Medical Image Analysis

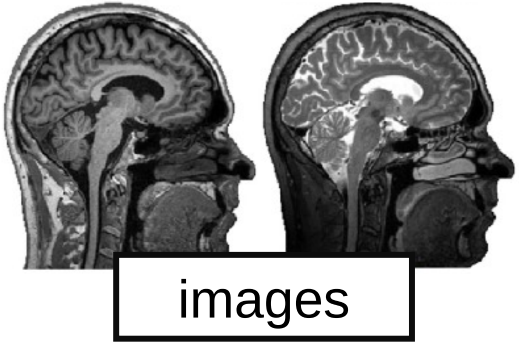
NBE-E4010

Aalto-yliopisto
Aalto-universitetet
Aalto University

Koen Van Leemput

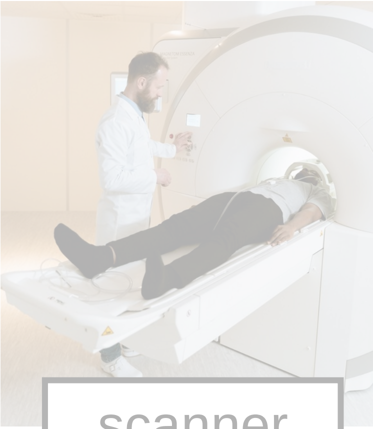
Fall 2023

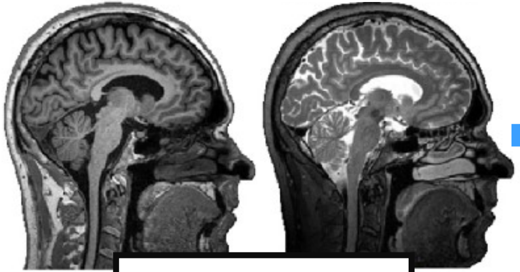
AI in medical imaging

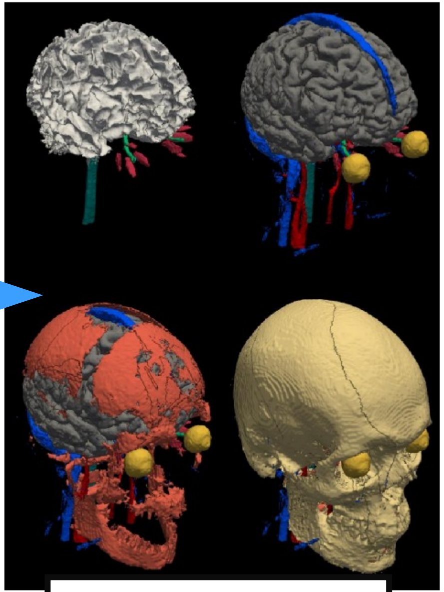


- acquire images faster
- visualize more details

AI in medical imaging







- expose the “unseeable”
- measure more consistently
- analyze images faster

Exposing the “unseeable”

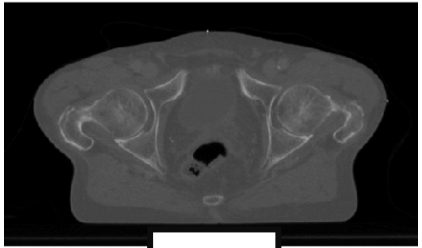
today

8 months ago

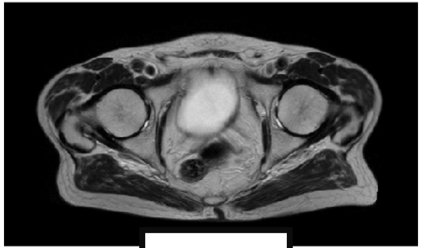
Exposing the “unseeable”

today

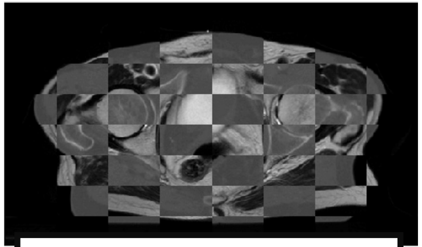
8 months ago



CT



MRI

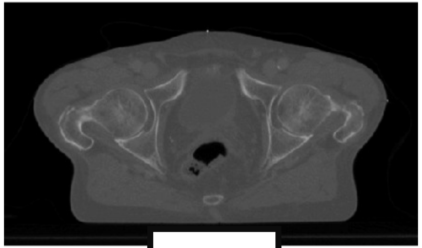


mosaic CT/MRI

Exposing the “unseeable”

