First year project – medical imaging

ITU, Spring 2021

Veronika Cheplygina

Hi!

2004-2010 MSc, computer science, TU Delft
2011-2015 PhD, machine learning, TU Delft
2015-2016 postdoc, medical imaging, Erasmus MC
2017-2020 assistant professor, medical imaging, TU Eindhoven

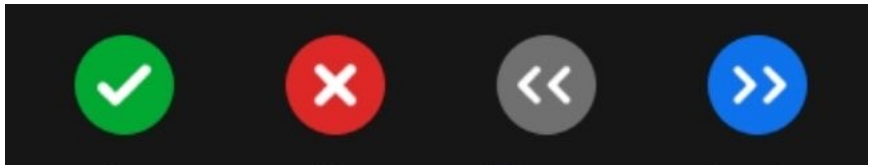
Medical imaging project - timeline

- Tue 6 – Introduction
- Fri 9 – Extract features from images
- Tue 13 – Classify image to predict diagnosis
- Fri 16 – Evaluate results
- Tue 20 – Open house / recent research (not for project/exam)

Today

- Introduction to medical images in general
  – Trivia quiz
- Project background about skin lesions
  – Exercise/activity (Google Docs)
- Project setup
- Working with images in Python (Google Colab)

Medical imaging trivia



A B C D

A – Van Gogh

B – Rembrandt

C – Vermeer

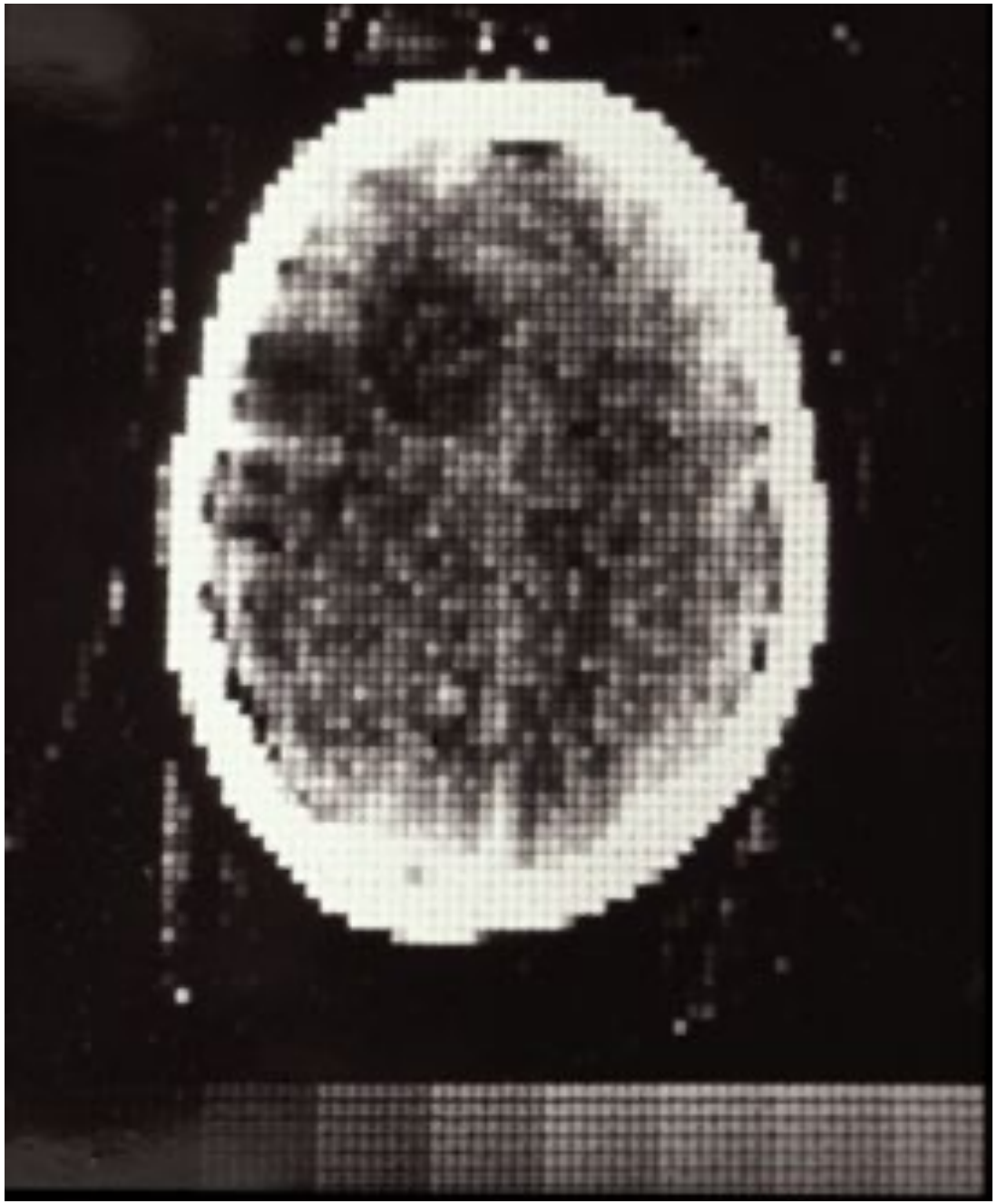
D - Breughel

A – 1795

B – 1845

C – 1895

D - 1945

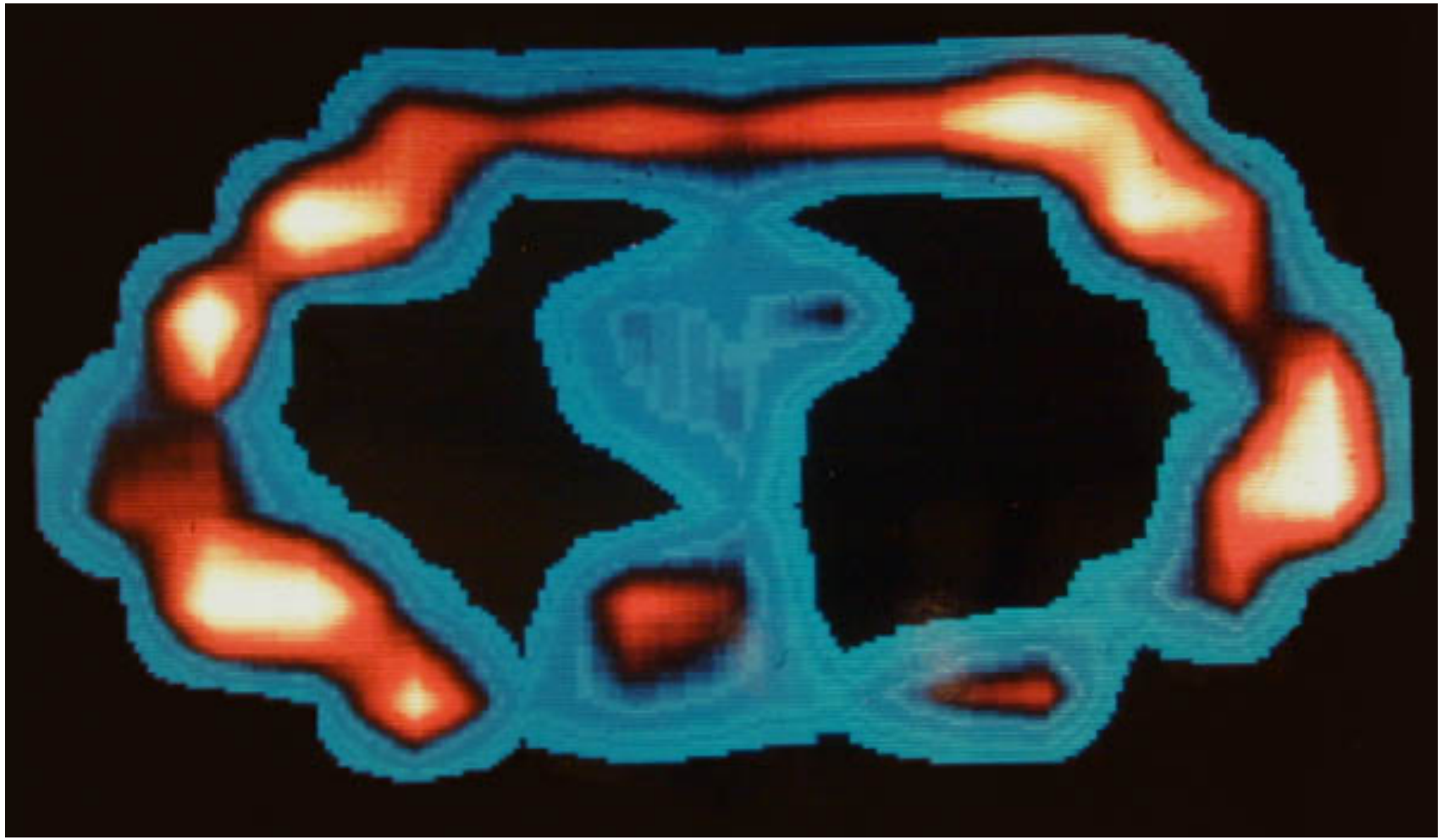


A – 1971

B – 1981

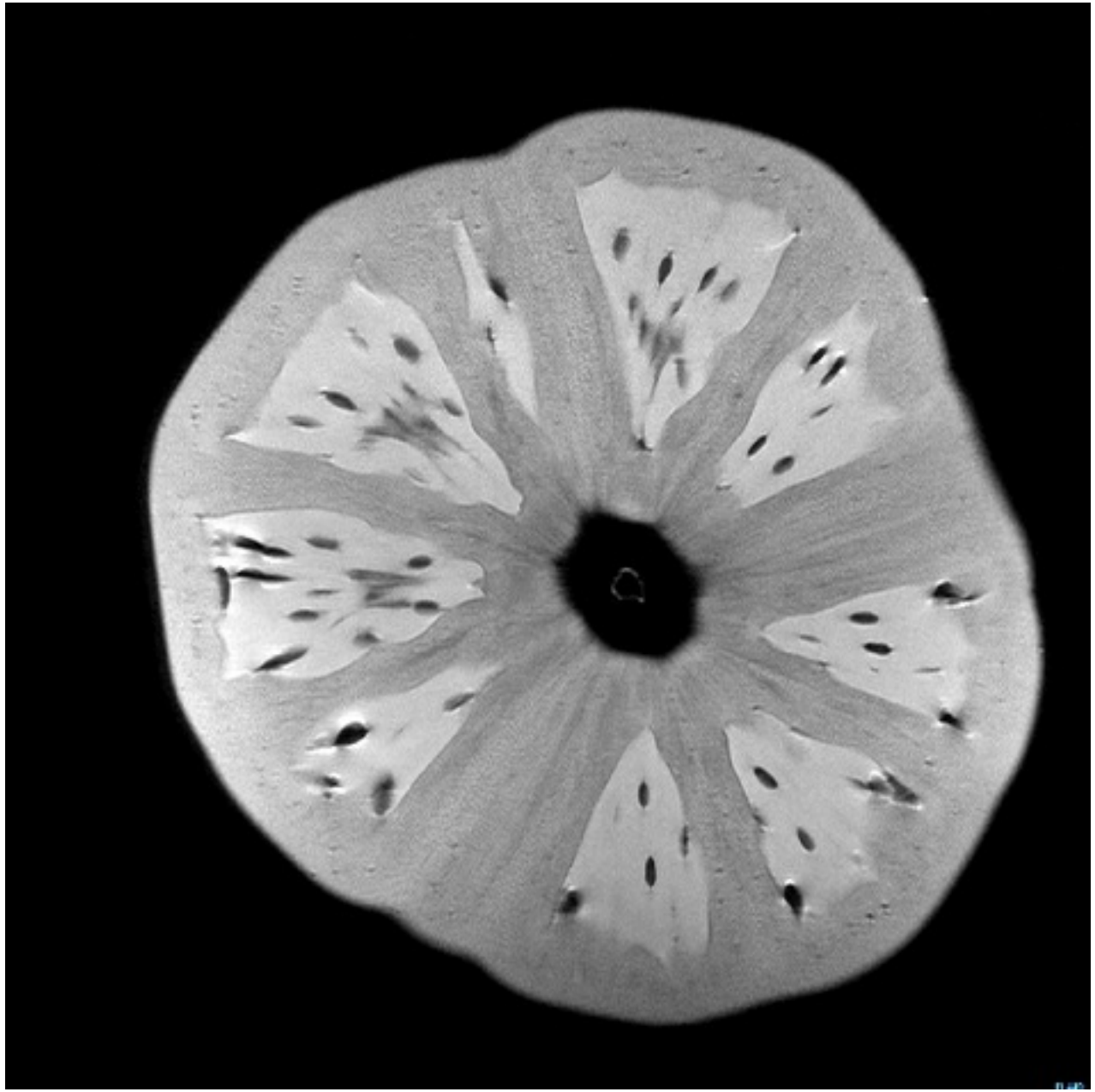
C – 1991

D - 2001



What is this?

(type in the chat)

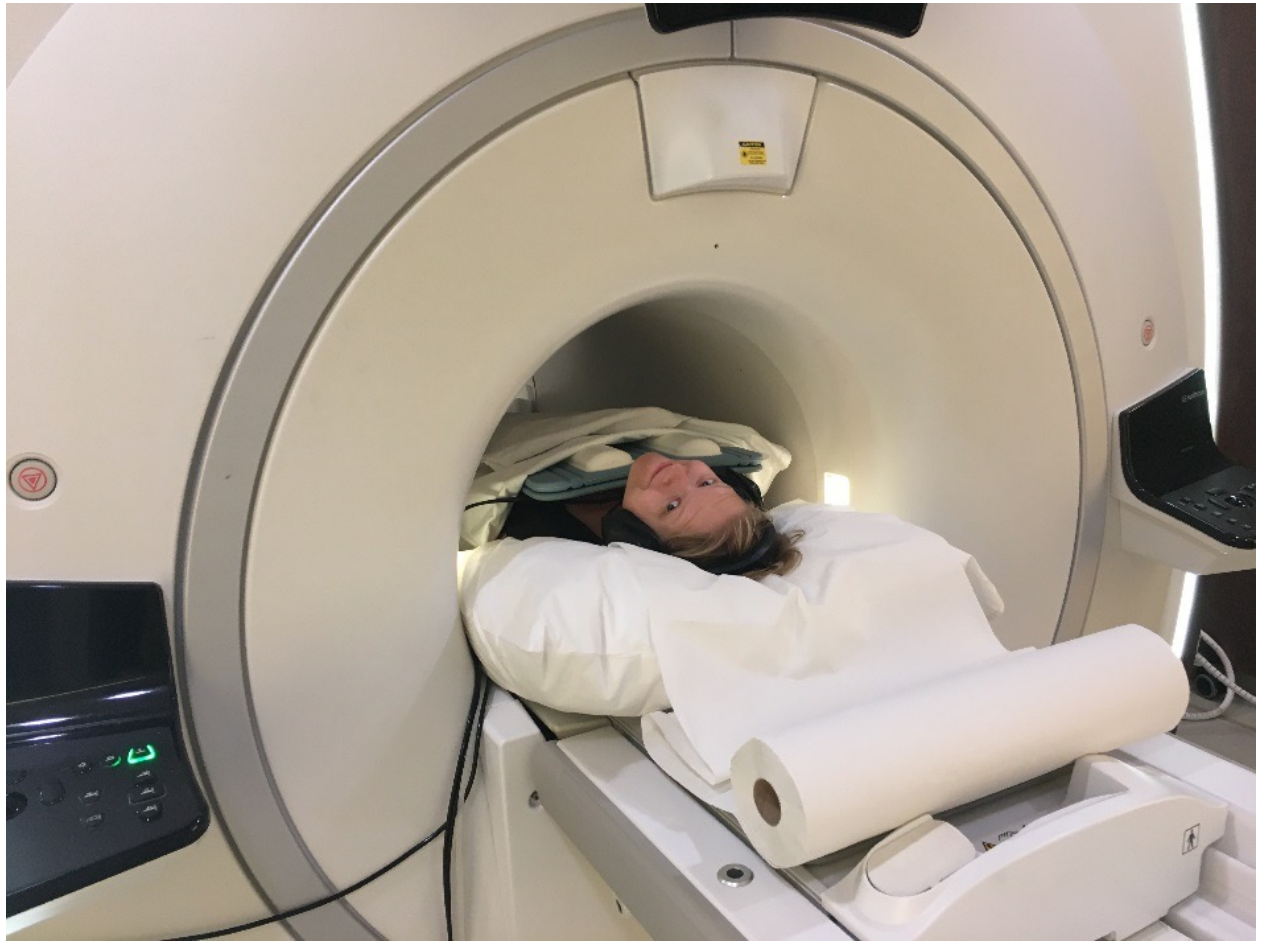


What is this?

