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主　論　文　の　要　旨

論文題目　Anatomical Structure Analysis of the Thoracic Area Based on Volumetric Images: From Blobs to Fibers
（塊状から筋状まで：3 次元画像に基づいた胸部における解剖構造解析）

氏　　名　　小田　紘久

論 文 内 容 の 要 旨

Anatomy is the field of study that reveals the structures of bodies. Computational anatomy is a subfield of anatomy that introduces computational techniques to analyze structures. Image processing with computer vision techniques is undeniably fundamental for revealing anatomies. For instance, segmenting organs allows us to investigate the target organs' shapes and sizes. In this thesis, I focus on anatomies in the thorax.

There are various imaging techniques, such as endoscopes, X-ray computed tomography (CT), magnetic resonance imaging (MRI), and microscopes, some of which are available for use in living bodies, including clinically available CT and MRI scanners. Although optical or electron microscopes have much higher resolution than clinically available CT or MRI scanners, they cannot be used for living bodies and usually produce only 2-dimensional images of a tiny region.

For revealing anatomical structures sterically using computational techniques, analyzing from 3-dimensional images is preferred, such as from CT or MRI images. However, since the spatial resolutions of these imaging techniques are not very high, some anatomies are vague and unclear. Non-clinical high-resolution imaging techniques, such as micro-focus X-ray CT (μCT), are also available to acquire images of small tissues that cannot be observed on the CT or MRI images of living bodies. However, there are still small structures that appear vague and unclear in μCT volumes.

This work aims to make it possible to reveal anatomical structures in the thorax with 3-dimensional images. As mentioned, a common difficulty is vague and

unclear images of small tissues. We approach this problem by 1) a novel filtering technique and 2) image evaluation for analysis.

The first topic is a mediastinal lymph node detection method based on intensity targeted radial structure tensor (ITRST) analysis. We propose a new image processing filter for lymph nodes on CT volumes. Mediastinal lymph nodes are around only 10 mm in diameter, have low contrast on CT volumes, and unclear boundaries. Typical filters are often negatively affected by surrounding regions having higher contrast. The proposed detection method based on ITRST analysis correctly detected lymph nodes even if with various surrounding tissues or regions, e.g., contrast-enhanced blood vessels, air, etc. In the experiments, the proposed method's detection rate was 84.2 %, with 9.1 false positives per volume for lymph nodes whose short axis was at least 10 mm, which outperformed the conventional filtering methods.

The second topic is cardiac fiber tracking. μCT volumes acquired by a desktop-type scanner are vague for cardiac fibers compared to a more expensive high-resolution imaging technique (refraction-contrast X-ray CT). Evaluating the efficacy of μCT volumes for fiber tracking is vital for further investigation using μCT. Although fiber tracking is possible using structure tensor analysis, it is unclear that μCT is useful. Comparing results from μCT and refraction-contrast X-ray CT allows us to discuss the efficacies and limitations of these imaging techniques. In the experiments, fiber orientations estimated by two imaging techniques have closely resembled under the correlation coefficient of 0.63. Two imaging techniques' fiber tracking results were also similar and followed the anatomical knowledge. The μCT volume's limitations were found for the artifacts and stitching scanning.

This thesis consists of five chapters. Chapter 1 provides the motivations of the author's research as the introduction. Chapter 2 describes background information, including anatomical study fields, imaging techniques for anatomical studies, and thoracic anatomies. Chapter 3 describes the mediastinal lymph node detection method. Chapter 4 describes cardiac fiber tracking from μCT volumes, and Chapter 5 provides a summary and description of our future work.