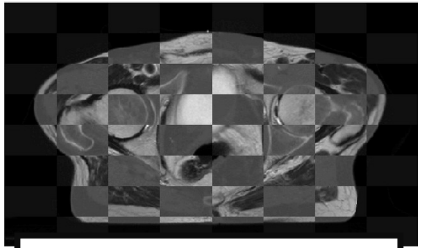
today

8 months ago



CT

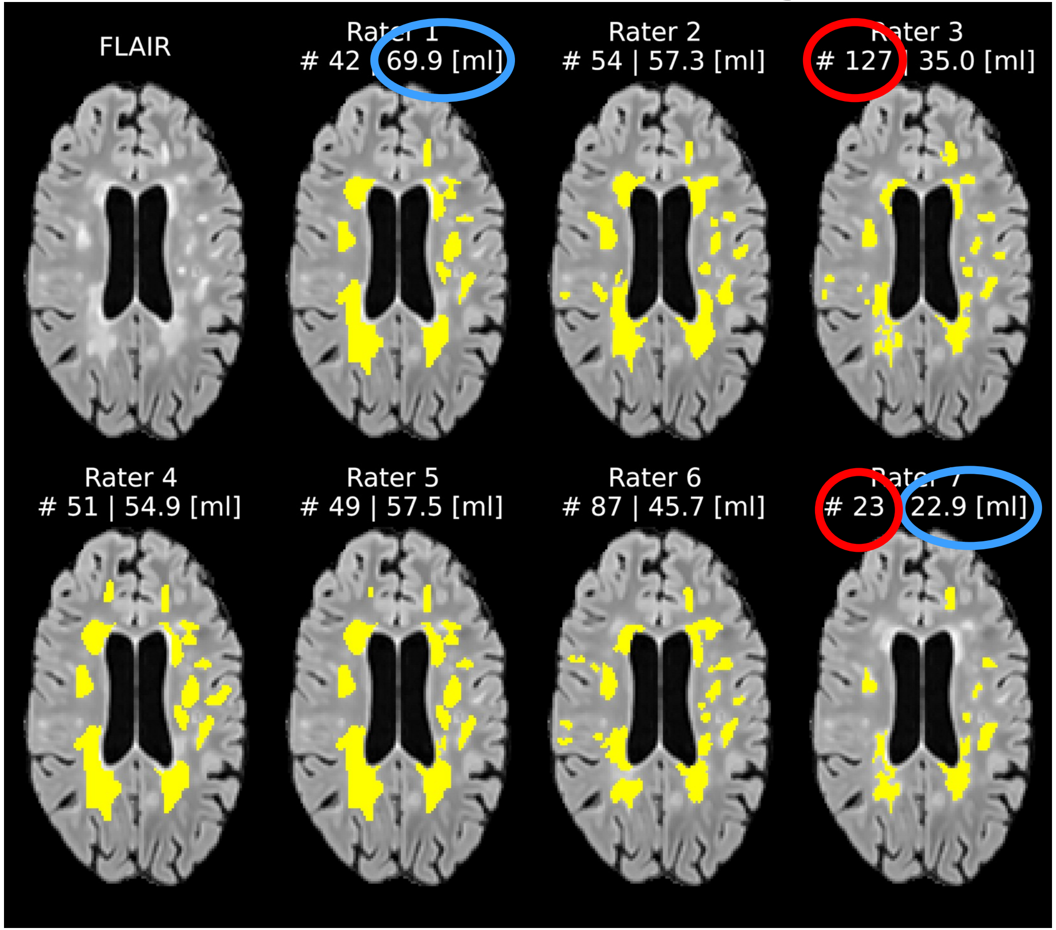
MRI



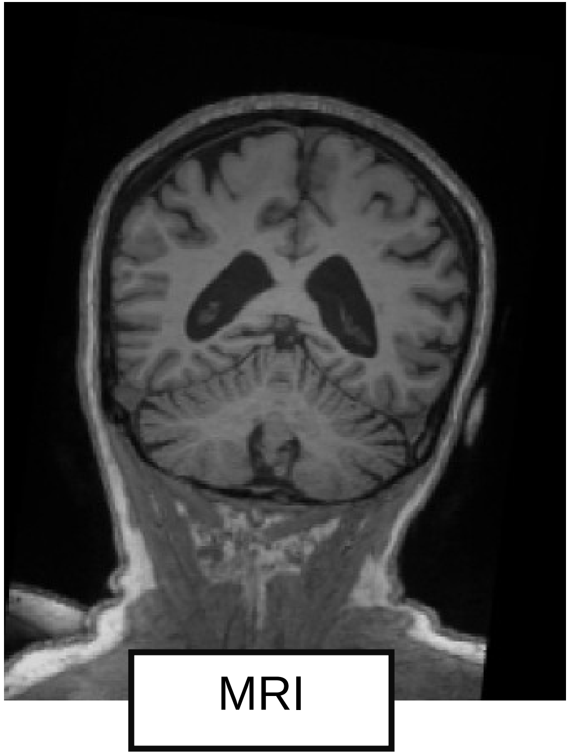
mosaic CT/MRI