(type in the chat)

- "The anatomy lesson of Dr. Nicolaes Tulp", 1632 by Rembrandt
- The hand of Anna Bertha Ludwig, wife of Wilhelm Roentgen in 1895
- First clinical CT scan: Atkinson Morley's Hospital, October 1971
- First ever MRI scan of a live human being (4:45 AM July 3, 1977).
- 3T MR scan of a tomato https://insideinsides.blogspot.com/

- 2014 in The Netherlands
  - 9K CT scans / 100K people
  - 5K MR scans/ 100K people



http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_resource_statistics_-_technical_resources_and_medical_technology&oldid=280129

- Future?

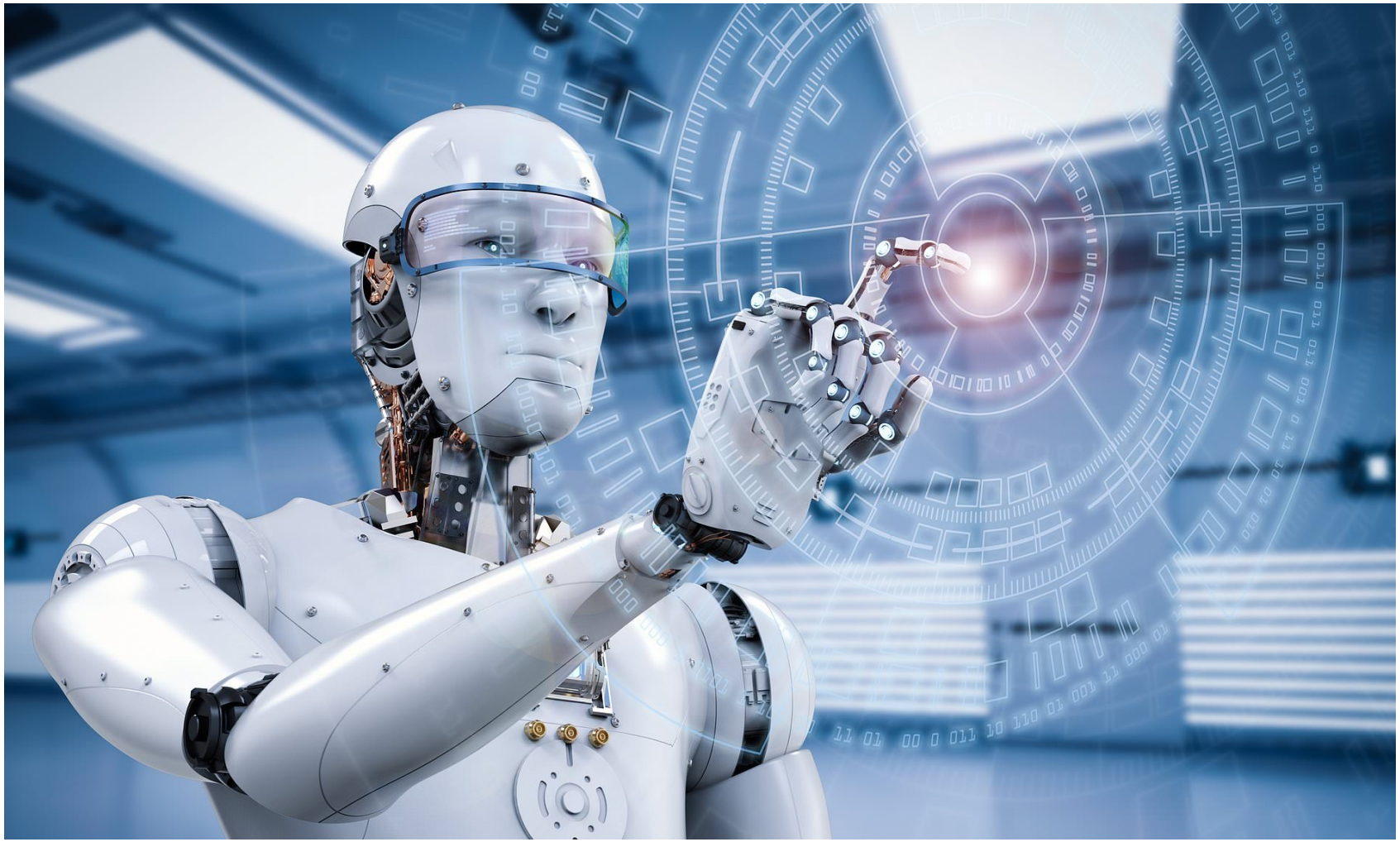
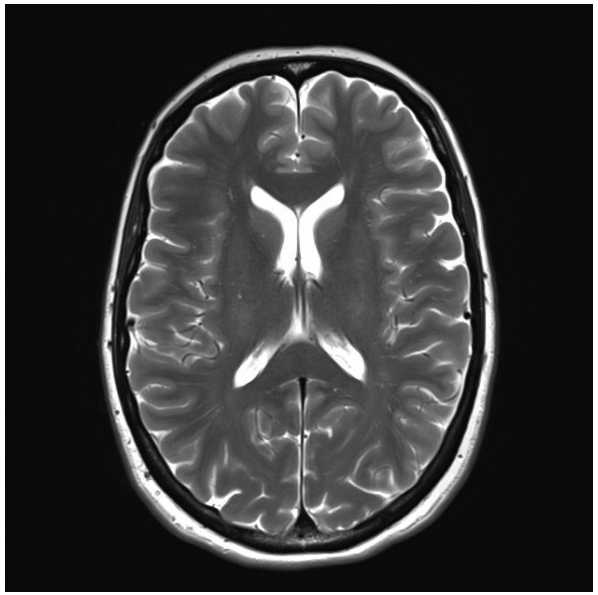
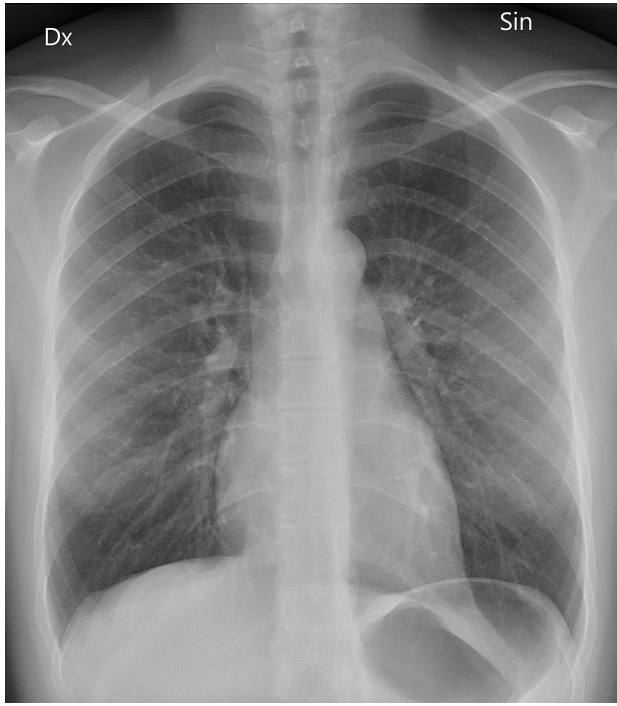


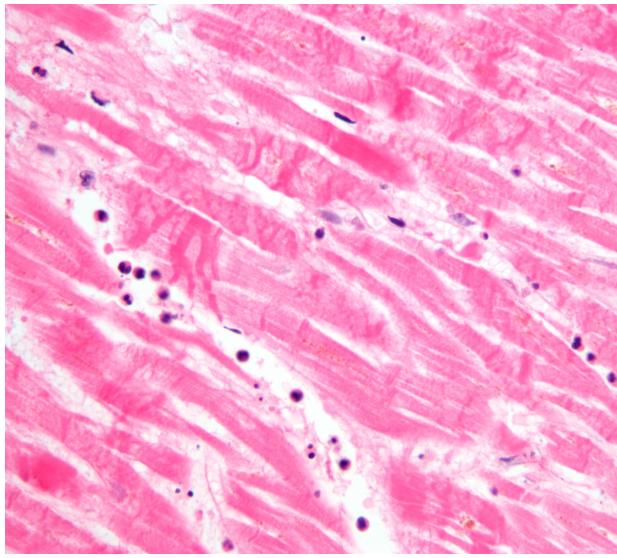
Image: DailyMail

What is medical imaging?

- Different organs/modalities
- X-ray, CT, MR, ultrasound, histopathology, …
- 2D, 3D, 3D with time, …







Images: Wikipedia

What is medical imaging?

