8DC00 Medical Image Analysis

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Mitko Veta

Technische Universiteit **Eindhoven** University of Technology

Where innovation starts

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: Computer-aided surgery, 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. Cornel Zachiu (UMC Utrecht)

Cornel Zachiu is an applied mathematician and computer scientist, specialized in the research and development of high-performance medical image processing algorithms. He currently works as a postdoc at the University Medical Center of Utrecht, focusing on the research, development, implementation, quality assurance and clinical translation of medical image registration algorithms for external beam radiotherapy guidance.

Dr. Geert-Jan Rutten (ETZ Tilburg)

Geert-Jan Rutten works as a neurosurgeon in the Elisabeth Tweesteden Hospital in Tilburg (2007-). He specializes in oncological surgery and deep brain stimulation and is interested in developing new methods to improve the safety and efficacy of brain tumor surgery. His research revolves around two main topics: cognitive functions and clinical use of advanced neuroimaging techniques. Geert-Jan studied physics (1992) and medicine (1997) in Utrecht and did his PhD on presurgical use of functional MRI (2002). He trained in neurosurgery in Utrecht and Tilburg. Geert-Jan is the author of a book on language in the brain: the Broca-Wernicke Doctrine (2017).

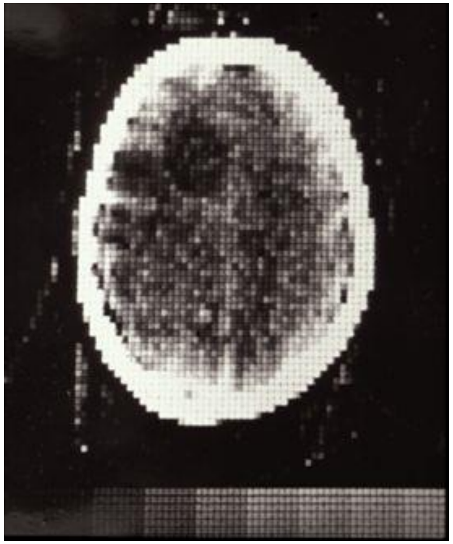
IMAG/e TU/e Technische Universiteit Eindhoven University of Technology

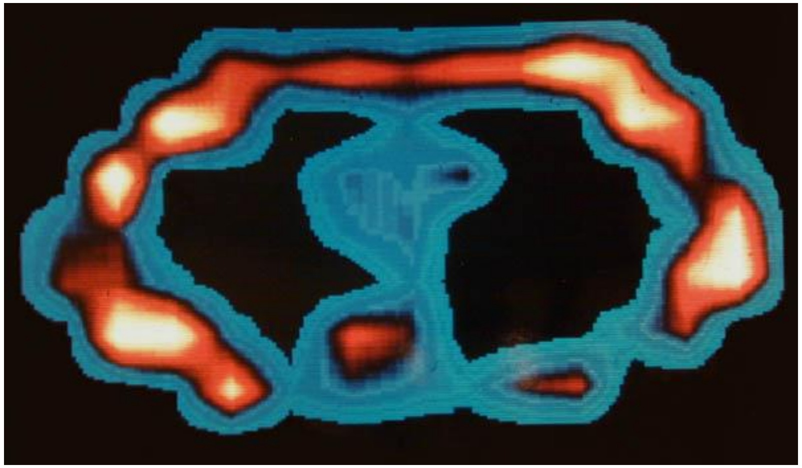
Teaching assistants:

Friso Heslinga (PhD candidate)

