



**Glasgow:** J Knapper, F Whiteford  
**Bath:** E Meng, K Bumke, K Harrington, J Stirling, J Collins, W Wadsworth, N Campbell, Y Wang, B Vodenicharski  
**Cambridge:** S McDermott, F Ayazi, P Cicuta  
**IHI:** C Mkindi, V Mayagaya, J Mduda  
**STICLab:** V Sanga, P Nyakyi, G Mwakajinga



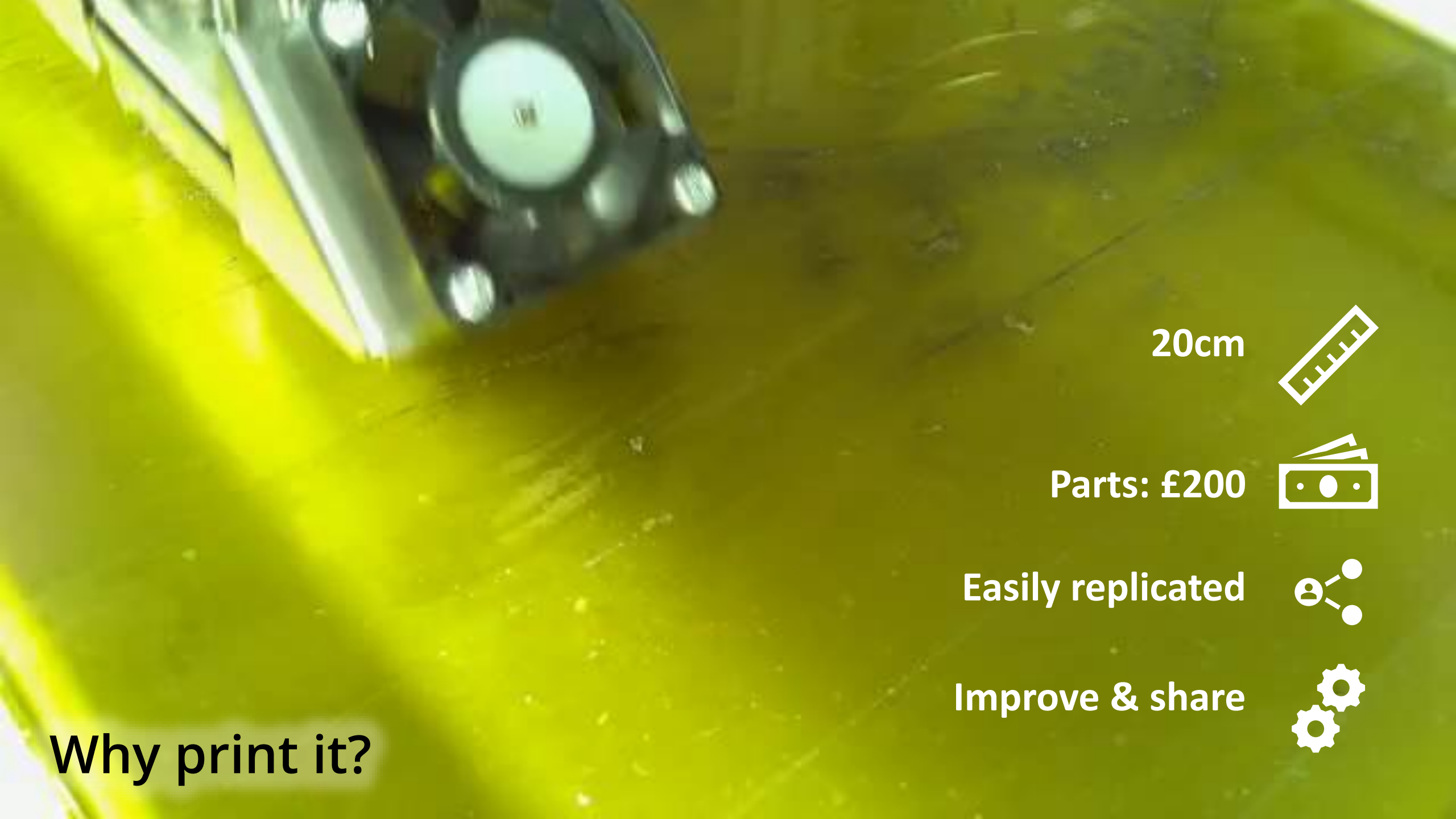
openflexure  
microscope

# Smart microscopy for everyone with the Web of Things

Richard Bowman, WoT GC, 15/2/2024







20cm



Parts: £200



Easily replicated



Improve & share



Why print it?



