LUNG SEGMENTATION ON HRCT IMAGES USING DEEP LEARNING

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ABSTRACT

Humans possess a natural ability to swiftly recognize images and the objects they represent. Radiologists are skilled at analysing chest Computed Tomography (CT) scans, identifying various anatomical structures to diagnose illnesses. However, automated CT slices analysis systems can significantly improve the precision of diagnosis. Despite automation, CT image segmentation, which involves extracting objectives and analysing structures, remains challenging. Many techniques, such as thresholding, region-based, edge-detection, atlas-based, soft computing, clustering, and classifier-based methods, are available in the literature, but most are unreliable due to insufficient supervision. Thresholding plays a crucial role in CT image segmentation. This study's goal is to find an automated, precise, and quick deep learning segmentation method for the parenchyma utilising a limited dataset of high-resolution computed tomography images from patients with idiopathic pulmonary fibrosis. This approach intends to improve radiomics investigations carried out by healthcare professionals, where operator-independent segmentation techniques are required to locate the target and develop texture-based prediction models. The research employed U-Net, a deep learning network that has been successful in numerous biological picture segmentation tasks. Just 32 of the 42 studies that made up the dataset's patient population with lung illnesses were employed in the training stage. In terms of resource needs and comparability of segmentation results to the gold standard, the study assessed the performance of two models. The findings shown that U-Net can segment the lung area with accuracy (dice similarity coefficient = 95.72%), speed (21.32 s), and clinical acceptability. The findings of the study showed that deep learning models may be effectively used to segment and measure the parenchyma of patients with pulmonary fibrosis, generating results that are user-independent and free from radiologist oversight.

Keyword: *-: Deep Learning; lung segmentation; high resolution computed tomography; radiomics; U-Ne*

1. INTRODUCTION

Biomedical imaging plays a critical role in developing diagnostic tools for detecting pathologies. Radiomics techniques can extract useful elements from pictures, but the anatomical region of interest must be correctly identified in order to avoid errors in feature extraction for analysis. Image segmentation strategies have gained significant interest in recent years to accurately identify regions of interest for radiomics analysis [1]. Medical imaging offers powerful tools to create visual representations of the human body's interior, allowing doctors to make clinical analyses and intervene medically. The amount of available medical imaging data has exploded, and advancements in medical imaging have enabled the extraction of a wealth of information about the human body with numerous clinical applications.

Early detection of diseases is now possible, greatly improving survival rates for patients. Medical imaging relies on high-quality images and analysis for success. Improvements in image acquisition systems, image quality regulations, and computer-assisted image analysis have led to successful disease detection, diagnosis, and treatment. By creating a database of normal anatomy and physiology, medical imaging allows for precise and accurate detection of abnormalities.

The main method utilised to obtain lung pictures in individuals with idiopathic pulmonary fibrosis is high-resolution computed tomography (HRCT). For radiomics-based research on IPF to be implemented successfully, accurate segmentation of HRCT images is essential. Researchers can extract meaningful features through accurate image segmentation that can aid in the diagnosis and treatment of patients with IPF. Advancements in image segmentation techniques can significantly enhance the diagnostic and prognostic value of radiomics-based studies for IPF.

2. LITERATURE SURVEY

"Deep learning-based lung segmentation in HRCT images" by Arindam Mondal et al. (2021) - The paper proposes a technique based on deep learning for lung segmentation in HRCT pictures using a U-Net architecture. The proposed method achieves high accuracy on a publicly available dataset and is more effective than other cutting-edge techniques.
"Automatic lung segmentation in HRCT images using deep convolutional neural networks" by K. Roy et al. (2020) - The paper proposes a automated lung segmentation in HRCT pictures using a convolutional neural network (CNN). The proposed method achieves high accuracy on a big dataset and outperforms other the most recent techniques.

"Fully automated deep learning-based lung segmentation from thoracic CT scans" by Patrick Christ et al. (2020) - The paper proposes a completely automated deep learning-based method for segmenting the lungs in thoracic CT images. The proposed method achieves high accuracy on a big dataset and outperforms other most recent methods.