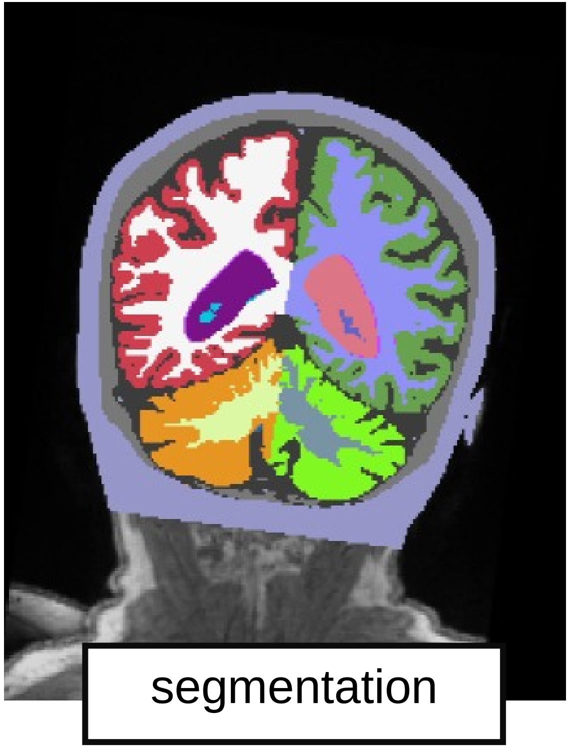
Measuring more consistently

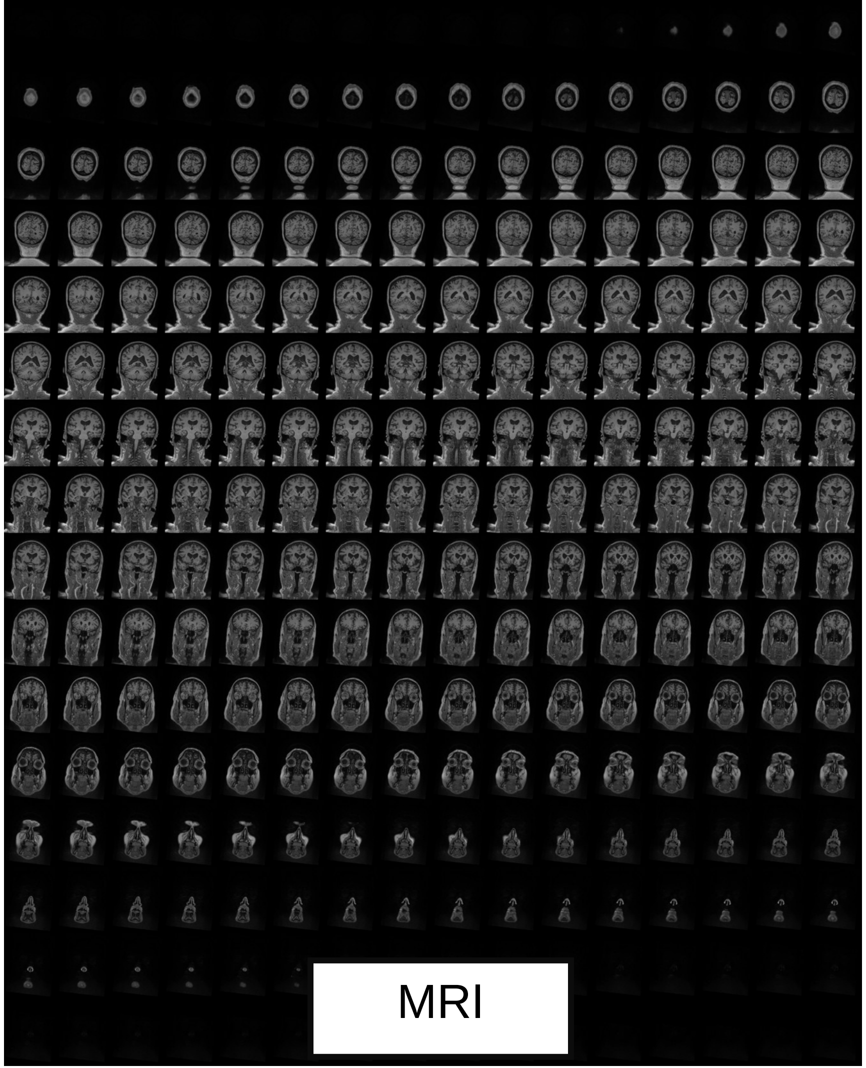
Quantifying lesions in multiple sclerosis (MS):
- number (#)
- volume (ml)