# Microscopy for everyone

**200M** cases/year  
**500,000** deaths



**Quality Assurance**

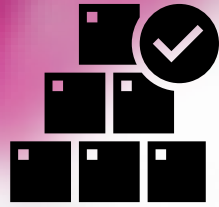


**Training**



**Local Production**

# A global community project



**Easily to build** for reproducibility, accessibility, and improvement

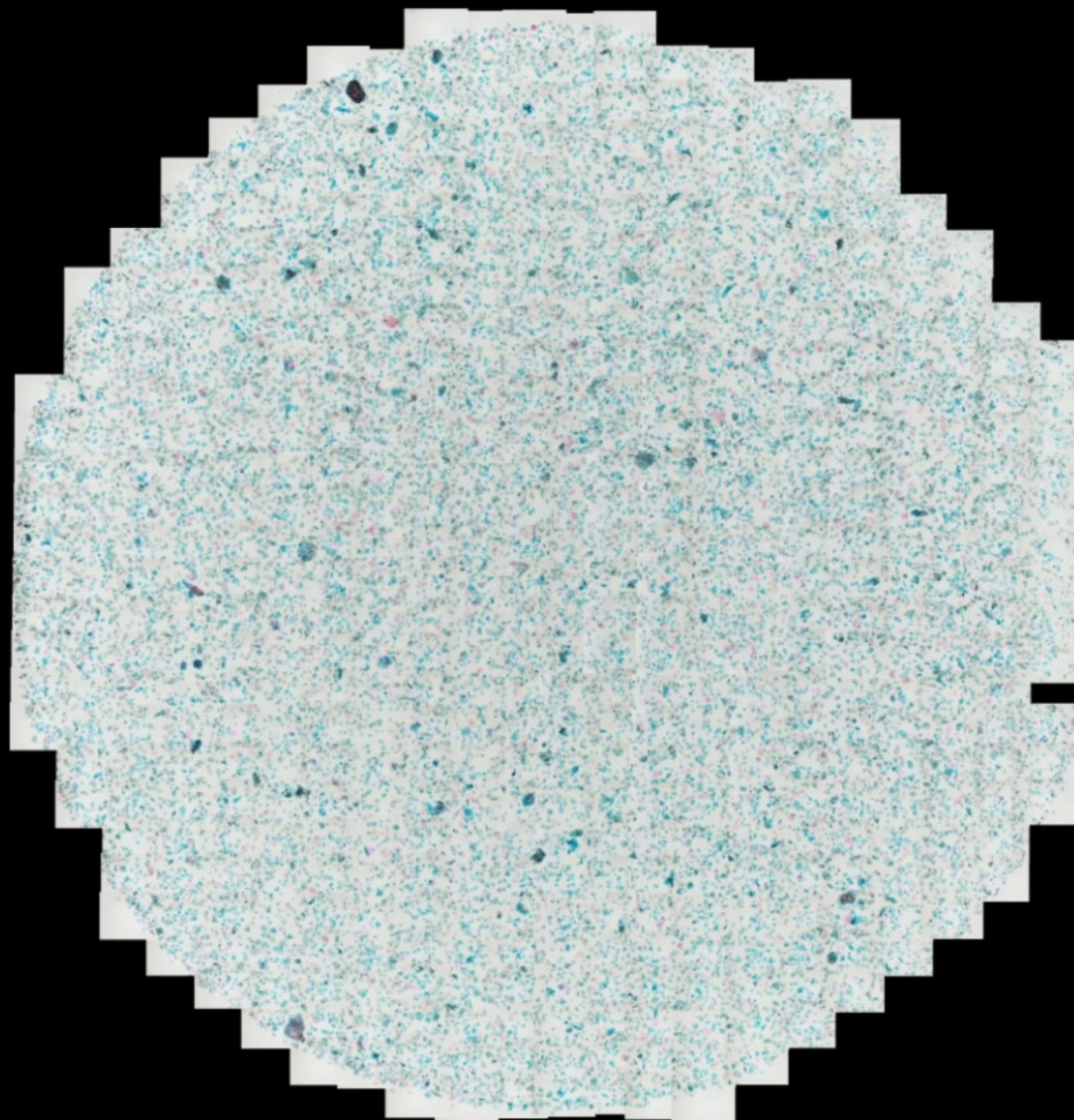


open source  
hardware

**Open hardware** & software development



Culture, infrastructure, and effort to **build community**





# #OPENFLEXURECON2022

**1. TANZANIA**

Valerian Sanga & Paul Nyakyi, Bongo Tech & Research Labs

**MALARIA DIAGNOSIS**

1<sup>ST</sup> EVER MAKER SPACE IN TANZANIA

- Engineering & Consultancy
- Robots & Automation
- R&D Projects
- Youth development
- IoT
- Digital Manufacturing

**THE FUTURE**

- Construct office Space
- Initiate Tanzania OSH Summit
- Host first Tanzania OSH Summit

Joram Mduda, Ifkara Health Institute

COLLECTING TISSUE SAMPLES & SCAN IMAGING

WE PROVED YOU CAN PRODUCE A DIAGNOSIS DEVICE THAT'S **LOCALLY MANUFACTURED**

LOCAL REPAIRS

ARE OPTICAL SENSORS JUST FOR EXPERTS? **NO!**

**OPTICAL SECTIONING**

**ROBOTIC MICROSCOPY FOR EVERYONE!**

TATSUNOKE MATSUI, MIE UNIVERSITY

**JAPAN**

**CONVENTIONAL OPTICAL**

OBSERVED IMAGE = WELL FOCUSED IMAGE + BLURRED OUT-OF-FOCUS IMAGE

**STRUCTURED ILLUMINATION**

OBSERVED IMAGE = FOCAL PLANE + OUT-OF-FOCAL PLANE

YOU CAN COMBINE SEVERAL MEASUREMENTS TO GET BACK ONLY THE WELL-FOCUSED IMAGE!

**11. NIAMH BURKE, UNIVERSITY COLLEGE DUBLIN**

**DEMOCRATISING DISCOVERY**

TACKLING THE PROBLEM OF MARINE MICROPLASTICS POLLUTION WITH OPEN & ACCESSIBLE IMAGING TOOLS

**SMOOTH MOVES IN THE Z-AXIS**

IMMEDIATE MEASURE

DIRECTLY MEASURE

MODIFY

**10. JOE KNAPPER, UNIVERSITY OF BATH**

**MAKING AUTO-FOCUS & SCANNING MORE RELIABLE!**

BY TEACHING THE MICROSCOPE HOW TO CORRECT FOR ERRORS

**9. SAMUEL McDERMOTT, UNIVERSITY OF CAMBRIDGE**

**MAKING SCRIPTING EASY WITH BLOCKLY**

DRAG & DROP

PERFORM SMART EXPERIMENTS

SCRIPTING A SERIES OF OPERATIONS

**8. OLIVER HIGGINS, UNIVERSITY OF GLASGOW**

**ALGORITHM**

USE ON SMARTPHONE

DISEASE STATUS

NEEDLE IN A HAYSTACK

**APP**

**7. JELLYLAB!**

OLIVER HIGGINS, UNIVERSITY OF GLASGOW

Automated detection of HELMINTH INFECTION USING 3D PRINTED MICROSCOPY

**3. USA**

DANIEL ROSEN, BAYLOR COLLEGE OF MEDICINE

**MEDICAL EDUCATION**

RESEARCH PROJECTS

- Assess integration of HMRE
- Investment validation of dysplasia in squamous lesions of the esophagus
- Instrument validation of cervical cytology smears

**PROBLEM SOLVED**

Using images acquired with OFM to train pathology & med students

WRONG PICTURE = WRONG DIAGNOSIS

**WHY OPENFLEXURE?**

- HIGH IMAGE RESOLUTION
- LOW INFRASTRUCTURE
- ENERGY EFFICIENT
- LOW NETWORK REQUIREMENTS
- OPEN SOURCE SOFTWARE

**EDUCATIONAL WEBSITES DEVELOPED:**

- GENERAL SURGERY PATHOLOGY CASES
- PROSTATE CANCER
- ENDOCRINE PATHOLOGY
- LUNG CANCER
- CERVICAL CYTOLOGY SMEARS

**5. GERMANY**

**F&M**

FOLLOWS FUNCTION

DESIGNING CIRCUITS FOURIER VS MODULAR OPTICS

**RAPID PROTOTYPING FOR OPTICS**

BENEDICT DIEDERICH, OPEN UC2

**SPLIT THE MICROSCOPE**

HIDDEN WIRES

UC2 ATTACHMENT

BIOLOGICAL PROTOCOLS

MICROSCOPIC IMAGING

IMAGE ANALYSIS

SMART ALGORITHMS DECISION MAKING

**6. FERNANDO CASTRO, RE-GOSH - AUVV COOPERATIVE**

**AGROECOLOGICAL TRANSITION**

CONTEXT:

