

Keep an open mind

Whilst preparing our Bulletin article on Tracker – a truly superb open source motion analysis program – we were reminded of other great free or open source Apps that we use regularly in our mobile devices course or software that we use as part of other workshops.

During one of our recent physics professional learning courses Oliver Higgins and Matthew Smith from Glasgow University delivered a workshop based on using a smartphone, some cling film and a few drops of water to construct a simple microscope [1].

Delegates immediately recognised how useful this activity would be during lockdown as a blended learning activity. Oliver and Matthew also demonstrated a simple 3D printed structure that, with the addition of a simple glass bead, became an effective microscope. During their presentation they mentioned that in the research phase of their project they were influenced by the work done by the University of Bath with their Openflexure microscope.

The Openflexure microscope project led to more investigation into both flexures and Open-Source Hardware. Flexures are, at their most basic, simply thin strips of plastic or metal designed to bend, within their elastic limit, in a particular way and are commonly used in manufacturing. Typical examples are the plastic buckle and the lens cap shown in Figure 1. The buckle contains two

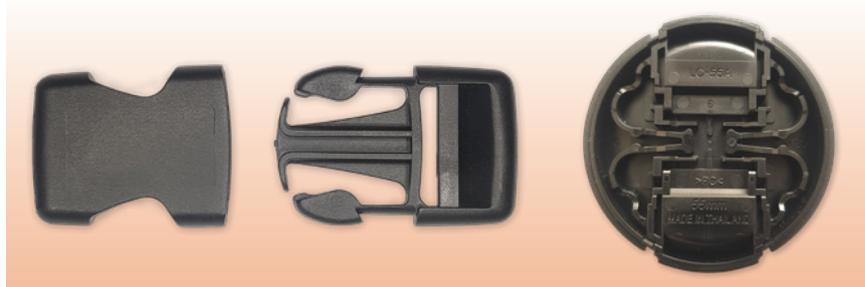


Figure 1 - Flexure buckle and lens cap.

flexure ‘prongs’ and the lens cap four curved flexure strips designed to act like a spring.

The definition of Open-Source Hardware, taken from Joshua M. Pearce’s book *Open-Source Lab: How to Build Your Own Hardware and Reduce Research Costs* is: “tangible artefacts – machines, devices, or other physical things – whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things”. The book

from 2014 discusses benefits, cost savings, licensing, building a “Rep Rap” machine (3D printer), microcontrollers as well as giving construction details for several items of lab equipment.

A video of Dr Joshua Pearce talking about open source hardware can be seen on youtube [2].

We had already, coincidentally, constructed the Geiger kit (Figure 2) referenced in the book and had used our 3D printer to make test-tube >>



Figure 2 - Geiger counter.



Figure 3 - Test tube rack.

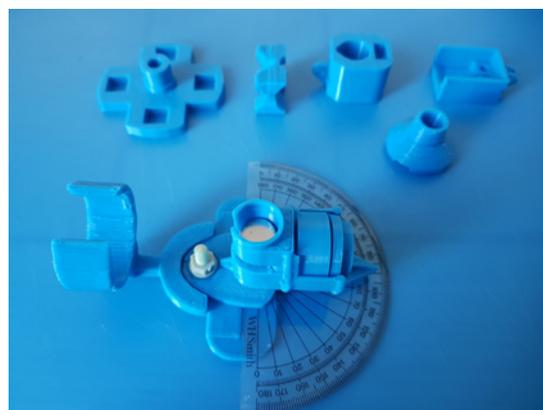


Figure 4 - Beta particle spectrometer.



Figure 5 - 3D printed parts.



Figure 6 - The Raspberry Pi, Pi camera and Arduino Nano.

racks (Figure 3) and to make a beta particle spectrometer [3] for our Vernier Go-Direct radiation monitor Figure 4.

It was thought that constructing an Openflexure microscope would make an ideal IDL project for a STEM club and would follow on from the work done by Oliver Higgins and Matthew Smith at Glasgow University. It would also provide something new to microscope use in the classroom and provide features not readily available in traditional school microscopes for example auto-focussing, the ability to automatically stitch images together to form one large high resolution image and computer control of the microscope including over a network.

So we firstly printed the 3D parts and tools (Figure 5) and acquired the hardware: Arduino Nano, Raspberry Pi 4 2GB, Pi camera v2, Viton (a synthetic rubber and fluoropolymer elastomer) bands and three stepper motors (a DC motor designed to rotate a small fraction of a revolution on each command rather than

continuously) and associated driver boards (Figure 6). Some nuts and bolts and a white LED and resistor were also needed. A kit of the 3D printed parts and a nuts and bolts kit can also be purchased from [4]. A small discount on the 3D printed parts can be obtained using the code SSERC21 at the checkout.

The microscope is easy to customize. Different parts are available to 3D print depending on whether you wish

to use a Raspberry Pi camera lens or a microscope objective lens or whether you wish to use transmitted or reflected light. We chose a basic set up to prove the principle. Configuration, download links and build Instructions can be found at [5].