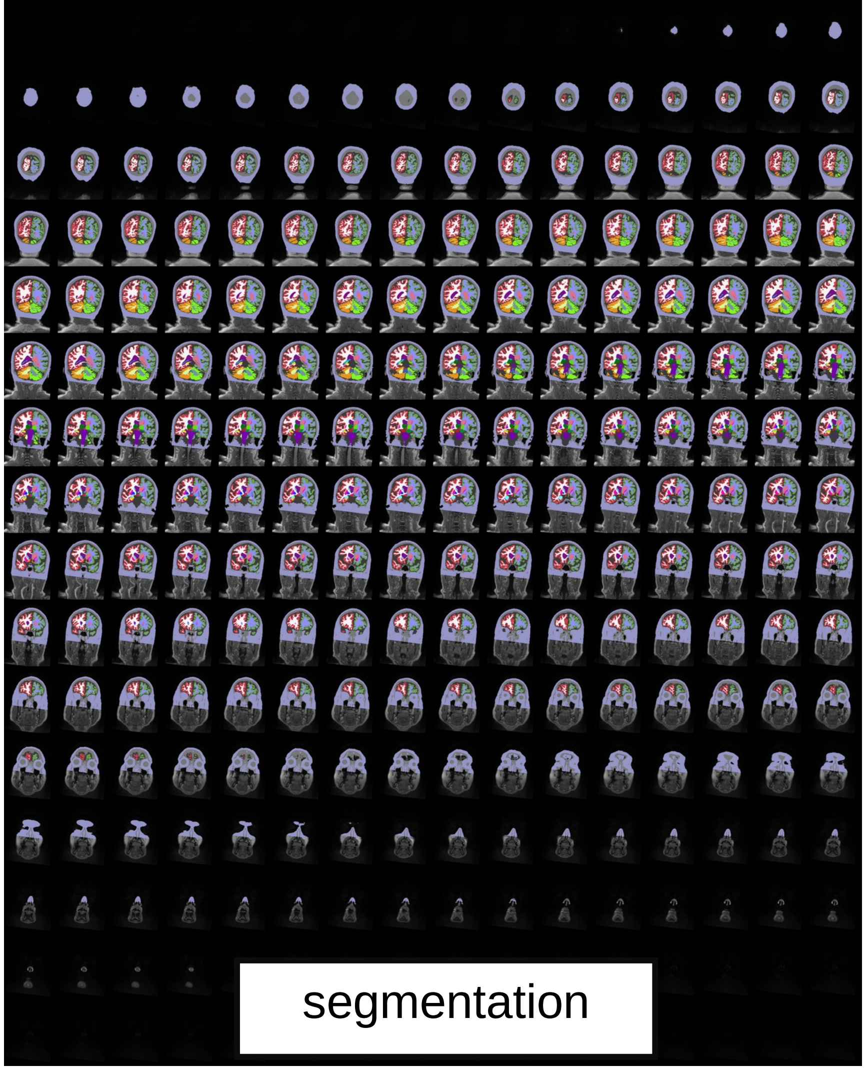


Analyzing images faster



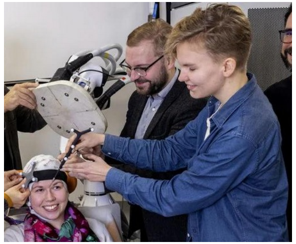



MRI


segmentation

Who are we?

- ✔ Koen Van Leemput (Professor, Neuroscience and Biomedical Engineering, Aalto University)
- ✔ Ida Granö (Doctoral Researcher, Neuroscience and Biomedical Engineering, Aalto University)
- ✔ Raymond Khazoum (Doctoral Researcher, Computer Science, Aalto University)


- ✔ Axel Thielscher (Professor, Health Technology, Technical University of Denmark)
- ✔ Oula Puonti (Postdoctoral Researcher, Health Technology, Technical University of Denmark)
- ✔ Merle Diedrichsen (Doctoral Researcher, Health Technology, Technical University of Denmark)



Who are you?

- ✔ MSc in Life Science Technologies: 46
- ✔ Exchange studies: 8
- ✔ BSc in Electrical Engineering: 4
- ✔ MSc in Computer, Communication and Information Sciences: 3
- ✔ PhD in Science: 2
- ✔ BSc in Chemical Technology: 2
- ✔ MSc in Engineering Physics: 1
- ✔ BSc in Engineering: 1

67 students at Aalto

37 students at the Technical University of Denmark

Learning objectives

After this course you should be able to:

- ✔ Implement smoothing and interpolation operations in images
- ✔ Explain coordinate systems used in medical imaging
- ✔ Perform landmark-based and intensity-based image registration
- ✔ Select the most appropriate similarity measure for specific image registration problems
- ✔ Implement rigid, affine and nonlinear spatial transformation models
- ✔ Solve segmentation problems using generative models
- ✔ Perform image segmentation using example-based learning
- ✔ Weigh the advantages and limitations of model- vs. example-based techniques

Teaching form

Lectures:

- ✔ Tuesdays 14:15-16:00
