

8DC00 Medical Image Analysis

Maureen van Eijnatten
Mitko Veta

Outline for today:

- Course introduction
- Python
- Introduction to image registration and geometrical transforms



Dr. Maureen van Eijnatten

Background: BSc and MSc in Medical Technology & Physics (VU University Amsterdam), PhD in Medical Image Processing for 3D Printing (Amsterdam UMC)

Research: Image-guided treatments, deep learning, cone-beam CT



Dr. Mitko Veta

Background: BSc in Electrical Engineering (Macedonia), MSc in Digital Signal Processing (Macedonia), PhD in Medical Image Analysis (UMC Utrecht)

Research: Deep learning, histopathology image analysis

Guest lecturers

dr. Navchetan Awasthi (postdoctoral researcher)

dr.ir. Theo van Walsum (Erasmus MC)

dr. Marijn van Stralen (CTO MRIguidance b.v.)

Teaching assistants:

Luuk van der Hoek (MSc student)

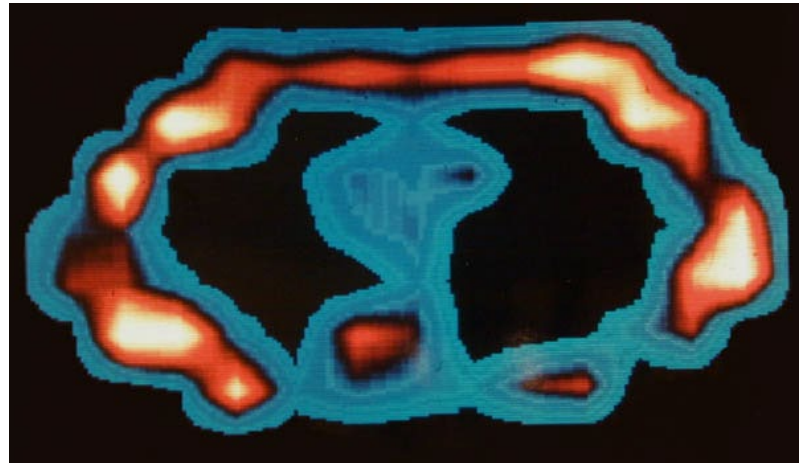
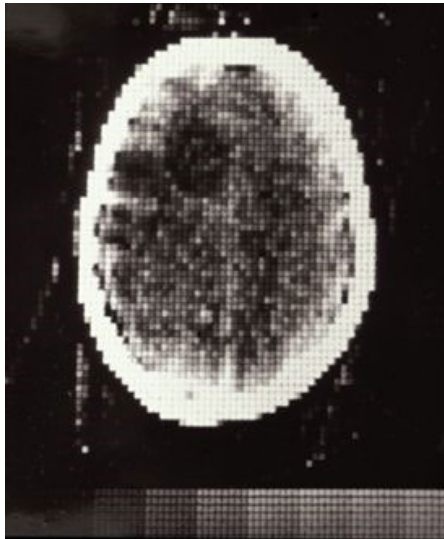
Roderick Westerman (MSc student)

Myrthe van den Berg (MSc student)