FERTILITY

HEALTH

MEDICAL DEVICE CERTIFICATION

NOT A TOY

**LIVING SOIL**

WORKSHOPS

MICROBIOLOGICAL AGROPACHA

**DIY SOIL MICROSCOPE**

SHORT GUIDE TO SOIL MICROSCOPY

**17. STEPHANE FADANKA, MBOALAB**

**CATALYSE**

LOCAL SUSTAINABLE DEVELOPMENT

**MAKER SPACE**

**COMMUNITY BASED INNOVATION HUB**

TRAINING

WORKSHOPS

EXHIBITIONS

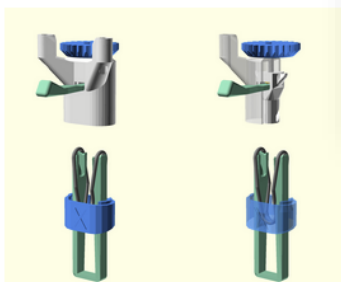
CAMEROON

**TRANSLATING THE SOFTWARE**

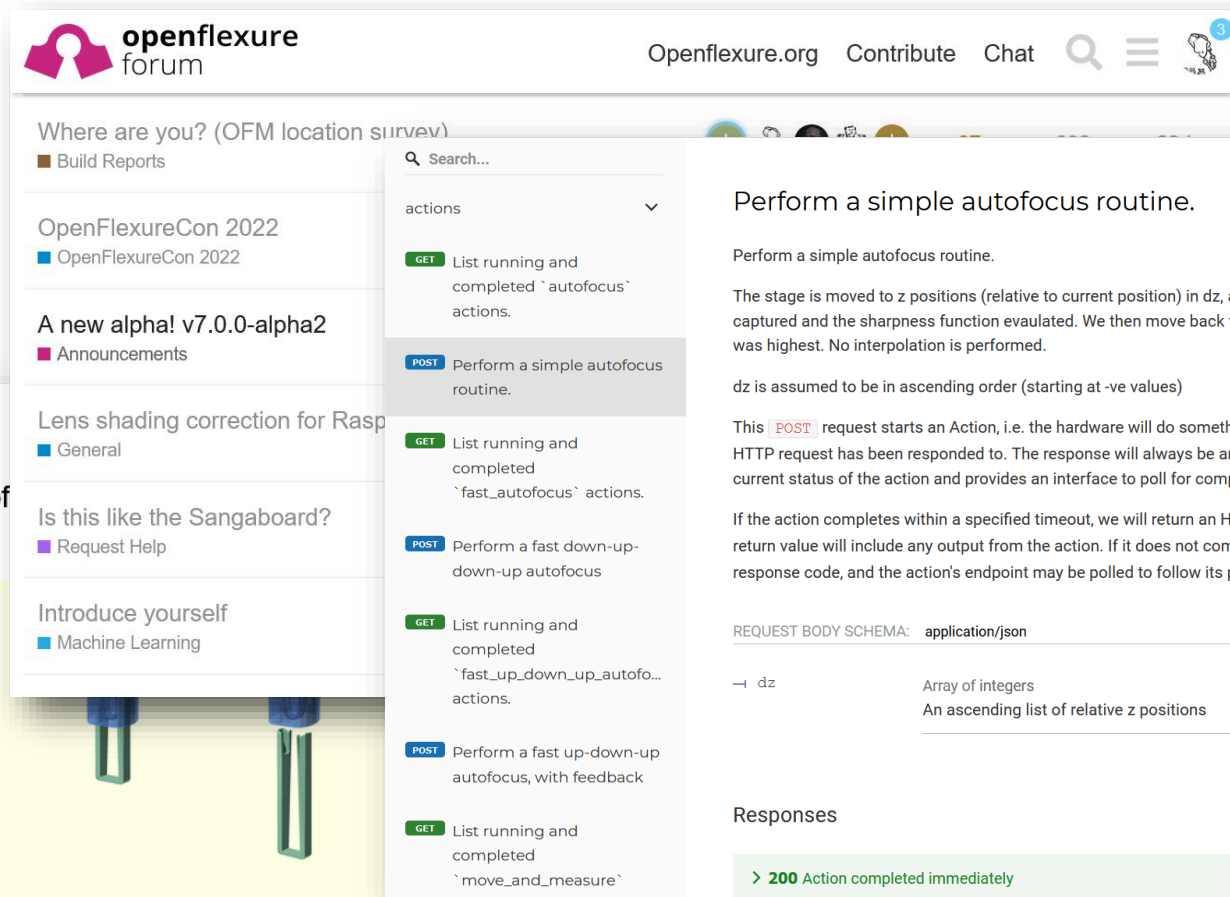


## Step 5: Attaching

This is the trickiest part of each actuator.



- Take the foot for the x actuator
- Loop a viton band through the foot
- Push the band tool through the foot hook the band onto the tool on each side.
- Push the band tool cover onto the bottom of the band tool
- Align the foot under the microscope so that the letter faces outwards



openflexure  
forum

Openflexure.org Contribute Chat

Where are you? (OFM location survey)

Build Reports

OpenFlexureCon 2022

A new alpha! v7.0.0-alpha2

Lens shading correction for Rasp

Is this like the Sangaboard?

Introduce yourself

actions

GET List running and completed `autofocus` actions.

POST Perform a simple autofocus routine.

GET List running and completed `fast\_autofocus` actions.

POST Perform a fast down-up-down-up autofocus

GET List running and completed `fast\_up\_down\_up\_autofo...` actions.

POST Perform a fast up-down-up autofocus, with feedback

GET List running and completed `move\_and\_measure` actions.

### Perform a simple autofocus routine.

Perform a simple autofocus routine.

The stage is moved to z positions (relative to current position) in dz, and at each position an image is captured and the sharpness function evaluated. We then move back to the position where the sharpness was highest. No interpolation is performed.

dz is assumed to be in ascending order (starting at -ve values)

This **POST** request starts an Action, i.e. the hardware will do something that may continue after the HTTP request has been responded to. The response will always be an Action object, that details the current status of the action and provides an interface to poll for completion.

If the action completes within a specified timeout, we will return an HTTP status code of **200** and the return value will include any output from the action. If it does not complete, we will return a **201** response code, and the action's endpoint may be polled to follow its progress.

REQUEST BODY SCHEMA: application/json

dz Array of integers  
An ascending list of relative z positions

### Responses

> 200 Action completed immediately

POST /api/v2/extensions/org.openflexure...

### Request samples

Payload

Content type  
application/json

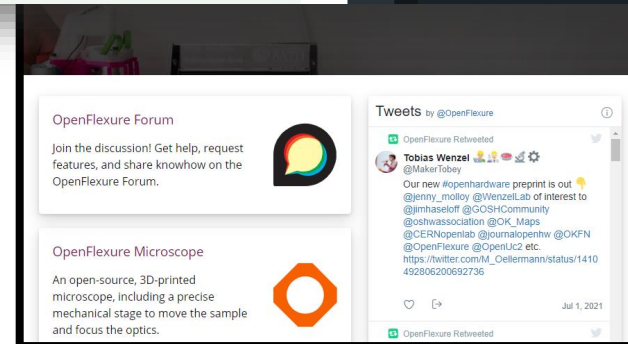
Copy Expand all Collapse all

```
{
  - "dz": [
    -300,
    -200,
    -100,
    0,
    100,
    200,
    300
  ]
}
```

### Response samples

200 201 5XX

Content type



OpenFlexure Forum

Join the discussion! Get help, request features, and share knowhow on the OpenFlexure Forum.