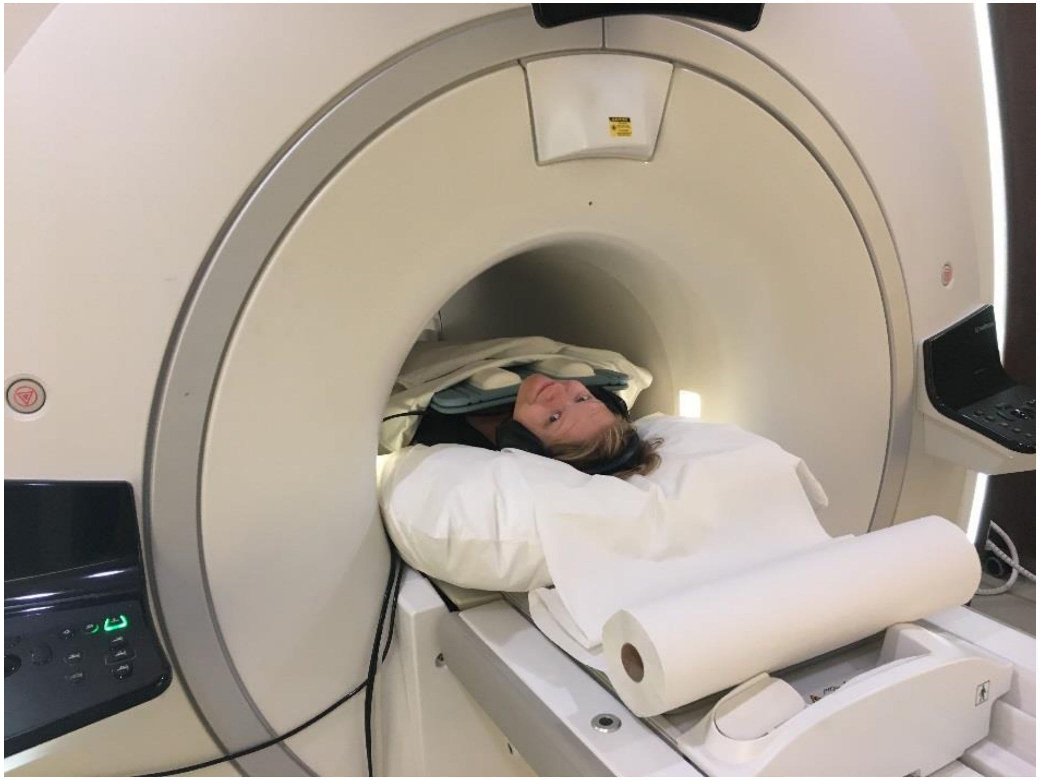
Leander van Eekelen (MSc student)
Glenn Bouwman (MSc student)
Stijn Bunk (MSc student)
Luuk van de Hoek (MSc student)

