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A Novel Method to Detect Lymphangioleiomyomatosis (LAM) Using CNN-LSTM on Computed Tomography

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***Abstract:** "Detection of Lymphangioleiomyomatosis (LAM) using CNN-LSTM framework on CT images", Lymphangioleiomyomatosis (LAM) is a progressive lung disease marked by uncommon cystic growths, often diagnosed using high-resolution CT scan images. The complex nature of LAM's radiological findings and the need for specialized knowledge make early and correct diagnosis difficult, even though it is essential for successful treatment. In order to automate the detection of LAM in CT images, this study introduces an advanced deep learning approach that integrates CNN with LSTM networks. A well-annotated dataset of CT scans from patients with LAM and healthy controls was used to create and evaluate the model. To increase model robustness and generalizability, extensive preprocessing was used, including lung area segmentation and data augmentation. Accuracy, sensitivity, specificity, and AUC-ROC were among the key performance indicators that demonstrated how well the model distinguished between LAM and non-LAM cases. The accuracy of the CNN-LSTM model for detecting Lymphangioleiomyomatosis (LAM) using CT scan images is approximately 80%. By providing a dependable, non-invasive, and scalable approach to early LAM identification, this novel CNN-LSTM design lessens the need for expert interpretation and improves diagnostic effectiveness.*

***Keywords:** Lymphangioleiomyomatosis (LAM) disease, Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), Deep Learning, Image Classification, CT Scan Images.*

I. INTRODUCTION

Lymphangioleiomyomatosis (LAM) is an uncommon, progressive lung condition that predominantly impacts women. typically, between the ages of 20 and 40. The illness is typified by the aberrant proliferation of cells that resemble smooth muscle, which can damage other organs and cause cysts in the lungs. Numerous cysts arise within the lung tissue as a result of this aberrant cell proliferation interfering with the lungs' regular function. Breathing problems result from these cysts' injury to lung tissue, which also affects air exchange.

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Breathlessness, particularly during physical effort, a persistent cough, chest pain, and wheezing are typical signs of LAM. People may develop more severe symptoms as the illness worsens, like pneumothorax (collapsed lung), which causes abrupt chest pain and breathing difficulties. Fatigue, hemoptysis (coughing up blood), and pleural effusion (fluid buildup around the lungs) are possible additional symptoms. LAM can result in kidney problems, particularly the growth of benign tumors known as angiomyolipoma's, in addition to symptoms connected to the lungs. Abdominal pain or, in certain situations, bleeding may result from these tumors. LAM is primarily generated by alterations in the DNA sequence of either the TSC1 or TSC2 regions that can disrupt normal gene function, which control cell growth and division. These mutations lead to uncontrolled cell proliferation in the lungs and other organs, resulting in the formation of characteristic lung cysts. LAM can occasionally strike people who don't have any known hereditary illnesses. Nonetheless, it is frequently linked to Tuberous Sclerosis Complex (TSC), a hereditary condition that results in the formation of benign tumors in a number of organs.

The exact reason for LAM's higher prevalence in women is unclear, but estrogen is believed to influence its onset and progression. Early recognition and interference are crucial to Controlling the health impacts and minimizing potential associated medical risks such as lung failure Although there is no cure, treatments can assist patients in controlling their symptoms and improving their overall quality of life

II. LITERATURE SURVEY

The purpose of this research aims to evaluate Investigating the potential reconvertion of a Silver Beam filter and deep learning technique to minimize radiation exposure during chest CT imaging for LAM patients without compromising diagnostic image quality in 2024. While maintaining diagnostic precision. Regular CT scans are linked to an increased risk of radiation exposure, despite the fact that they are essential for assessing lung involvement in cystic lung disorders. Without compromising the diagnostic integrity of the scans, beam-shaping energy filters could provide a safer imaging alternative by improving image quality and lowering radiation dosages. While guaranteeing precise cyst measurement and maintaining picture quality in cases of cystic lung disease, the Silver Beam filter and deep learning reconstruction Collaboratively minimize radiation exposure in chest CT scanning procedures [1].