- ✔ Live-streamed to/from Denmark
- ✔ Konetekniikka 1, 216 (until mid-October); Terveysteknologian talo, F239a (from mid-October)
- ✔ Two guest lectures: Jyrki Lötjönen (Combinostics) and Eero Salli (HUS Radiology)

Exercises:

- ✔ Mondays 12:15-14:00
- ✔ Terveysteknologian talo, luentosali 1 - F175a
- ✔ Python + Jupyter notebooks
- ✔ Group-work (max. 3 students per group)
- ✔ 2-3 weeks to submit a group report (6 reports in total)
- ✔ **Grading:** Peergrade + teachers' final assessment

no exam!

Logistics

https://mycourses.aalto.fi/

- ✔ Course material (lecture slides, book, …)
- ✔ Announcements
- ✔ Discussion fora
- ✔ Submission of exercise reports

Week 1

Lecture: Introduction to the course, Python and Jupyter notebooks

Week 2

Lecture: Image smoothing and interpolation

Week 3

Exercise session: Image smoothing and interpolation

Discussion forum: Image smoothing and interpolation exercise

Lecture: Coordinate systems, spatial transformations, landmark-based registration

Week 4

Exercise session: Image smoothing and interpolation (cont.)

Lecture: Intensity-based methods for registration

Week 5

Exercise session: Landmark-based registration

Discussion forum: Landmark-based registration exercise

Lecture: Nonlinear registration with Gauss-Newton

Week 6

Exercise session:Mutual Information-based registration

Discussion forum: Mutual information-based registration

Lecture: Model-based segmentation I

Week 7

Exercise session: Nonlinear registration

Discussion forum: Nonlinear registration exercise

Lecture: Model-based segmentation II

Week 8

Exercise session: Model-based segmentation

Discussion forum: Model-based segmentation

Neural Networks

Week 9

Exercise session: Model-based segmentation (cont.)

