PhD Thesis Title: "An algorithm to improve deformable image registration accuracy in challenging cases of locally-advanced non-small cell lung cancer"

Author:	Christopher L. Guy
Email:	christopher.guy@vcuhealth.org
Institution:	Virginia Commonwealth University
Supervisor:	Dr. Geoffrey D. Hugo
Graduation Date:	July 14, 2017
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ABSTRACT:

A common co-pathology of large lung tumors located near the central airways is the collapse of portions of the lung due to blockage of airflow by the tumor. Not only does the lung volume decrease as collapse occurs, but fluid from capillaries also fills the space no longer occupied by air, greatly altering tissue appearance. During radiotherapy, typically administered to the patient over multiple weeks, the tumor can dramatically shrink in response to the treatment, thus restoring airflow to the lung sections which were collapsed when therapy began. While the return of normal lung function is a positive development, the change in anatomy presents problems for future radiation sessions. The treatment was planned on lung geometry, which is no longer accurate. The treatment must be adapted to the new lung state so that the radiation continues to accurately target the tumor while safely avoiding healthy tissue. However, to account for the dose delivered previously, correspondences of anatomy between the former plan's image when the lung was collapsed and the re-expanded lung in a current image must be obtained. This process, known as deformable image registration, is performed by the registration software.

Most registration algorithms assume that identical anatomy is contained in the images and that intensities of corresponding image elements are similar. Both assumptions are untrue when collapsed lung re-expands. This work's goal was to develop an algorithm that accurately registers images in the presence of lung expansion. The lung registration method matched CT images of patients aided by vessel enhancement and information of individual lobe boundaries. The algorithm was tested on eighteen patients with lung collapse using physician-specified correspondences to measure registration error. The image registration algorithm developed in this work, which was designed for challenging lung patients, resulted in accuracy comparable to that of other methods when large lung changes are absent.

References to author publications that relate specifically to the dissertation:

1. **Christopher L. Guy**, Elisabeth Weiss, Nuzhat Jan, Gary E. Christensen, Geoffrey D. Hugo. Technical Note: A method for quality assurance of landmark sets for use in evaluation of deformable image registration accuracy of lung parenchyma. Medical Physics. 46(2), 766-773 (2019). https://doi.org/10.1002/mp.13336

2. **Christopher L. Guy**, Elisabeth Weiss, Gary E Christensen, Nuzhat Jan, and Geoffrey D Hugo. CALIPER: A Deformable Image Registration Algorithm for Large Geometric

Changes during Radiotherapy for Locally-Advanced Non-Small Cell Lung Cancer. Medical Physics. 45(6), 2498-2508 (2018). https://doi.org/10.1002/mp.12891

3. **Christopher L. Guy**, Elisabeth Weiss, Nuzhat Jan, Leonid Reshko, Gary E. Christensen, and Geoffrey D. Hugo. The Effect of Atelectasis Changes on Tissue Mass and Dose during Lung Radiotherapy. Medical Physics. 43(11), 6109-6117 (2016). https://doi.org/10.1118/1.4965807