- Different tasks, before/during/after a study or treatment
- Goal is often to measure something and compare to a reference
- Registration, segmentation, diagnosis

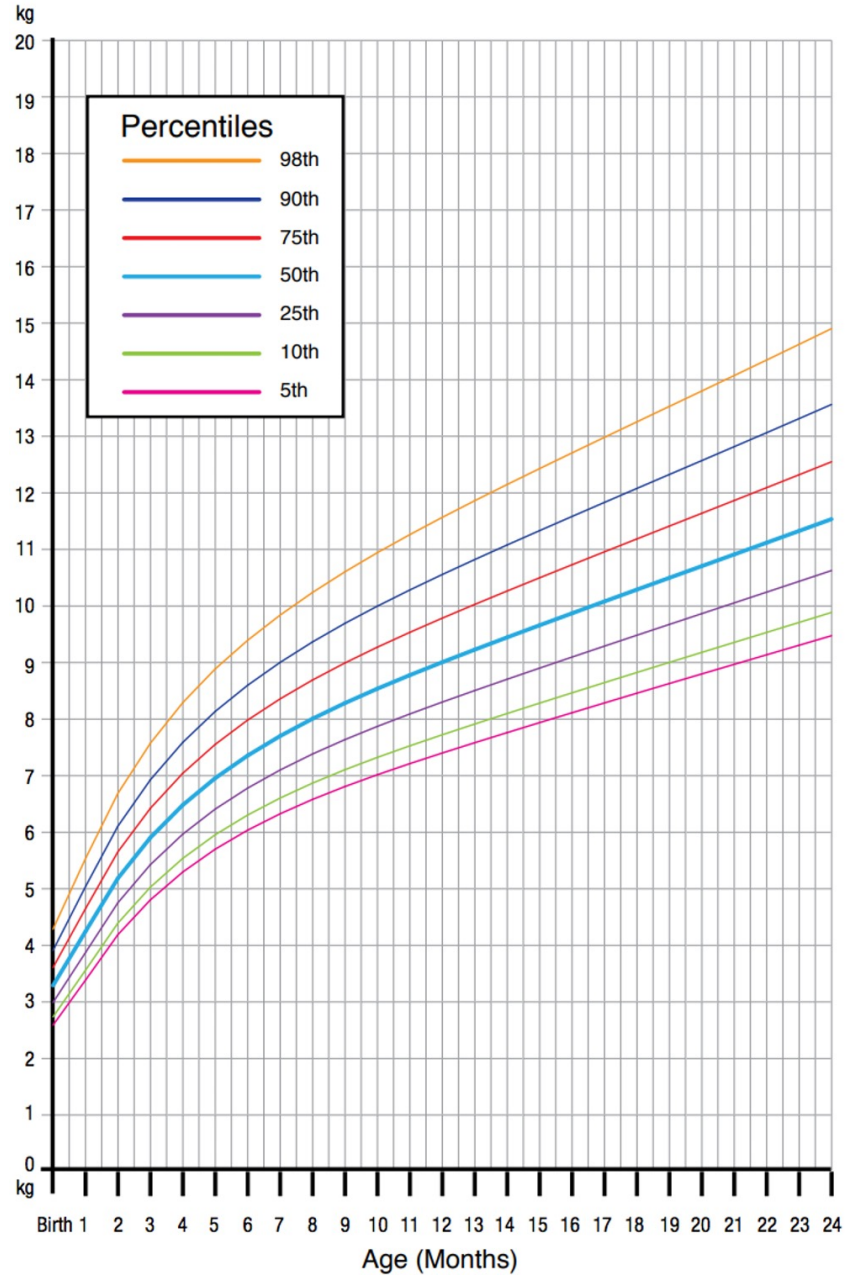


Image registration

- Find corresponding positions between two images / align them
- Several images of the same subject (different modaility, follow-up scans)
- Images of different subject (population study)

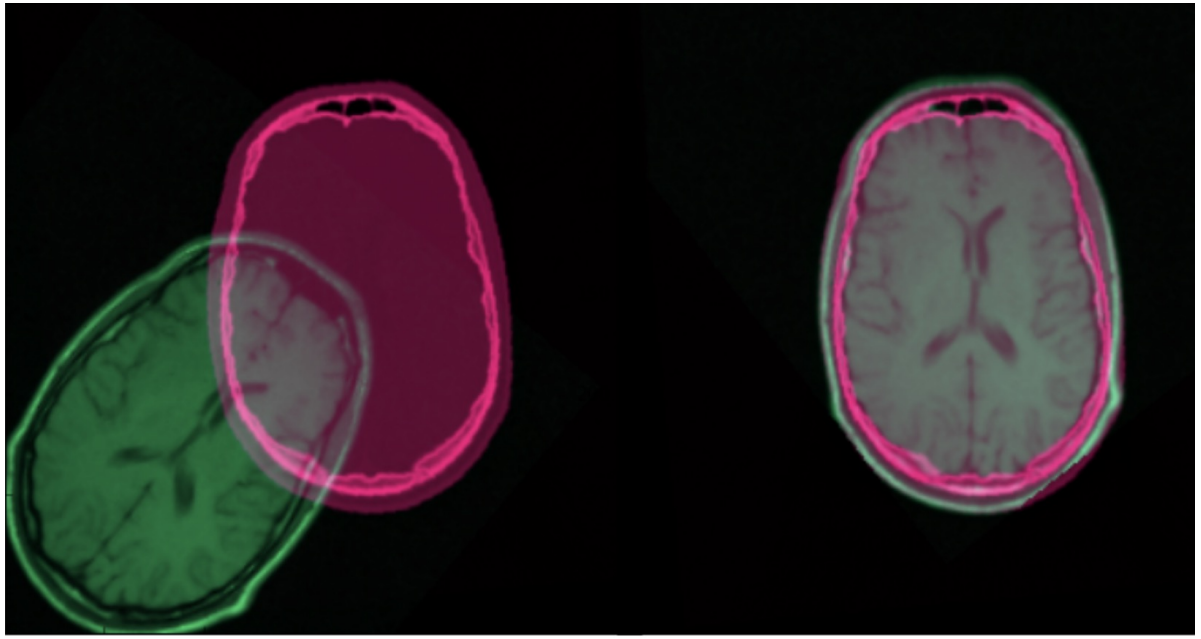
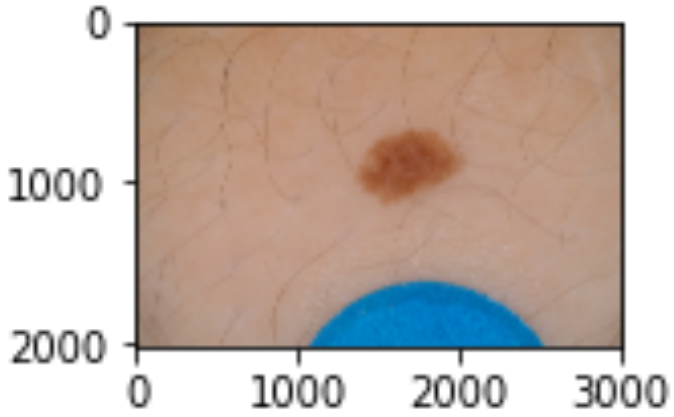
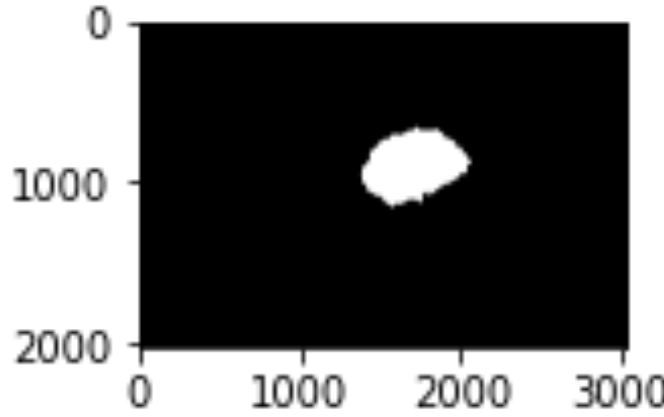


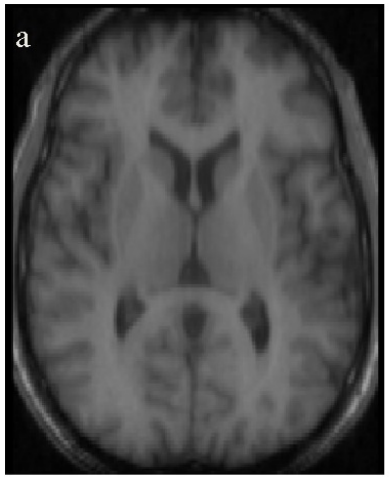
Image: https://medium.com/sicara/image-registration-sift-deep-learning-3c794d794b7a

Image segmentation

- Outline a structure in the image (=label each pixel)
- Organ, material, abnormalities like tumors







