Medical Image Analysis

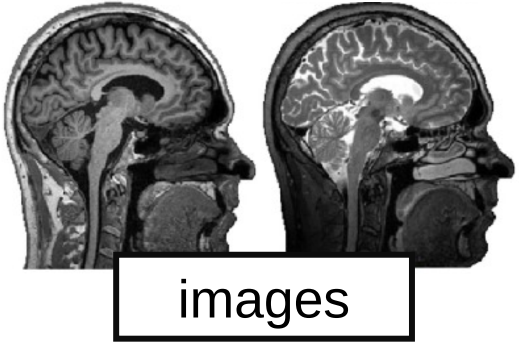
NBE-E4010

Aalto-yliopisto
Aalto-universitetet
Aalto University

Koen Van Leemput

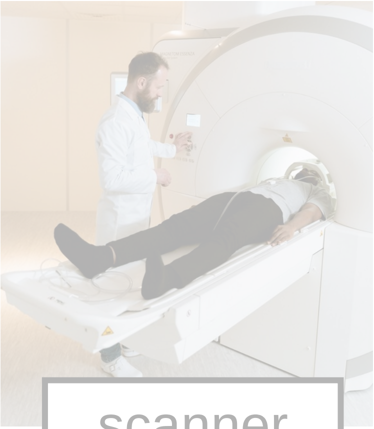
Fall 2024

AI in medical imaging

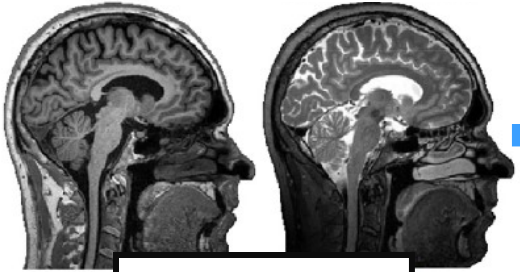


- acquire images faster
- visualize more details

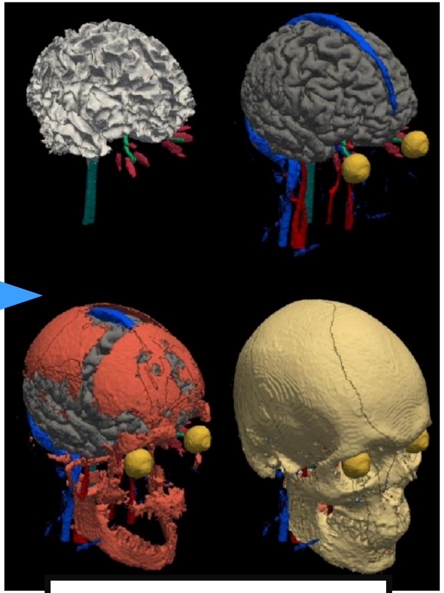
AI in medical imaging



scanner



images



information

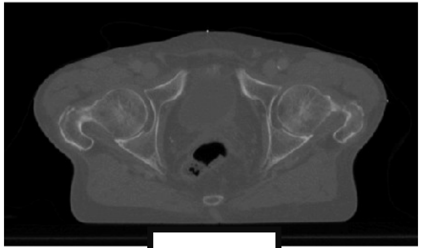
- expose the “unseeable”
- measure more consistently
- analyze images faster

Exposing the “unseeable”

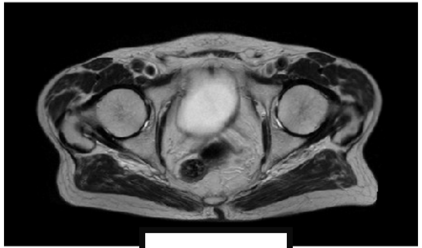
Exposing the "unseeable"

today

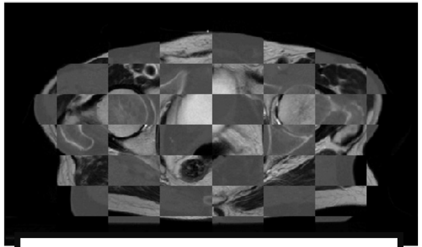
8 months ago



CT



MRI

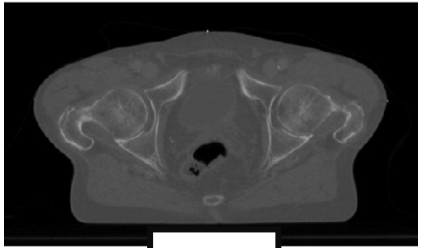


mosaic CT/MRI

Exposing the “unseeable”

