IMAG/e

TU/e Technische Universiteit Eindhoven University of Technology

8DC00 Medical Image Analysis

Maureen van Eijnatten
Mitko Veta

Where innovation starts

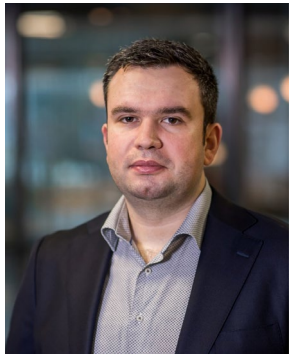
Outline for today:

- 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: 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)

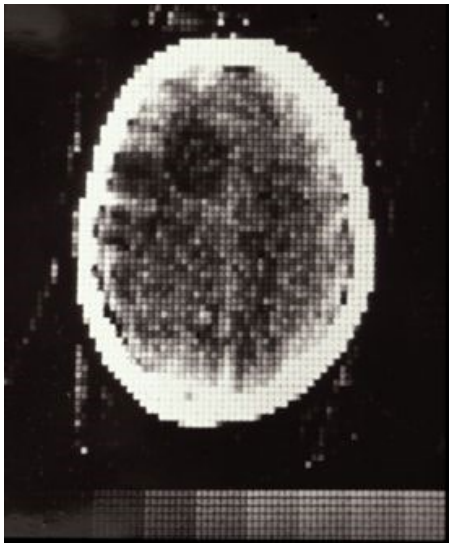
Roderick Westerman (MSc student)

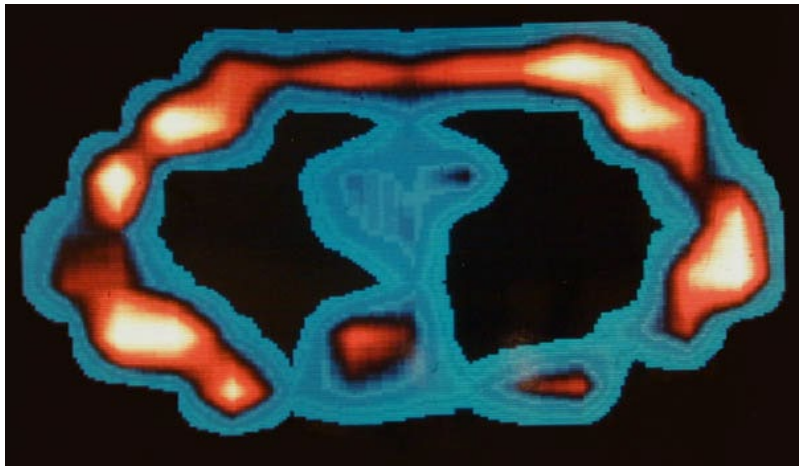
Myrthe van den Berg (MSc student)

Tim Jaspers (MSc student)