You



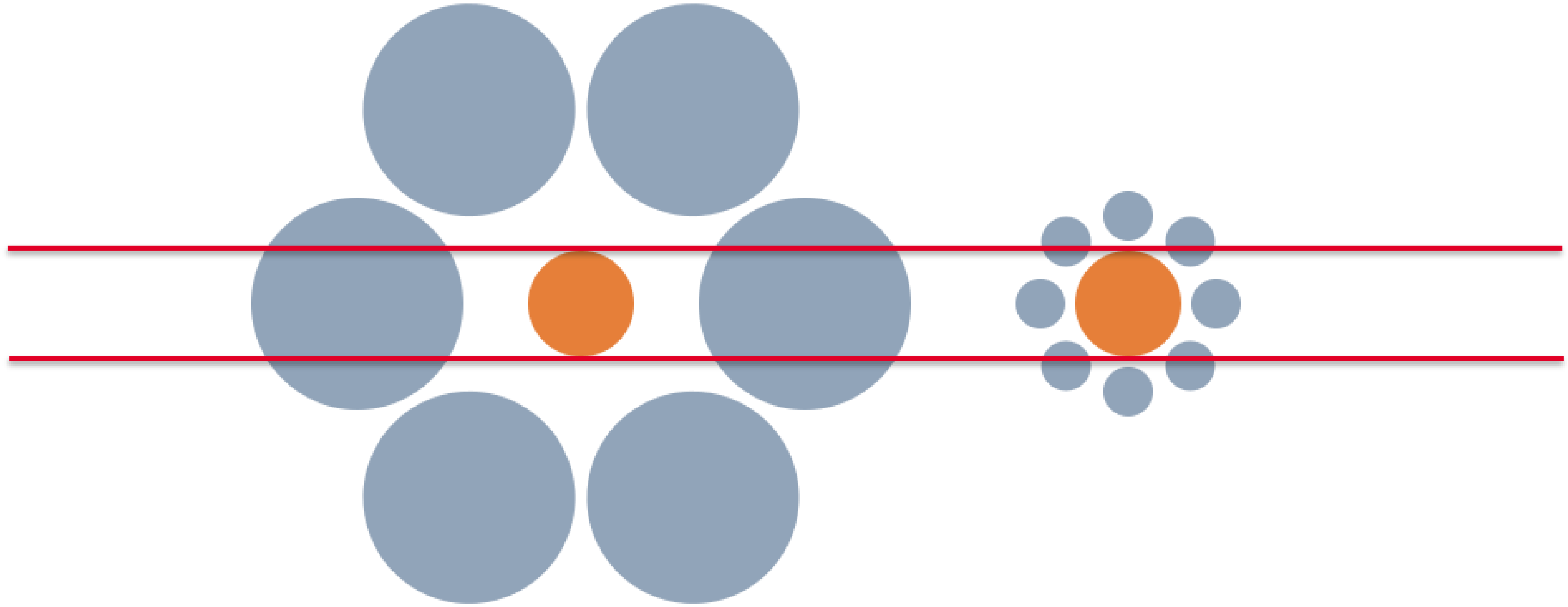


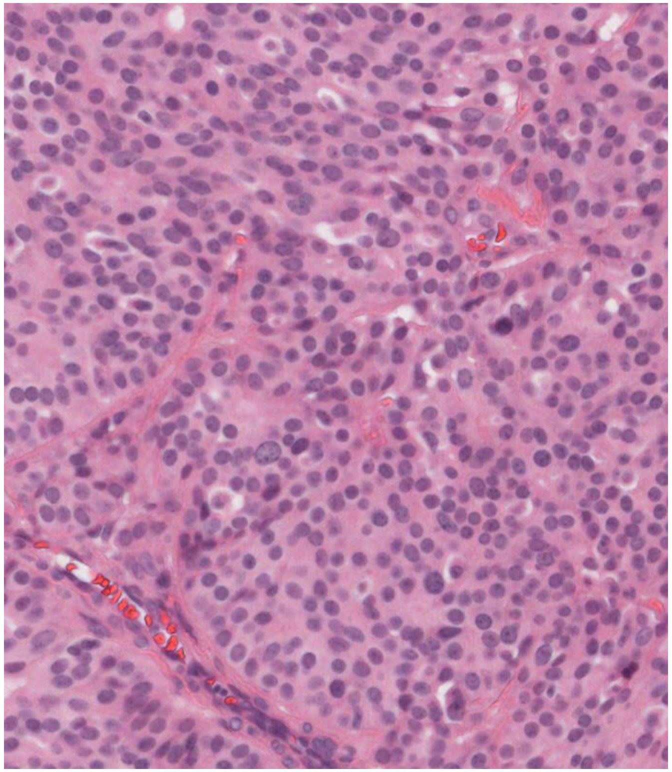
Present day in the Netherlands: 9K CT scans, 5K MR scans per 100K people