This case study seeks to examine forecast individual lung disease progression, focus specifically on patients with LAM who have not yet received treatment and create personalized predictions about disease trajectory and potential development (2023). Using data from the global leadership (NHLBI) LAM Registry (216 patients) and the UK LAM Natural History longitutional (185 patients), the combined model demonstrated high accuracy, achieving an AUC of approximately 0.80. It reliably predicted 5-year transplant-free survival probabilities and the likelihood of lung function deterioration in sirolimus-naive patients. The model effectively forecasted FEV1 levels, the rate of FEV1 decline, and sustained FEV1 reductions in both derivation and validation cohorts [2].

Objective of this case study Examining medical challenges that can arise when pregnant women was diagnosed has LAM(2024).Most women developed symptoms during pregnancy, with diagnoses frequently occurring during or shortly after. Two women were asymptomatic, six had prior LAM diagnoses, and two cases were linked to tuberous sclerosis. Symptoms typically appeared at an average age of 29.5 years, with a median gestational presentation age of 20.5 weeks. Among the cases, 12 involved first pregnancies, 5 were subsequent pregnancies, and 7 lacked parity information. Cases were evenly distributed across trimesters. Most LAM diagnoses occurred during or immediately following pregnancy, with symptoms first emerging during this period [3].

In this investigation advanced machine learning techniques analyzing deep learning algorithms to distinguish between idiopathic pulmonary fibrosis and pulmonary lymphangioleiomyomatosis in complex diffuse cystic lung disease diagnostics. Using clinical data from 288 patients, the research aimed to develop powerful computational tools for early and accurate disease detection. The study systematically evaluated multiple deep learning architectures to identify the most precise and reliable models for clinical applications. This work addresses the critical demand for innovative diagnostic solutions in rare and complex lung diseases, improving outcomes and treatment planning [4].

The case report highlights the rare occurrence of uterine LAM, typically considered a benign condition that requires no treatment. However, as shown in this case, it can unexpectedly Spontaneous tissue disruption affecting young female patients, leading to severe complications. In some instances, uterine LAM may progress to malignancy, including sarcomatous transformation or metastasis. The study underscores the importance of thoroughly investigating uterine LAM in patients with a background of TSC presenting with unexplained uterine bleeding or abdominal discomfort, expanding knowledge on the disease's diverse presentations and diagnostic challenges [5].

- **A Comprehensive Consultation Involving**

16 specialized experts in the field of a Lymphangioleiomyomatosis (LAM) and Interstitial Lung Diseases (ILD) conducting a systematic, multi-round modified Delphi survey to comprehensively evaluate and validate propositions related to unsupervised exercise training protocols for LAM patients, using a predefined consensus threshold. A survey asking about the advantages and disadvantages of remote fitness training was also completed by 60 LAM patients. There was agreement on seven out of ten statements.to evaluate exercise- induced hypoxemia and evaluate the need for requirement for addtional oxygen support before initiating remote exercise program, experts agreed that a clinical exercise test should be conducted in person. In addition, the panel suggested that patients with significant resting pulmonary hypertension, high cardiovascular risk, or a propensity for falls be referred to a rehabilitation facility [6].

In this research they examined the psychological aspects of LAM patients, potential support needs for LAM patients 87 LAM patients, averaging 48 years of age and 10.1 years post- diagnosis [7]. Among the participants, 34.5% required supplemental oxygen, while 75.9% received treatment with sirolimus or everolimus [8]. According to psychological evaluations, 14% of patients reported spiritual difficulties, 2% displayed signs of demoralization [9], 55% had depression, and 46% had anxiety. Resilience and social support were sufficient overall [10]. It's interesting to note that the "non-severe" group, who did not require oxygen therapy [11], exhibited more severe anxiety symptoms [12]. The psychological challenges that women with LAM encounter are highlighted in this study [13], with a focus on the protective effects of resilience and social support [14]. The results highlight the necessity of early psychological assessment and treatment to avoid mental health issues and enhance patients' general wellbeing with LAM [15].

The research established the detailed exploration of a LAM's metastatic characteristics, examination of dysregulated cellular signaling mechanisms and comprehensive analysis of tumor microenvironment interactions primary objective is an exploring innovative LAM treatment strategies through in-depth analysis of tumor-host molecular interactions, extending beyond current Sirolimus therapy revealing intricate LAM pathological mechanisms to develop precision-targeted therapeutic interventions.