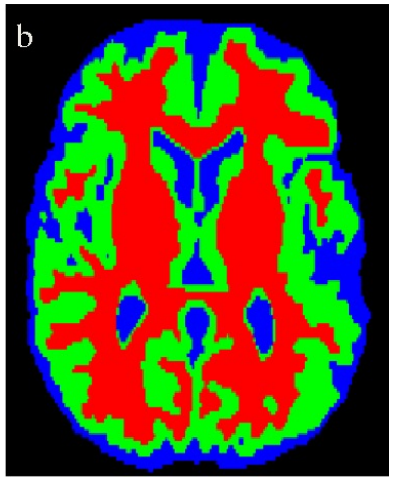


Image: https://www.semanticscholar.org/paper/A-Review-of-Medical-Image-Segmentation%3A-Methods-and-Withey-Koles/1b699b098ec7a5e539afd8370d71a82d41e3370d/figure/0

Classification / diagnosis

- Label an entire image (or set of images)
- Often with detection/localization of abnormalities

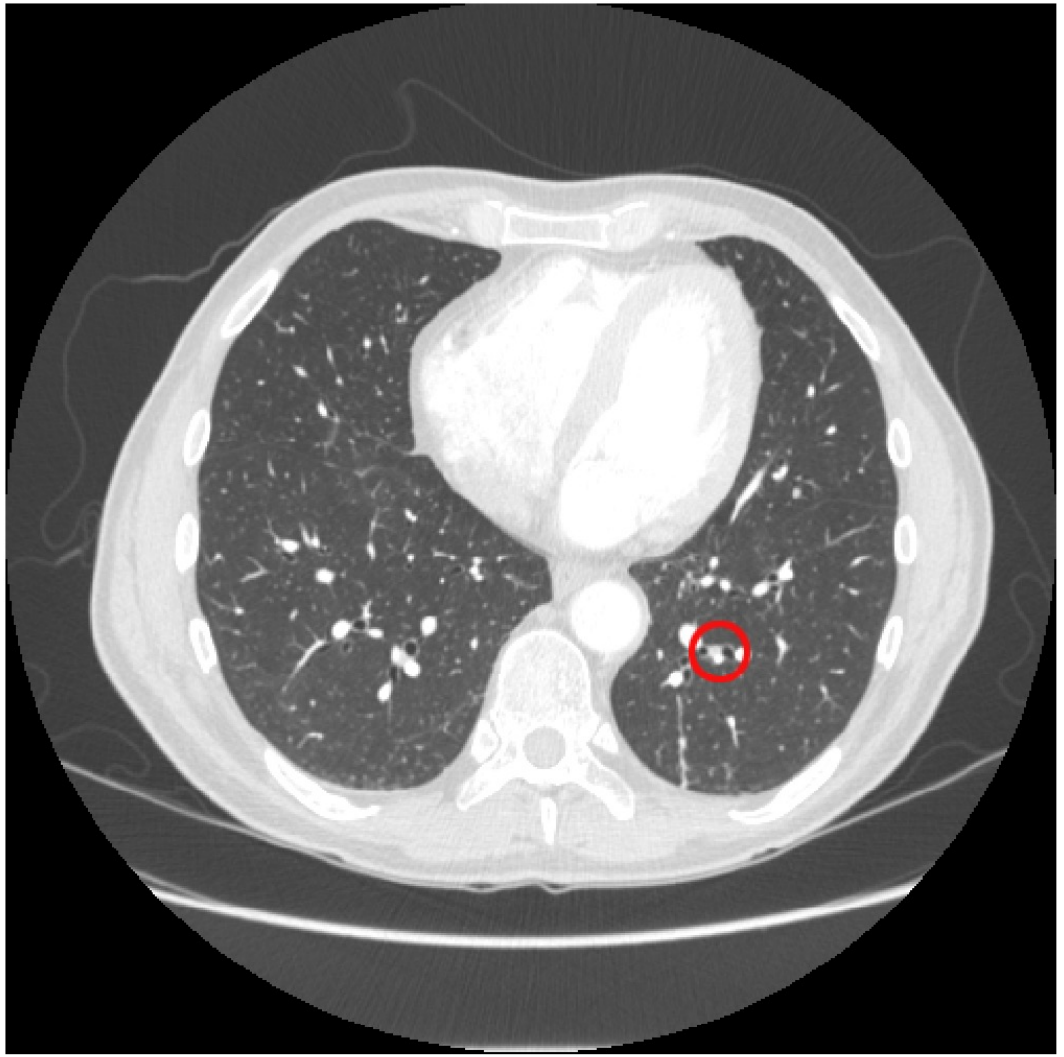
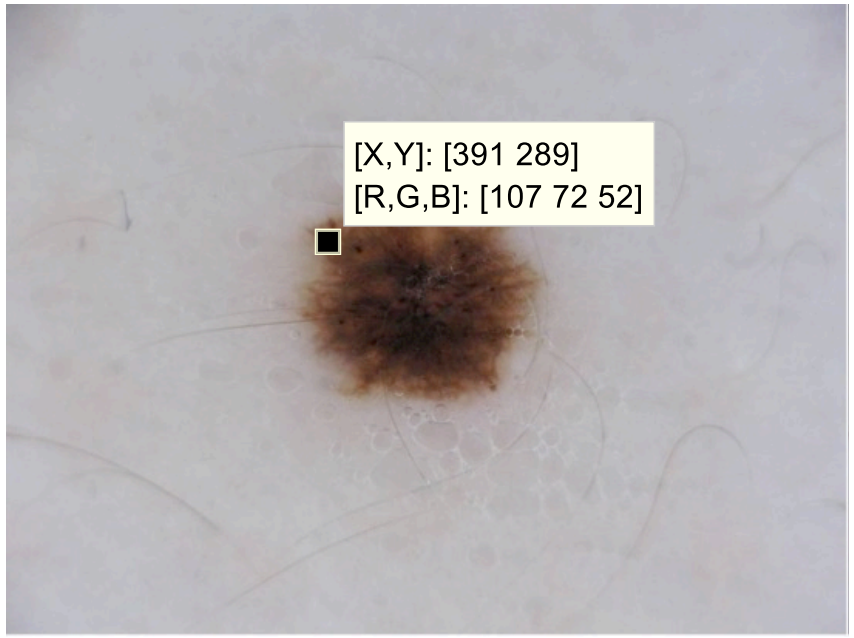


Image:
https://journals.plos.org/plosone/article/figure?id=10.1371/journal.pone.0210551.g011

Project background

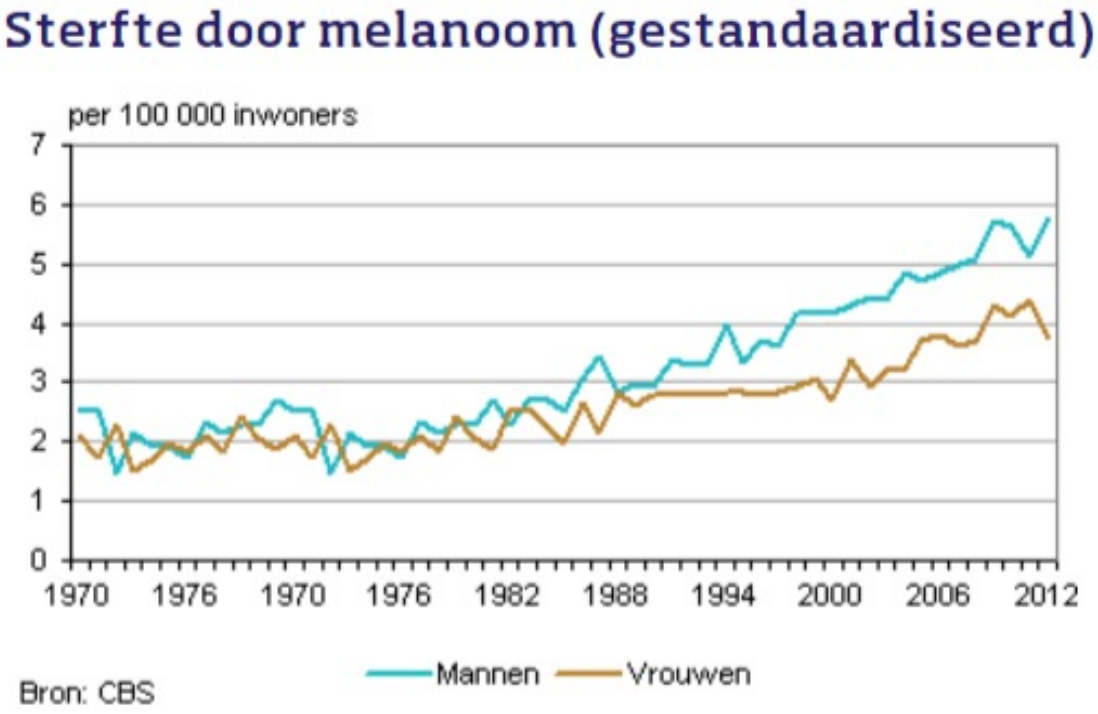
This project

- Diagnosis of skin lesions



Skin cancer

- One of the most common cancers
- Different subtypes, for example
  - Basal cell carcinoma
  - Melanoma
    (rare but dangerous)



https://www.cbs.nl/nl-nl/nieuws/2013/38/toename-sterfte-door-huidkanker

Skin cancer

- Early detection improves survival
- People may be hesitant to see a doctor (UK survey shows 45% with cancer-related symptoms do not)
- But too many doctor's visits are also not desirable, especially with corona

