Automatic AI-Based Segmentation and Holographic Interactive Visualization of Pulmonary Airways

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The health of the lungs is significant importance to human well-being. As a vital respiratory organ, lung diseases have a high incidence and mortality rate worldwide. Accurate segmentation of the pulmonary airways, including the trachea and bronchi, is crucial for the diagnosis of lung diseases. The recent coronavirus has further shown the importance of accurately distinguishing the lung airways from the lung parenchyma to assist in diagnosis. Therefore, developing an automated segmentation method that can accurately segment the lung airways from lung CT images is essential. Despite extensive research in this field, challenges still remain. The unique tree-like structure of the lung airways and the fine-grained details at the terminal bronchioles pose difficulties for achieving precise segmentation using existing methods. In addition, emerging virtual reality and augmented reality technologies have revolutionized the interaction and visualization of 3D images in recent years. There is great potential to improve traditional diagnostic and surgical approaches, communication with patients and medical education through interactive holography and visualization of regions of interest in computed tomography (CT) images.

In this study, firstly, we propose a novel dual-encoder network for accurate lung airways segmentation. Our method can efficient capture the local and global features using the combination of Convolutional Neural Networks (CNNs) and Transformer network. We evaluate our method on a private lung CT dataset provided by Shandong University and on the LIDC-IDRI public dataset and demonstrate its superiority over existing methods. Secondly, we also present a system that leverages hybrid virtual reality technology, specifically Microsoft HoloLens 2, in conjunction with deep learning algorithms. This approach is crafted into a user-centric pipeline aimed at furnishing medical practitioners with an intuitive, three-dimensional holographic visualization of the airway section in the lungs. A unique feature of this system is the integration of audience perspectives and shared scenarios, allowing medical professionals to expose the Mixed Reality (MR) world to a broader audience. The system's output grants a true-to-life 3D representation of the intricate airways in the lungs, offering an immersive, interactive, and collaborative experience. This capacity to visualize the complexity of airways enhances medical professionals' understanding of the patient's lung architecture.

Overall, this study presents a novel segmentation network and demonstrates the potential of combining MR hardware and deep learning networks in medical applications, the system developed in this study could be a useful tool for medical staff to visualize and quantify the lung region and may help to improve the diagnosis and treatment of diseases.