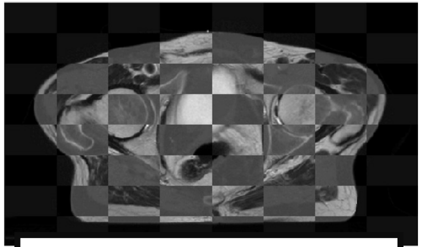
today

8 months ago



CT

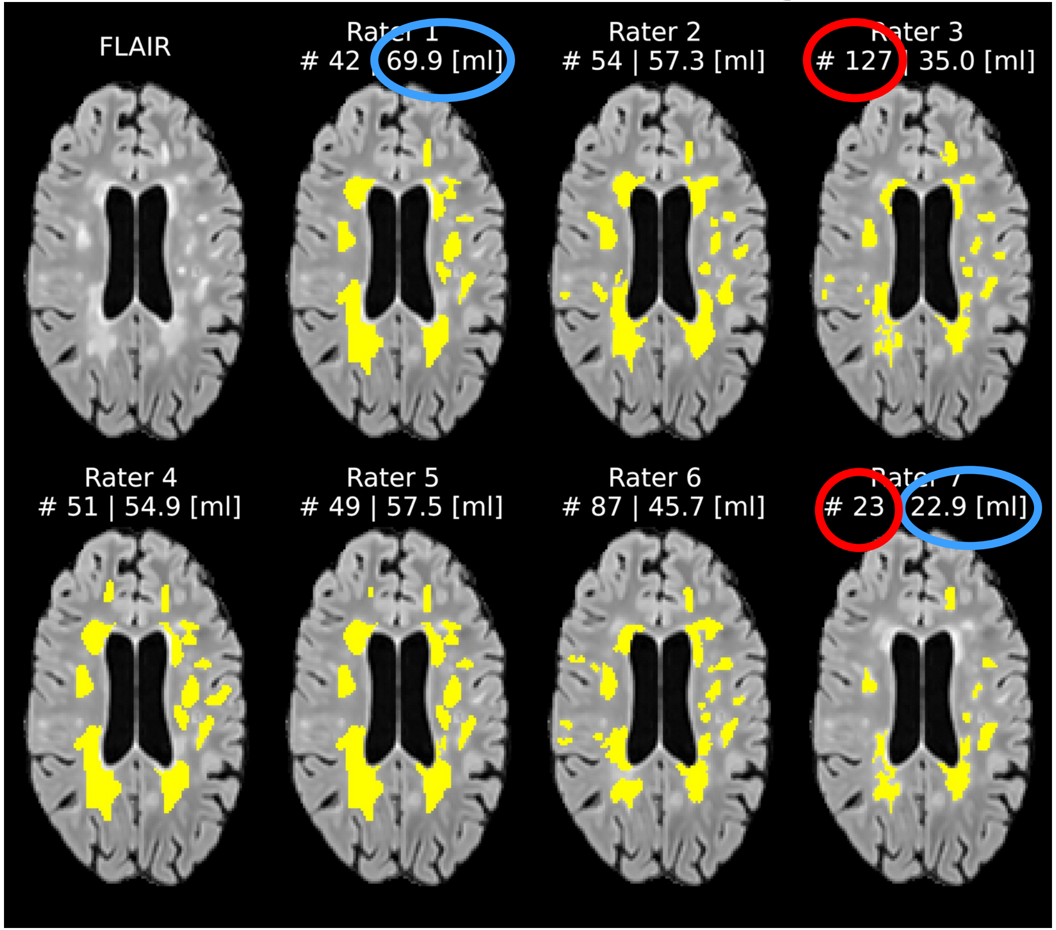
MRI



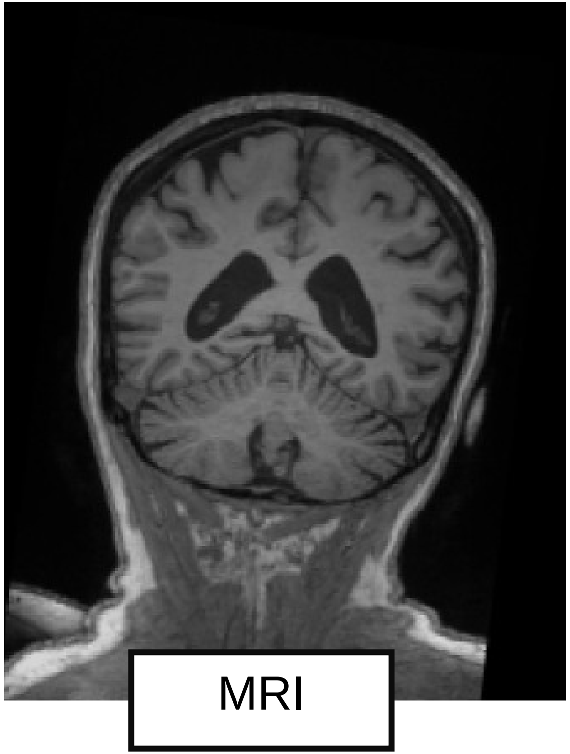
mosaic CT/MRI