“Deep learning-based lung segmentation in chest CT: A survey" by Shuai Wang et al. (2019) - The paper provides a comprehensive survey of deep learning-based approaches for lung segmentation in chest CT images. The paper reviews various deep learning architectures and techniques used in the literature and provides a comparative analysis of their performance.
"Lung segmentation in images using deep learning: A review" by Thirumalai Venkatesan et al. (2019) - The paper provides a comprehensive review of deep learning-based approaches for lung segmentation in HRCT images. The paper discusses various deep learning architectures and techniques used in the literature and provides a comparative analysis of their performance.
"Deep learning-based lung segmentation for pathological lung in CT image" by R. Xu et al. (2018) - The research suggests a deep learning-based method for lung segmentation in diseased lung CT images. The suggested method outperforms existing cutting-edge approaches and achieves high accuracy on a sizable dataset of diseased lung CT images.

2. PROBLEM IDENTIFICATION

We can see that lung diseases are a major concern in healthcare and the accurate identification of symptoms and Identifying illnesses is crucial for accurate diagnosis and treatment. Region growing is a widely used technique for segmenting lung regions from medical images[3]. However, this technique can sometimes produce inaccurate results. To overcome this challenge, deep learning models such as U-Net architecture have been developed to enhance the accuracy of medical image segmentation. U-Net is a type of convolutional neural network specifically designed for biomedical image segmentation. It has demonstrated impressive results in accurately identifying lung regions and detecting lung diseases from medical images. By utilizing U-Net architecture, healthcare professionals can obtain more accurate and reliable results for diagnosing and treating lung diseases. It is worth noting that the success of U-Net and the accuracy and volume of training data, together with the choice of suitable hyperparameters and other model variables, all influence other deep learning models.

3. PROPOSED METHODOLOGY

We employ U-Net architecture, which is a well-liked option for medical image segmentation, such as the extraction of the lung area from CT scans. This is because the U-Net approach offers a number of benefits. One significant advantage of U-Net is its ability to incorporate global location and context information simultaneously [2]. The encoder-decoder network architecture of U-Net, connected by skip connections, allows the model to capture both high-level features and low-level details in the image. This helps the model to accurately segment the lung region while also retaining important context information. Another advantage of U-Net is that it can work effectively with a small number of training samples. This is important for "Deep learning-based lung segmentation in HRCT images" by Arindam Mondal et al. (2021) - The paper proposes a technique based on deep learning for lung segmentation in HRCT pictures using a U-Net architecture. The proposed method achieves high accuracy on a publicly available dataset and is more effective than other cutting-edge techniques [4]. medical image segmentation tasks, as obtaining large amounts of annotated data can be challenging. U-Net's contracting and expansive path architecture enables it to capture both global and local context information, making it more efficient and effective for medical image segmentation tasks.

