Medical images are very interesting as input for AI. But what types of medical images exist? A short introduction!

- Why do we want to do deep learning on medical images?
- Introduction to the different types of Medical Images
- Challenges related to applying AI to medical images.

Why do we want to do deep learning on medical images

- Deep learning can sometimes do better than a human
- Deep learning is a second opinion
- To save human resources, i.e. time.
  - Amount of available images can be large, difficult to see the total picture
  - Some tasks are very labor intensive, for example drawing brain regions in 3D image volume.

- Mammography interpretation
  - A lot of these, radiologists could use some help!
- Chest x-rays
  - A vast number of chest x-rays are taken, but radiologists are too few
- Cancer detection in histological tissue sections (Prostate)
- Detect neurological diseases (Alzheimers) in MR images
- Detect fractures in x-rays
- Segmentation of brains into anatomical brain regions
  - Very time consuming task!

X-ray

- First technique for imaging of the interior of a body

- X-rays are sent through the body and the rays coming through are detected

- Images tissue density
  - ->Bone and air cavities stand out

- 2D imaging techique
- Anatomical images

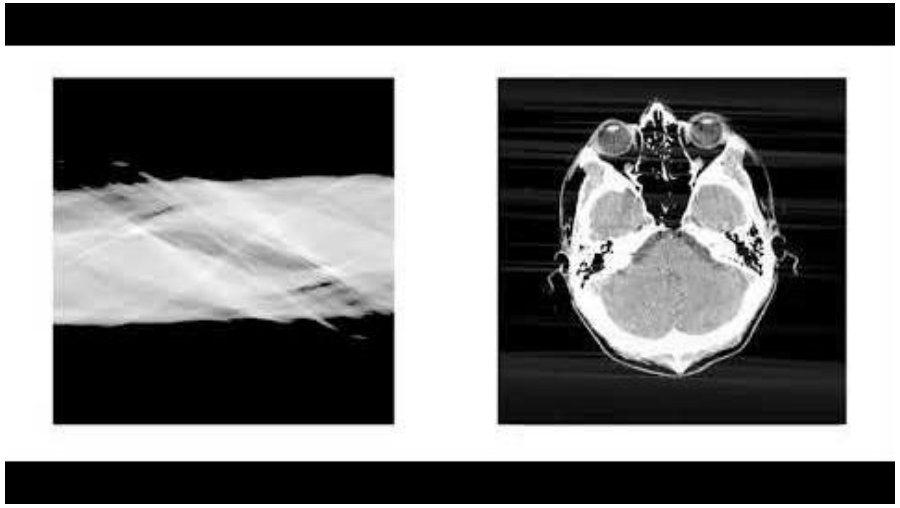
- Uses ionizing radiation

Fluoroscopy

- Same as x-ray, but uses a constant input of x-rays to produce live images

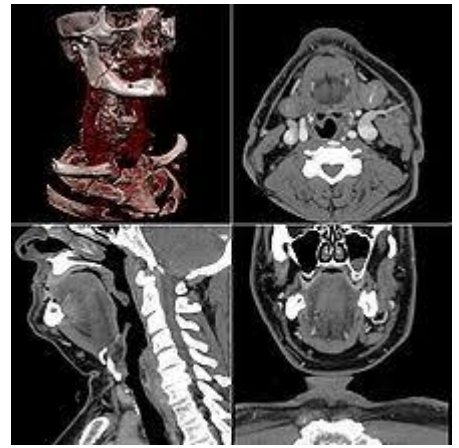
X-ray Computed tomography (CT)

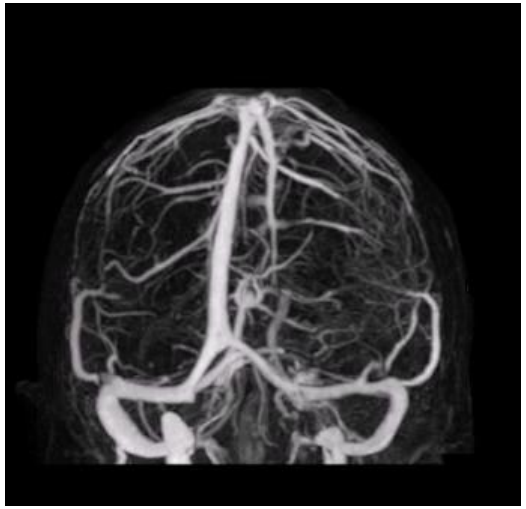
- X-rays from many angles are combined to form 3D image volume