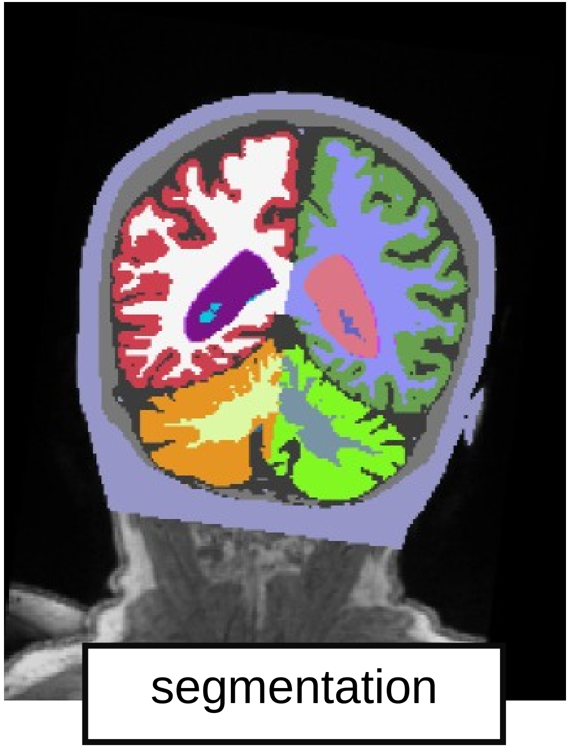
Measuring more consistently

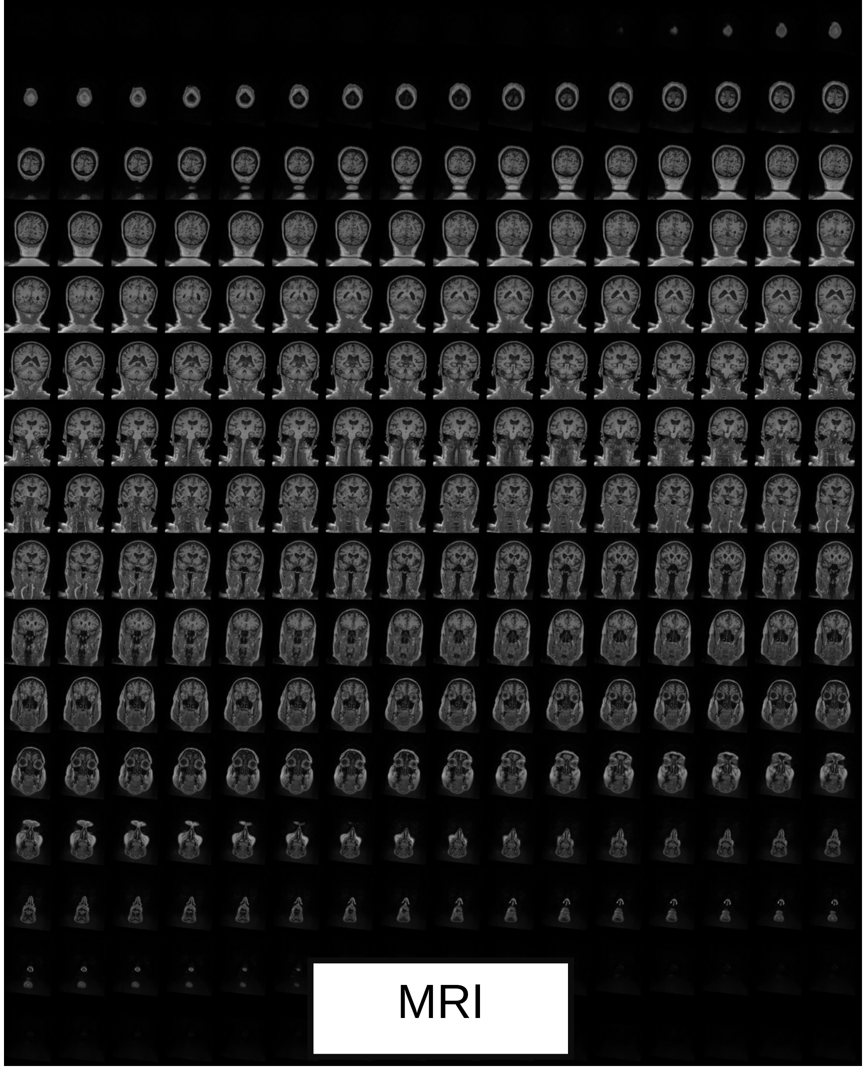
Quantifying lesions in multiple sclerosis (MS):
- number (#)
- volume (ml)

