

EE 367 Project Proposal

David Hsu (team of 1)

Title:

Mitigating spatial resolution anisotropy in a limited-angle positron emission tomography system.

Motivation

My PhD research project is related to building a dual-panel positron emission tomography (PET) scanner for breast cancer scans. PET is a medical imaging modality, which utilizes injections of materials called radiotracers into the body, in order to target areas with high specificity. Often, the radiotracer is a type of glucose that targets areas with high glucose metabolism, which is a trait found in most cancerous tissues. In this way, the radiotracer is accumulated in cancerous tumors, where they emit pairs of photons traveling outward from the tumor, 180 degrees from each other (see Fig. 1). These co-linear photon lines-of-responses that are emitted from the body are used to create an image of radiotracer distribution inside the body.

Tomography-based systems generally involve sufficient angular sampling of projection data, with each projection mapping to a line in Fourier space. However, the system we are building in our lab does not have full angular sampling of the field-of-view. Our system is designed to take mammogram-style scans, with gentle compression of the breast between two detector paddles. As shown in Fig. 2, the mammogram-style design of our system means that, for every point in the field-of-view of the system, there are certain angles (represented by red arrows) which are not able to be sampled by our system, while other angles (black arrows) can be.

The insufficient sampling causes issues in the reconstruction of the image. Spatial resolution anisotropy is one of the biggest issues, varying over all 3 cartesian axes, even at the center of the field-of-view. This anisotropy can lead to weird situations where an elongated tumor is visible in one scan but not another, due to a different orientation of the panels (called “mammographic views”). This degrades the sensitivity and specificity of the scanner.

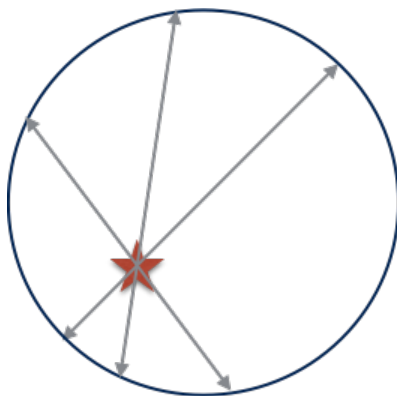


Fig. 1 – Lines-of-Responses from a tumor

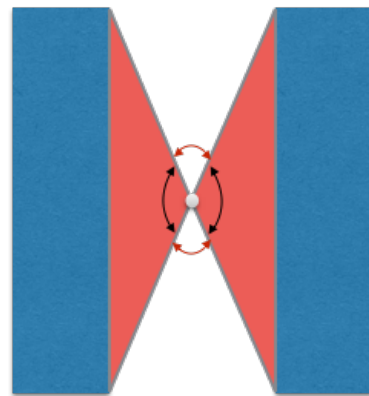


Fig. 2 – Incomplete angular sampling

Project Overview & Related Work

There has been work conducted on this issue for computed tomography (CT) systems. In particular, [1] offers a well-cited method using anisotropic TV minimization in angular space, and [2] offers a formulation of [1] in 3-dimensional space (which is what we would need for our system). However, the algorithms would need to be changed for our system, which has an irregular distribution of angular sampling density due to our novel detector design [4]. I am proposing to use [3] as a first basis to test how TV regularization can even be applied to our system, and if time allows, to try using [1] and [2] as well.

Milestones, Timelines, Goals

Our system currently uses a maximum-likelihood expectation maximization (MLEM) algorithm. The milestones I would like to achieve:

1. Implement TV regularization for our current MLEM algorithm. Hopefully this can be done in 2 weeks, before 2/20.
2. Make changes to TV regularization, in order to modify it to anisotropic TV regularization for limited-angle tomography. I hope this can be done in 1 week, before 2/27.
3. I will take whatever algorithm I have on 2/27, and perform image statistics comparisons (SNR, contrast-to-noise, uniformity, spatial resolution anisotropy). This will all go into the final report.

References

- [1] Chen, Zhiqiang, et al. "A limited-angle CT reconstruction method based on anisotropic TV minimization." *Physics in medicine and biology* 58.7 (2013): 2119.
- [2] Isernhagen, C. F., et al. "Three-dimensional anisotropic regularization for limited angle tomography." *Current Directions in Biomedical Engineering* 1.1 (2015): 283-285.
- [3] Jonsson, Elias, Sung-cheng Huang, and Tony Chan. "Total variation regularization in positron emission tomography." *CAM report* (1998): 98-48.
- [4] Levin, Craig S. "Promising new photon detection concepts for high-resolution clinical and preclinical PET." *Journal of Nuclear Medicine* 53.2 (2012): 167-170.