193.067 Free and Open Technologies
TU Wien, winter term 2019/2020.
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Project #1: Open-source light tomography demo kit

Idea: Build an open-source educational kit that demonstrates the principle of computerized tomography (CT) - from data acquisition to image reconstruction - using light instead of X-radiation.

For example, see this demo: https://www.youtube.com/watch?v=IQ6cam99k-g

Prime examples of such projects are:

- DiffuserCam (https://waller-lab.github.io/DiffuserCam/)
- OpenEIT (https://openeit.github.io/ and https://github.com/OpenEIT/OpenEIT)

Goals:

- Design, implement, and release open-source hardware, image reconstruction software, and an accompanying dataset
- Document all outcomes and make them publicly available under a suitable license
- Learn about medical imaging

Difficulty: Medium-Difficult
Subjects: open software, open hardware, open educational resources, 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
    - Stepper or servo motor
    - Strong light source, white canvas
    - Material penetrable by light (e.g. overhead transparencies)
    - Laptop/Desktop PC
- Python, Jupyter Notebooks, conda/pip, Git, basic linear algebra

Milestones:

1. Build setup and capture initial data in controlled environment
2. Implement image reconstruction using simulated data and then real data
3. Implement visualisation and try with different materials/objects
4. Document and release

Estimation:

Bonus:

- Find a creative way to visualise 3D results (e.g. using https://tomviz.org/ or VR)
- 3D-print different objects
- Experiment with different reconstruction algorithms
- Optimise for (near) real-time application.

Hint: Work in a controlled environment, separate code into data capture/hardware control (shell script) and into reconstruction (Jupyter notebook), start with downsampled data.

References:

- Radon transform https://en.wikipedia.org/wiki/Radon_transform
- Tomographic reconstruction https://en.wikipedia.org/wiki/Tomographic_reconstruction
- Tomography toolboxes (e.g. ASTRA, ODL, TomoPy) https://tomopedia.github.io/software/
- See also operator discretisation library (ODL) https://odlgroup.github.io/odl/getting_started/first_steps.html