Medical Image Analysis

NBE-E4010

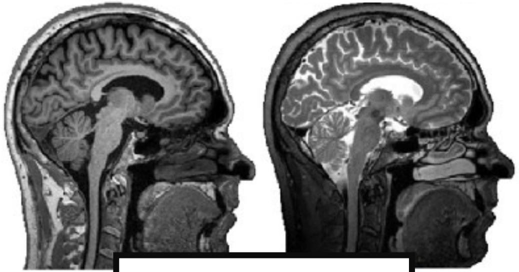
Aalto-yliopisto
Aalto-universitetet
Aalto University

Koen Van Leemput

Fall 2026

AI in medical imaging

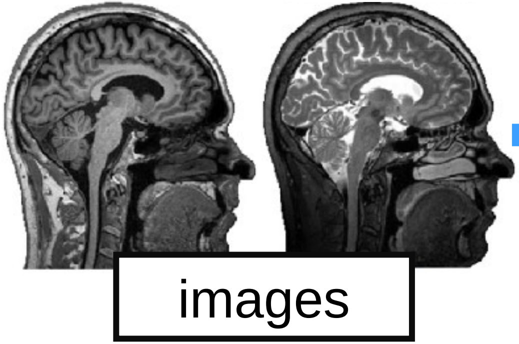
scanner

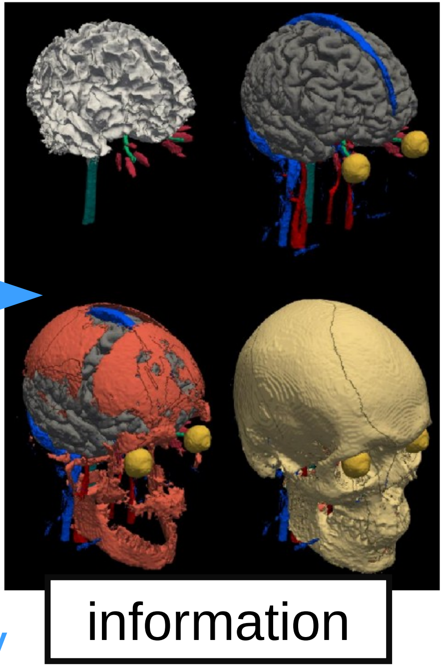


images

- acquire images faster
- visualize more details

AI in medical imaging





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

Exposing the “unseeable”

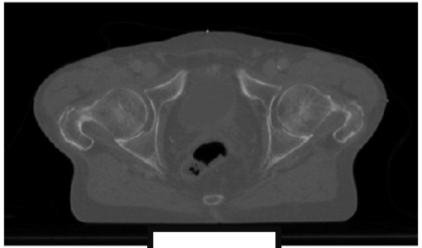
today

8 months ago

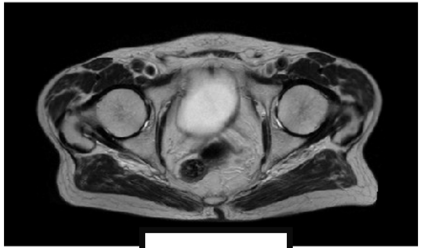
Exposing the “unseeable”

today

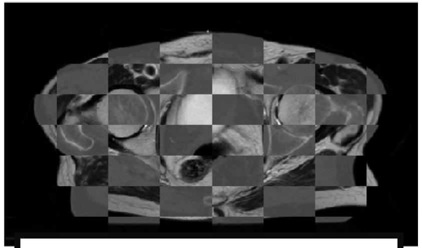
8 months ago



CT



MRI

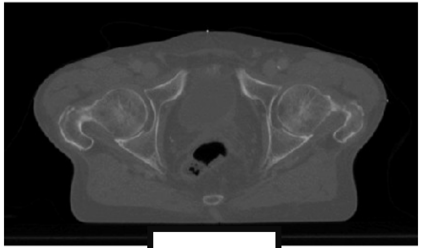


mosaic CT/MRI

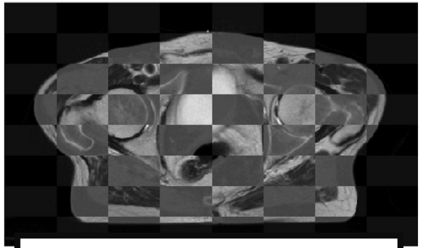
Exposing the “unseeable”