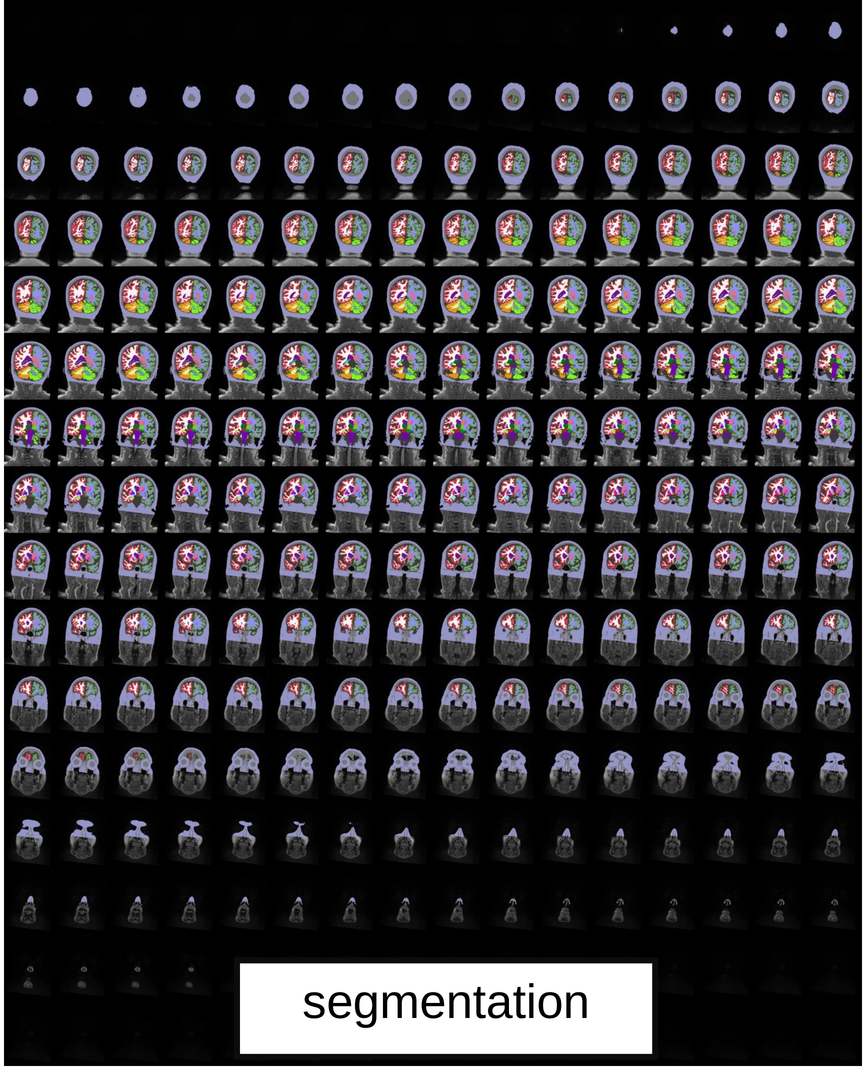


Analyzing images faster






MRI


segmentation

Want to know more?

Artificial Intelligence in medical imaging: From research to clinical practice – Koen Van Leemput

https://youtu.be/iiw4j-Frljo

Learning objectives

After this course you should be able to:

- ✔ Implement image smoothing and interpolation techniques
- ✔ Use spatial coordinate systems in medical images
- ✔ 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 discriminative methods (neural nets)
- ✔ Weigh the advantages and limitations of generative vs. discriminative techniques in medical image analysis

Who are we?

- ✔ Koen Van Leemput, teacher (Professor, Neuroscience and Biomedical Engineering)
- ✔ Ida Granö, TA (Doctoral Researcher, Neuroscience and Biomedical Engineering)
- ✔ Matias Vuokko, TA (Doctoral Researcher, Neuroscience and Biomedical Engineering)
- ✔ Amir Hassankhani, TA (Doctoral Researcher, Neuroscience and Biomedical Engineering)




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

Physical attendance:
- not required in lectures or exercise sessions
- but but...

Teaching form

Lectures:

- ✔ Mondays 12.15-14.00
- ✔ Lecture recordings are made available (if I manage...)
- ✔ Two guest lectures: Aino Nieminen (Disior) and Eero Salli (HUS Radiology)

Exercises:

- ✔ Thursdays 12.15-14.00
- ✔ Python + Jupyter notebooks
- ✔ Group-work (max. 3 students per group)
- ✔ 2 weeks to submit a group report (6 reports in total)
- ✔ Peer grading using FeedbackFruits

Student presentations:

- ✔ Instead of the lectures on 21 Oct and 25 Nov
- ✔ Students present their fellow students’ exercise reports

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Course grading:
- peer grading quality (10%)
- teachers' final score on reports (80%)
- student presentation (10%)

Student presentations:

- ✔ Instead of the lectures on 21 Oct and 25 Nov