Guest lecture: Jyrki Lötjönen (Combinostics)

Week 10

Exercise session: Neural networks

Discussion forum: Neural networks exercise

Guest lecture: Eero Salli (HUS)

Week 11

Exercise session: Neural networks (cont.)

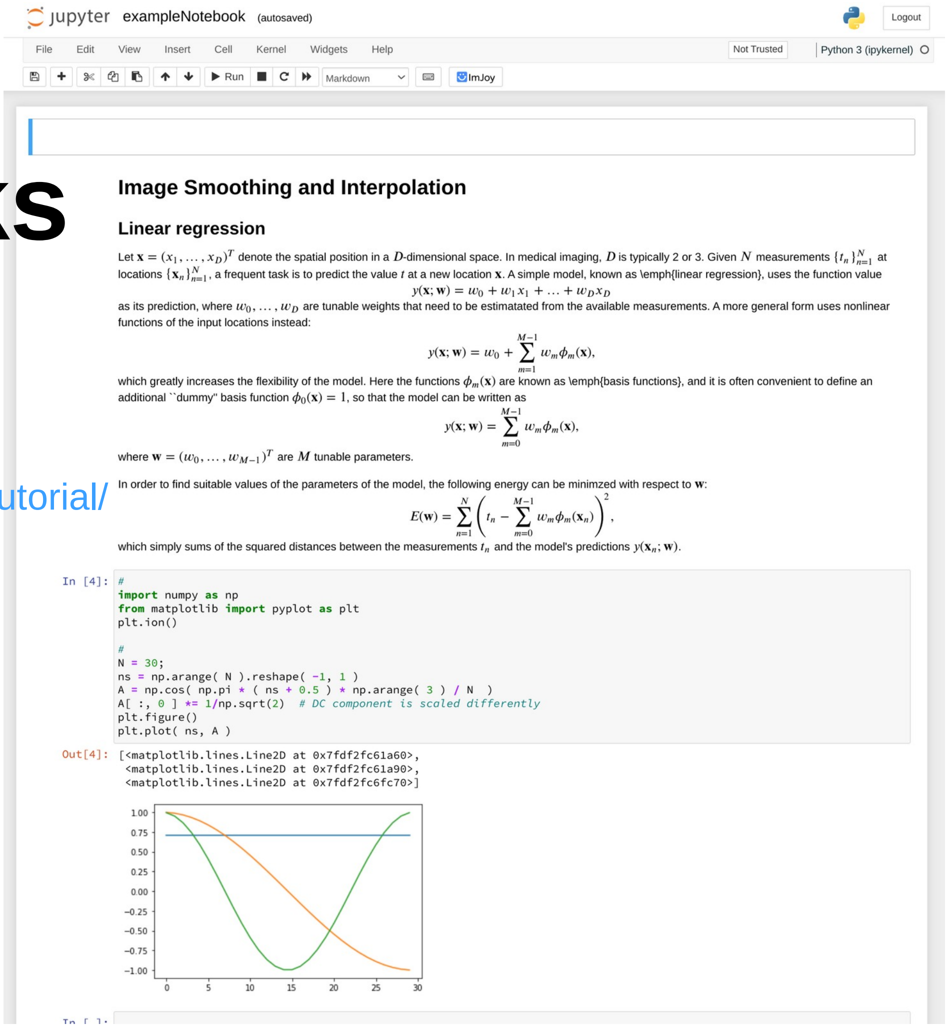
Lecture: Neural networks in practice I

Week 12

Lecture: Neural networks in practice II

Python and Jupyter Notebooks

- ✔ Python: https://lectures.scientific-python.org/
- ✔ Jupyiter Notebooks: https://www.dataquest.io/blog/jupyter-notebook-tutorial/