today


8 months ago

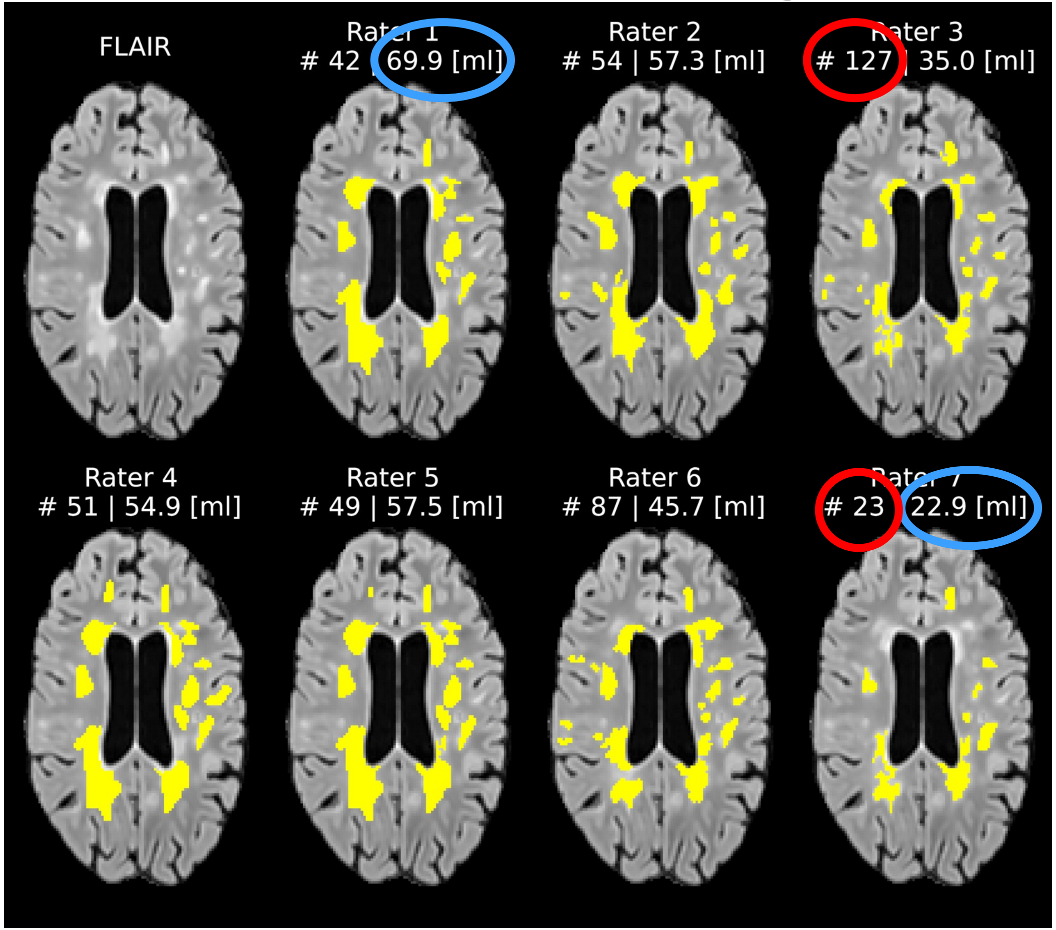

CT


MRI

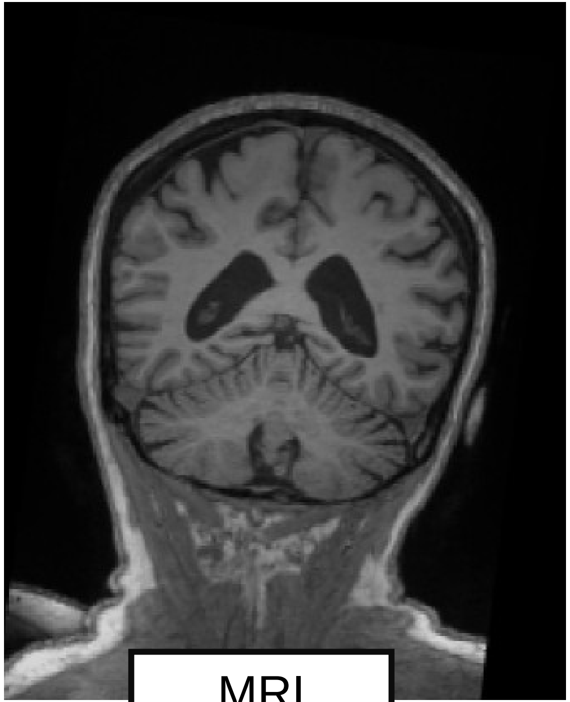

mosaic CT/MRI