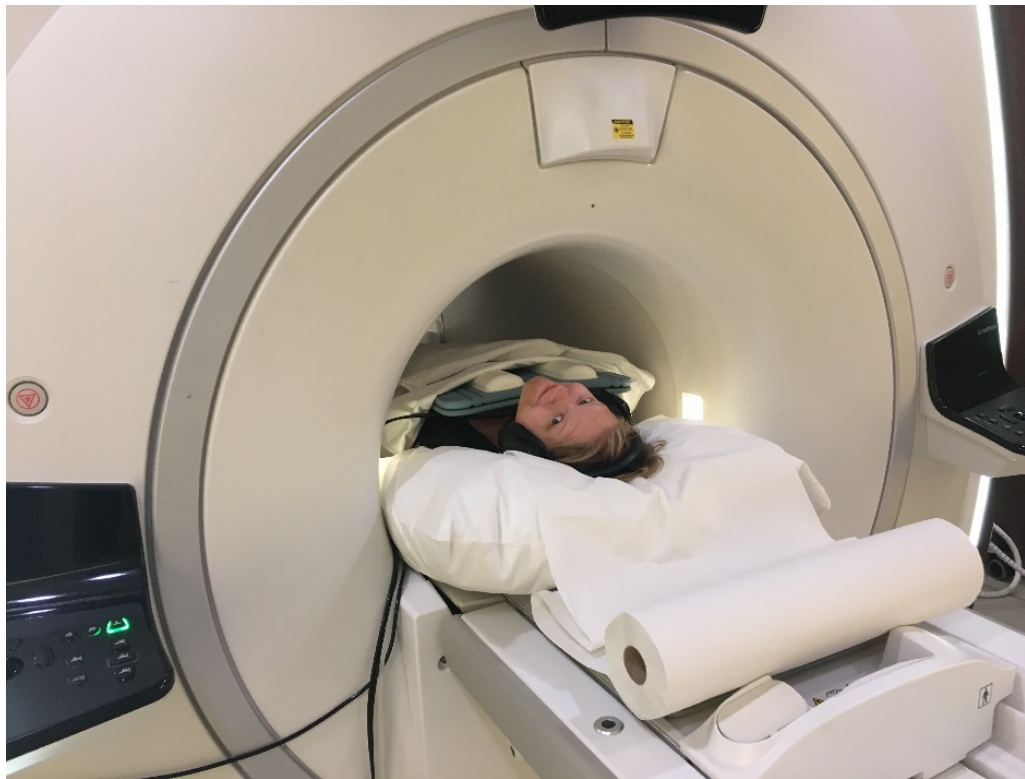
Tim Jaspers (MSc student)

Luuk Jacobs (MSc student)

