UCL REGISTRY
Department of Student Administration
Student Records
UCL, Gower Street London WC1E 6BT
Tel: +44 (0)20 7679 7005/6 Fax: +44 (0)20 7679 7920
researchdegrees@ucl.ac.uk

ABSTRACT OF THESIS

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Examination to be entered for *(please tick as appropriate)*: MPhil ☐ PhD ☒ MD(Res) ☐

STUDENT DETAILS *(as registered on PORTICO)*

Surname: **YANG** Student Number: **59020642**

Forenames: Guang

THESIS DETAILS

Approved Field of Study *(this will appear on the statement confirming your award)*

Computer Science and Medical Physics

Approved Title of Thesis:

Numerical Approaches for Solving the Combined Reconstruction and Registration of Digital Breast Tomosynthesis

ABSTRACT *(This form will be sent to the publisher of the Index to Theses. The abstract should not exceed 300 words)*

Heavy demands on the development of medical imaging modalities for breast cancer detection have been witnessed in the last three decades in an attempt to reduce the mortality associated with the disease. Recently, Digital Breast Tomosynthesis (DBT) shows its promising in the early diagnosis when lesions are small. In particular, it offers potential benefits over X-ray mammography - the current modality of choice for breast screening - of increased sensitivity and specificity for comparable X-ray dose, speed, and cost.

An important feature of DBT is that it provides a pseudo-3D image of the breast. This is of particular relevance for heterogeneous dense breasts of young women, which can inhibit detection of cancer using conventional mammography. In the same way that it is difficult to see a bird from the edge of the forest, detecting cancer in a conventional 2D mammogram is a challenging task. Three-dimensional DBT, however, enables us to step through the forest, i.e., the breast, reducing the confounding effect of superimposed tissue and so (potentially) increasing the sensitivity and specificity of cancer detection.

The workflow in which DBT would be used clinically, involves two key tasks: reconstruction, to generate a 3D image of the breast, and registration, to enable images from different visits to be compared as is routinely performed by radiologists working with conventional mammograms. Conventional approaches proposed in the literature separate these steps, solving each task independently. This can be effective if reconstructing using a complete set of data. However, for ill-posed limited-angle problems such as DBT, estimating the deformation is difficult because of the significant artefacts associated with DBT reconstructions, leading to severe inaccuracies in the registration.

The aim of my work is to find and evaluate methods capable of allying these two tasks, which will enhance the performance of each process as a result. Consequently, I prove that the processes of reconstruction and registration of DBT are not independent but reciprocal.

This thesis proposes innovative numerical approaches combining reconstruction of a pair of temporal DBT acquisitions with their registration iteratively and simultaneously. To evaluate the performance of my methods I use synthetic images, breast MRI, and DBT simulations with in-vivo breast compressions. I show that, compared to the conventional sequential method, jointly estimating image intensities and transformation parameters gives superior results with respect to both reconstruction fidelity and registration accuracy.