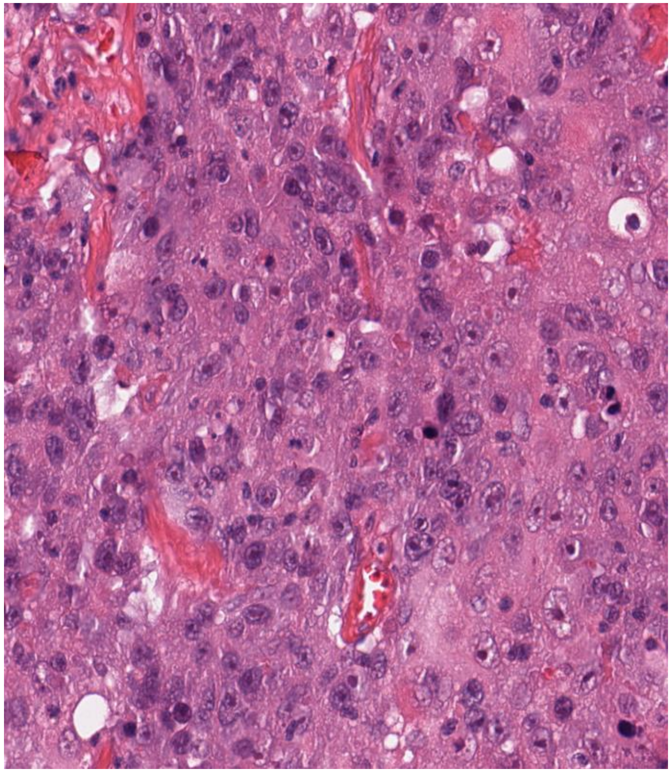


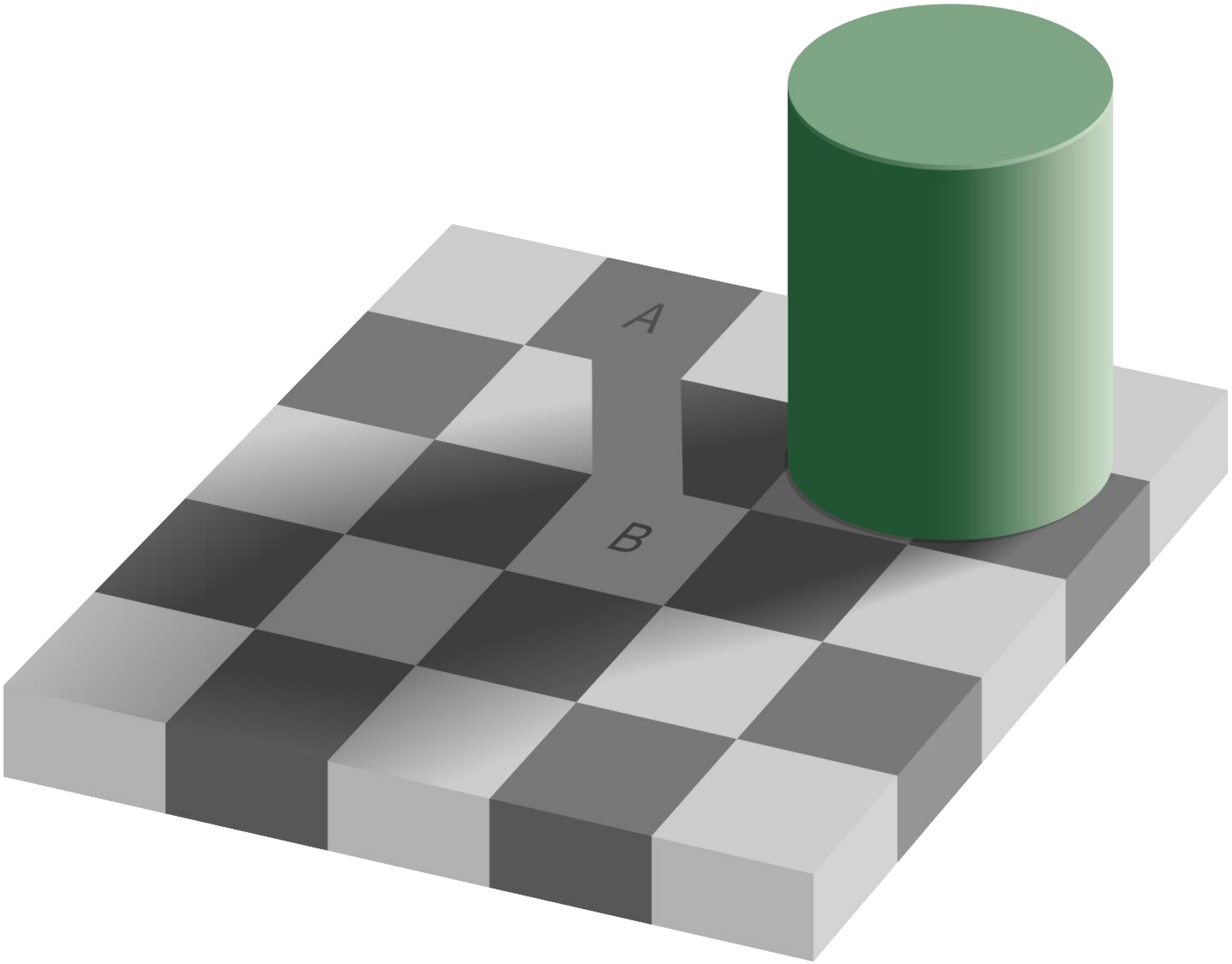
Source: Eurostat (2014)

