Your Paper

You

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Abstract

Radiation-based breast cancer imaging techniques

1 Problem and Definitions

Lowering the dosage of radiation based cancer techniques.

1.1 Dense Breast Tissue

Also called fibroglandular tissue.

1. Less fatty tissue and more 'dense' tissue. Includes milk glands etc...
2. More in younger, lowers BMI, hormone therapy for menopause
3. As in Figure 1 DBT makes detecting breast cancer difficult
4. DBT also increases the risk of breast cancer

2 Alternative Treatments

1. 3D Mammogram
2. MRI
3. Ultrasound
4. Contrast-Enhanced (Iodine)
5. Molecular Breast Imaging (Tc Tracer)

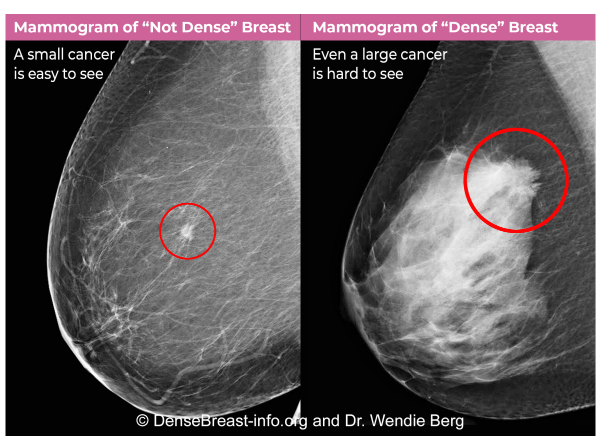

Figure 1: COPYRIGHTED IMAGE. Do not publish. Dense Breast Tissue Tumour Problem

3 Molecular Breast Imaging

From everything I remember, this is the technique described during the interview. The key details are:

1. Contrast Agent: Tc 99m
2. Uptake time is typically 40-60 minutes
3. Dose is high enough for concern
4. Fantastically effective, bypasses dense issue problem
5. Practically problematic

4 Practical Problems with MBI

4.1 Prep Time

1. Patient prep requires an injection from a trained professional. This is also uncomfortable
2. Injection must be timed carefully

Question: To what extent can this step be automated? (Automatically detect best injection site?). Very unlikely but nice to know.
Answer: ML Guided IV placement is a thing. But this is unlikely to be useful for this project.

4.2 Wait Time

1. Patients need to wait 40-60 minutes to accumulate in potential tumours.
2. Obvious solution is to make classifier that works on earlier images.
3. Can potentially increase metabolic rate of patient to increase uptake? (Medical side can advise).
4. There are 2 signs of accumulation? The increasing of the brightness in one spot, and the subsequency decrease of it afterwards? Because all the Tc is uptaken by the tumour, it follows that perhaps the point directly after it has a lower density. Can detect this peak then dip through a taylor series breakdown?

Question: How mechanically does the Tc flows in the veins. What are other signs of accumulation I should be aware of?
Answer: Tracers like Tc get stuck in tumours more because of Enhanced Permeability and Retention Effect (EPR). The tumour makes faulty blood vessels, which leak more, so more tracer is deposited in the intracellular space in the tumour. And they also lack lymphatic drainage. Also they're more active metabolically which means they take in more blood flow.

4.3 Imaging The Patient

1. Camera takes images for 10-40 minutes
2. Breast is compressed and needs to stay still for this time -¿ annoying
3. Camera has to wait to collect more photons
4. Motion causing blurring here
5. High dose means repeat scans are unwanted
6. Enhance low-dose images

Question: What are the exact consequences of halving a dose?
Answer: It is NOT a halving of the signal:

1. Inverse square law for reduced dose due to distance and spread of gamma. 1/2 dose -¿ 1/4 photons
2. Poisson distribution on the event reduces by more than half which means fewer photons vs more noise means a poorer signal/noise ratio
3. Exponential Decay in the amount of photons

4.4 Interpreting Images

1. A nuclear medicine radiologist needs to look at them
2. Abnormal uptake patterns of tracer
3. Not all radiologists are trained in nuclear imaging
4. Look different from X-rays or MRIs

Question: How are the images collated EXACTLY? Does this Have much ML scope?
Answer: Images are taken at regular frequency by the camera, then collated together

5 NHS Priorities

1. Minimising Dose vs Faster Patients: ChatGPT tells me that minimising the dose is likely the research priority.
2. 10-20% approx are hard to interperet because of movement. IDEA Classify the ones with significant blurr and give to specialist
3. 15-30% hard to interpret due to noise
4. 5-10% poor calibration of equipment
5. 10-15% insufficient contrast

1. 1. Something that works at reduced dose
2. 2. Anything that classifies it for the radiologist will help a similar amount
3. 3. Help de-noising/motion blur during or after capture

6 Interesting Things

1. Radiation at any given spot scatters outwards. What we want is actually radiation that is travelling perpendicular to the camera (cos that tells you where exactly it came from). A lead plate with little straight columns in it called a collimeter causes this.
2. The deeper the tumour, the harder it is to see (more noise in front)

7 Ideas

7.1 Dealing with Noise at Source (Gamma Camera)

Motion blurring can come from suboptimal ways the gamma camera is collating the final image. You can refine this process by using ML motion detection to find moments of motion and discard their frames from the final collation.

7.2 Point of maximal gamma saturation

One could start any frame preprocessing by estimating the point where the patient hax maximal uptake in the tumour. This neighbourhood of points will give the best signal-noise ratio

7.3 Stable Diffusion: Making Low Dose Images Look High Dose

This is the more promising idea by far

1. Start with a good high-dose image dataset
2. Artificially make them look lower dose (can do this by subsampling the frames collated to create them), avoiding neighbourhood of peak uptake etc..
3. This way, one can make progressively 'lower dose' images
4. Use this to train the reverse diffusion process!

References