"Many of the people we interviewed had red flag symptoms but felt that these were trivial and didn't need medical attention, particularly if they were painless or intermittent." - Dr Katriina Whitaker

http://www.cancerresearchuk.org/about-us/cancer-news/press-release/2015-01-26-patients-dismissing-trivial-symptoms-could-delay-cancer-diagnosis

Apps to evaluate skin cancer

- Examples:
  - OddSpot (TU Eindhoven)
  - SkinVision
  - Many others

- Some apps ask you questions like
  - "What is the color of the spot"

- Output is often a probability, an indicator of how urgent it is to see the doctor, etc.

Group activity – Find out more about skin lesion apps

https://tinyurl.com/27h4uupx (also on LearnIT)

Say hi to your group!

Copy paste the template into a new document for your group, make it viewable via link, share in chat

Background for your project

Main idea

- Use **features** from previous (e.g. cancer/non-cancer) lesions to create a predictive algorithm

- Measure these features for a new app user, and estimate their risk/diagnosis/etc

Age	…	Color	…
20		Brown	
25		Brown	
40		Light red	
70		Red	

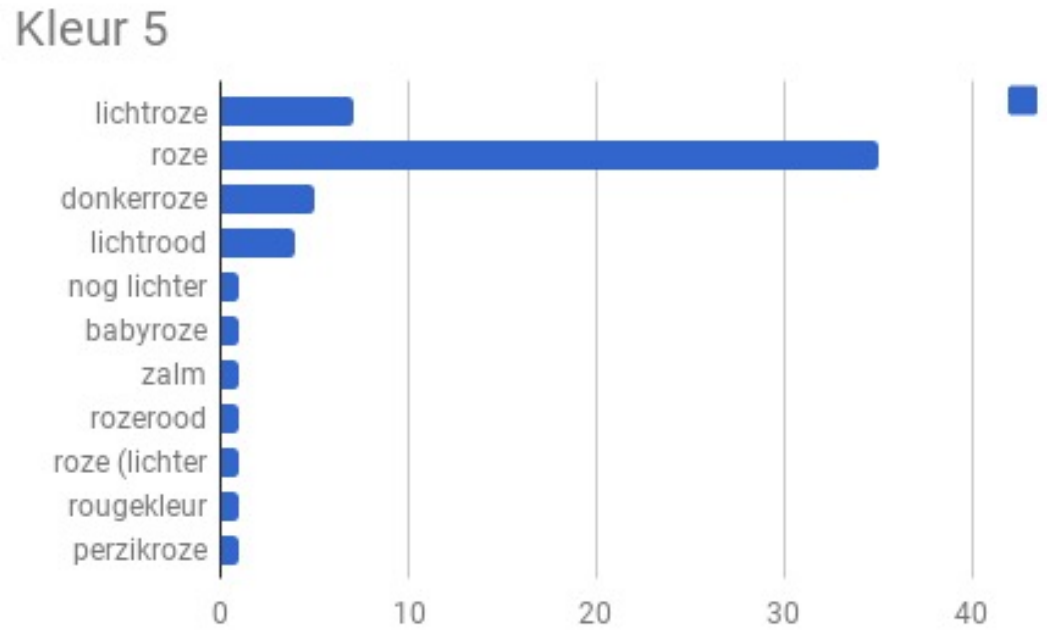
Cancer
yes
no
yes
?

Problem with subjective answers

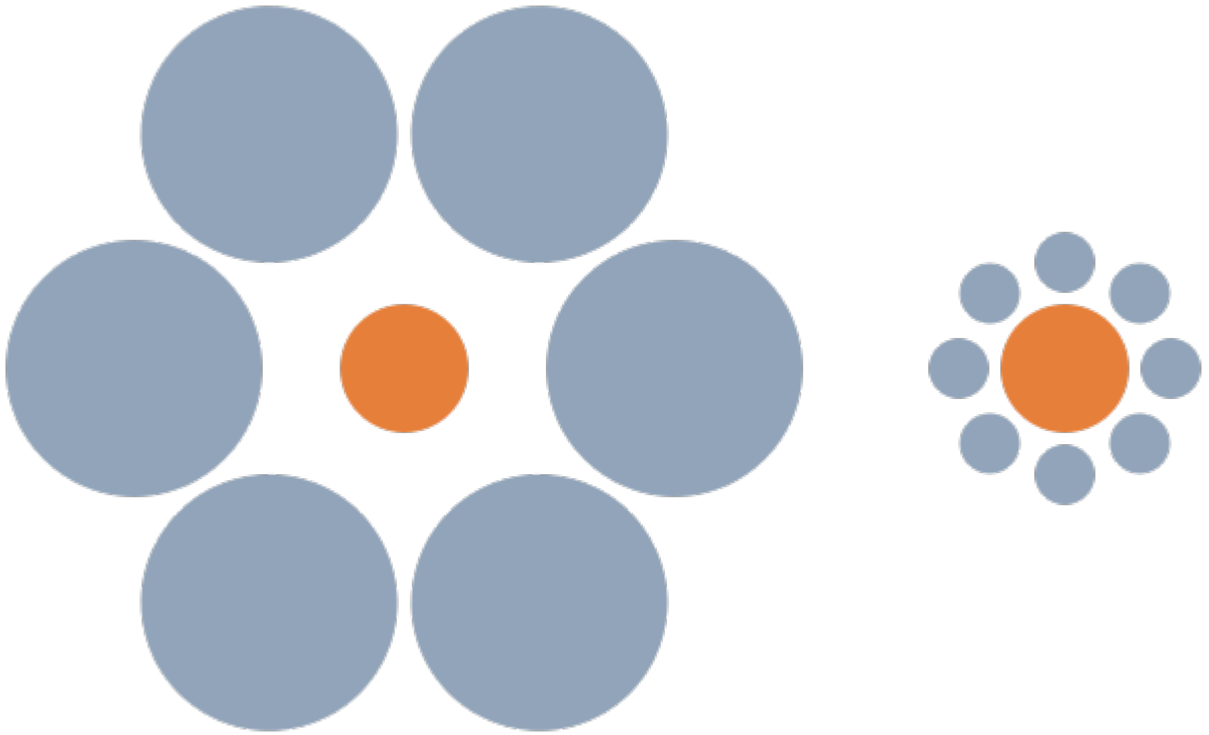
https://www.jads.nl/oddspot.html

Our vision is subjective

- Previous students called this color both “light pink” and “dark pink”

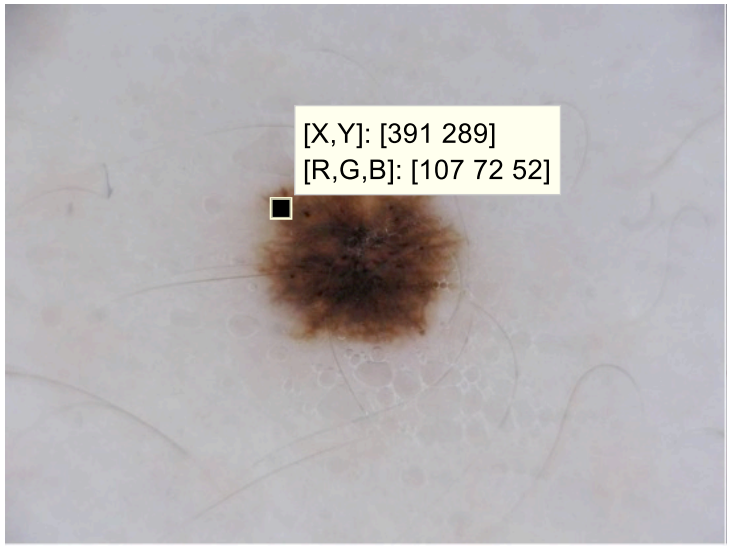


- Vision is subjective, surroundings change our perception



https://commons.wikimedia.org/wiki/File:Mond-vergleich.svg

Algorithms could help with this



- A color image has 3 numbers per pixel – Red, Green, Blue
- Black = [0 0 0], red = [255 0 0], white= [255 255 255]
- For the same pixel, the value stays the same

https://challenge.kitware.com/#challenge/n/ISIC_2017%3A_Skin_Lesion_Analysis_Towards_Melanoma_Detection

