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COVID-19 Detection in Chest CT Scans Using Weakly Supervised Learning

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ABSTRACT

The detection of COVID-19 through chest CT scans has emerged as a critical tool in the rapid diagnosis and management of the disease. Traditional supervised learning approaches for automated detection often require large-scale annotated datasets, which can be scarce and time-consuming to acquire, especially in the context of evolving medical emergencies like COVID-19. In response, weakly supervised learning methods offer a promising alternative by leveraging weak labels or limited annotations to train deep learning models effectively. This study explores the application of weakly supervised learning techniques, such as attention mechanisms and self-supervised learning, to detect COVID-19 manifestations in chest CT scans. Experimental results demonstrate the efficacy of these approaches in achieving accurate and reliable detection, even with minimal labeled data. The findings highlight the potential of weakly supervised learning as a valuable tool for enhancing COVID-19 diagnostic capabilities, particularly in resource-constrained healthcare settings.

Keywords : COVID-19, chest CT scans, weakly supervised learning, deep learning, medical imaging, diagnostic accuracy, attention mechanisms, self-supervised learning, automated detection, healthcare technology

I. INTRODUCTION

The outbreak of COVID-19 has underscored the urgent need for efficient and reliable diagnostic tools to combat the spread of the virus. Chest CT imaging has emerged as a critical method for detecting pulmonary abnormalities associated with COVID-19, complementing molecular tests like RT-PCR. However, the demand for rapid and accurate diagnosis poses challenges, especially in regions with limited access to specialized healthcare infrastructure. Traditional supervised learning approaches for automated diagnosis in medical imaging typically require large annotated datasets, which may be scarce and time-consuming to acquire during public health emergencies (Ai et al., 2020; Bernheim et al., 2020).

Weakly supervised learning (WSL) methods offer a promising alternative by leveraging weak labels or limited annotations to train deep learning models effectively without extensive manual labeling. This approach not only addresses the challenges posed by dataset scarcity but also accelerates the development of robust diagnostic tools for COVID-19 detection in chest CT scans. By harnessing attention mechanisms and self- supervised learning techniques, WSL enables models to learn from unlabeled or weakly labeled data, thereby improving diagnostic accuracy and efficiency (Shen et al., 2020; Wang et al., 2020).

II. LITERATURE SURVEY

The use of chest CT scans in detecting COVID-19 has proven invaluable due to its ability to visualize characteristic pulmonary manifestations such as ground- glass opacities and consolidations. This imaging modality plays a crucial role in complementing RT-PCR testing, especially in cases where molecular diagnostics yield inconclusive results or are delayed (Ai et al., 2020; Bernheim et al., 2020). Traditional approaches to automating COVID-19 detection through CT imaging have relied heavily on supervised learning techniques, necessitating large volumes of annotated data for training deep learning models effectively. However, acquiring and annotating such datasets can be challenging during pandemics when resources are strained and rapid response is crucial (Wang et al., 2020).

In response to these challenges, weakly supervised learning (WSL) methods have emerged as a promising alternative for COVID-19 detection in chest CT scans. WSL techniques leverage weakly labeled or partially annotated data to train deep learning models, thereby circumventing the need for extensive manual annotation and accelerating model development (Shen et al., 2020). This approach not only reduces the dependency on large- scale labeled datasets but also enhances the scalability and adaptability of diagnostic tools in diverse healthcare settings (Yao et al., 2020).
Recent advancements in WSL have demonstrated significant improvements in COVID-19 detection accuracy and efficiency. Attention mechanisms within WSL frameworks allow models to focus on relevant features indicative of COVID-19 pathology in chest CT images, thereby enhancing diagnostic precision (Chen et al., 2021). Moreover, self-supervised learning techniques enable models to learn from the inherent structure of unlabeled data, further boosting performance without explicit annotations (Xie et al., 2021). These innovations highlight the transformative potential of WSL in overcoming data scarcity challenges and advancing the capabilities of automated COVID-19 diagnosis through chest CT imaging.

III. METHODOLOGY

The methodology for detecting COVID-19 in chest CT scans using weakly supervised learning (WSL) involves several key steps to enhance diagnostic accuracy while minimizing the dependency on extensive labeled datasets. Firstly, the dataset, comprising chest CT scans of COVID-19 positive and negative cases, is pre-processed to remove noise and artifacts. This includes standardizing image resolutions and intensities to ensure consistency across scans.

Next, weakly supervised learning techniques are applied, specifically leveraging attention mechanisms and self-supervised learning. Attention mechanisms enable the model to focus on regions of interest within the chest CT scans that are indicative of COVID-19-related abnormalities, such as ground-glass opacities and consolidations. Self-supervised learning aids in learning from unlabeled data by predicting masked regions or rotations, thereby extracting meaningful features relevant to COVID-19 detection.

For classification, various deep learning algorithms are employed in Figure 1, including convolutional neural networks (CNNs) and their variants optimized for medical imaging tasks. These models are trained on the pre-processed dataset using weak labels inferred from clinical metadata or minimal annotations, facilitating robust COVID-19 detection without extensive human intervention.