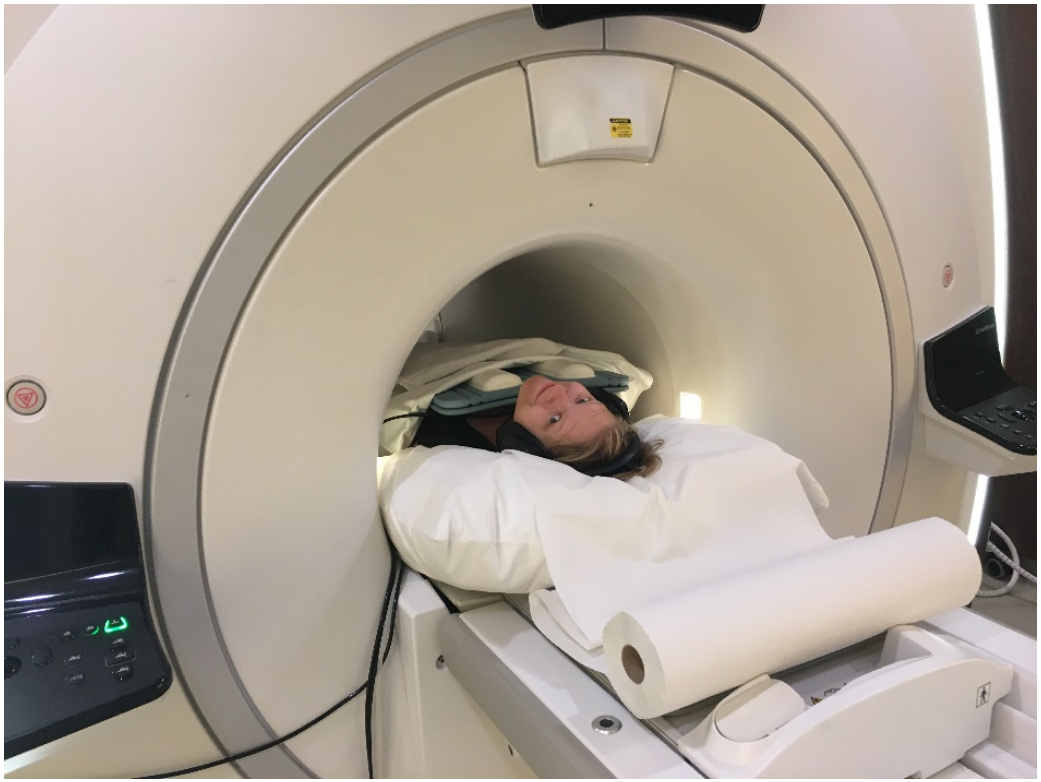
Luuk Jacobs (MSc student)