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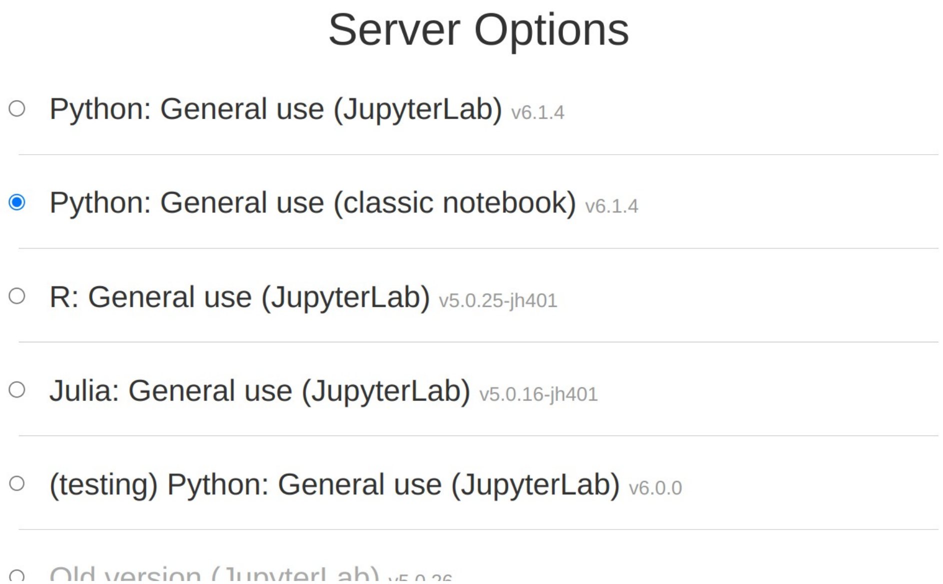
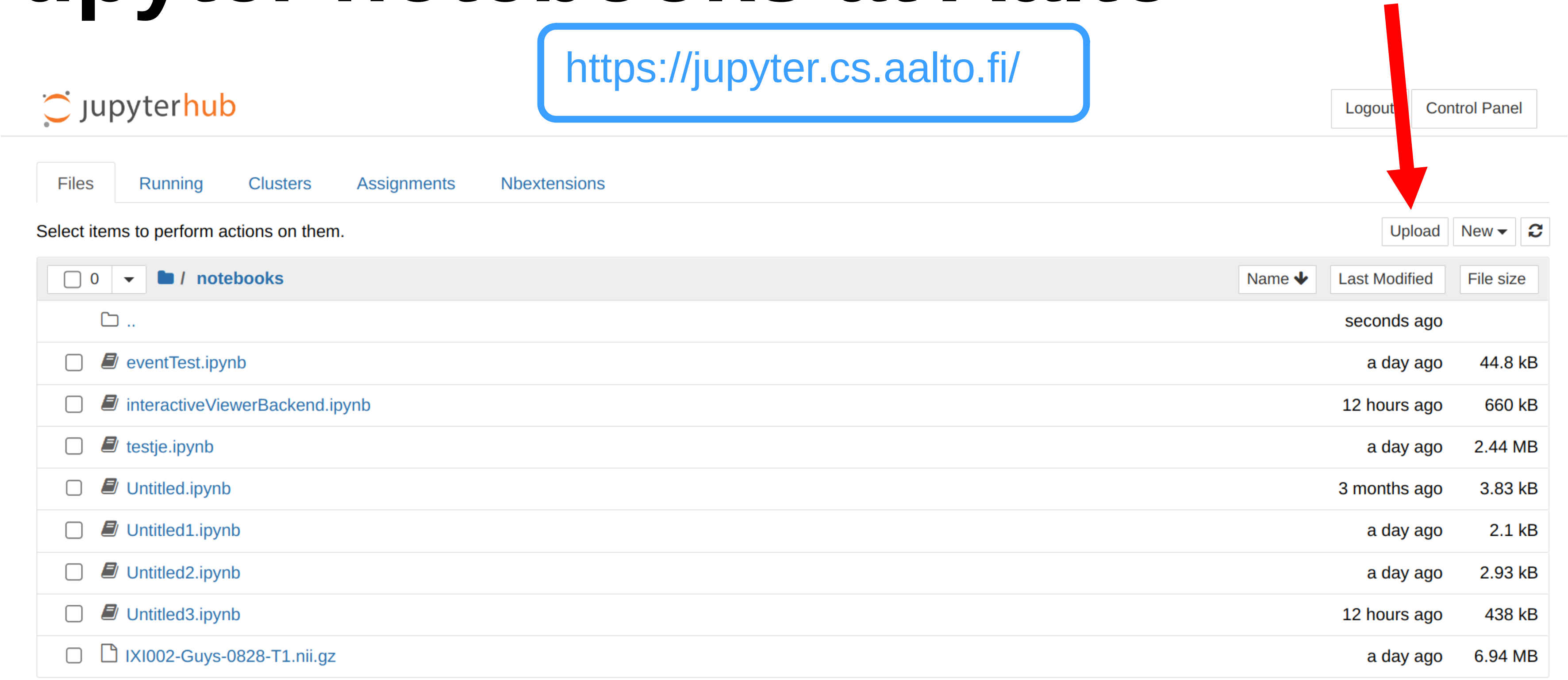
Jupyter notebooks at Aalto