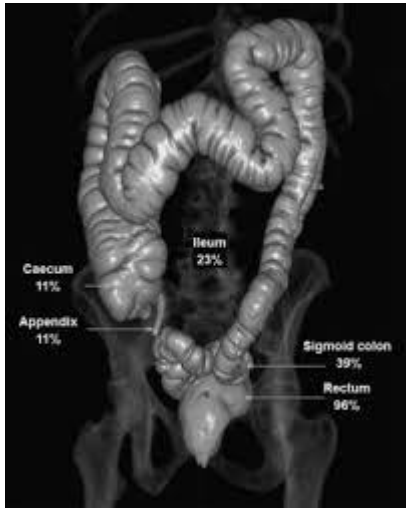


CT continued

- Can produce images with very high resolution (0.5 mm)
- Reconstruction can give 2D slices in arbitrary directions
- Contrast







CT continued

- Many applications
  - Head/neck – infarction, tumours, calcifications, bone trauma

    MR is usually better, but may not be available or takes too long in emergency situations
  - Lungs
  - Angiography – imaging of arteries and veins
  - Heart
  - Skeleton
  - Abdomen
- Higher radiation doses than x-ray 

Magnetic resonance imaging (MR or MRI or NMR)

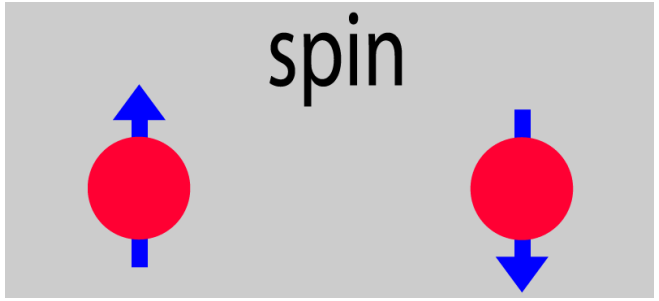
- Different settings in MR-machine gives different images! Many imaging machines in one!

