IMAG/e

TU/e Technische Universiteit Eindhoven University of Technology

8DC00 Medical Image Analysis

Cian Scannell

Ruisheng Su

Where innovation starts

Outline for today:

- Course introduction
- Introduction to image registration
  - Causes of misalignment
  - Applications of medical image registration
  - Classification of image registration methods
- Geometrical transforms
  - Recap linear algebra
  - Rigid and affine transformations
  - Non-linear transformations

Dr. Ruisheng Su – r.su@tue.nl

Background: BSc in Electrical Engineering (Shandong University, China), MSc in Electrical Engineering (Technical University of Munich, Germany), PhD in Medical Image Analysis (Erasmus MC, Erasmus University Rotterdam)
Research: Deep learning, medical image analysis in neurovascular diseases, image-guided interventions

Dr. Cian Scannell – c.m.scannell@tue.nl

Background: BSc in Mathematical Sciences (University College Cork, Ireland), MRes in Medical Imaging, PhD in Biomedical Engineering (King's College London, UK)
Research: Deep learning, quantitative MRI, cardiovascular imaging & modelling

Teaching assistants:

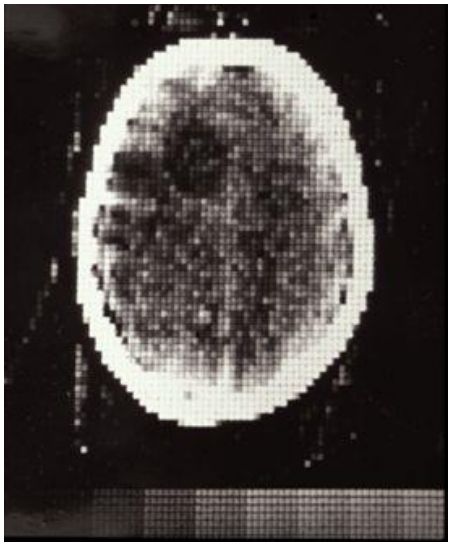
Rebecca Pelsser

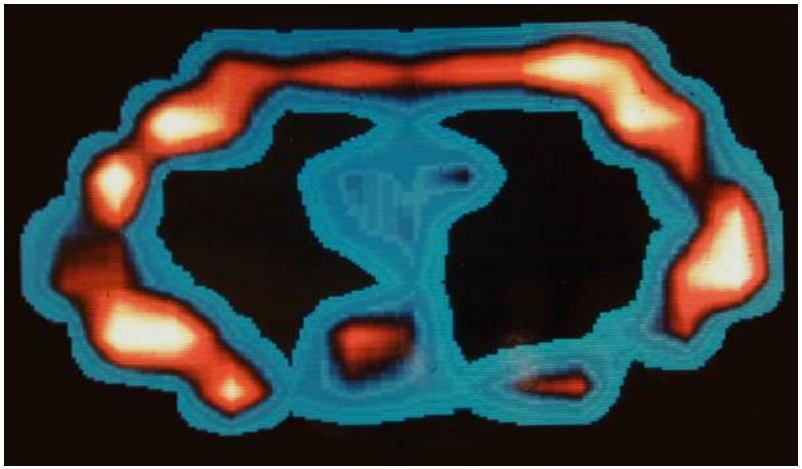
Mike Albertz

Sarah de Ruiter

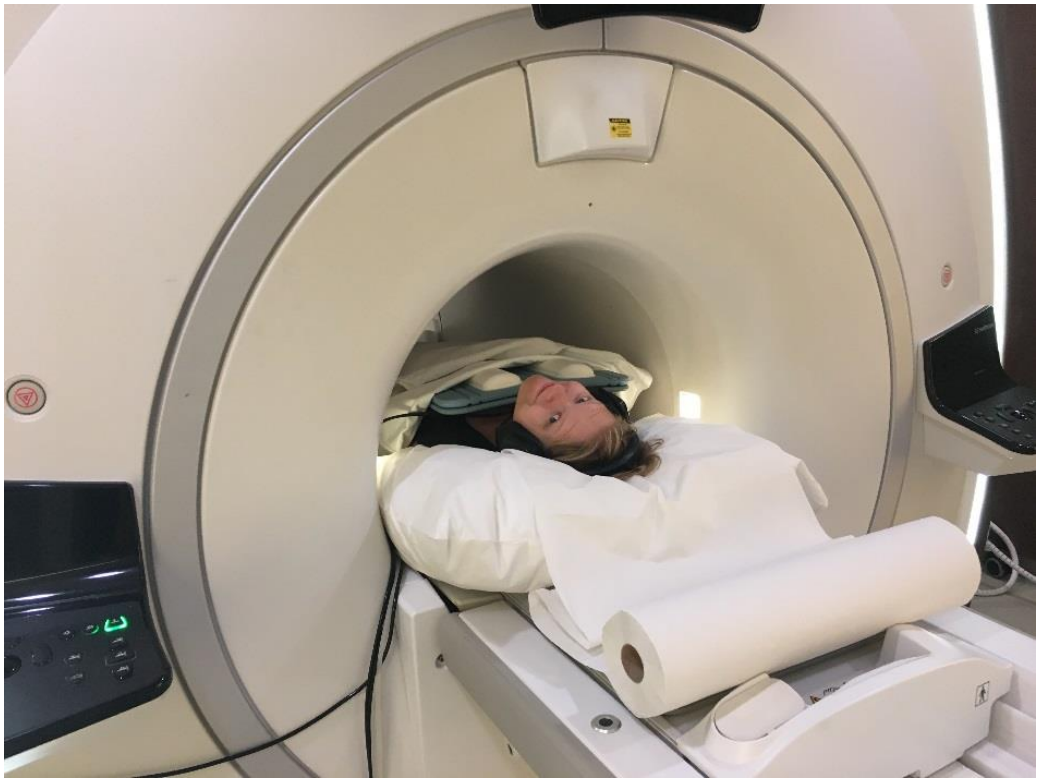
Jasper Bongers

Marijn de Lange



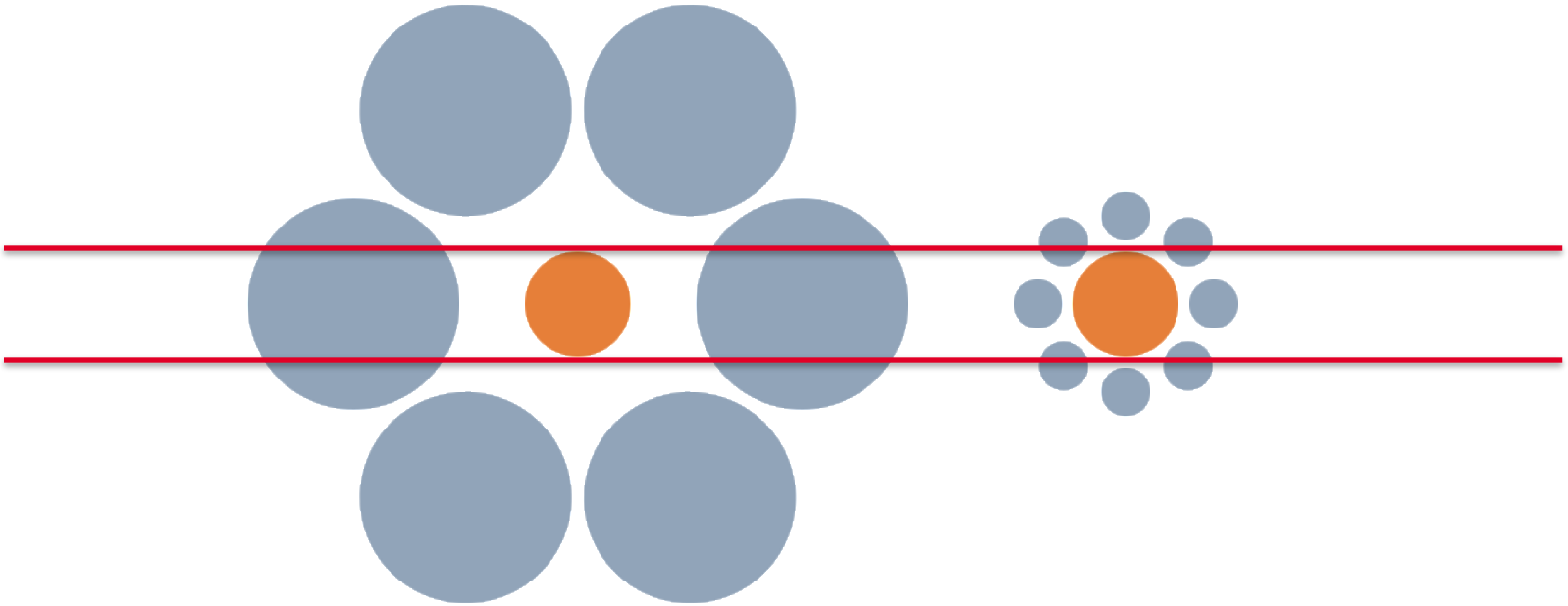


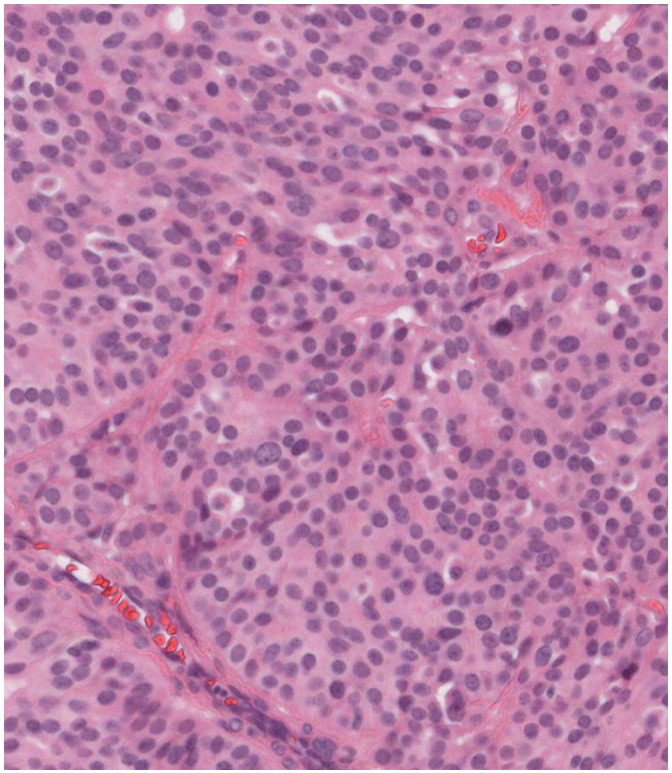
Present day in the Netherlands: 9K CT scans, 5K MR scans per 100K people

