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# Phase-retrieval Effect on Angiographic X-ray Imaging

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Phase-retrieval Effect on Angiographic X-ray Imaging
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Abstract:
In this thesis, a comparison between propagation-based and speckle-based phase contrast imaging methods for angiography was conducted through both computational and experimental studies. The computational research involved simulations developed in Geant4 and the PEPI package using angiographic phantoms composed of a PMMA cylinder, blood, and an atherosclerotic plaque constructed from a mixture of PMMA and Calcium Hydroxyapatite. Additionally, a polychromatic source with a tungsten anode and a silicon photon-counting detector were simulated. On the experimental side, the study was conducted in the High Energy Laboratory at Universidad de los Andes using a phantom with the same characteristics, as well as one built from a pig artery. We also employed a Hammamatsu L6622-01 tungsten anode X-ray tube and a Medipix3RXV1 silicon sensor detector.
The primary objective of the project was to quantify the effect of phase retrieval on the quality of angiographic images. For this, the Paganin algorithm (for propagation-based images) and MIST (for speckle-based images) were applied to both computationally and experimentally obtained images. Finally, we calculated the CNR (Contrast-to-Noise Ratio) and the absorbed dose by the phantom to evaluate which method provides better image quality in terms of absorbed dose.
The results showed that, as implemented, the phase retrieval algorithms indicate that the propagation-based technique provides better quality in terms of dose compared to the speckle-based technique for angiographic images. It was demonstrated that a phase image retrieved by MIST shows approximately 12% higher dose than one retrieved by the Paganin algorithm. Since the doses are relatively similar, the main difference between the methods is the CNR calculated on the atherosclerotic plaque. The main weakness of speckle-based images is the presence of significant statistical fluctuations due to the sandpaper used, which attenuates approximately 44% of the incident radiation, negatively affecting the standard deviation of the region of interest and drastically reducing the CNR. This implies that the image quality is considerably lower in terms of absorbed dose.
For future work, we propose more precise measurements of the incident and absorbed radiation by the phantom at an experimental level, using technologies such as Timepix and the NOMEX detector. Additionally, as our results are highly dependent on the phase retrieval algorithms used, we suggest employing other algorithms, such as Beltrán (propagation-based) and UMPA or XSVT (speckle-based). Lastly, we propose replicating the study using effective energies close to 35 keV with the use of filters on the X-ray tube, aiming to enhance the phase effects of the incident waves on the blood within the phantom, thus achieving higher image quality.

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