III. EXISTING SYSTEM

Convolutional neural network (CNN) advanced machine learning technique has been used in many machine learning applications due to its speed and accuracy. It is a neural network designed with a grid-like structure comprising Convolutional Neural Network (CNN) architecture: strategically layered neural framework where the convolutional layer serves as the primary computational engine, processing and extracting critical feature patterns through sophisticated algorithmic interactions. 20% of the data were put aside for testing when the dataset was first splits into training and testing subsets. After that, we trained the model and built a Convolutional Neural Network Classifier. we calculated the model's accuracy and predicted the values from the test dataset.

Diagnosing LAM traditionally requires a comprehensive evaluation using multiple diagnostic techniques. High-resolution computed tomography (HRCT) is crucial for detecting characteristic features like thin-walled lung cysts and pneumothorax, which are indicative of LAM.. Pulmonary function tests assess lung capacity and airflow limitations, offering insight into respiratory health. Clinical evaluation, including a detailed review of symptoms and medical history, is equally critical. In cases where LAM is strongly suspected, a lung biopsy may be performed to confirm abnormal smooth muscle cell proliferation, providing definitive diagnostic evidence.

IV. PROPOSED SYSTEM

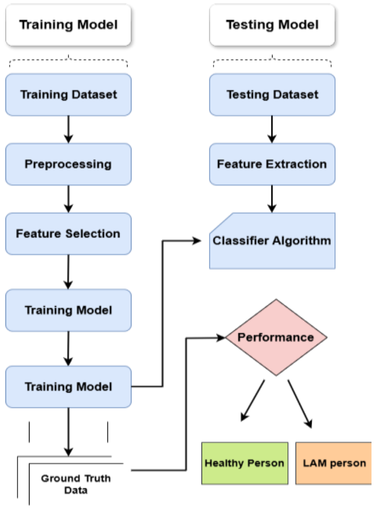
Sophisticated deep learning diagnostic methodology for Lymphangioleiomyomatosis (LAM) utilizing an innovative neural network approach: combining Convolutional Neural Networks (CNN) for advanced feature extraction with Long Short-Term Memory (LSTM) method to comprehensively analyze complex sequential medical imaging patterns. This innovative approach revolutionizes CT image analysis by employing a multi-phase process designed to capture and interpret complex spatial and temporal disease markers. The system aims to address the challenges of LAM diagnosis with advanced precision, offering a transformative solution in medical imaging.

The approach begins with an extensive preprocessing phase, ensuring optimal image quality by precisely segmenting CT images, normalizing contrast, and reducing noise. These preparatory steps minimize computational artifacts and enhance diagnostic accuracy. Following preprocessing, a pre-trained Convolutional Neural Network (CNN) model is employed to extract critical morphological and textural features associated with LAM, such as lung cysts and structural abnormalities. This step captures intricate patterns within the CT images, providing a robust foundation for further analysis. By combining precise preprocessing with advanced feature extraction, the technique ensures reliable detection and interpretation of key disease markers linked to LAM.

An important component of the system is the LSTM network, which sequentially processes the characteristics that the CNN collected to find contextual linkages and minute temporal dependencies across several CT scan slices. Beyond the limitations of static image evaluation, this dynamic, temporal analysis offers a more thorough insight of illness progression. The system seeks to increase diagnostic accuracy, expedite manual interpretation procedures, and offer useful quantitative data on illness progression by integrating these cutting-edge deep learning algorithms.

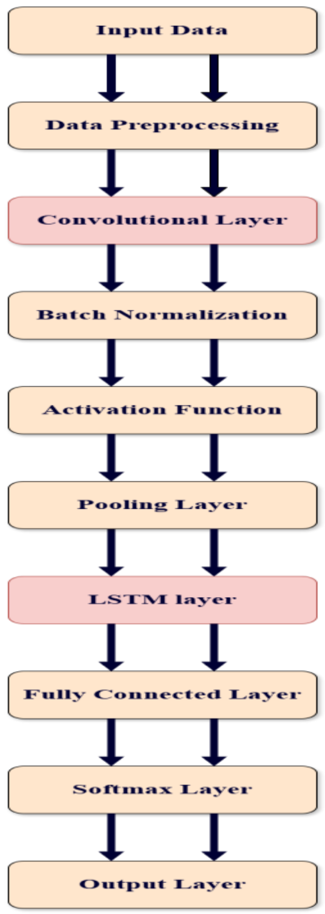
The model's performance will be assessed using various standards, including responsiveness, specificity, accuracy, and the region beneath the ROC curve. The system's results will be compared with diagnoses made by expert radiologists. Medical imaging could be completely transformed by this cutting-edge diagnostic tool, particularly in the detection and tracking of uncommon and complicated lung conditions like LAM.