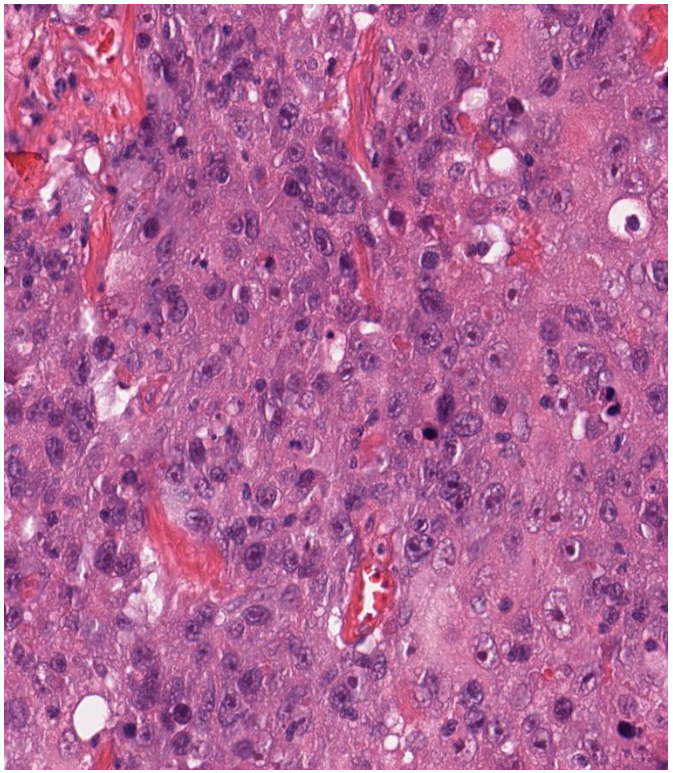


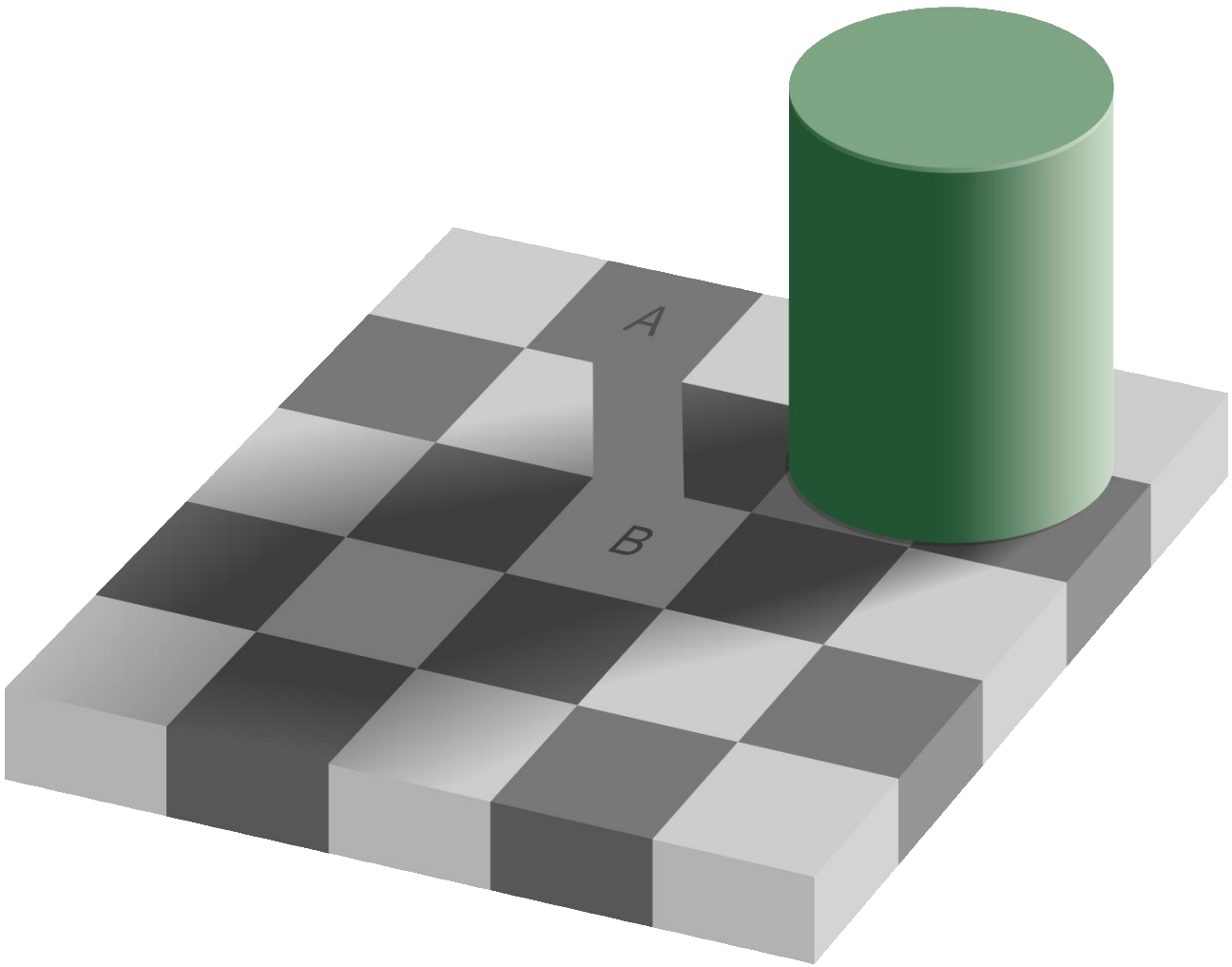
Source: Eurostat (2014)

Why automatic image analysis?