Why automatic image analysis?





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B

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 Deep 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

Course schedule

Tuesdays and Thursdays: lectures and practicals

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.

Lecture schedule

Week	Date	Lecturer	Topics
1	**1 Sept.**	**Maureen**	**Course introduction; Software demo; Image registration (1)**
	3 Sept.	Maureen	Image registration (2); Geometrical transformations
2	8 Sept.	Maureen	Point-based registration
	10 Sept.	Maureen	Intersity-based registration; Evaluation metrics
3	15 Sept.	*Catch-up day (no lecture)*	
	17 Sept.	Cornel Zachiu (UMCU)	Guest lecture 1: Image analysis for adaptive radiotherapy
4	22 Sept.	Mitko	Introduction to CAD; k-NN; Decision trees
	24 Sept.	Mitko	Generalization and overfitting
5	29 Sept.	Mitko	Logistic regression; Neural networks
	1 Oct.	Friso	Convolutional neural networks
6	6 Oct.	Friso	Deep learning frameworks and applications
	8 Oct.	Friso	Unsupervised machine learning
7	13 Oct.	Maureen	Deep learning for deformable image registration
	15 Oct.	Geert-Jan Rutten (ETZ)	Guest lecture 2: Image analysis in neurosurgery applications
8	20 Oct	*Self-study (no lecture)*	Active shape models
	22 Oct	*Self-study (no lecture)*	Active shape models

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

Self-study: Active shape models

- Study the following papers:
  - The original paper by Cootes and Taylor (1995): Active Shape Models: Their Training and Application
  - A variation on this method by Van Ginneken et al. (2002): Active shape model segmentation with optimal features

- Assignment: submit (at least one) DIY exam question via Canvas

- Best question* = 0.5 bonus points at final exam and question will be used in the exam!

  * Assessed by teachers, assessment criteria: clearly written question and correct answer, demonstrates good understanding of the material.

Important deadlines:

1. 09/09 Complete Python quiz in Canvas (**mandatory**)
2. 25/09 Submit first project
3. 23/10 Submit second project
4. t.b.d. Written exam

Communication – digital platforms we will use during this course

canvas

- Communication
- Python quiz
- Hand in assignments (project work, DIY exam questions)

Microsoft Teams

- Online (live) lectures
- Support for practical work (exercises and projects)

GitHub

- 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.