OpenFlexure Microscope

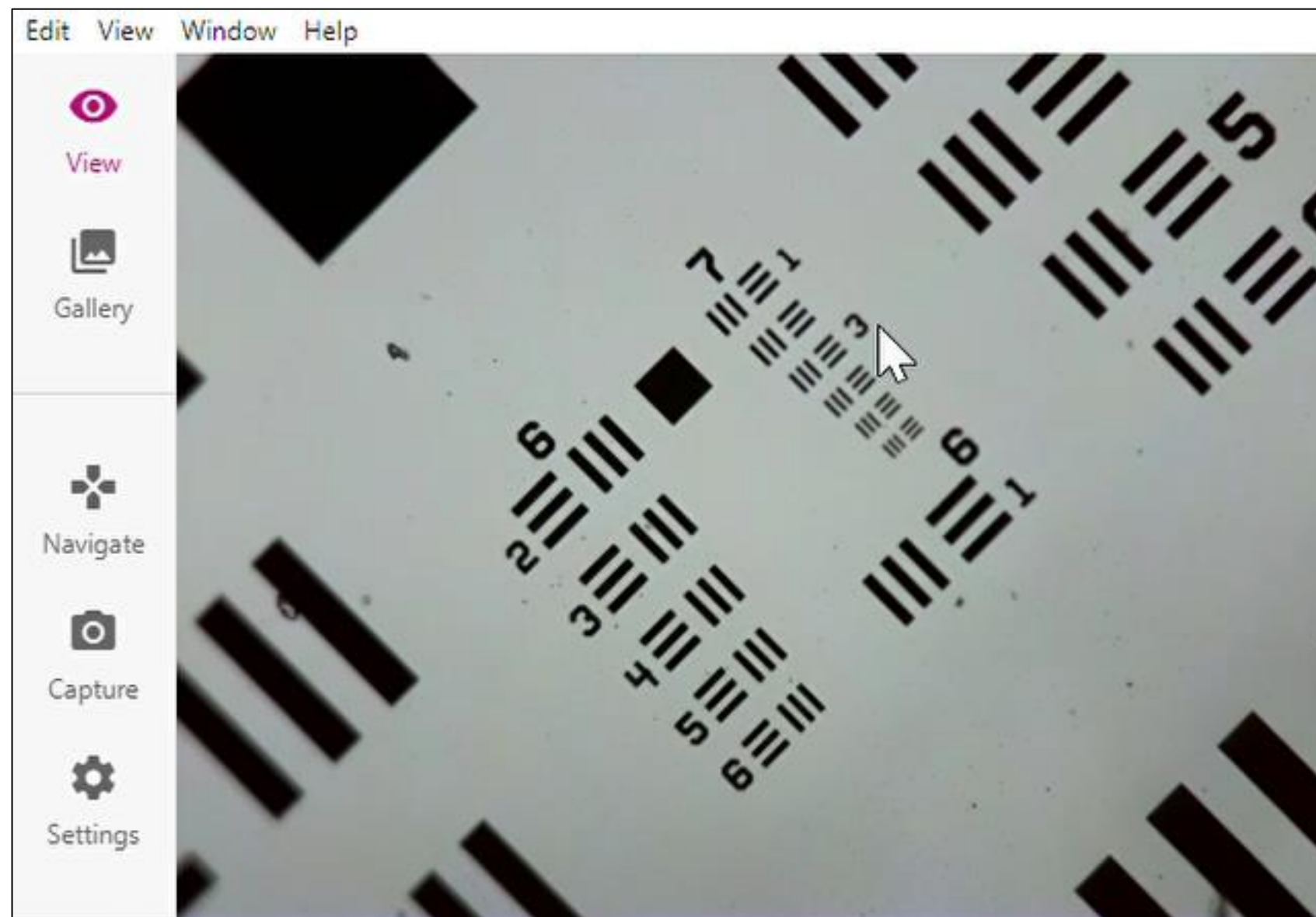
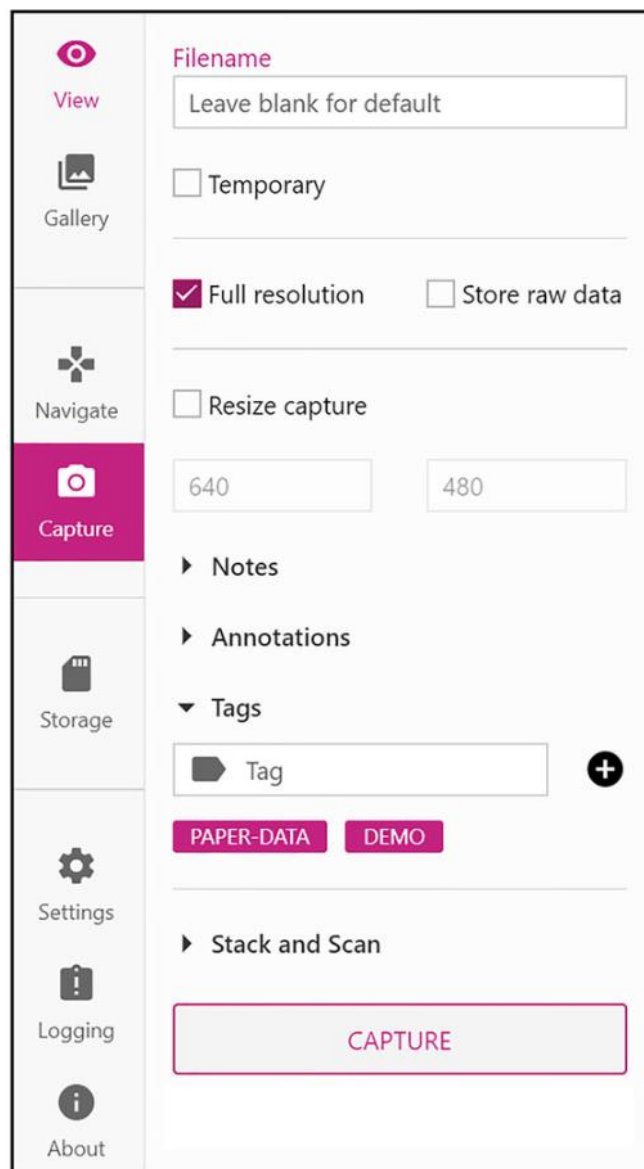
An open-source, 3D-printed microscope, including a precise mechanical stage to move the sample and focus the optics.