- ✔ Students present their fellow students' exercise reports

Logistics

https://leempko.github.io/mia/

- ✔ Course material (book, slides)
- ✔ Schedule

https://mycourses.aalto.fi/

- ✔ Announcements
- ✔ Discussion fora
- ✔ Exercises (input data, report submissions, peer grading)

Week	Date	Activity	Location	Topic	
1	Mon 2 Sep	Lecture	F239a	Introduction to the course	- slides: pdf - jupyter notebook example
2	Mon 9 Sep	Lecture	F239a	Image smoothing and interpolation	- chapter 1 in the book (html pdf) - slides: html pdf
	Thu 12 Sep	Exercise	F239a	Smoothing and interpolation	- submission deadline: Wed 25 Sep at 23:59
3	Mon 16 Sep	Lecture	F239a	Coordinate systems, linear spatial transformations, landmark-based registration	- sections 2.1-2.3 in the book (html pdf) - slides: html pdf
	Thu 19 Sep	Exercise	F239a	Landmark-based registration	- submission deadline: Wed 2 Oct at 23:59
4	Mon 23 Sep	Lecture	F239a	Intensity-based registration	- section 2.4 in the book, excluding Gauss-Newton optimization (html pdf) - slides: html pdf
	Thu 26 Sep	Exercise	F239a	Mutual Information-based registration	- submission deadline: Wed 9 Oct: at 23:59
5	Mon 30 Sep	Lecture	F239a	Nonlinear registration	- sections 2.2.2 and 2.4 in the book, especially Gauss-Newton optimization (html pdf) - slides: html pdf
	Thu 3 Oct	Exercise	F239a	Mutual Information-based registration (cont.)	- submission deadline: Wed 9 Oct: at 23:59
6	Mon 7 Oct	Lecture	F239a	Model-based segmentation I	- sections 3.1-3.3 in the book (html pdf) - probability refresher: html pdf - slides: html pdf
7	Mon 21 Oct	Lecture	F239a	Student presentations of the first three exercises	
	Thu 24 Oct	Exercise	Y202a	Nonlinear registration	- submission deadline: Wed 6 Nov at 23:59
8	Mon 28 Oct	Lecture	F239a	Model-based segmentation II	- sections 3.4-3.5 in the book (html pdf) - slides: html pdf