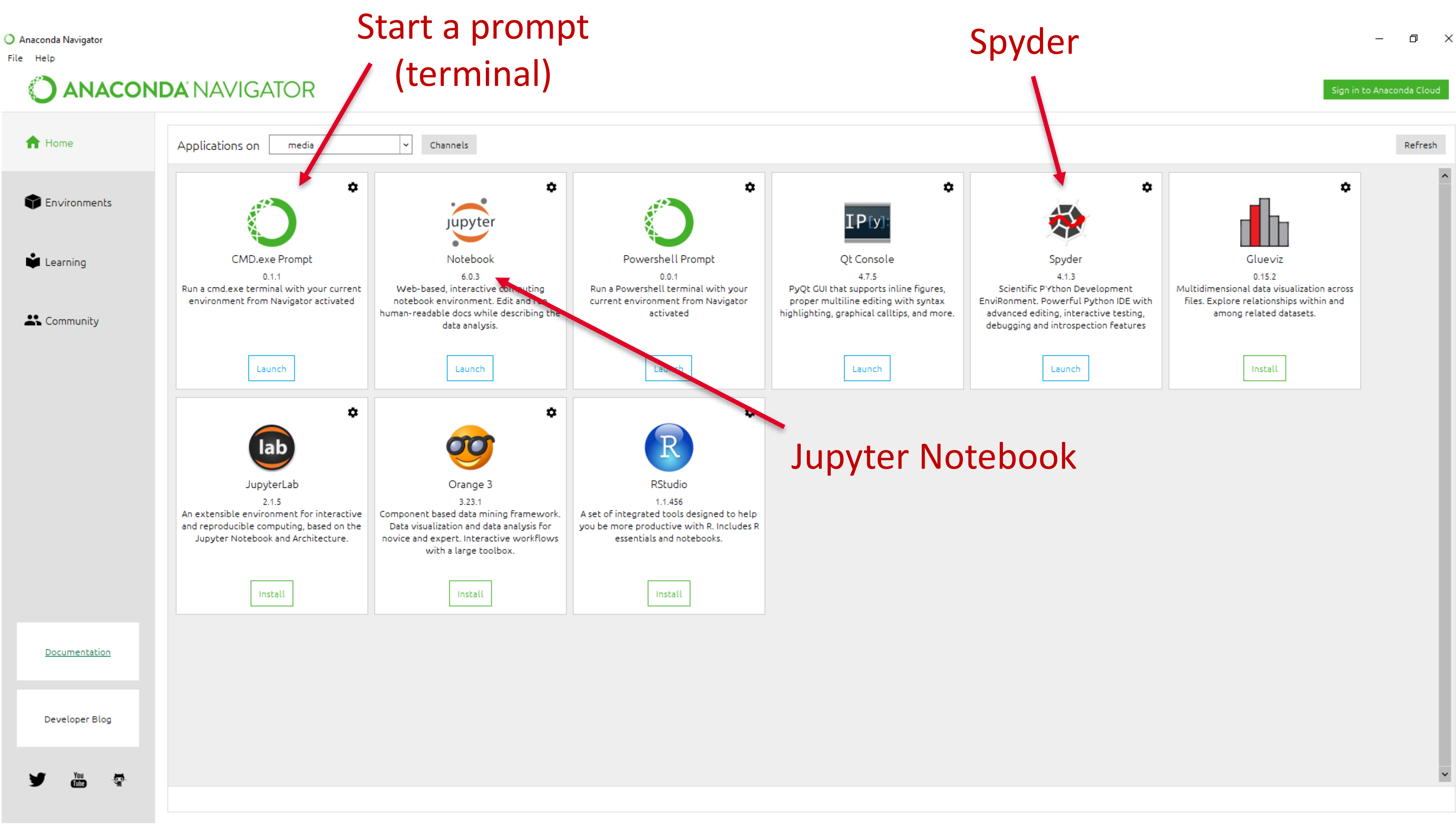
- **Demonstrate that you have attempted to answer the questions or solve the problem**
  - Formulate a provisional answer (does not matter if it is correct or not)

- **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 Notebooks

If you prefer a GUI: Anaconda Navigator



- **Setting up a Python environment: demo by Stijn Bunk**