You



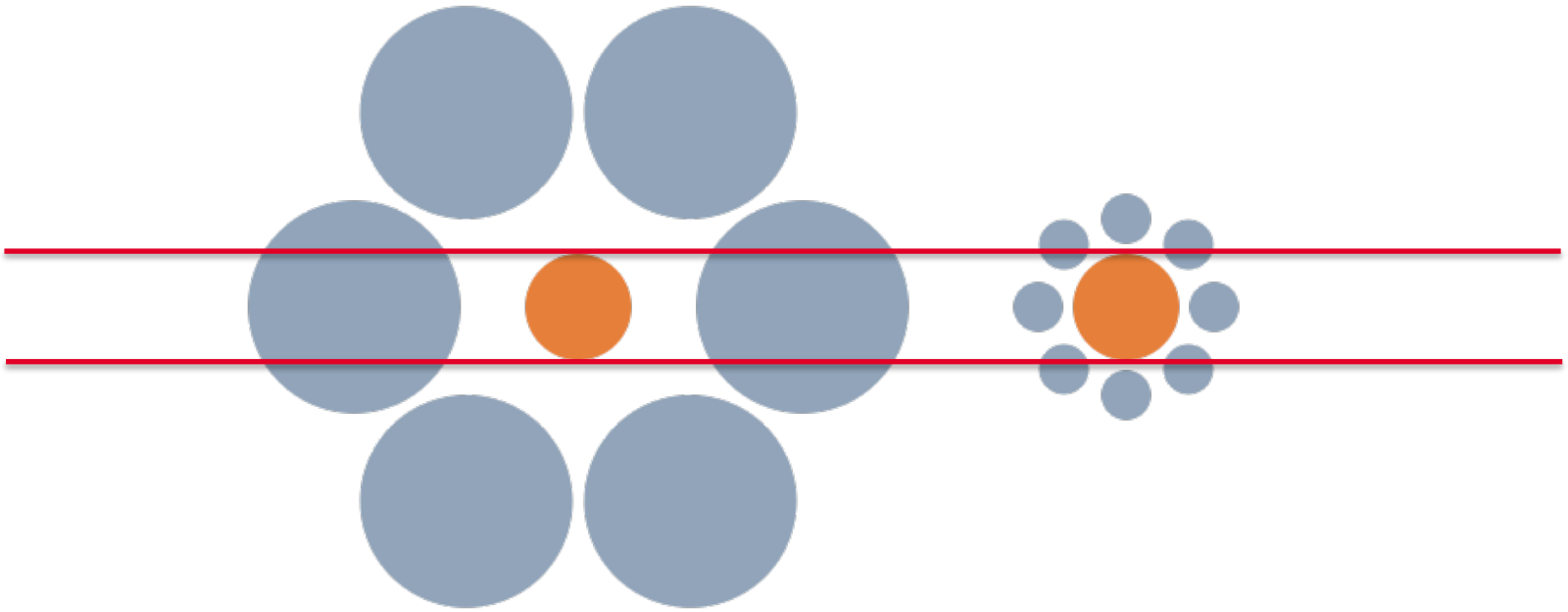


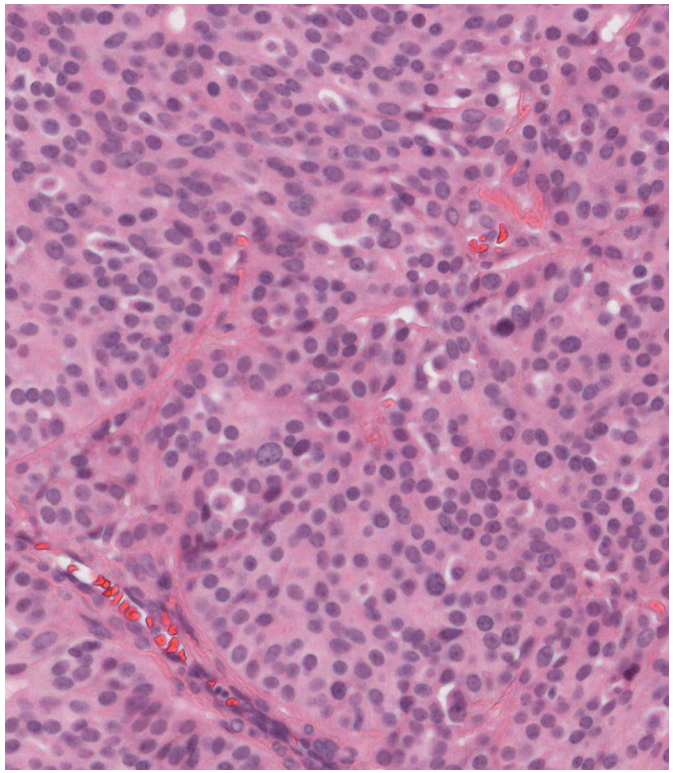
Present day in the Netherlands: 9K CT scans, 5K MR scans per 100K people