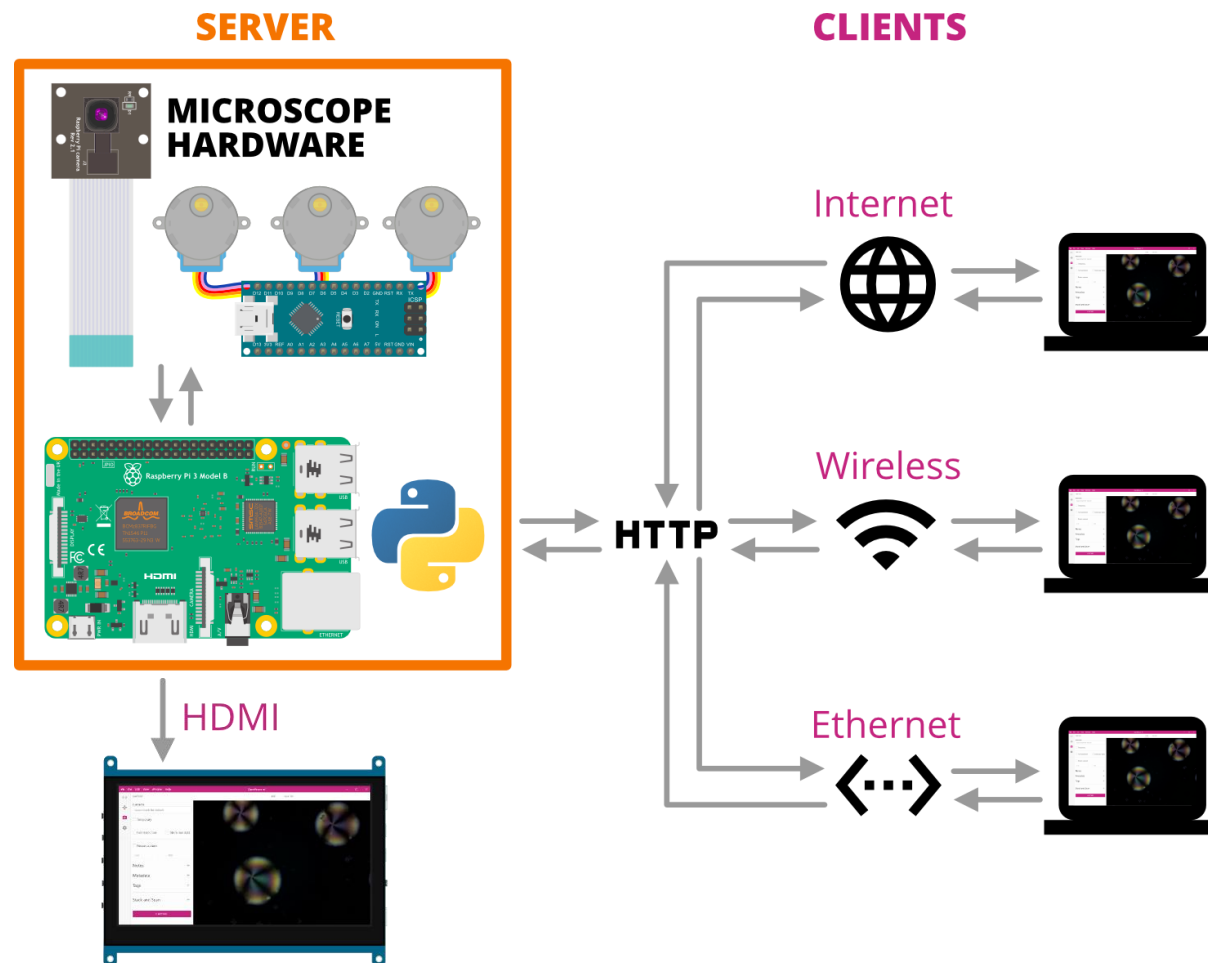
Tweets by @OpenFlexure

Tobias Wenzel @MakerLobby

Our new openhardware preprint is out! @jenny\_molloy @WenzelLab of interest to @jimhaseloff @GOSHCommunity @oshwassociation @OK\_Maps @CERNopenlab @journalopenhw @OKFN @OpenFlexure @OpenJ2 etc. https://twitter.com/M\_Celleermann/status/1410492806200692736