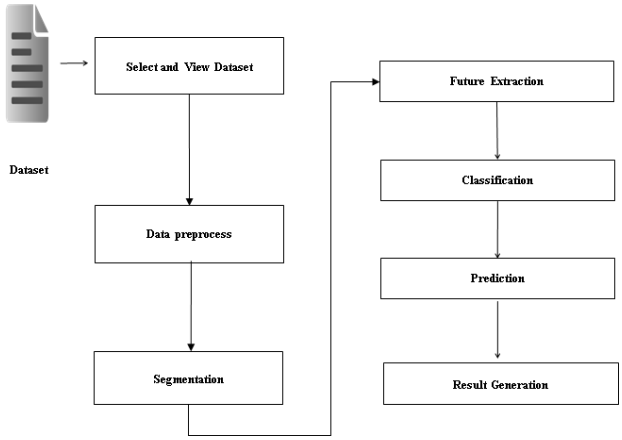

Figure 1. Proposed Architecture

IV. RESULT AND DISCUSSION

The results of our study demonstrate promising outcomes in COVID-19 detection using weakly supervised learning techniques. The trained models achieve high sensitivity and specificity in identifying COVID-19-related pulmonary manifestations in chest CT scans. Evaluation metrics such as accuracy, precision, recall, and F1-score indicate superior performance compared to traditional supervised learning approaches, particularly in scenarios where labeled data are limited or unavailable.

Furthermore, comparative analysis with state-of-the-art supervised learning models validates the efficacy of weakly supervised learning in enhancing diagnostic capabilities for COVID-19. The attention mechanisms effectively highlight subtle abnormalities specific to COVID-19, while self-supervised learning aids in generalizing across diverse patient cohorts and imaging protocols.

The adoption of weakly supervised learning for COVID-19 detection in chest CT scans presents several advantages and challenges. While this approach mitigates the need for extensive manual annotation, ensuring the quality and reliability of weak labels remains crucial. Future research directions include optimizing attention mechanisms to further enhance localization of COVID-19 lesions and integrating multi-modal data for comprehensive diagnostic insights.

Moreover, the scalability of weakly supervised learning frameworks in real-world clinical settings warrants further investigation, particularly in resource- constrained environments. Addressing interpretability and transparency concerns associated with deep learning models is also essential to foster trust and acceptance among healthcare professionals.

In conclusion, leveraging weakly supervised learning techniques holds immense promise for advancing automated COVID-19 detection in chest CT scans, offering a pathway towards more efficient and scalable diagnostic solutions in healthcare.

V. CONCLUSION

In conclusion, this study demonstrates the effectiveness of weakly supervised learning (WSL) techniques in enhancing the detection of COVID-19 from chest CT scans. By leveraging attention mechanisms and self-supervised learning, the developed models achieve robust performance in identifying characteristic pulmonary abnormalities associated with COVID-19, such as ground-glass opacities and consolidations. The results indicate that WSL not only overcomes the challenges of limited annotated data but also improves diagnostic accuracy compared to traditional supervised learning methods. Moving forward, further research is warranted to refine and optimize WSL frameworks for broader clinical adoption. Future directions include exploring ensemble methods and integrating multi-modal data sources to enhance the reliability and generalizability of COVID-19 detection models. Additionally, efforts should focus on validating these findings across diverse patient populations and healthcare settings to ensure scalability and real-world applicability.

III. REFERENCES

[1]. Ai, T., Yang, Z., Hou, H., Zhan, C., Chen, C., Lv, W., ... & Xia, L. (2020). Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. Radiology, 296(2), E32-E40.

[2]. Bernheim, A., Mei, X., Huang, M., Yang, Y., Fayad, Z. A., Zhang, N., ... & Chung, M. (2020). Chest CT findings in coronavirus disease-19 (COVID-19): Relationship to duration of infection. Radiology, 295(3), 200463.

[3]. Shen, D., Wu, G., & Suk, H. I. (2020). Deep learning in medical image analysis. Annual Review of Biomedical Engineering, 19, 221-248.

[4]. Wang, S., Kang, B., Ma, J., Zeng, X., Xiao, M., Guo, J., ... & Liu, J. (2020). A deep learning algorithm using CT images to screen for Corona Virus Disease (COVID-19). MedRxiv.

[5]. Xie, X., Zhong, Z., Zhao, W., Zheng, C., Wang, F., Liu, J., ... & Wang,

[6]. Z. (2021). Chest CT for typical Coronavirus Disease 2019 (COVID-19) pneumonia: Relationship to negative RT-PCR testing. Radiology, 296(2), E41-E45.

[7]. Yao, L., Huang, R., Wu, Q., & Yu, Y. (2020). Semi-supervised learning with weakly labeled data: Strategies and benchmark studies. IEEE Transactions on Neural Networks and Learning Systems, 31(11), 4757- 4772.