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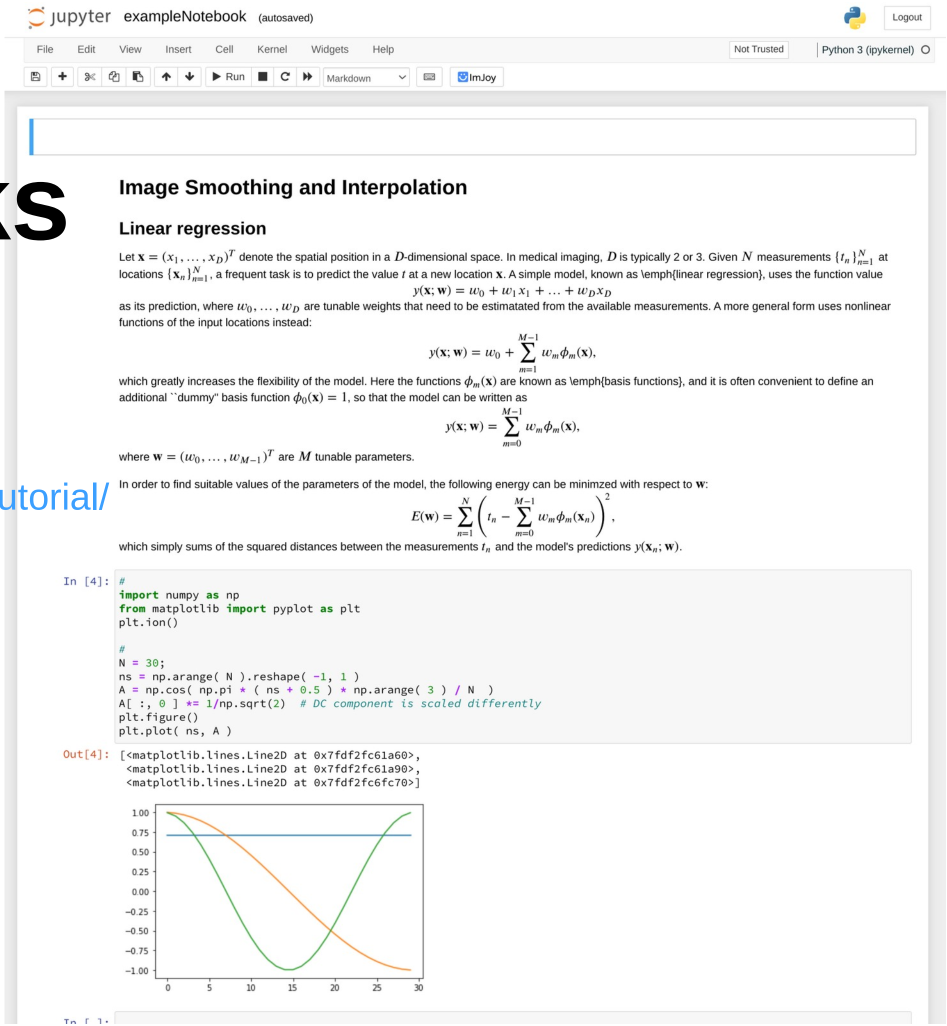
Python and Jupyter Notebooks