Measuring more consistently

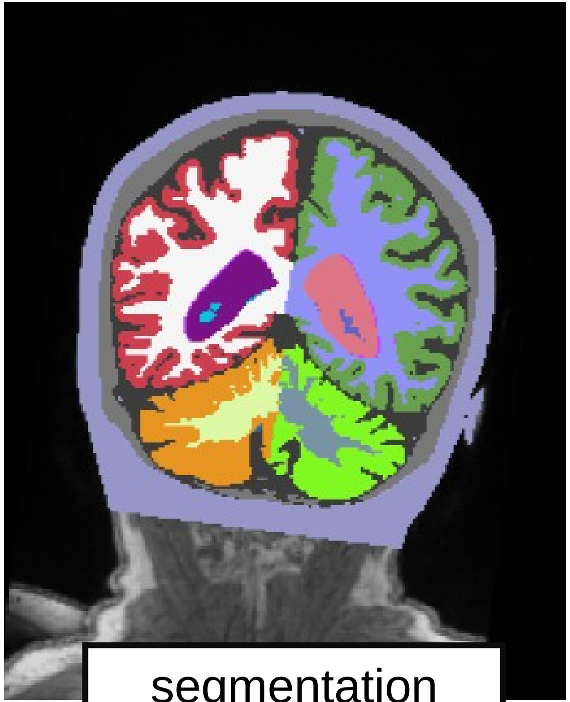
Quantifying lesions in multiple sclerosis (MS):
- number (#)
- volume (ml)