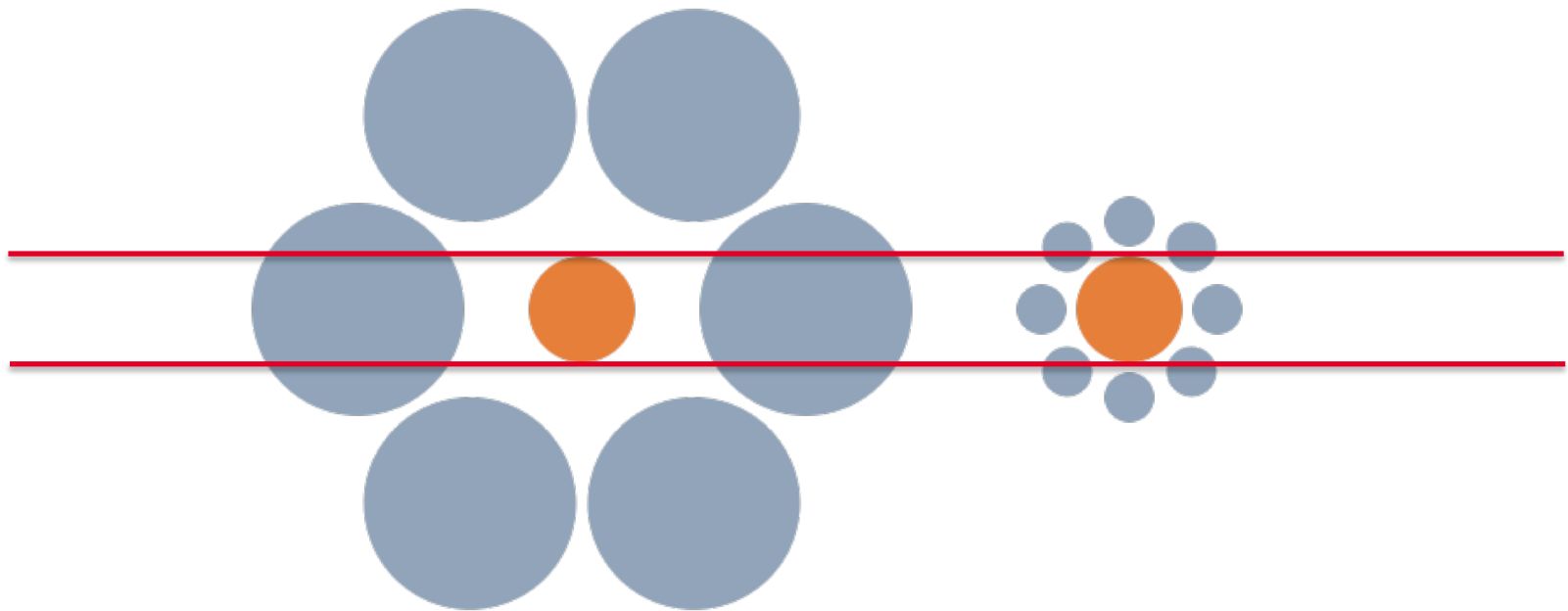
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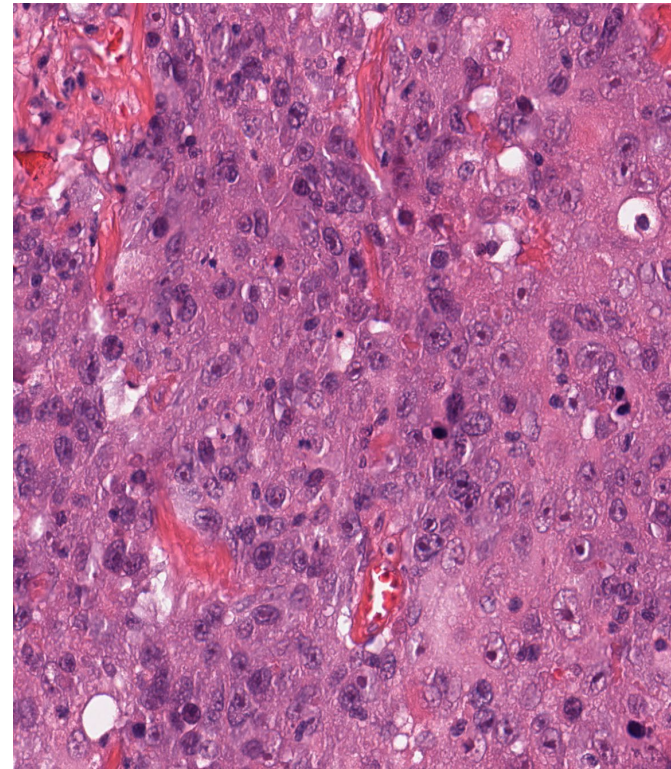
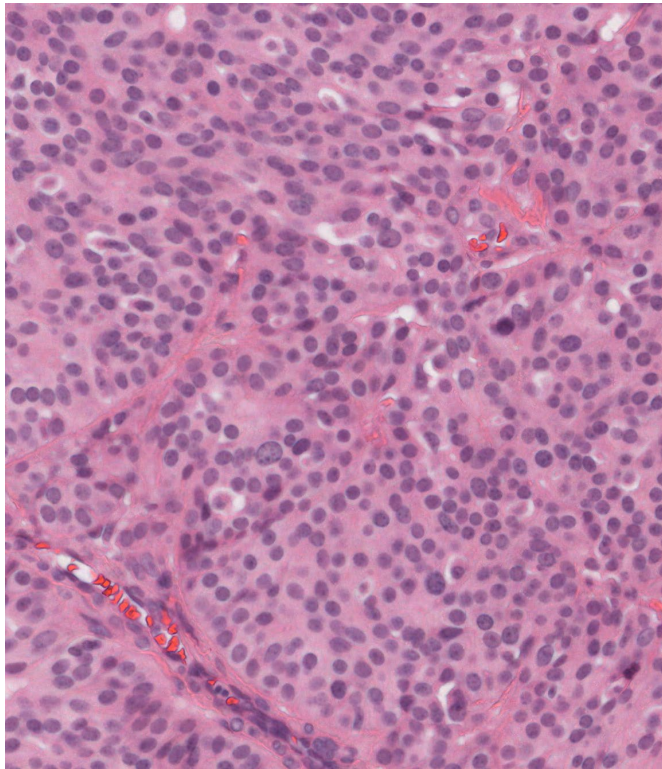