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



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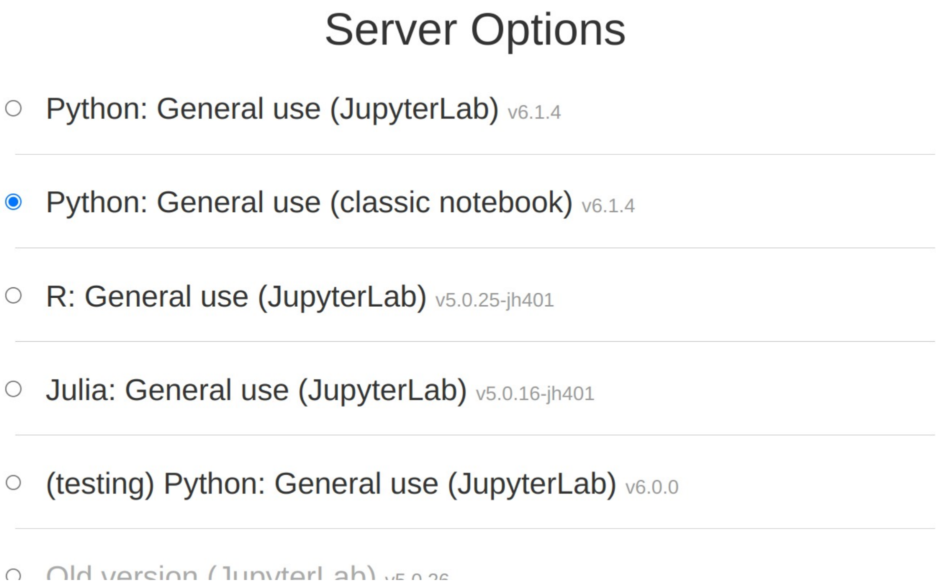
Jupyter notebooks at Aalto