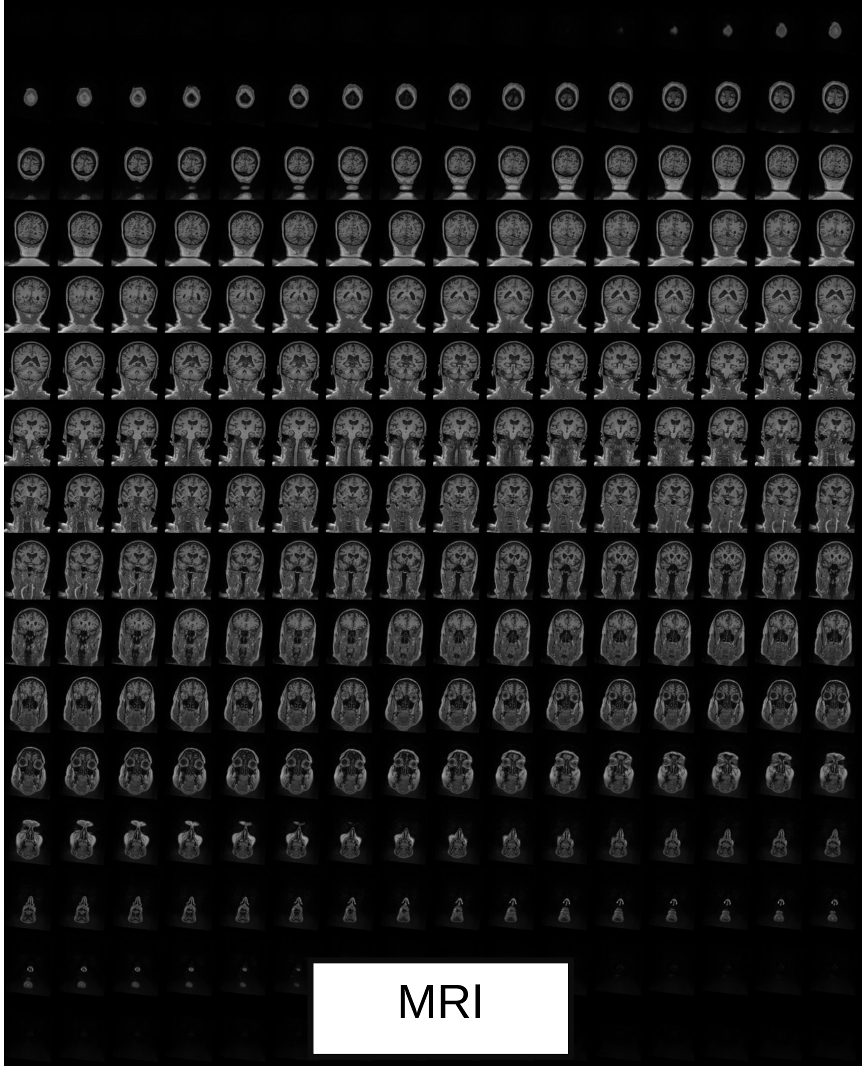
Analyzing images faster

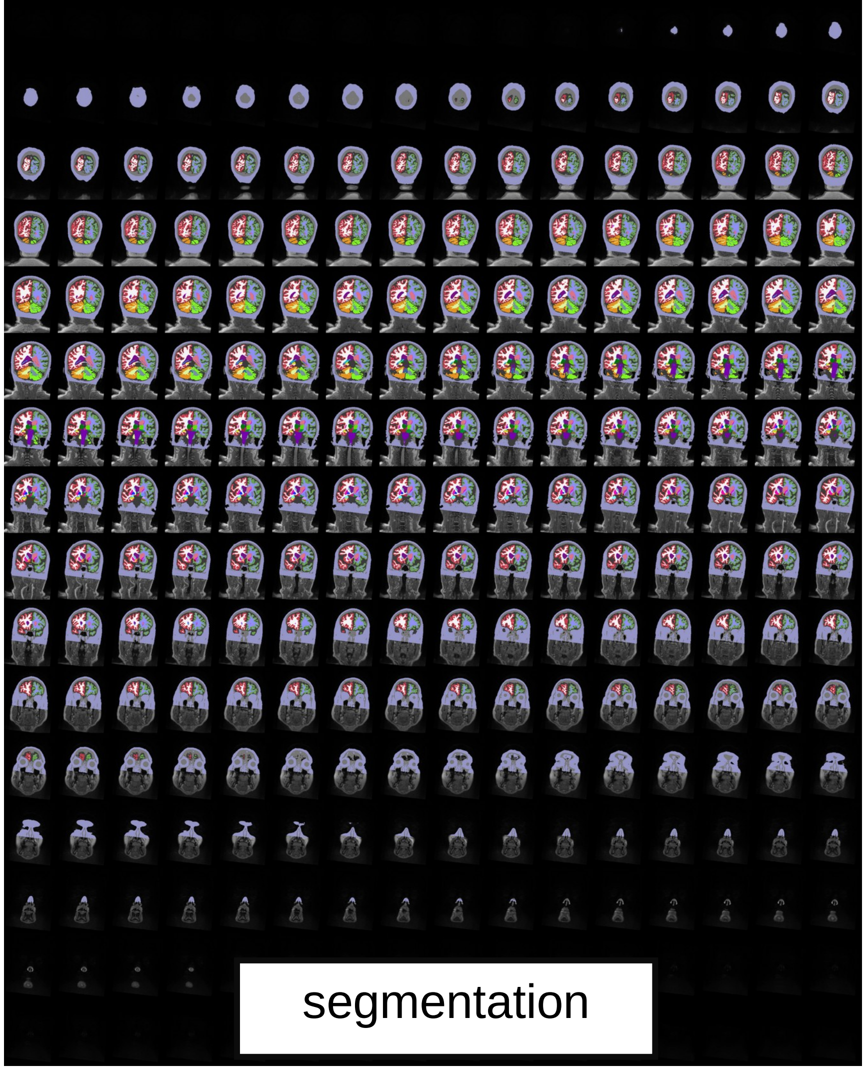


MRI



segmentation


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
- ✔ Solve segmentation problems using generative models
- ✔ Perform image segmentation using discriminative methods (neural nets)

A “do” course

Who are we?

- ✔ Koen Van Leemput, teacher (Professor, Neuroscience and Biomedical Engineering)
- ✔ Karl Olsson-Lalor, TA (Doctoral Researcher, Neuroscience and Biomedical Engineering)
- ✔ Alessandro De Florio, TA (Doctoral Researcher, Neuroscience and Biomedical Engineering)

Who are you?

- ✔ Master's Programme in Life Science Technologies (ELEC): 21
- ✔ Exchange studies (SCI): 10
- ✔ Master's Programme in Life Science Technologies (SCI): 5
- ✔ Master's Programme in Life Science Technologies (CHEM): 2
- ✔ Master's Programme in Life Science Technologies (Science and Technology): 2

Teaching form

Lectures:

- ✔ Mondays 12.15-14.00 (U141 U3, Otakaari 1)
- ✔ Two guest lectures (one from industry, one from university hospital)
- ✔ The “correct” exercise solutions will be discussed in class

Exercises

- ✔ Tuesdays 10.15-12.00 (A123 A1, Otakaari 1)
- ✔ Python/NumPy + Jupyter notebooks
- ✔ Group-work **(2-3 students per group)**
- ✔ Six exercises in total, submission deadline after < 2 weeks (Friday evening)
- ✔ Peer grading + light review by TAs **(informal feedback)**

- try to find group members today
- go to MyCourses and select a group
- no 1-student “groups” please

- get more detailed feedback by attending lectures and exercise sessions
- numerical scores don’t directly affect your grade

Exam:

- ✔ **Individual oral exam**, determines your grade
- ✔ Blindly pick one of your own exercise reports and discuss