But algorithms also have problems

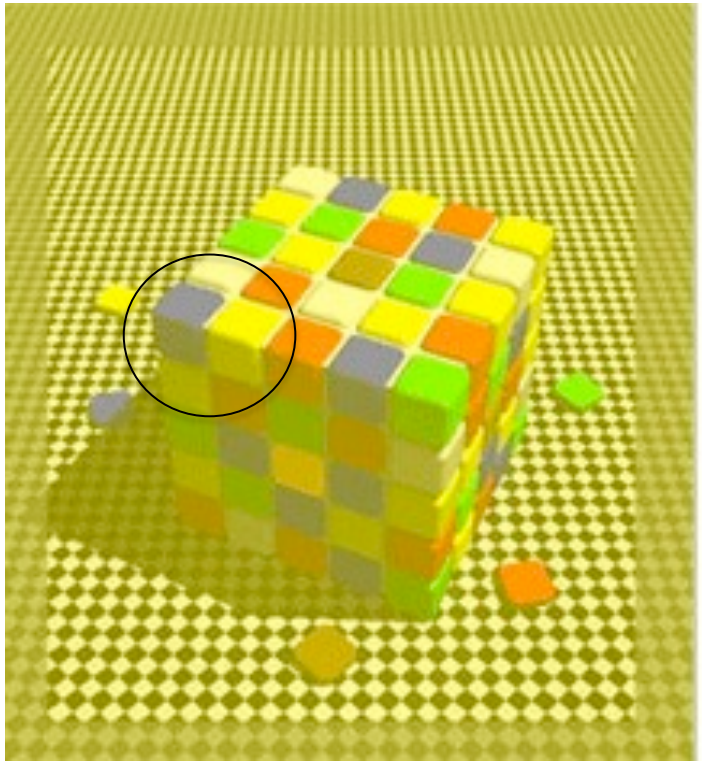
- Changing one pixel changes the algorithm decision if it's a cat or a dog

Cat(Dog)

Dog(Cat)

Su, J., Vargas, D. V., & Kouichi, S. (2017). One pixel attack for fooling deep neural networks. arXiv preprint arXiv:1710.08864.

Algorithms also have problems



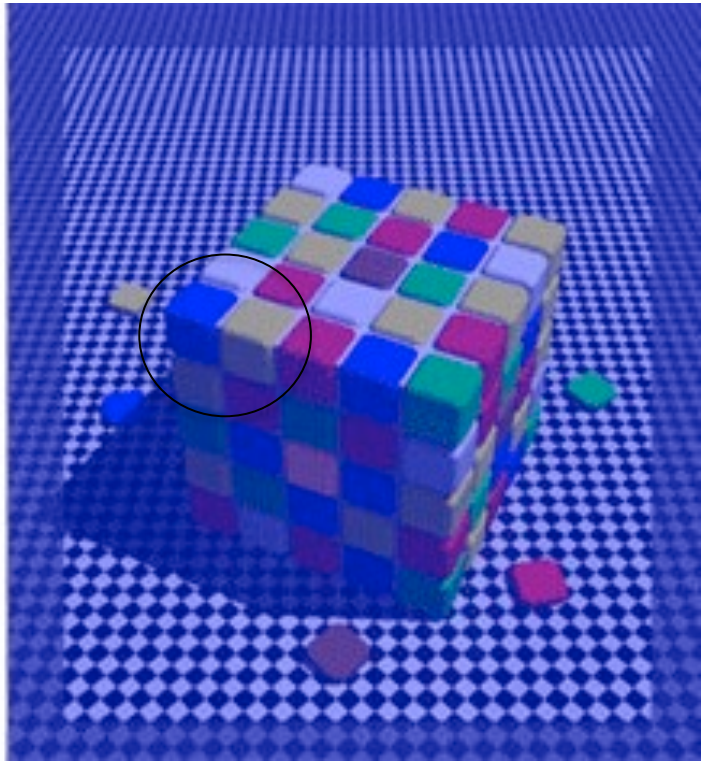


Image R. Beau Lotto http://www.labofmisfits.com/articles/illusionsoflight.asp

Algorithms also have problems

- "Blue" in the left image is the same as "yellow" in the right!

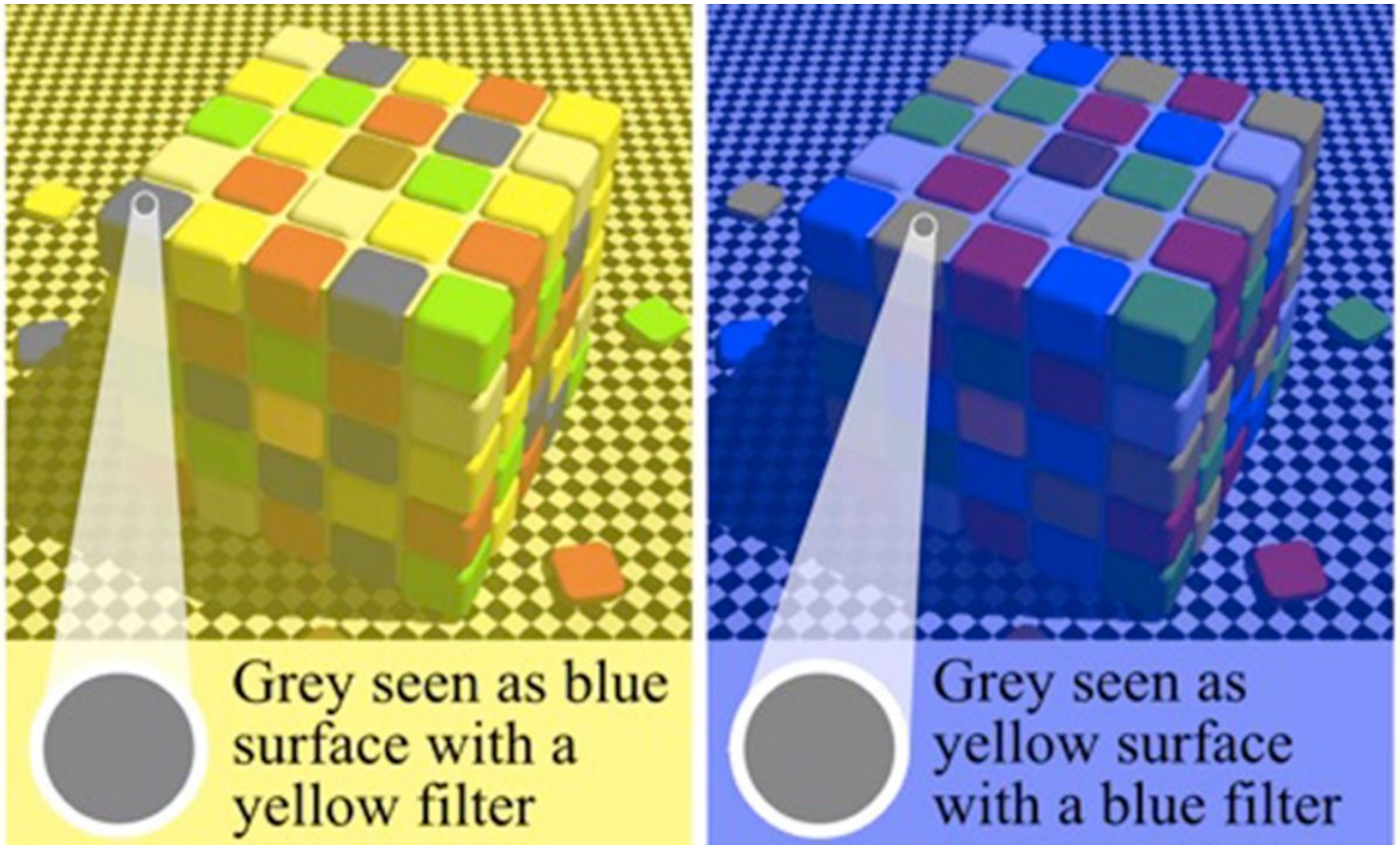
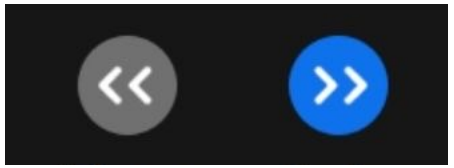


Image R. Beau Lotto http://www.labofmisfits.com/articles/illusionsoflight.asp

Remember this?