- Excellent for soft tissue imaging - high contrast

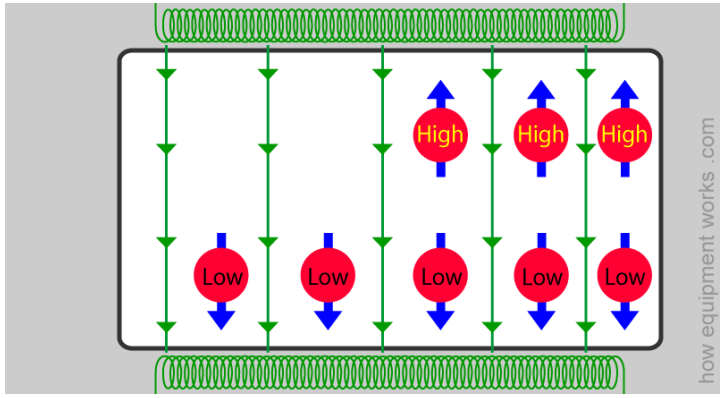
- No radiation dose

Super short intro to MR theory

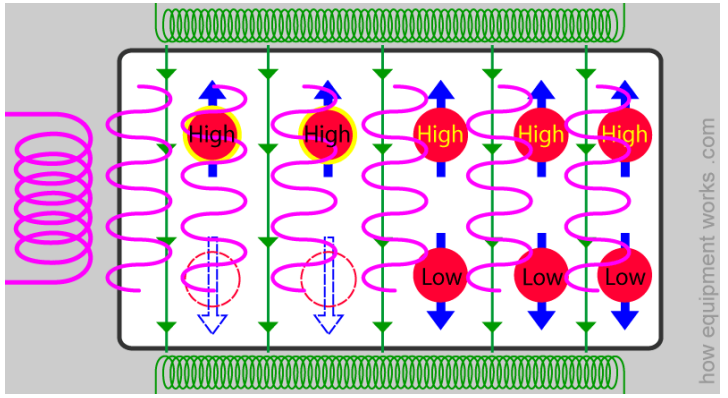
Hydrogen nuclei have spins



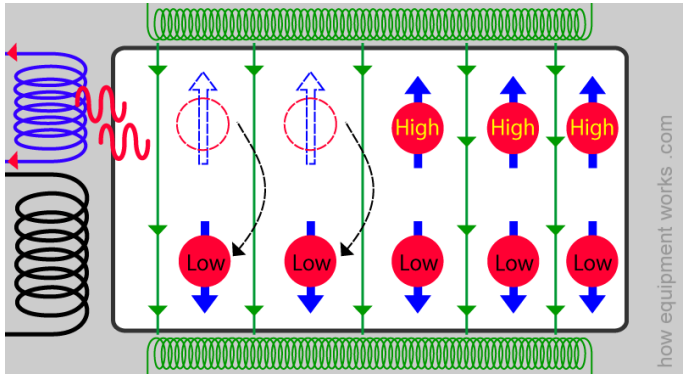
We add an external magnetic field



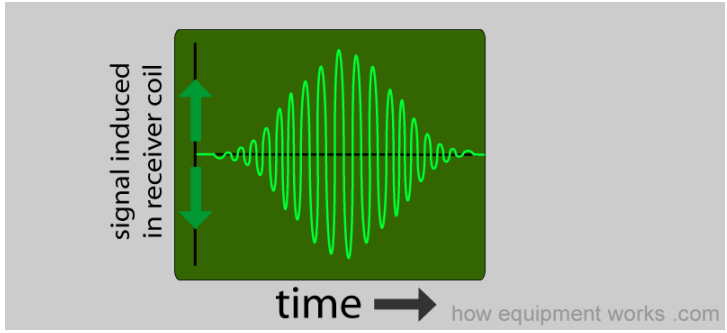
Radiowaves are applied



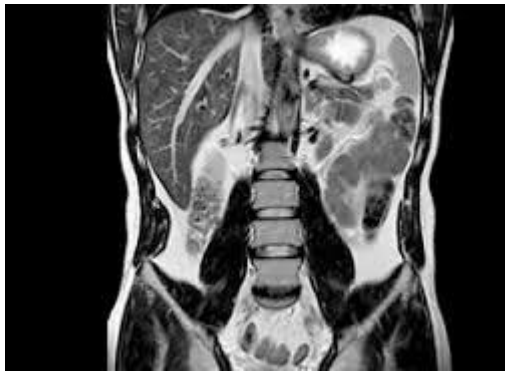
Nuclei emits radiowaves…



A signal is detected…

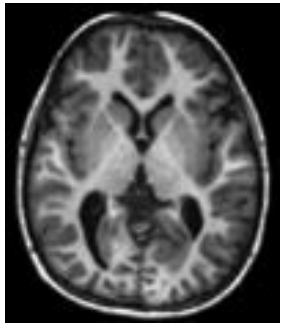
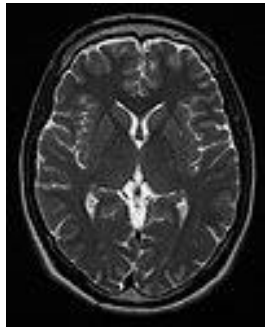
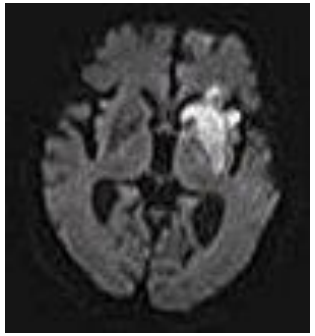


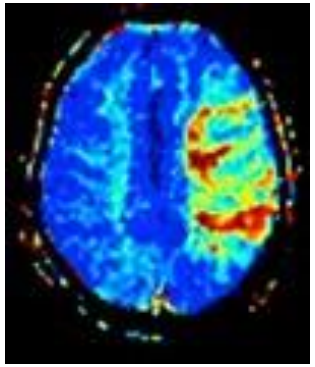
Images are formed!