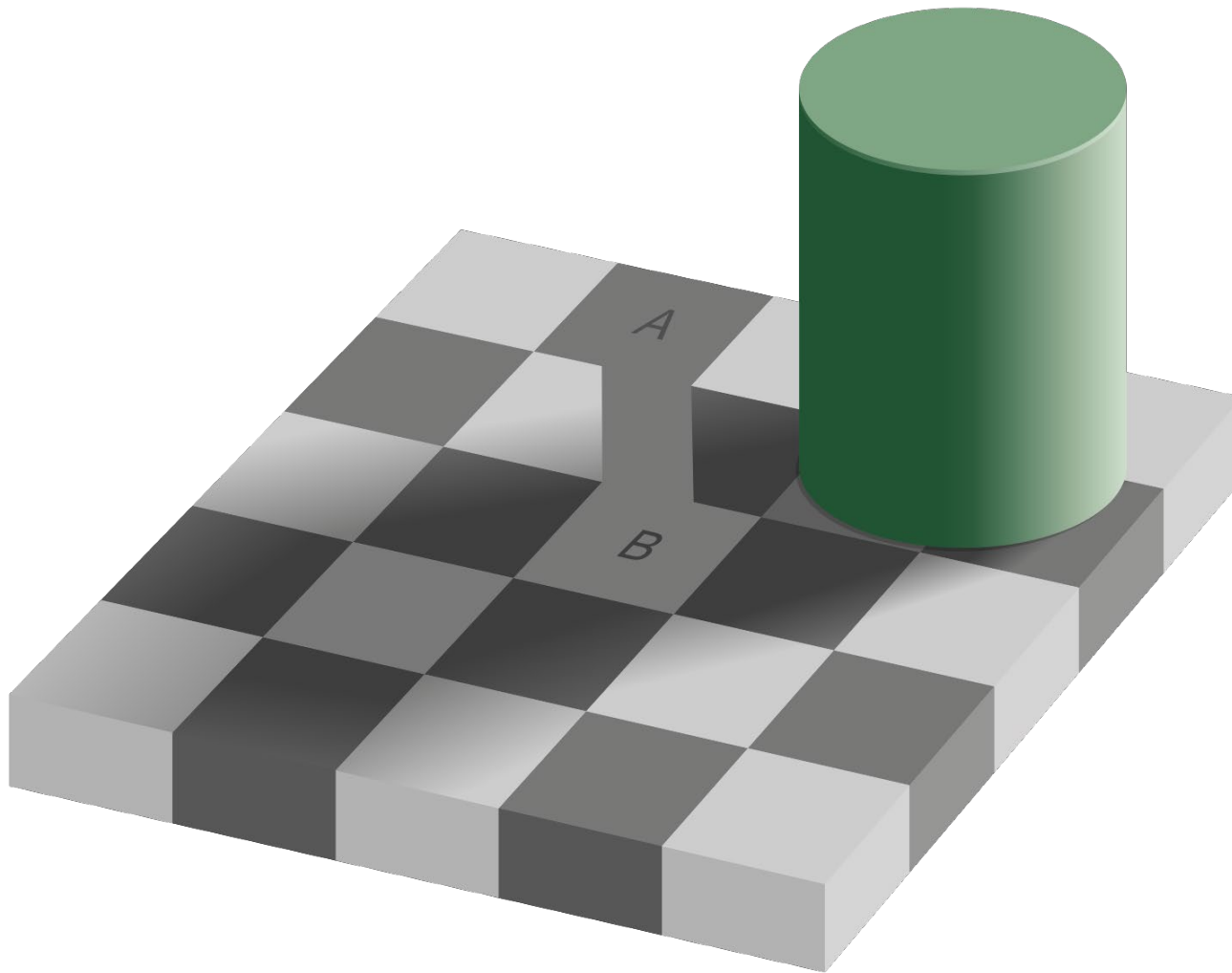
Present day in the Netherlands: 9K CT scans, 5K MR scans per 100K people



Why automatic image analysis?