The downloaded image (copy of the software) for the Raspberry Pi was written to a microSD card and the programme (sketch) for the Arduino Nano was loaded onto the board. >>



Figure 7 - Traditional slide movement.

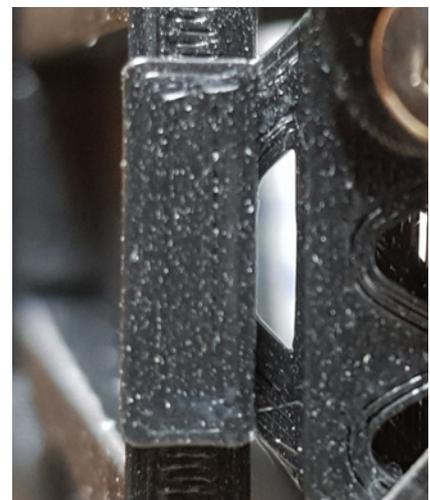


Figure 8 - Close-up of two flexures.

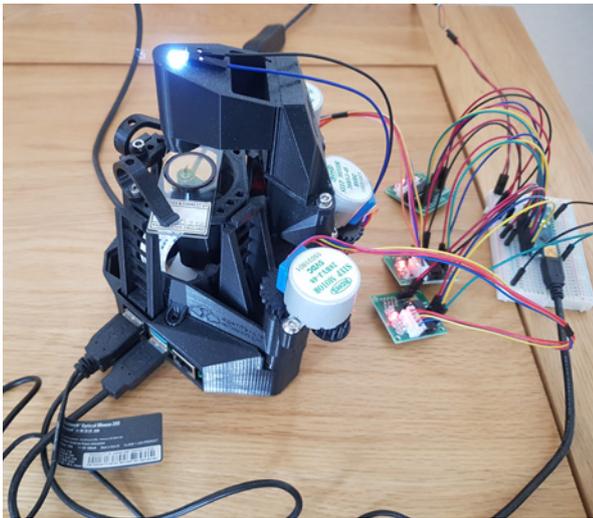


Figure 9 - The Openflexure microscope (Stepper motor driver boards and Arduino Nano uncased).

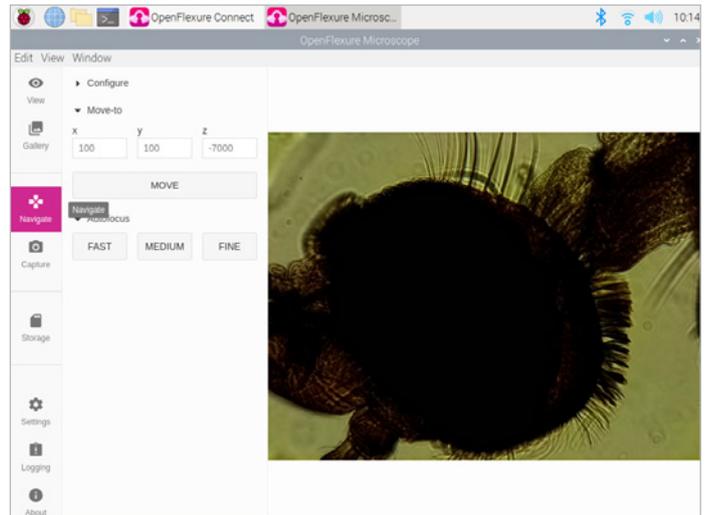


Figure 10 - The Openflexure control software.

A computer monitor, mouse and keyboard were borrowed for the initial set-up.

The microscope was then constructed following the instructions on the website above.

Moving a microscope slide a small precise distance on a microscope stage typically involves a manually operated, screw driven mechanism with a Vernier scale as shown in Figure 7. The Open flexure microscope achieves this electrically using a stepper motor, an M3 nut and bolt and flexures (Figure 8) for both X and Y axis movement.

Firmware

Sitting between software and hardware we have firmware. Traditionally hardware devices, such as soldering irons, may now come with freely available firmware. The firmware on the MiniwareTS100 soldering iron (Figures 9 & 10) allows you to set various temperatures, timings and low voltage cut off levels. 3rd party, open-source, versions of the firmware are

available with enhanced features that for example allow for automatic rotation of the LCD screen, allow for a cut-off voltage to suit a wider range of battery chemistries or a temporary temperature increase. Updating firmware is usually just a matter of downloading a file to your computer and executing it with the device plugged in or just copying the updated file to the device. <<

References

- [1] <https://oliverhiggins93.github.io/macrophotographyworkshop/refraction/index.html>
- [2] <https://www.youtube.com/watch?v=kBz1Z-V2ps4>
- [3] <https://www.vernier.com/vernier-ideas/an-inexpensive-beta-radiation-spectrometer/>
- [4] <https://openflexure-industries.square.site/>
- [5] <https://openflexure.org/projects/microscope/build>



Figure 11 - An image from the microscope. Mosquito x13. Resolution 1.5µm.



Figure 12 - The Miniware TS100.



Figure 13 - Soldering Iron with firmware v2.18.