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



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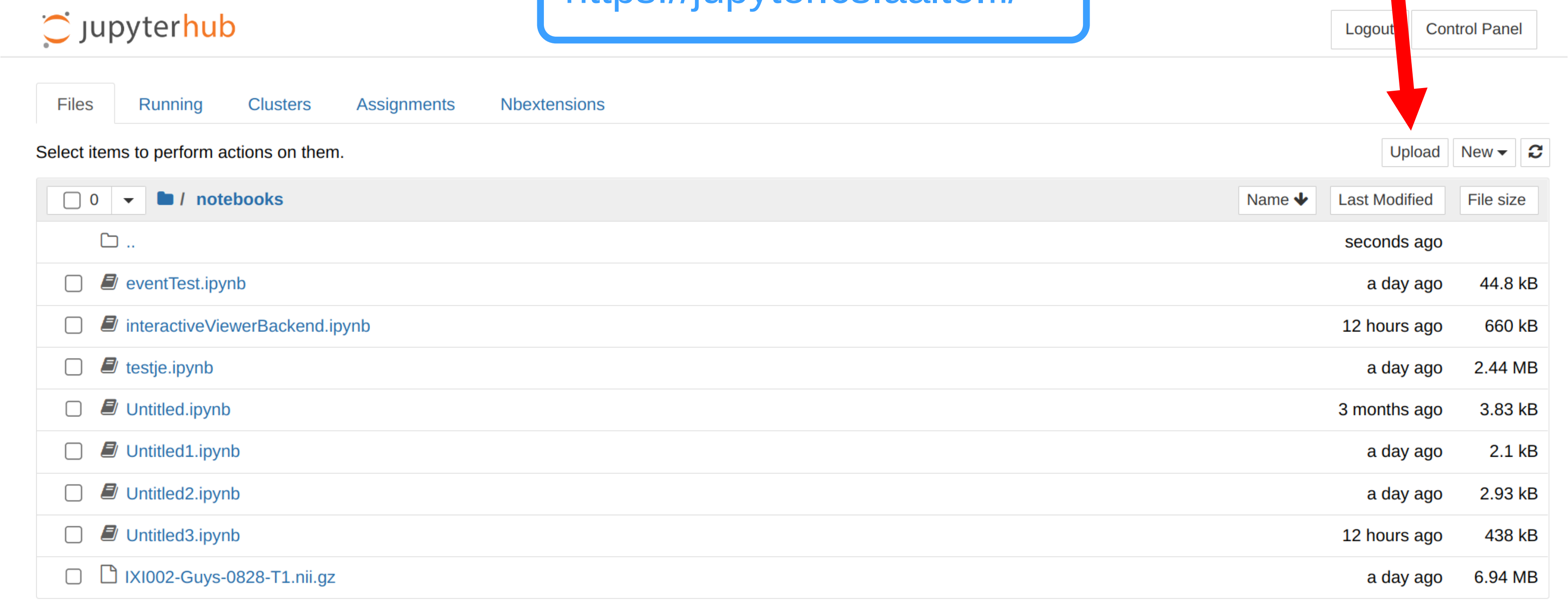
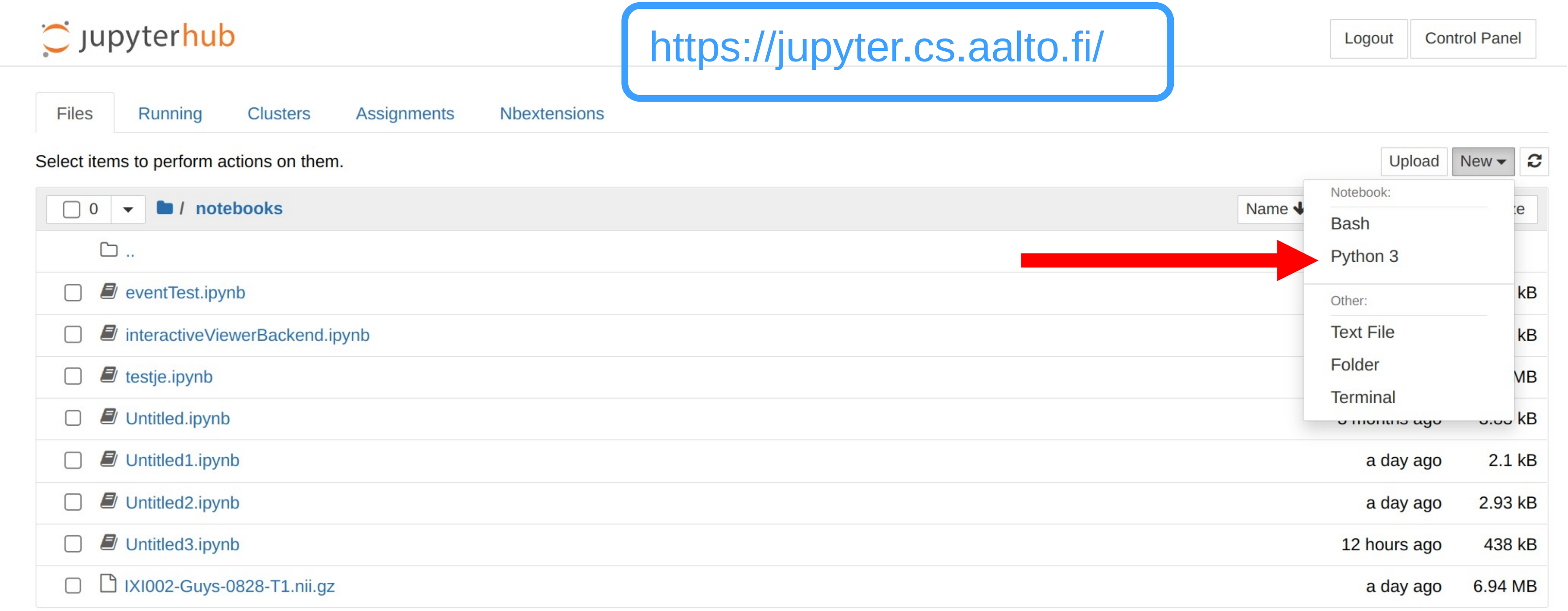


Jupyter notebooks at Aalto



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