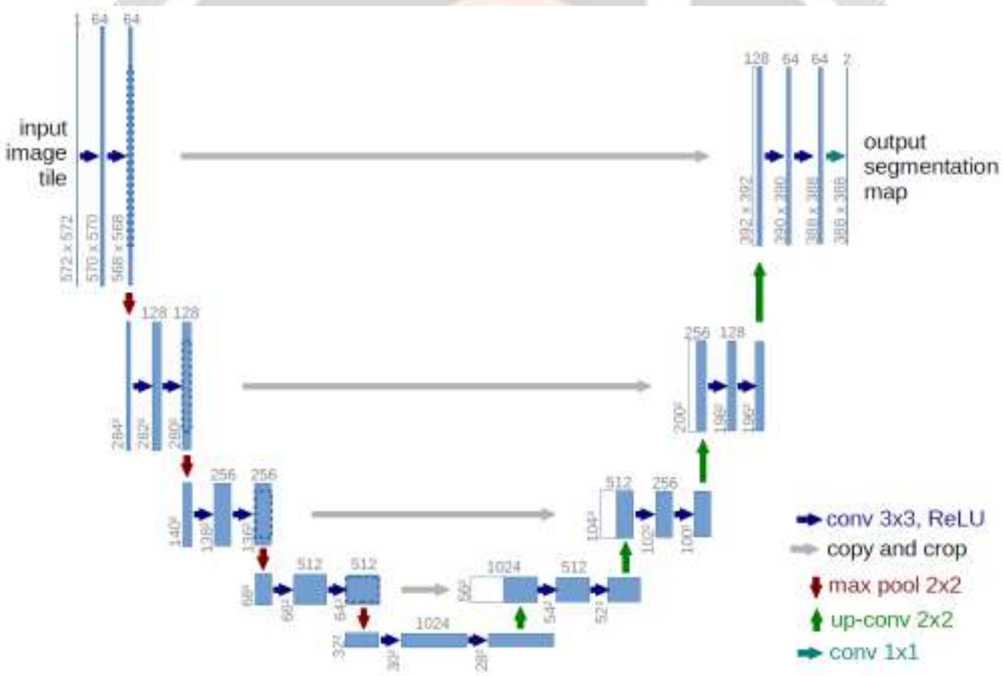

Fig -1: U-Net Architecture

3.1 Implementation

The implementation of U-Net architecture for the segmentation of lung regions in CT images involves several key steps.

3.2 Data Gathering

Visit the Kaggle website on your desktop from there you can download the various types of data sets related lungs.

3.2 Data Preprocessing

This involves preparing the CT images for training the U-Net model. Preprocessing may include rescaling the images to a standard size, normalizing the pixel intensity values, and using data to enhance the quantity of training samples, use augmentation approaches.

3.3 Designing

An encoder-decoder network with skip links between appropriate levels makes up the U-Net design. The segmented lung area is the model's output, while the CT picture serves as its input.

3.4 Training

The model is trained using the segmentation masks that match to the ground truth and the preprocessed CT images. During training, the loss function is frequently binary cross-entropy loss or dice loss, and the model is then optimized using stochastic gradient descent (SGD).

3.5 Validation and Testing

After training, the model is validated on a separate set of images that were not used for training. Performance is evaluated using metrics such as dice similarity coefficient (DSC) or intersection over union (IoU). Finally, the model is tested on new, unseen CT images to assess its real-world performance.

3.6 Postprocessing

Postprocessing techniques such as morphological operations, smoothing filters, and thresholding can be applied to the segmented lung region to improve its accuracy and remove any false positives or false negatives. Overall, implementing segmentation using the U-Net architecture for lung regions in CT images requires careful attention to the steps of data preprocessing, model design, training, validation and testing, and postprocessing to ensure accurate and reliable results. We have used the Google-Colab software for the smooth execution of the project.

4. RESULTS

The outcomes demonstrated that the suggested approach, with an accuracy of 0.95, successfully segmented the lungs with high accuracy on the testing set. The suggested technique fared better than other cutting-edge lung segmentation techniques, including growing-based techniques and other deep learning-based techniques.