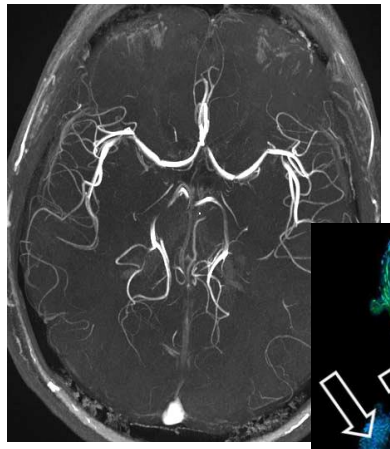
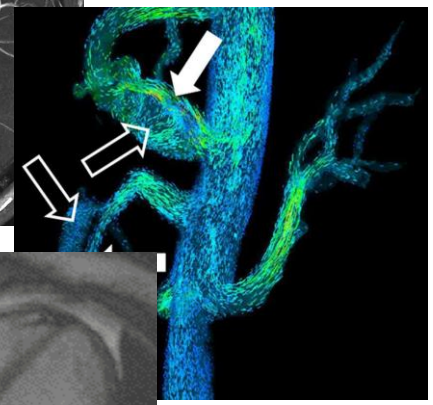
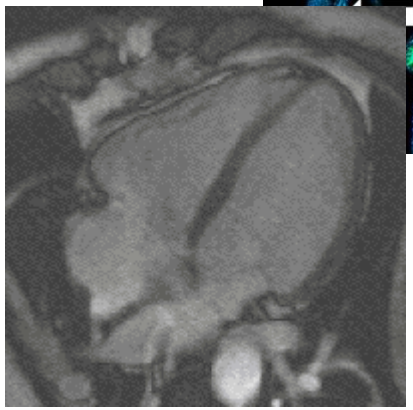
MRI can image different tissue properties

- T1 and T2
- Diffusion weighted
- Perfusion weighted

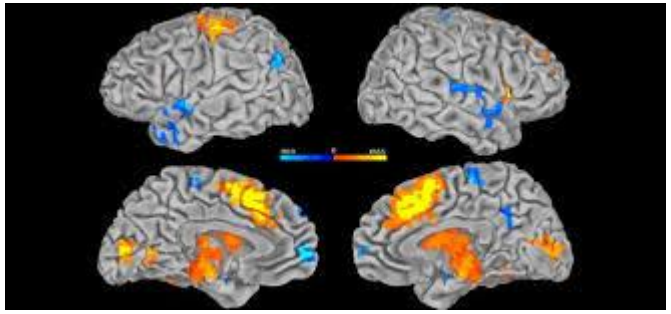


and many more!