- ✔ Active course participation (peer grading, quality of exercise reports) is taken into account for grading

- during weeks 30 Nov - 4 Dec or 7-11 Dec
- pick a suitable time slot in MyCourses (coming up)

Logistics

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

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

https://mycourses.aalto.fi/

- ✔ Group selections
- ✔ Exercises (input data, report submissions, peer grading)
- ✔ Important announcements
- ✔ Discussion fora (*secondary* place to ask questions)

Week	Date	Activity	Location	Topic	
1	Mon 31 Aug	Lecture	U141	Introduction and group selection	- introduction: pdf - example jupyter notebook
2	Mon 7 Sep	Lecture	U141	Image smoothing and interpolation	- chapter 1 in the book (html pdf) - slides: html pdf
	Tue 8 Sep	Exercise	A123	Smoothing and interpolation	submission deadline: Fri 18 Sep at 23:59
3	Mon 14 Sep	Lecture	U141	Coordinate systems, linear spatial transformations, landmark-based registration	- sections 2.1-2.3 in the book (html pdf) - slides: html pdf
	Tue 15 Sep	Exercise	A123	Landmark-based registration	submission deadline: Fri 25 Sep at 23:59
4	Mon 21 Sep	Lecture	U141	Intensity-based registration	- section 2.4 in the book, excluding Gauss-Newton optimization (html pdf) - slides: html pdf
	Tue 22 Sep	Exercise	A123	Landmark-based registration (cont.)	submission deadline: Fri 25 Sep at 23:59
5	Mon 28 Sep	Lecture	U141	Nonlinear registration	- sections 2.2.2 and 2.4 in the book, especially Gauss-Newton optimization (html pdf) - slides: html pdf
	Tue 29 Sep	Exercise	A123	Intensity-based registration	submission deadline: Fri 9 Oct at 23:59
6	Mon 5 Oct	Lecture	U141	Model-based segmentation I	- sections 3.1-3.3 in the book (html pdf) - probability refresher: html pdf - slides: html pdf