- Is the dress white/gold, or blue/black?



White/gold **Blue/black**

Apps could have problems also

- SkinVision reported to have problems in an external study

06 juni 2018 14:33
Laatste update: 06 juni 2018 16:51

23

De Nederlandse smartphoneapp SkinVision zou ongeschikt zijn om een betrouwbaar oordeel te vellen over het risico op huidkanker, stelt de beroepsvereniging voor dermatologen NVDV in een onderzoek.

In this project you will..

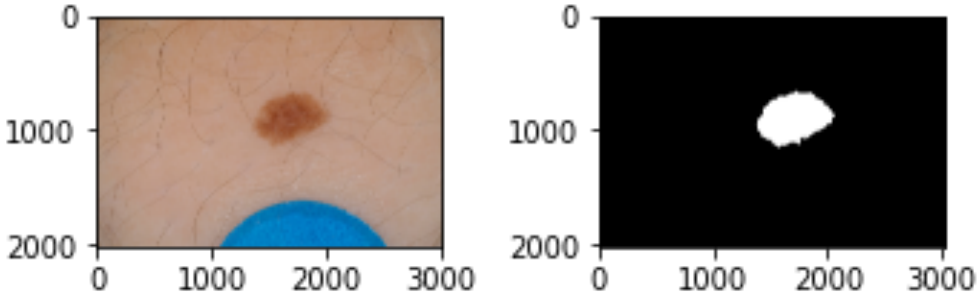
- Investigate how image processing can diagnose skin lesions. Is it reliable? What should we be aware of? Etc
- You will use public skin lesion data, and learn to:
  - Measure features from an image
  - Classify an image as suspicious/cancerous or not
  - Evaluate your results

Project guidelines

Github: https://github.com/vcheplygina/fyp2021p3

- 150 images images from ISIC 2017 challenge

- Data folder
  - Image (JPG)
  - Segmentation mask (PNG)
  - Meta-data CSV file



	image_id	melanoma	seborrheic_keratosis
2	ISIC_0001769	0.0	0.0
3	ISIC_0001852	0.0	0.0
4	ISIC_0001871	0.0	0.0

Github:
https://github.com/vcheplygina/fyp2021p3

- Example features
- Example code

Guidelines - Data

- You are encouraged to find/use other data
  - ISIC
  - PH2
  - PAD-UFES-20
  - …
- Github is not great for large datasets, use osf.io for example

Guidelines - Data

- Additional “labels”

https://github.com/vcheplygina/crowdskin

- Students who annotated images on medically relevant properties (e.g. asymmetry)

Ralf Raumanns

Fontys University of Applied Science, Eindhoven & Eindhoven University of Technology, Eindhoven

Geverifieerd e-mailadres voor fontys.nl

machine learning medical image analysis crowdsourcing bias

Guidelines - Methods

- You are encouraged to use more than the “default” method on Github
- However, your understanding/analysis is most important, don’t just try all options in a toolbox without motivation

Guidelines – Research questions

- You can ask different research questions

  – Compare different features/classifiers
  – Test your predictions on other datasets
  – Investigate differences based on age, sex ..
  – Etc

Guidelines - General

- Ask questions on LearnIT
- The requirements for the report / Github are as similar to the other projects as possible
- However, you can use more figures

Guidelines - Exercises

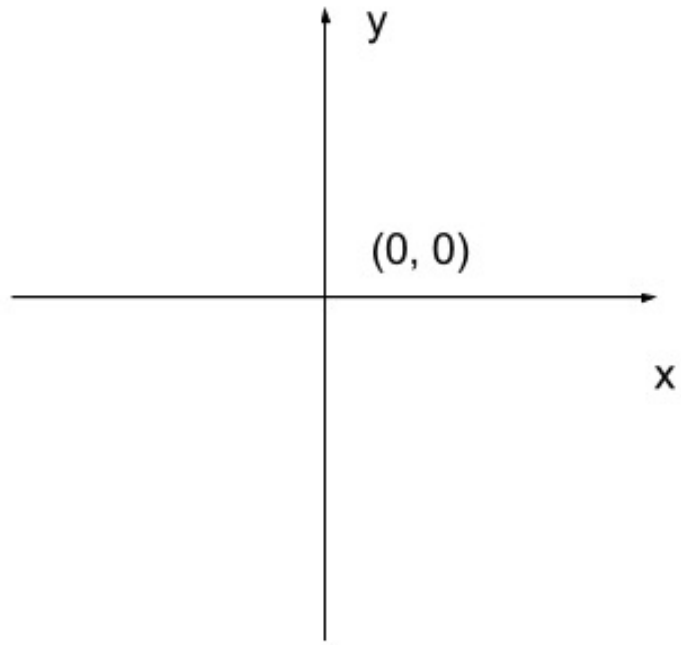
- There are also exercises (with the teaching assistants)
- The exercises are for you to practice, and understand the methods better.
- You do not need to finish all the exercises, to finish the project.

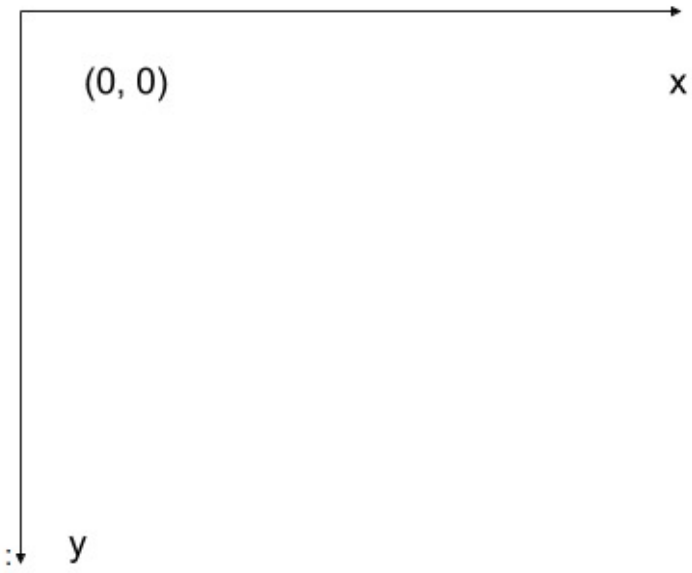
Working with images (in Python)

Getting started with images

An image is essentially an array of numbers. The first two axes index the coordinate of the image.

0 0 0
0 1 0
0 0 0





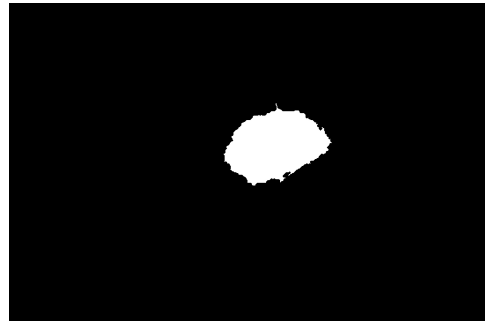
https://datacarpentry.org/image-processing/02-image-basics/index.html

Getting started with images

Depending on the type of image, there might be one or more values at that location.

1 value → binary (values 0 or 1) or grayscale image

e.g. 200x100 uint8



https://datacarpentry.org/image-processing/02-image-basics/index.html

Getting started with images

3 values → color image (Red, Green, Blue, often 256 values)

e.g. 200x100x3 uint8

https://datacarpentry.org/image-processing/02-image-basics/index.html

Getting started with images

R G B components “mix” to create the color, but it works differently than with painting.

Higher number = more of that color.

[0, 0, 0] = no color = black

Color name	RGB triplet	Color
Red	(255, 0, 0)	
Lime	(0, 255, 0)	
Blue	(0, 0, 255)	
White	(255, 255, 255)	
Black	(0, 0, 0)	
Gray	(128, 128, 128)	
Fuchsia	(255, 0, 255)	
Yellow	(255, 255, 0)	
Aqua	(0, 255, 255)	
Silver	(192, 192, 192)	
Maroon	(128, 0, 0)	
Olive	(128, 128, 0)	

https://datacarpentry.org/image-processing/02-image-basics/index.html

Getting started with images

RGB is only one way to represent colors, may not be intuitive

For example, RGB is not “perceptually uniform”

Further reading: https://en.wikipedia.org/wiki/List_of_color_spaces_and_their_uses

Getting started with images

Notebook (link also on LearnIT):

https://tinyurl.com/3j3ksv59

Getting started with images

More general exercises you can do if you like:

https://datacarpentry.org/image-processing/