https://jupyter.cs.aalto.fi/



Jupyter notebooks at Aalto



Jupyter notebooks at Aalto

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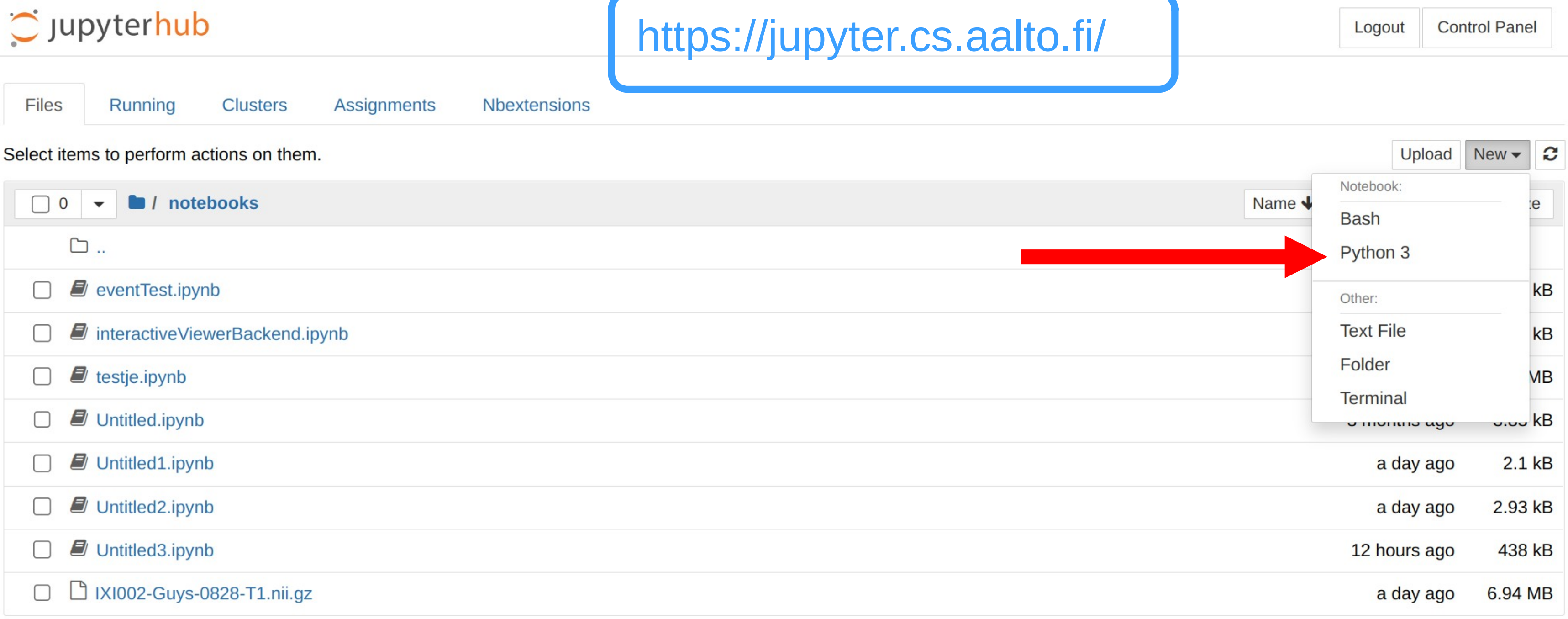

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