Exam Questions Medical Imaging – per category

CT

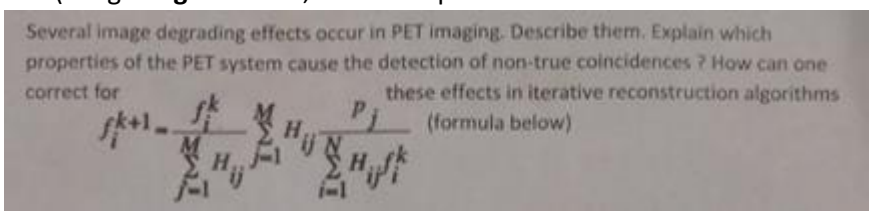
- Which properties of X-rays can you change (amount of rays + energy of photons)
- How are x-rays produced? What are the different components used (don't remember the exact question but the point was that you had to explain the filter, the collimator grid,.. and where they were placed and why they're needed.) + what is beam hardening
- Explain principle of CT, reconstruction, 3rd generation
- Give components of 3rd generation CT, which acquisition methods are used? How do you go from measurements to final image in HU?
- 5th gen CT?
- helical CT → slices? How is this done?
- What is the difference between the backprojection of the projection of an object and the original object. Explain the different steps in the filter backprojection algorithm. Why is this algorithm the standard method in CT but not for PET and SPECT? How are the CT data transformed before one can reconstruct the linear attenuation coefficient?
- FBP algorithm (derivation needed)

SPECT

- How does standard gamma camera for SPECT work (Anger principle) + different components?
- Why are collimators important in SPECT + how do they look like?
- Why is a mechanical collimator an essential component to acquire projections? How do you determine the position in the detector of a gamma camera?
- What properties do collimators have? (Sensitivity/spatial resolution). Give different types of collimators used and their pros/cons.

PET

- How are positrons produced and how is this used to produce molecular imaging? How is this method **better than SPECT** in terms of sensitivity? What are limitations ins spatial resolution?
- PET (image **degradations**, how to implement them in the iterative formula)



- Image degrading effects in PET (make sure you got all of them: countrate, scattered coincidence, random coincidence, attenuation, partial volume effect) + how are they corrected for in the iterative reconstruction method (formula normal method is given).
- Evolution in PET scanners

SPECT vs. PET

- Why is the **sensitivity** of a standard PET >>> SPECT? What happens with the sensitivity when the axial length is doubled? How can you further enhance the sensitivity when you have very FAST detectors? What is the potential of a so called Total Body Scan?
- Similarities/Differences/Pros/Cons between SPECT and PET, based on **sensitivity / resolution / price** + also with regards to **isotopes**
- Difference between the **scintillation material** in SPECT and PET, Describe and the different requirements/properties on these detectors/materials.

General:

- What are the different types of reconstruction techniques used in imaging (CT, SPECT, PET), what are their advantages?

US

-What are the different components in an ultrasound transducer and describe their function?
-Which physical interactions occur between the ultrasound waves and the body of the patient? Why do we need to time gain compensation? What is the advantage and disadvantage of using higher frequencies?
-Explain how we go from A to B to M mode imaging

- How does image reconstruction work for US?

MRI

- Explain 3 different gradients applied in MRI (slice, frequency, phase), how are gradient coils used in MRI?
- Draw the sequence for MRI, what is spin echo?
- What is T1/T2 relaxation, what is TE/TR, how to change these parameters to give different weights to the image?
- What is the benefit and problem of using STRONG magnetic fields (7 Tesla)
- How is FID (Free Induction Decay) measured + what is Zeeman effect

Enhancement + Filtering

Enhancement:

- Questions about histograms (linear mapping, equalization, what happens to histograms when you have strong/weak contrast). Principle, working, uses, disadvantages.

Filtering:

- mean filtering, median filtering, bilateral filtering
- first order differential using compact masks, derive that gradient magnitude is rotation invariant, second order differential (explain, draw, how is it used in practice), unsharp filtering, how would you do unsharp filtering with to enhance only weak edges
- What is Low pass filtering + give a 3x3 gaussian? What is Mean filtering, why is this not a perfect low-pass filter (use FT)? What is median filtering + why does it preserve edges better? What is symmetric nearest neighbour filtering, how does it preserve edges? What is bilateral filtering?
- Unsharp mask filtering:
  A) What are the applications of such a filter?
  B) General principle, different steps + intensity profile steps
  C) Give 3x3 mask and give its properties
  D) Risk of applying this filter on noisy images, how can this be avoided?

Registration

- Intensity based registration
  A) MSD and NCC: give formula and the relation they assume
  B) entropy and joint entropy: give formula, concept and interpretation in case of an image
  C) MI: give formula and explain all the terms
  D) give an example where MI can be used but not MSD and not NCC
  E) compare an image with the same image. In case i) you add salt and pepper noise to the second image, in case ii) you add an intensity gradient to the 2nd image (figures of what he means are given). What is more affected? MSD or MI?

Segmentation

- image segmentation (otsu, region based, multi-atlas)
- Give an overview of region-based segmentation methods. Discuss the following aspects:
  A) Explain the principle of thresholding
  B) Describe automated thresholding using the otsu method. For which type of histogram does this method work best?
  C) Describe in words or pseudo code the different steps of a standard region growing algorithm. Advantage of region growing over thresholding?
  D) Propose two variants to the standard region growing algorithm, by changing the criterion or adapting the algorithm in another way, and describe for what type of data this could be advantageous.