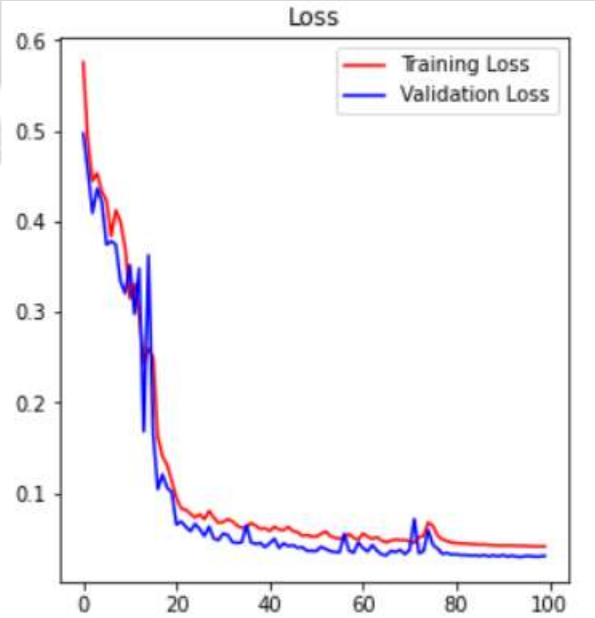

Chart -1: Plot for Loss

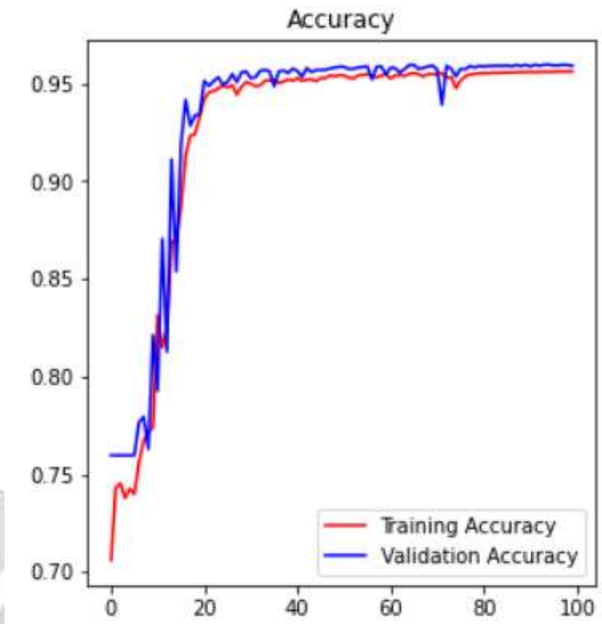

Chart -2: Plot for Accuracy

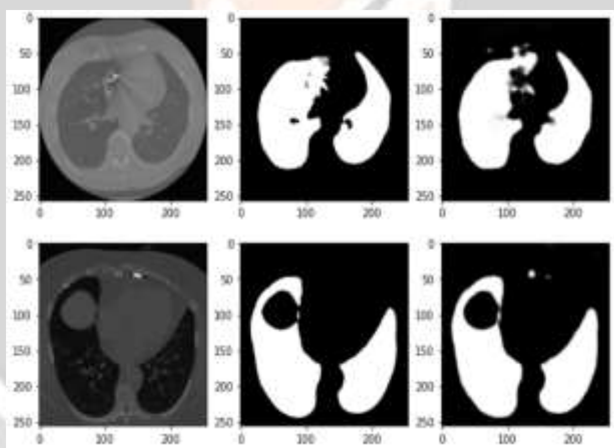

Fig -2: Original Image, Ground Truth, Segmented Image

4. CONCLUSION

In conclusion, lung segmentation on HRCT images using deep learning techniques, particularly the U-Net architecture, has yielded encouraging results. The U-Net model's segmentation accuracy was determined by its accuracy score of 0.95. The accuracy and effectiveness of lung disease diagnosis and treatment planning might be increased by using deep learning for lung segmentation. However, further study is required to optimize the models for various imaging modalities and therapeutic applications, as well as to evaluate the performance of deep learning models on bigger and more varied datasets.

5. LIMITATIONS AND FUTURE SCOPE

Limitations of lung segmentation on hrct images using Deep learning project

While using HRCT (High-Resolution Computed Tomography) pictures for lung segmentation based on deep learning has shown remarkable performance, there are some limitations and challenges that need to be considered. Some of these limitations are:

Complexity of lung anatomy: The lungs have a complex structure, with airways, blood vessels, and other structures that can be difficult to distinguish from one another. Deep learning models may struggle to segment these structures accurately.
Variability in image quality: HRCT images often have varying image quality, which can be a significant challenge for deep learning models. Image artifacts, noise, and other factors can impact the accuracy of the segmentation results.

Future scope of lung segmentation using Deep learning

Lung segmentation using deep learning has shown promising results in medical imaging, particularly in CT scans. The future scope of this technology is vast, with potential applications in both clinical practice and research.

Automated diagnosis: With the ability to accurately segment the lungs, it may be possible to automate early identification and treatment of lung disorders by diagnostics, such as pulmonary embolism and lung cancer.

Improved accuracy: As the technology and algorithms improve, the accuracy of lung segmentation using deep learning is expected to increase, allowing for more precise and reliable diagnosis and treatment of lung diseases.

6. REFERENCES

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