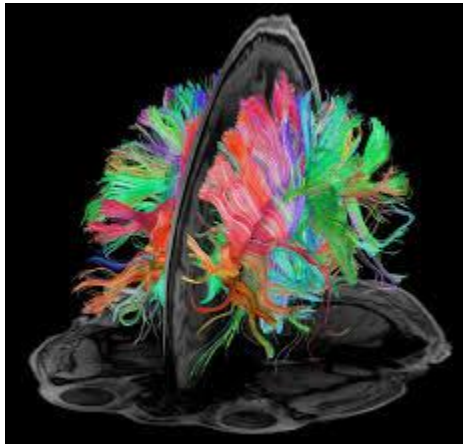




Anatomical vs functional imaging

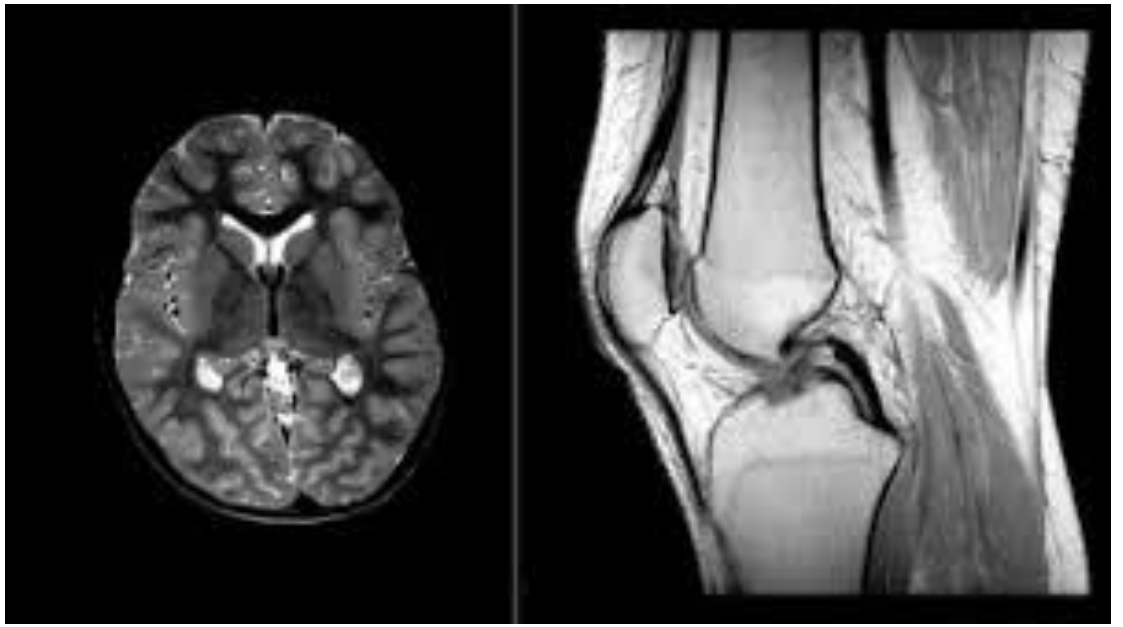
fMRI



DTI



Anatomical

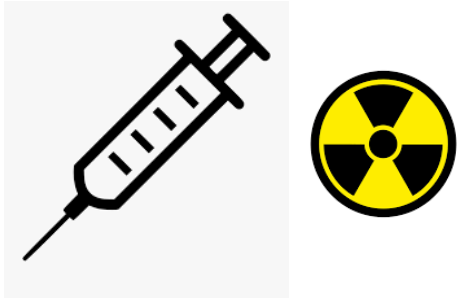


MR continued

- Different image series are acquired in one imaging session
  - The combined information brings out more information
- Hazards
  - Noise: Mechanical stress in coils produces high noise
  - Radiowaves may heat tissue like in a microwave oven
- MRI is so exciting that Paul Lauterbur and Peter Mansfield received the nobel prize in medicine 2003 for their work in Magnetic Resonance Imaging

Nuclear medicine

- Radioactive isotopes are used for imaging



- Mainly three different techniques
  - Single photon emission computed tomography (SPECT) – 3D
  - Positron emission tomography (PET) – 3D
  - Scintigraphy – 2D