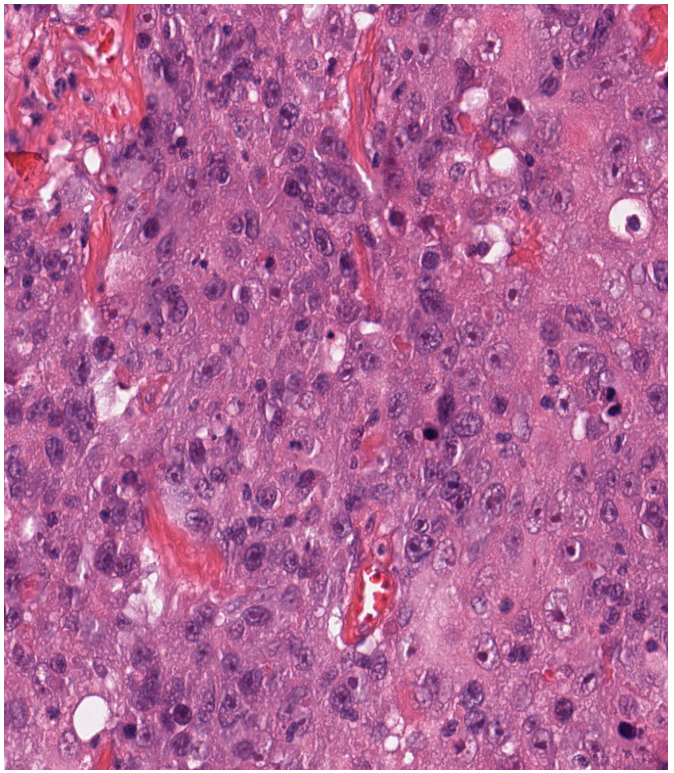


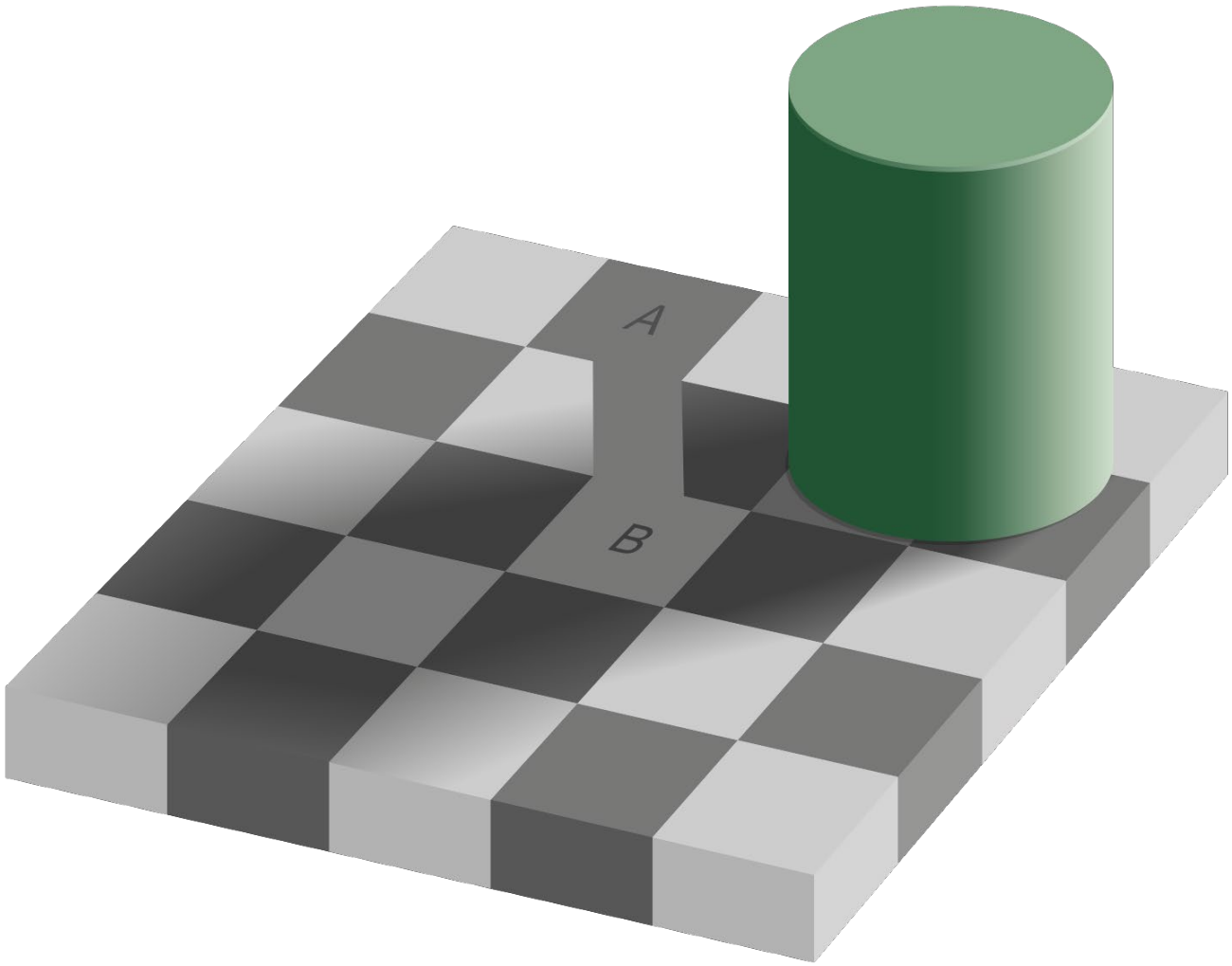
Source: Eurostat (2014)

Why automatic image analysis?








A
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 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

LO 5

Notebook 0.1

Module 1 (week 1-3): Image registration

LO 1+2

- 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)

LO 5+6

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

LO 3+4

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

<u>Additional course material</u> (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

LO = 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.

Lecture schedule

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.	Marijn van Stralen	MRIguidance b.v.

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?