A
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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:

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

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

8P361 Project Imaging (3rd year BSc)

BEP in Medical Image Analysis

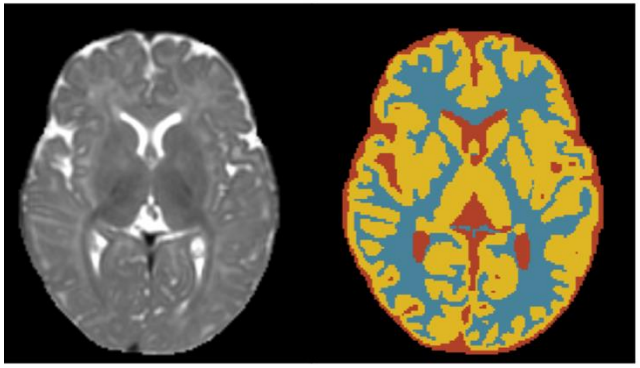
Master:

8DM20 Capita Selecta in Medical Image Analysis (MSc)

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

Overview of different medical image analysis tasks (2D, 3D, 3D+, …)

Image segmentation

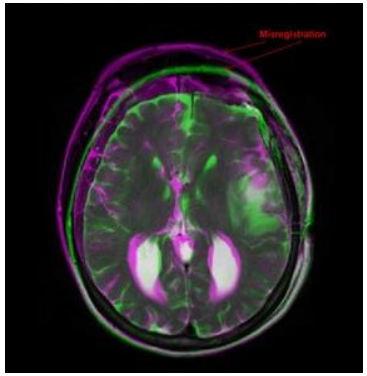


Dividing an image into multiple regions with similar properties (e.g., intensity values).

NB: these regions typically correspond to different anatomical structures.

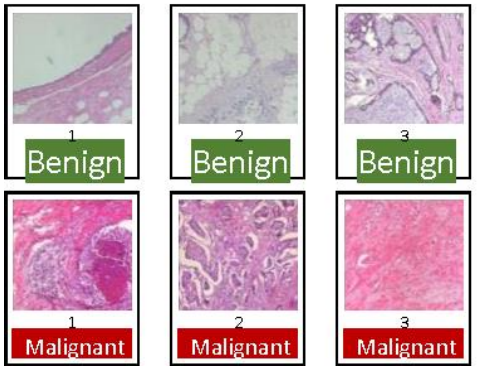
+ validation & active shape models (lecture no. 4!)

Image registration



Finding an optimal transformation that aligns two images.

Computer-aided detection (CAD)



Categorizing/labeling images based on specific rules.

Official definition: “systems that assist doctors in the interpretation of medical images, often based on machine learning”

This course

Course organization

Two main topics:

1. Medical image registration (Ruisheng)
2. Computer-aided diagnosis (Cian)

Lectures, exercises & project work

8DC00

Medical Image Analysis (MIA)

8DB00 Beeldvorming en -verwerking (year 2)

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 (e.g., optimization) in Python — Notebook 0.1

Module 1 (week 1-2): 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 3-7): Computer-aided diagnosis

Linear regression	Notebook 2.1
Logistic regression	Notebook 2.2
Building blocks of neural networks	Notebook 2.3
Deep learning frameworks & applications	
Unsupervised learning, principal component analysis (PCA)	Notebook 2.4

Project 2 (report + code)

Additional course material

- Active shape models (ASM) — Optional notebook
- Lecture on deep learning for medical image registration

Written exam

Legend: = MIA module; = assessment; = Jupyter notebook

Course schedule

Tuesdays and Fridays: 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; should be independent.

Report must contain a paragraph describing the contributions of each group member which can be used to to adjust individual grades to reflect a student's (lack of) contribution to the group

Exercises

Goals:

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

Projects

- 2 projects (registration, CAD)
- Each project is based on one or more **research questions** that you formulate yourself
- 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

Communication – digital platforms we will use during this course

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

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

Communication

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

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?