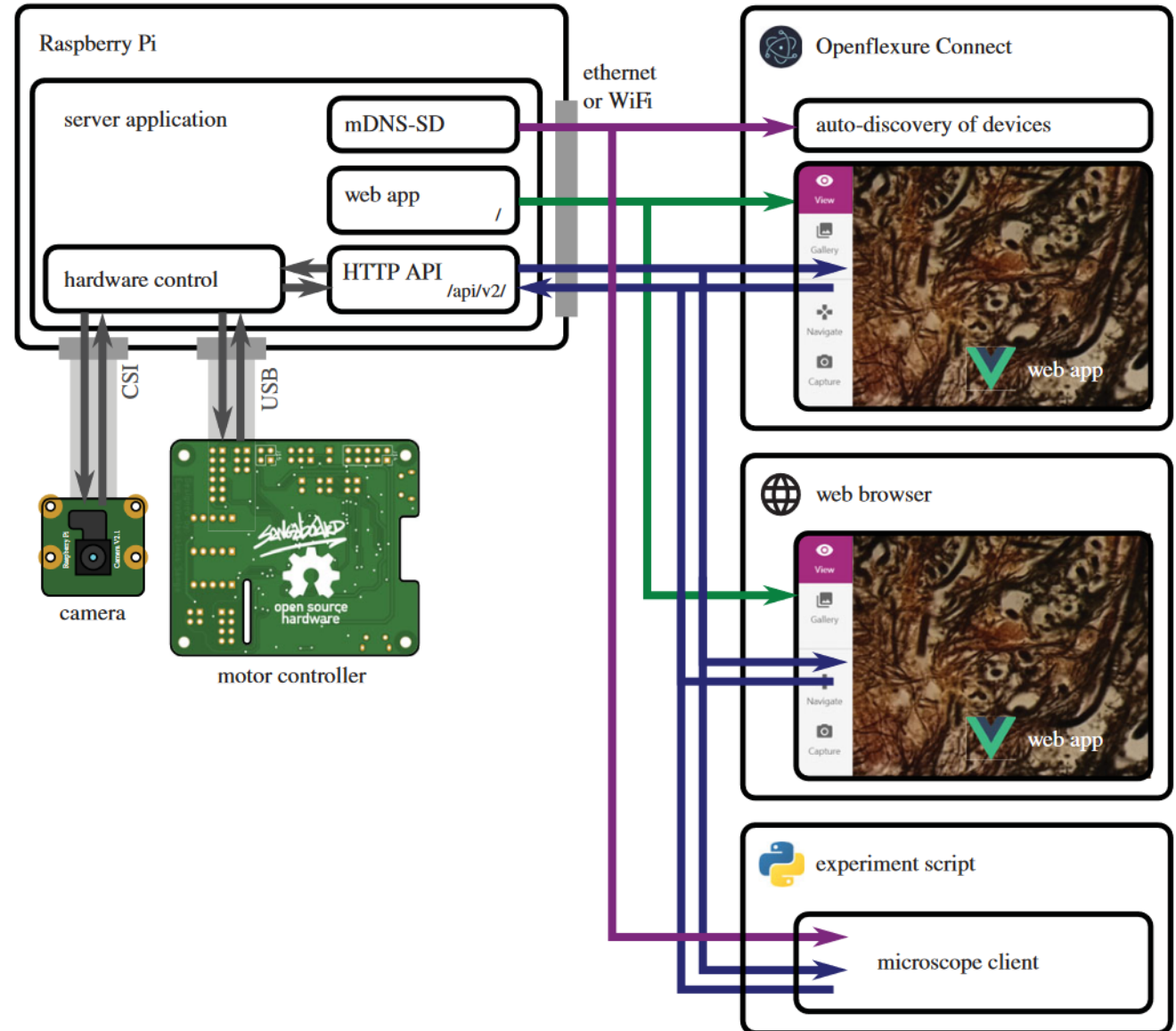








- Simple GUI
- Easily scriptable
- Script & GUI simultaneous
- Headless/unattended operation
- One computer, many microscopes



- Server: Python, FastAPI, LabThings (was Flask *et al.*)
  - Things are Python classes
  - Actions & properties are Python descriptors
  - The signature of a Thing and a ThingClient are ~compatible
  - FastAPI dependency injection for inter-thing dependencies
- GUI: Vue.js + Axios
  - Actions are started by a custom Vue component
  - Properties are read/written by another Vue component
  - Not (yet) using node-wot, I can't seem to use it with webpack (?)



```

Take a snapshot of the cells

In [19]: [[[locate_sample_with_opentrons()
microscope.capture_image_to_disk()]]]
Out[19]: <Response [201]>

Grab and Add Primary Antibody

In [20]: l_pipette = 8
l_wait_primary = 520 # minutes

In [36]: pipette.home()