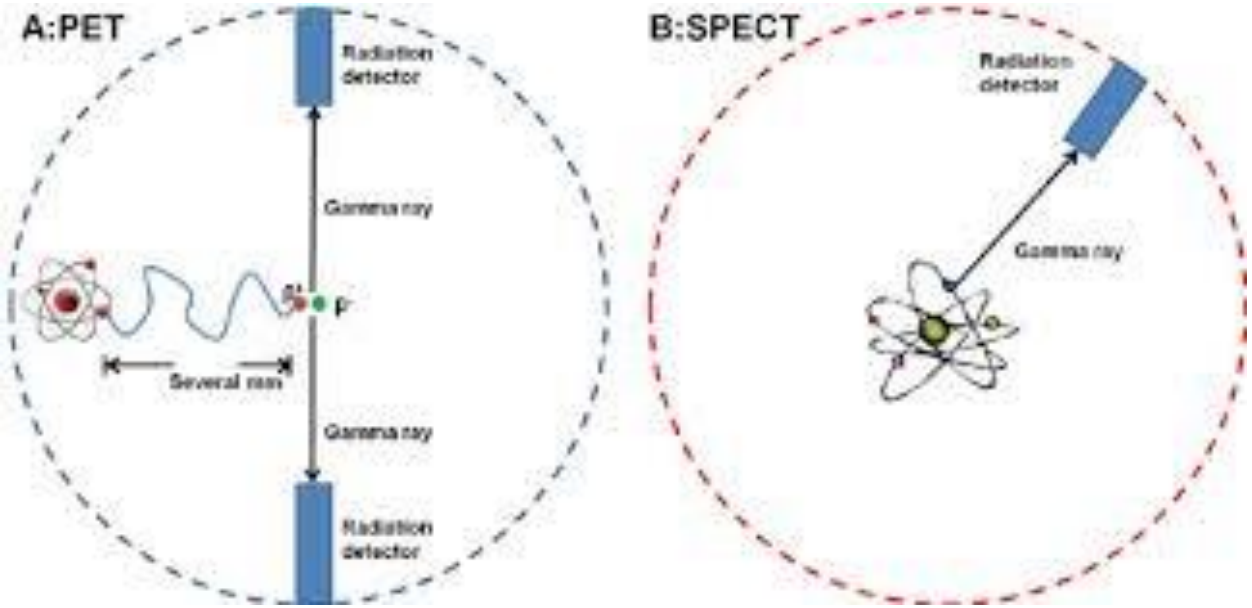
Images some sort of function

- We image where the isotopes aggregate

- Attaching the isotopes to different molecules enables imaging of different types of kinetics
  - Iodine mark the activity of thyroid gland – hyper- or hypoactivity or cancer
  - Technetium-99m mark activity in bone
  - Kidney function
  - F18-deoksyglukose marks tumor activity
  - ..

PET vs. SPECT

- PET: nucleus decays by positron emission
  - Positron annihilates when it hits an electron
    and produces TWO gamma photons going in opposite directions
- SPECT: nucleus decays by some process producing a gamma photon



Some nuclear medicine images

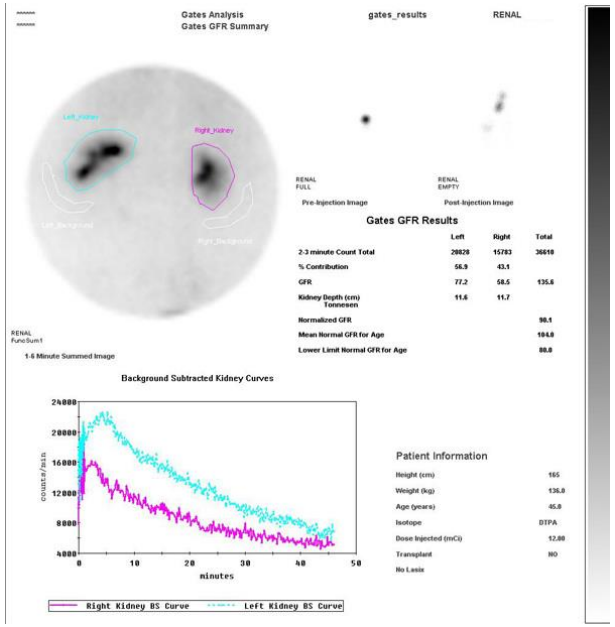


Image formats in medical imaging

- DICOM (**Digital Imaging and Communications in Medicine)**
  - **Used by all vendors of medical equipment**
  - **Used by image archive systems, Picture archiving and communication systems (PACS)**

- **NIFTI (mostly used in neurological science)**

Challenges

- Sufficient amounts of labelled data
- Going from 2D to 3D: huge amounts of data
- Lack of standardization of image acquisition
- Coregistration of different images series
- Geometrical distortions (MR)