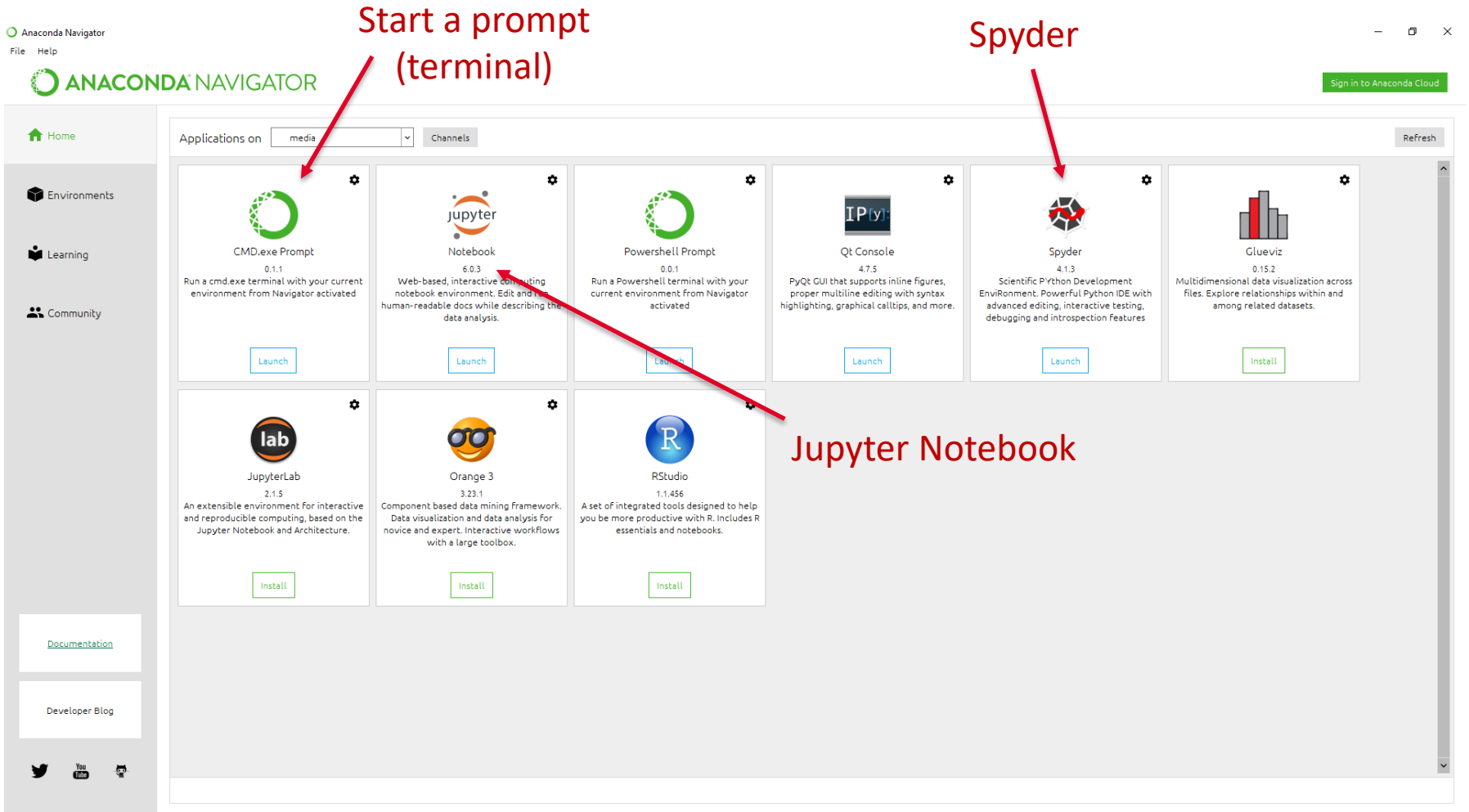
- **Start the question by explaining the context**
  - State the goal of the task you are working
- **Formulate a specific question**
  - “I don’t know how to solve Exercise 2” is not a specific question.
  - Be clear and honest about what you want to get out.
  - “Is this enough for the project work?”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



Example of setting up a Python environment:

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