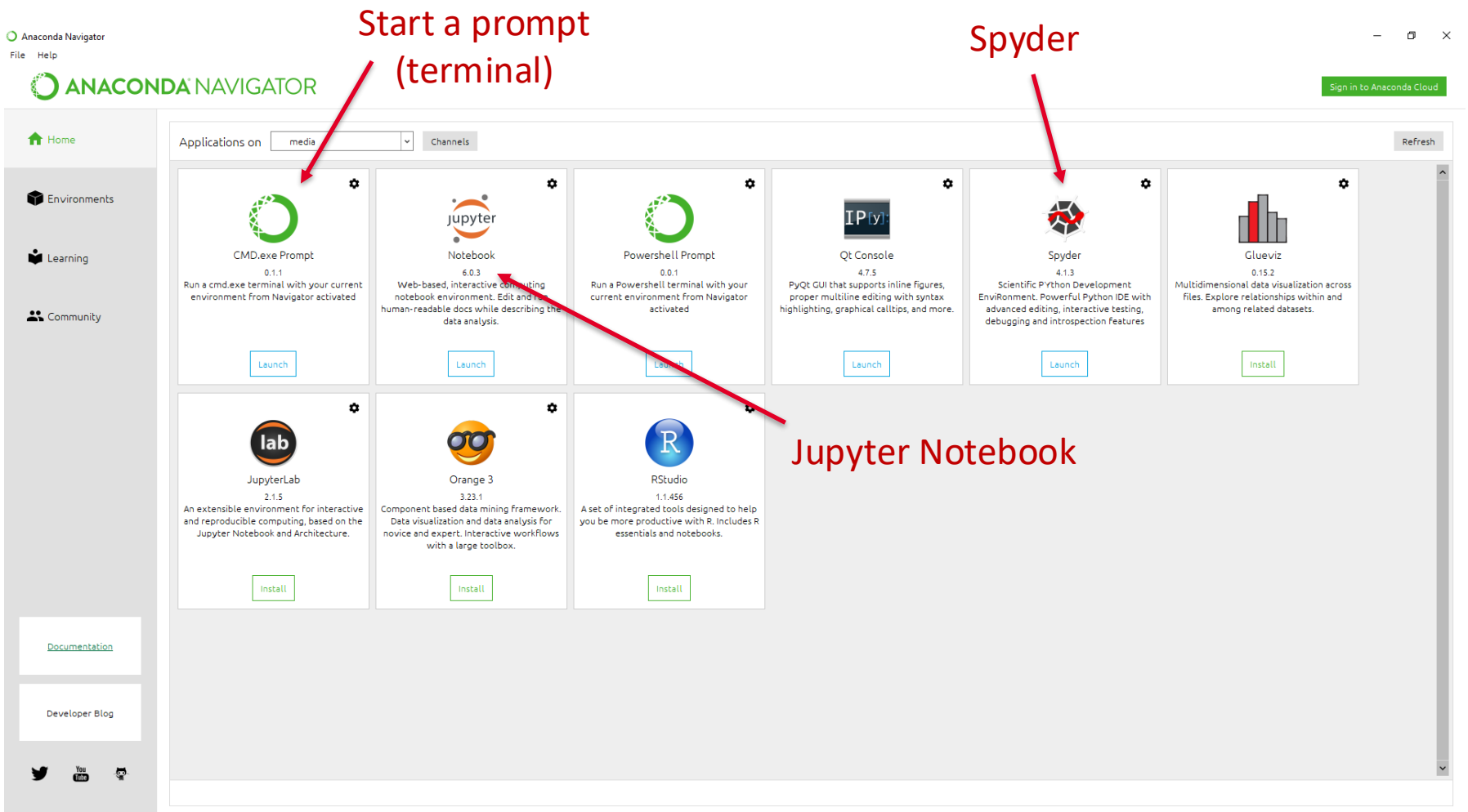
- **Start the question by explaining the context**
  - State the goal of the task you are working
- **Formulate a specific question**
  - “I don’t know how to solve Exercise 2” is not a specific question.
  - Be clear and honest about what you want to get out.
  - “Is this enough for the project work?”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