capabilities and a camera that could be used as a sensor. He decided to use Raspberry Pi with two cameras (one thermal) “to watch the pan and give me intelligent assistance while I focus on other things!” He says Raspberry Pi 4 was an obvious choice as it provides the processing power, I/O, and small size needed to bring these components together. “The best thing about Raspberry Pi is there's so much support and documentation online. Someone's always fixed your unfixable bug before!”



**Warning!**  
Hot surface

Ensure Raspberry Pi and components are kept away from the hot surface, and don't leave any pans unattended.

When the pan is placed under the sensor, OnionBot checks the contents against its image dataset and either issues the next cooking instruction or warns that something has gone wrong



A 7-inch Raspberry Pi touchscreen displays instructions, reminders, and alerts. Ben designed the robot's parts in Fusion 360 and 3D-printed them on a Prusa i3 MK3. He wrote the firmware in Python and a web interface based on HTML, CSS, and JavaScript. Overall, the project cost around £400.

AI was a major challenge of the project as Ben needed a huge number of food images. With no available pan cooking datasets, he set about

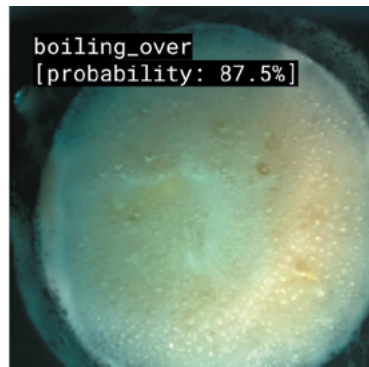
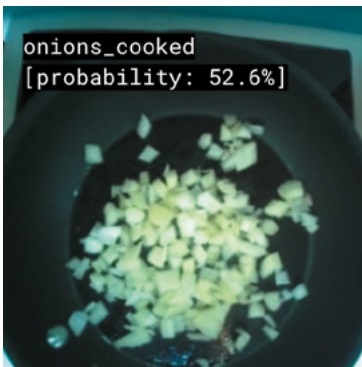
The wide-angle nature of the cameras means they don't need to be positioned very high above the pan. A 12V blower blows air over them to stop the lenses from steaming up due to condensation

OnionBot v0.2

The touchscreen acts as the sous-chef, displaying and following recipe instructions and prompting the human chef to stir the pot if they haven't done so for several minutes

### Quick FACTS

- ▶ Ben previously designed a Tamagotchi-style pet: [magpi.cc/gizmo](http://magpi.cc/gizmo)
- ▶ Don't forget to feed it! (Pasta, of course)
- ▶ Ben promised his tutor other robot recipes would follow
- ▶ So, he's encouraging others to help him succeed: [magpi.cc/onionbotpaper](http://magpi.cc/onionbotpaper)
- ▶ He recommends Google's Teachable Machine for a first ML project: [magpi.cc/teachablemachine](http://magpi.cc/teachablemachine)



- ◀ Ben ate nothing but pasta for a week while perfecting the recipe that OnionBot follows and collecting related images

OnionBot is so named because "the idea came to me when looking for an automated way to perfectly soften onions in a pan while I get on with the rest of the dish"

“ OnionBot was able to follow along the entire recipe, giving the head chef instructions and reminders ”



▲ Ben wanted to use computer vision to act as a chef's watchful eye over the pan. Based on what it senses, the OnionBot then tells the human chef what to do next

creating his own, along with an interface for the robot to access them for comparison. The method involves training a robot for each new recipe. As each milestone in the cooking process is completed, the user clicks a button on the web interface to save an image that is then labelled and stored in Google Cloud for use as a classifier.

### Know your onions

Ben chose a simple pasta with tomato sauce recipe as a repeatable experiment to test the system. Since machine learning models need large, varied datasets, Ben ate a lot of pasta and collected around 500 labelled images for each action in the recipe. He trained the classifiers using Google AutoML, which makes it extremely easy to make image classifiers, even without any machine learning experience. He recommends Google Coral AI USB Accelerator – “a great piece of kit that is plug and play straight into Raspberry Pi, and which speeds up machine learning models.”



He started simple, teaching the OnionBot to bring a pan of water to the boil. Harder challenges included: Are these onions cooked? Is the pan on the hob? Is the pan being stirred?

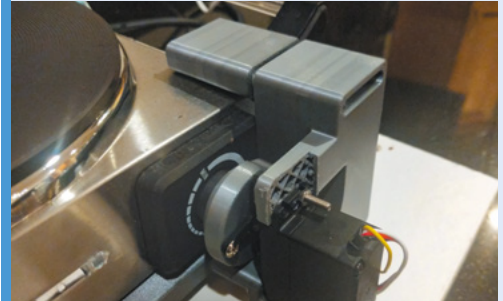
Multiple models were added to the final pasta recipe, which Ben converted into a robot-friendly version that uses the thermal sensor data and computer vision results to make decisions. “With a bit of tweaking, OnionBot was able to follow along the entire recipe, giving the head chef instructions and reminders on the touchscreen as it went along!”

The robot was able to advance through the instructions, making use of Ben’s image classification system. It autonomously controlled the pan temperature using PID feedback, detecting whether the pan is boiling over and, if so, turning down the heat. [M](#)

▲ Ben had to deliberately ruin some of his cooking in order to get images showing things going wrong

## Taste test

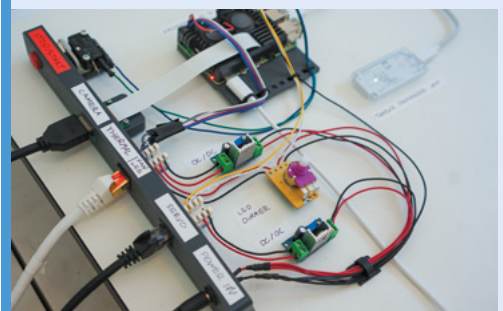
To replicate the OnionBot, you need a portable stove that can be controlled by a servo along with Raspberry Pi 4, camera, and thermal sensor. Full details and code are at [magpi.cc/onionbotgit](http://magpi.cc/onionbotgit).



- 01** Measure the dial on your stove and add an adapter that allows it to be controlled by the servo hooked up to your Raspberry Pi. A 360-degree servo motor is ideal.



- 02** Connect a wide-angle camera and thermal camera/sensor to Raspberry Pi, and position them above the stove top. Add a computer fan or blower to prevent condensation build-up.



- 03** Python Flask server runs on Raspberry Pi and makes system controls accessible over the local network. A web interface streams the cooking images in real-time and sends commands to Raspberry Pi.