The goal of medical image analysis is to develop automatic methods that enable **faster, more reliable and quantitative** analysis of medical images.

Learning goals

After completing the course, the student...

..has insight of the role of medical image analysis tasks in addressing clinical questions.

... has knowledge of how basic engineering and mathematical techniques can be used to design medical image analysis methods.

... can implement and apply medical image analysis methods.

... can analyze the results of medical image analysis methods.

Place of the course in the curriculum:

8QA01 Image Analysis Project (1st year BSc)

8DB00 Image Acquisition and Processing (2nd year BSc)

8DC00 Medical Image Analysis (3rd year BSc or MSc)

8P361 Project Imaging (3rd year BSc)

8DM20 Capita Selecta in Medical Image Analysis (MSc)

8DM40 Machine Learning in Medical Imaging and Computational Biology (MSc)

Course organization

Two main topics:

1. Medical image registration (Maureen)
2. Computer-aided diagnosis (Mitko)

Lectures, exercises & project work

8DB00 Beeldvorming en
-verwerking (year 2)

8DC00 Medical Image Analysis (MIA)

8DM20 Capita Selecta in
Medical Image Analysis (Master)

8DM50 Machine Learning in Medical
Imaging and Biology (Master)

Pre-assessment:

Python quiz
(week 1)

Covered during the whole course (Jupyter notebooks & 2 MIA-projects):

**Python
programming skills**

Programming skills, implementation of basic engineering
and mathematical techniques such as optimization in Python



Notebook 0.1

Module 1 (week 1-3): Image registration



Geometrical transformations

Notebook 1.1

Point-based registration

Notebook 1.2

Image similarity metrics

Notebook 1.3

Intensity-based registration

Notebook 1.4

Validation in medical image analysis

Notebook 1.5

Project 1
(report + code)



Module 2 (week 4-7): Computer-aided diagnosis



Introduction into machine learning

Linear regression

Notebook 2.1

Logistic regression

Notebook 2.2

Building blocks of
neural networks

Notebook 2.3

Deep learning
frameworks &
applications

**In-class
assignment**

Unsupervised
learning, PCA

Notebook 2.4

Project 2
(report + code)

+

**Reading
assignment**

Additional course material (assessment in written exam):

- *Active shape models* Optional notebook
- *Lecture on deep learning for medical image registration*
- *2 guest lectures on MIA applications*

Legend:



= MIA topic



= teaching strategy



= assessment



= learning outcome

Course schedule

Tuesdays and Thursdays: lectures and practicals (guided self-study)

Practicals:

You can work in **groups of up to 4 students** on:

- Exercises
- Project work

You can sign yourself up into a group on Canvas.

Focus is on exercises; project work should be independent.

Week	Date	Lecturer	Topics
1	7 Sept.	Maureen	Course introduction; Introduction into image registration
	9 Sept.	Maureen	Geometrical transformations
2	14 Sept.	Maureen	Point-based registration
	16 Sept.	Maureen	Image similarity metrics; Intersity-based registration
3	21 Sept.	Theo van Walsum	Guest lecture 1: Image-guided treatments
	23 Sept.	Maureen	Validation; active shape models
4	28 Sept.	Mitko	Introduction to CAD and machine learning
	30 Sept.	Mitko	Linear regression
5	5 Oct.	Mitko	Logistic regression; Neural networks
	7 Oct.	Navchetan	Convolutional neural networks
6	12 Oct.	Navchetan	Deep learning frameworks and applications
	14 Oct.	Navchetan	Unsupervised machine learning
7	19 Oct.	Maureen	Deep learning for image registration; questions & preparing for exam
	21 Oct.	t.b.d.	Guest lecture 2

Exercises

Goals:

- Help you study the material
- Develop code that can be used for the project work
- Not graded

Projects

- 2 projects (registration, CAD)
- Short report & code
- Graded

Detailed description of the project deliverables and assessment rubric can be found in the project handouts.