# protocol.home()
# get reagent
l_row = 8
l_primary = 8
l_secondary = 1
l_box = 2
l_gbs = 5
l_trash = 4
V_aspirate = 100

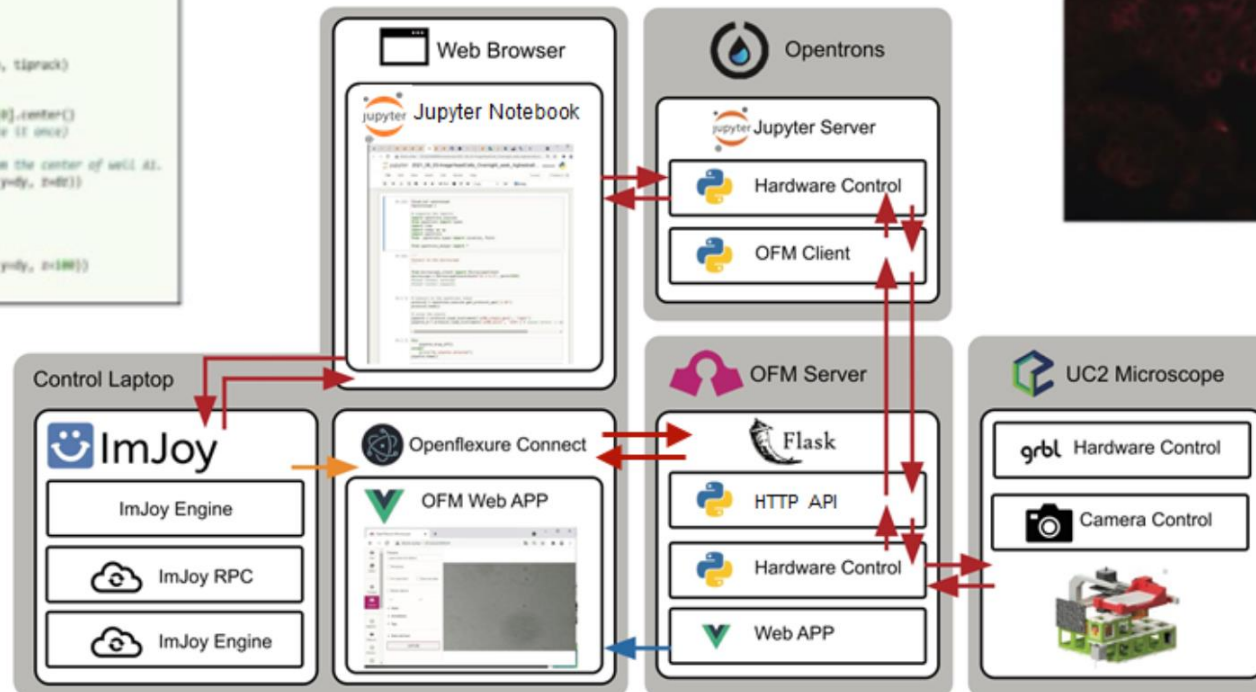
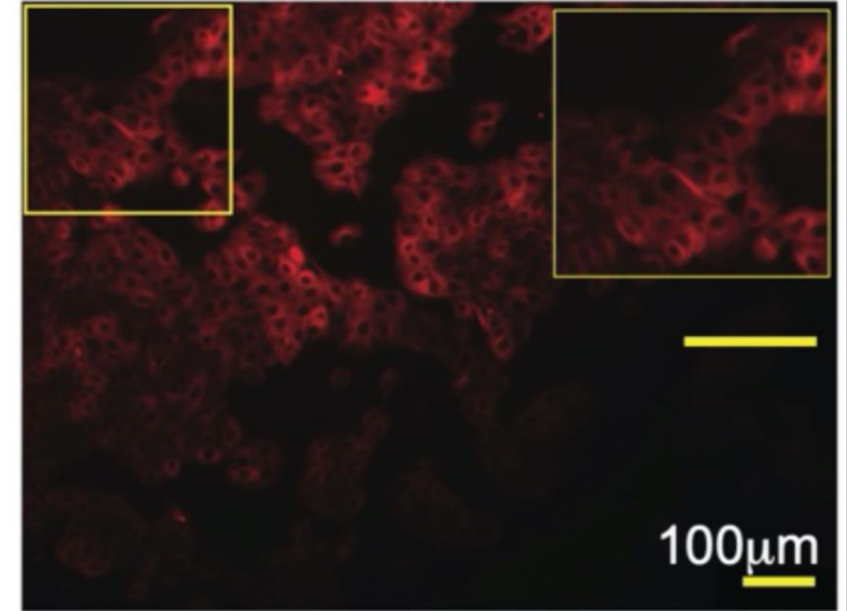
# pickup new pipette since we have a new reagent
l_pipette = pickup_fresh_pipette_tip(l_pipette, pipette, tiprack)

# get position of the first well of the microscope
pos_reagent = plate_reagents.columns[l_row][l_primary].center()
dx=0; dy=-1; dz=35 # offset-coordinates (only calibrate 1x once)

# set a location 1 mm right, 1 mm back, and 1 mm up from the center of well A1.
adjusted_location = pos_reagent.move(types.Point(dx, y=dy, z=dz))
pipette.move_to(adjusted_location)
pipette.move_to(adjusted_location)
pipette.aspirate(V_aspirate)

# move head up
adjusted_location = pos_reagent.move(types.Point(dx, y=dy, z=100))
pipette.move_to(adjusted_location)

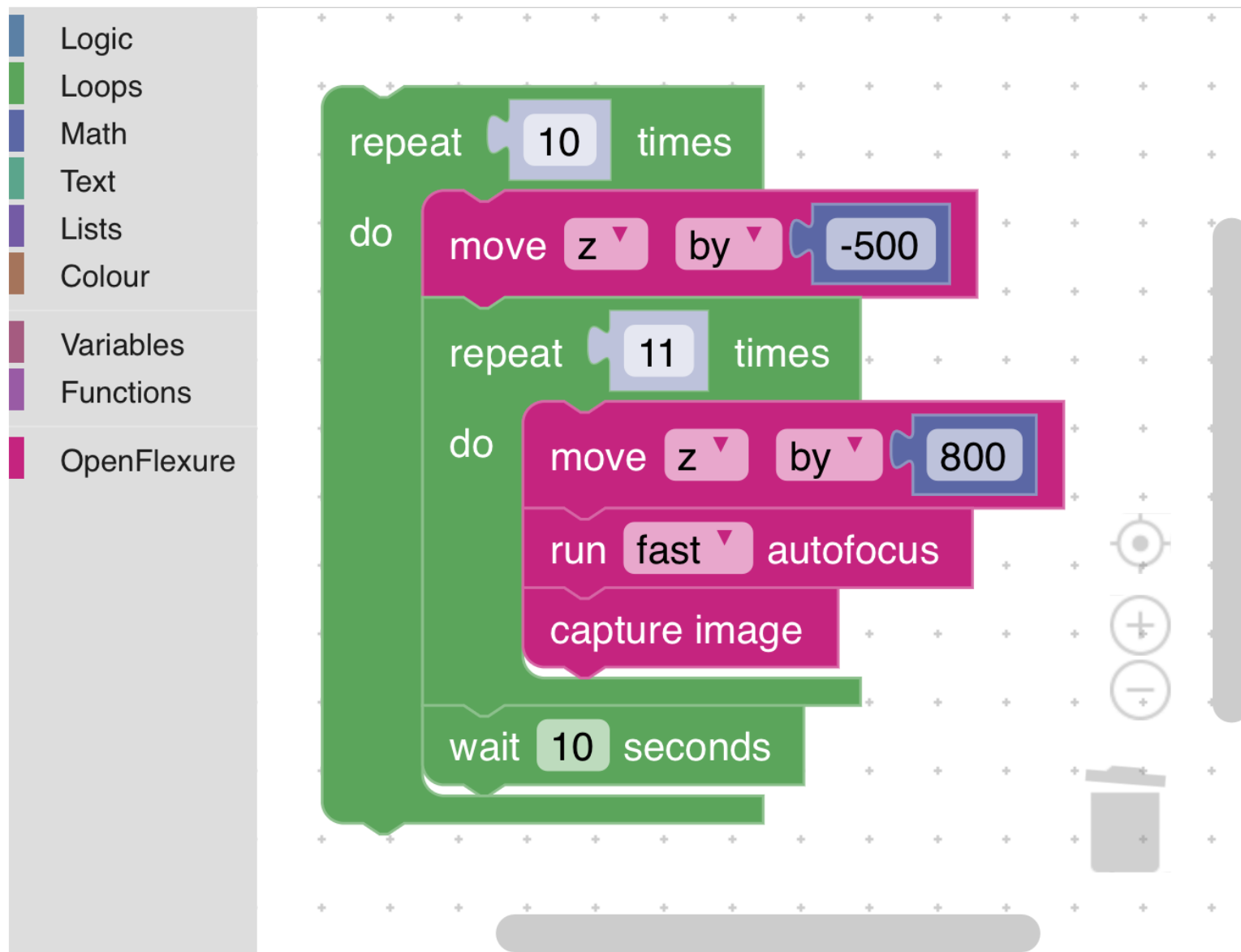
```



