# Project #2: Low-cost open-source microscopy

**Idea:** Build or enhance a cheap open-source microscope.

Possible directions:
- Try to achieve superresolution using sub-pixel information
  - https://en.wikipedia.org/wiki/Pixel_shift
  - https://en.wikipedia.org/wiki/Super-resolution_imaging
  - https://en.wikipedia.org/wiki/Demosaicing
  - https://www.cambridge.org/core/journals/microscopy-today/article/guidelines-for-understanding-magnification-in-the-modern-digital-microscope-era/E99CB37B30B5DCF7654A17A44A6A682F/core-reader
  - https://en.wikipedia.org/wiki/Diffraction-limited_system
  - https://en.wikipedia.org/wiki/Digital_microscope#Resolution
- Implement 3D reconstruction of objects
- Lens-less microscopy
  - DiffuserCam (https://waller-lab.github.io/DiffuserCam/)
  - Video from stills (PAPER)

**Goals:**
- Design, implement, and release open-source hardware, image reconstruction software, and an accompanying dataset.
- Document all outcomes and make them publicly available under suitable license.
- Learn about microscopes and super-resolution.

**Difficulty:** Medium

**Subjects:** open software, open hardware, open science

**Deliverables:**
- Github repository with source code.
- Documentation, manuals, and results (e.g. as PDF or Github page).
- Dataset on Zenodo (see e.g. the open X-ray tomographic datasets at https://www.fips.fi/dataset.php)

**Requirements and costs:**
- Hardware
  - Arduino/Raspberry Pi + Camera
  - Cheap lens, 3D printed/laser-cut parts
  - Laptop/Desktop PC
- Python, Jupyter Notebooks, conda/pip, Git, basic linear algebra

**Milestones:**
1. Research open-source microscopy setups
2. Build or extend setup

3. Capture data in controlled environment and check resolution limit
4. Implement e.g. super-resolution
5. Document and release

**Estimation:**

**Bonus:**
- 3D-print objects
- Find a cheap way to verify resolution
  - Instead of micrometer or USAF 1951 resolution test chart
- Experiment with different super-resolution algorithms
- Optimise for (near) real-time application.

**Hint:** Work in a controlled environment, separate code into data capture (shell script) and into reconstruction (Jupyter notebook), start with downsampled data, when capturing data try to set as many parameters as possible manually to ensure reproducibility.

**References:**