Guided project work: questions and extension of the code developed in the exercises that will guide you to a **minimal project solution**.

Assessment

- Projects
 - Medical image registration (15%)
 - Computer-aided diagnosis (15%)
- Written exam (70%), out of which 10% are questions related to the project, i.e. project accounts for 40% of the grade

Reading assignment:

- Study the following paper:

Graham, Simon, et al. "*Hover-net: Simultaneous segmentation and classification of nuclei in multi-tissue histology images.*" *Medical Image Analysis* 58 (2019): 101563.

<https://doi.org/10.1016/j.media.2019.101563>

- Give a brief summary of the proposed method and discuss its advantages and weak points in your second **project report**. Assessment will be included in the grade of the report.

Important deadlines:

1. 10/09 Complete Python quiz in Canvas (**mandatory**)
2. 01/10 Submit report & code project 1 (image registration)
3. 23/10 Submit report & code project 2 (CAD)
4. 02/11 9:00-12:00 Written exam

Communication – digital platforms we will use during this course



- Communication
- Python quiz
- Hand in assignments (project reports & code)



- Course overview
- Python code for exercises and projects
- Handouts lectures

Communication

Main communication channel is Canvas: post your questions in the Discussion section.

The single best answer by a student* will get plus half a grade for the project work.

* Assessed by teachers and student assistants, assessment criteria: clearly written and helpful, demonstrates good understanding of the material.

Emailing is **discouraged** (e.g. only for individual circumstances and not related to content). If you do email, use the tag [8DC00] in the subject line.

How to effectively ask questions?

- **Start the question by explaining the context**
 - State the goal of the task you are working
- **Formulate a specific question**
 - “I don’t know how to solve Exercise 2” is not a specific question.
 - Be clear and honest about what you want to get out.
 - “Is this enough for the project work?” is not allowed.

- **Demonstrate that you have attempted to answer the questions or solve the problem**
 - Formulate a provisional answer (does not matter if it is correct or not)
- **Python:**
 - Read the documentation
 - Error messages are informative!
 - Before asking for help, make sure that your problem is reproducible

- **How to get started with the exercises and project work?**
 - Github page: <https://github.com/tueimage/8dc00-mia>
 - Follow software installation instructions:
 - Anaconda / packages
 - Python
 - Jupyter

If you prefer a GUI: Anaconda Navigator

The screenshot displays the Anaconda Navigator interface. On the left is a sidebar with navigation options: Home, Environments, Learning, and Community. The main area shows a grid of application tiles. Red arrows point to specific tiles with labels: 'Start a prompt (terminal)' points to the 'CMD.exe Prompt' tile, 'Spyder' points to the 'Spyder' tile, and 'Jupyter Notebook' points to the 'Jupyter Notebook' tile. The tiles include icons, names, versions, descriptions, and buttons to 'Launch' or 'Install'.

Application	Version	Description	Action
CMD.exe Prompt	0.1.1	Run a cmd.exe terminal with your current environment from Navigator activated	Launch
Jupyter Notebook	6.0.3	Web-based, interactive computing notebook environment. Edit and run code, and view human-readable docs while describing the data analysis.	Launch
Powershell Prompt	0.0.1	Run a Powershell terminal with your current environment from Navigator activated	Launch
Qt Console	4.7.5	PyQt GUI that supports inline figures, proper multiline editing with syntax highlighting, graphical calltips, and more.	Launch
Spyder	4.1.3	Scientific Python Development Environment. Powerful Python IDE with advanced editing, interactive testing, debugging and introspection features	Launch
Glueviz	0.15.2	Multidimensional data visualization across files. Explore relationships within and among related datasets.	Install
JupyterLab	2.1.5	An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.	Install
Orange 3	3.23.1	Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows with a large toolbox.	Install
RStudio	1.1.456	A set of integrated tools designed to help you be more productive with R. Includes R essentials and notebooks.	Install

Example of setting up a Python environment:

<https://www.youtube.com/watch?v=AxSwTvnwCUU&t=45s>