## Live preview



To start using OpenFlexure with Blockly, connect to your microscope.



Blockly script for microscope automation:

- Logic
  - repeat 10 times
    - do
      - move z by -500
  - repeat 11 times
    - do
      - move z by 800
      - run fast autofocus
      - capture image
    - wait 10 seconds



- Learned about WoT when searching for ReST interface advice, ~4 years ago. Credit to postdoc Joel Collins for that.
- What has it solved?
  - Clear way to control hardware with HTTP
  - Nice documentation for hardware API
  - Cross-language, cross-platform hardware control
  - (future) linking up frameworks/ontologies with semantic types
- Pain points
  - Standard ways of dealing with long/interactive actions
    - Synchronisation – e.g. an Event that's associated with an Action
  - Detail on protocol bindings (e.g. websockets)
  - Where is Swagger for my Thing Description?
  - Thing Description is not *quite* JSON Schema

- Top-down taxonomy of instrument types, as classes
  - Advantage: abstraction
  - Disadvantage: not flexible
- Language-specific
- Complicated to install/set up environment
- Only one process at a time

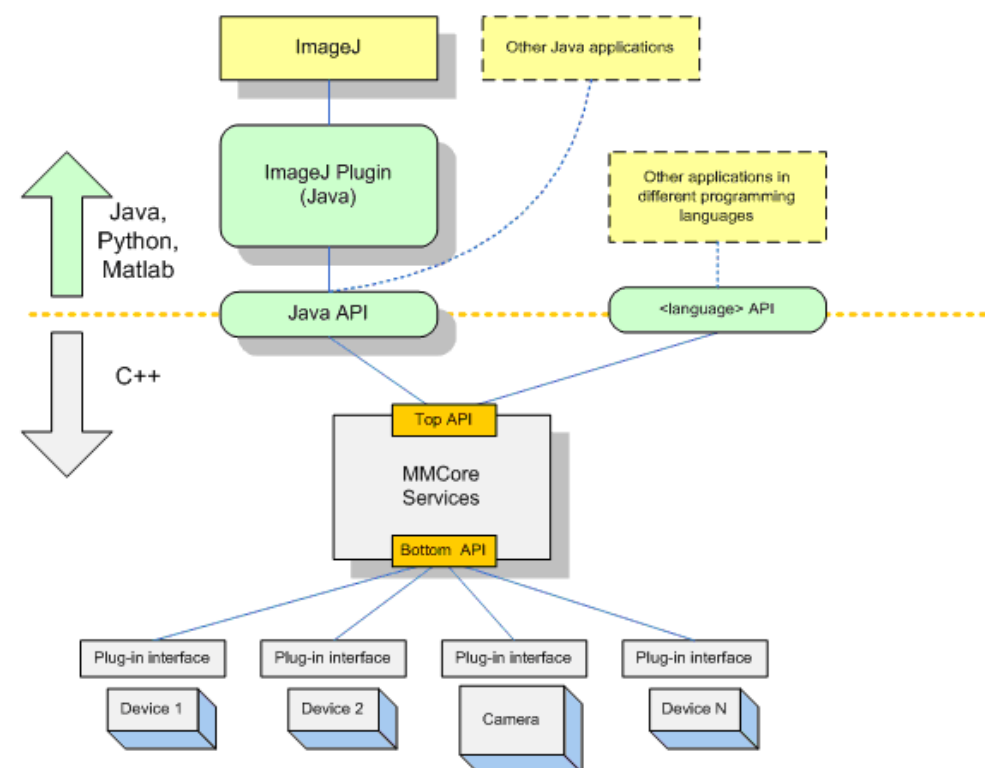
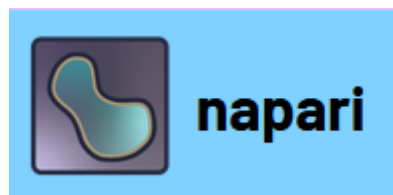


Microscope-  
Cockpit

ImSwitch: Generalizing microscope control in Python

Xavier Casas Moreno<sup>1</sup>, Staffan Al-Kadhimi<sup>1</sup>, Jonatan Alvelid<sup>1</sup>,  
Andreas Bodén<sup>1</sup>, and Ilaria Testa<sup>1</sup>

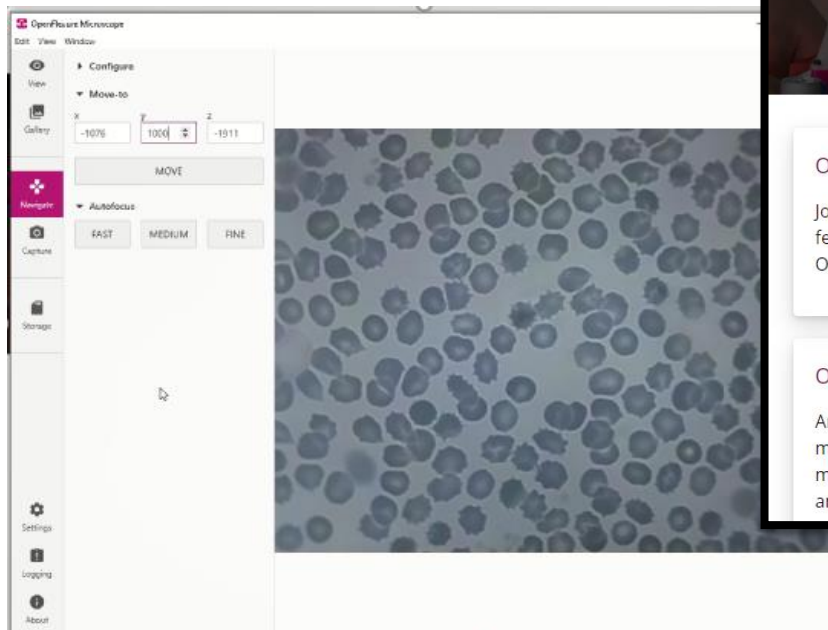
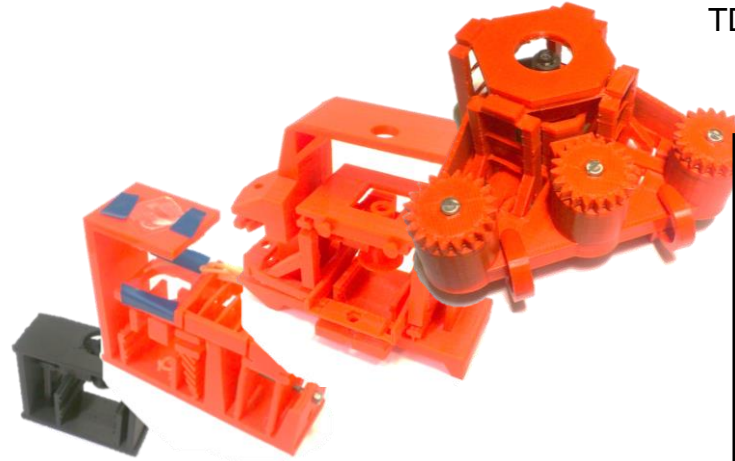
<sup>1</sup> SciLifeLab, KTH Royal Institute of Technology



- Standardised, cross-platform, language-independent way to run *and document* actions, get/set properties, watch for events [WoT – TD & protocol binding]
- Opt-in taxonomies, allowing frameworks to align gradually over time [WoT semantic types]
- Neat ways to determine compatibility of devices [TD?]
- Needs to be useful *immediately* without huge up-front time investment
- Gradually becomes more useful as it's more fully implemented



TDs of Richard's lab are available at <https://gist.github.com/rwb27/7e0c0b70a2e9b32cfa35a67fe1d7ae33>



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## The OpenFlexure Project

The OpenFlexure project makes high precision mechanical positioning available to anyone with a 3D printer - for use in microscopes, micromanipulators, and more.

### OpenFlexure Forum

Join the discussion! Get help, request features, and share knowhow on the OpenFlexure Forum.

### OpenFlexure Microscope

An open-source, 3D-printed microscope, including a precise mechanical stage to move the sample and focus the optics.

### Tweets by @OpenFlexure

OpenFlexure Retweeted

**Tobias Wenzel** @MakerTobey

Our new #openhardware preprint is out 🌟  
[@jenny\\_molloy](#) [@WenzelLab](#) of interest to  
[@jimhaseloff](#) [@GOSHCommunity](#)  
[@oshwassociation](#) [@OK\\_Maps](#)  
[@CERNopenlab](#) [@journalopenhw](#) [@OKFN](#)  
[@OpenFlexure](#) [@OpenUc2](#) etc.  
[https://twitter.com/M\\_Oellermann/status/1410492806200692736](https://twitter.com/M_Oellermann/status/1410492806200692736)

Jul 1, 2021

OpenFlexure Retweeted

[Motor cutout on illumination dovetail for delta stage](#)

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[Oring Alternatives - hair ties?](#)  
[Editable CAD files](#)

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[LED grid illumination](#)  
[Delta microscope RMS optics](#)

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[Should the logo say "microscope"?](#)  
[New forum Section for New Builds](#)

### Build Reports