Image Segmentation, Modeling, and Simulation in 3D Breast X-ray Imaging

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By
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ABSTRACT

The 3D imaging techniques represented by digital tomosynthesis (DTS) and cone beam CT (CBCT) have shown their potentials for replacing mammography as the next generation breast imaging modalities. However, both of them have their own drawbacks to overcome. The potential applications of 3D imaging techniques, the comparison between these three breast imaging techniques, and the possibility to combine the advantages of DTS and CBCT has initiated the interest for this dissertation.

In this study, we first develop methods for segmenting the breast CBCT images and for modeling the compressible breast. An automatic segmentation technique to separate the breast CBCT images into dense and adipose tissue regions is developed and verified. The calcification detection and breast density measurement related to this segmentation technique are also discussed. With the segmented breast CBCT data, we then develop a deformation technique to simulate the breast compression in mammographic imaging and generate compressible breast models.

To simulate the mammographic imaging, we develop a re-projection software based on ray-tracing algorithm. Various x-ray effects, such as focal spot, x-ray spectrum, and noise are incorporated in this software as needed. To obtain the tomosynthesis image, the iterative DTS reconstruction method is implemented. With this flexible simulation platform, mammography, DTS, and CBCT are simulated and the advantages of 3D imaging are demonstrated.

We also developed a novel imaging system design, called the orthogonal-view constrained digital tomosynthese (OVC-DTS). This technique, while retaining the simplicity of DTS imaging, could significantly improve the depth resolution over the regular DTS technique and provide nearly true 3D images for a compressed breast. We demonstrate the technique by both the simulation and experimental studies. This OVC-DTS might lead to a promising 3D breast imaging technique that can improve the screening, diagnosis, and management of breast cancer.