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Python/NumPy, Jupyter Notebooks

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

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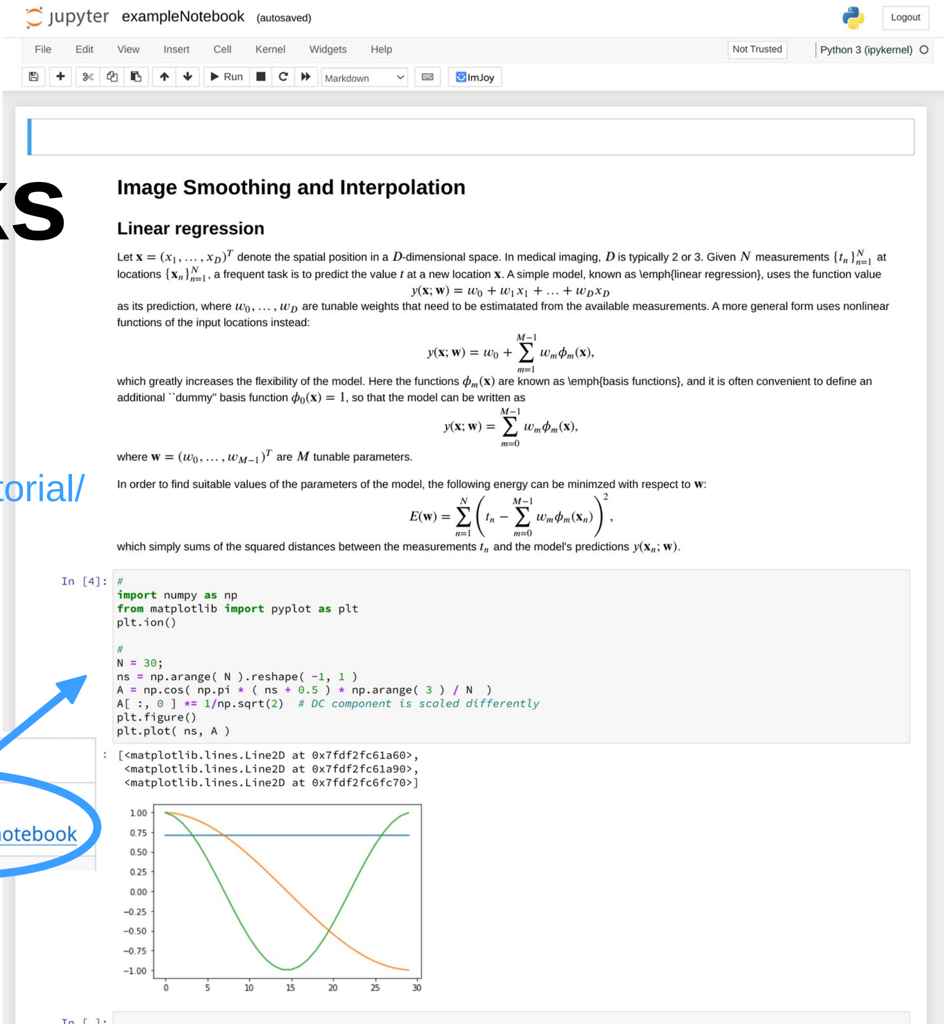

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To conclude...

Physical attendance

- ✔ Is expected in the lectures and the exercise sessions
- ✔ Your primary way to ask questions and get feedback
- ✔ (It’s technically possible to follow online, but strongly discouraged)

Solve exercises in groups (2-3 students per group) →

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Questions?

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