V. WORKFLOW MODEL



[Fig.1: Training and Testing Dataset Model]

The workflow model outlines a structured method for managing datasets, covering data collection, preprocessing, and division into training and testing subsets. The training dataset fine-tunes the model, while the testing dataset evaluates its performance, ensuring reliable validation of its accuracy, efficiency, and adaptability for precise disease detection.



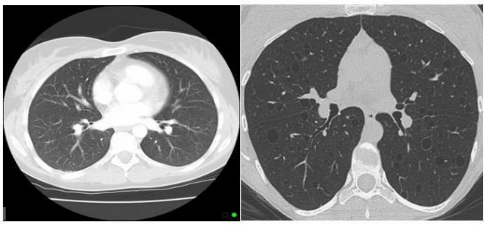
[Fig.2: CNN-LSTM Model]

The CNN-LSTM workflow integrates convolutional layers to extract spatial features and LSTM layers to analyze temporal patterns, enabling precise detection of disease markers in sequential medical data like CT scans.

VI. MODULLES

A. Dataset Collection

Computed Tomography (CT) scans of the abdomen and lungs should be included in a robust dataset in order to use deep learning to identify LAM. For the purpose of detecting characteristic LAM features such thin-walled cysts, pneumothorax, and structural abnormalities, lung CT scans are essential. This is complemented by abdominal CT scans, which show extra thoracic symptoms that are typical with LAM, such as kidney angiomyolipoma's (AMLs) and lymphatic involvement. When these imaging modalities are combined, a more thorough picture of the illness can be obtained, making it easier to distinguish it from other cystic lung conditions. Training precise and broadly applicable models requires a carefully selected dataset that includes a range of disease stages and imaging viewpoints.



[Fig.3: CT Images of Lungs]

B. Dataset Visualization

Introducing information as diagrams or outlines is a method known as information representation. It makes it much simpler to interpret large amounts of complex data. Data visualization tools like Tableau, Power BI, and Python can all be used to visualize our dataset. In this instance, we are utilizing the Python Matplotlib module. It is also used in high-level exploratory and machine learning data analysis (EDA).

Data visualisation is crucial, for the analysis of CT scans in LAM detection. Heatmaps, overlays, and 3D models highlight significant characteristics such lung cysts and angiomyolipoma's (AMLs). Using metrics like accuracy and loss, these visual tools track model performance and assist in validating predictions. In order to produce more accurate and trustworthy results, interactive visualisations aid in data exploration, spot biases, and improve dataset quality.

C. Disease Classification Using CNN

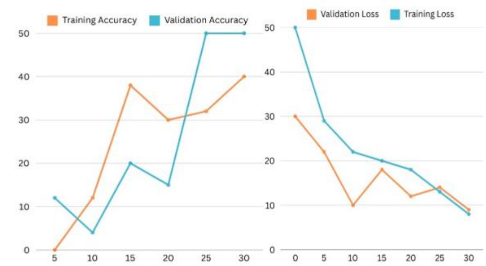
Convolutional Neural Networks (CNNs) are a robust deep learning technique widely used for disease identification and classification, especially in medical imaging. By automatically extracting hierarchical features from data such as CT scans, CNNs identify subtle patterns associated with conditions like LAM. The design includes convolutional layers to identify features, pooling layers to simplify dimensions, and fully connected layers to perform classification, effectively reducing dependence on manual feature extraction. This enhances both accuracy and efficiency. CNNs excel at distinguishing normal from abnormal findings and differentiating closely related conditions, making them indispensable for early diagnosis and tailoring personalized treatment strategies.

D. Disease Classification Using LSTM

Long Short-Term Memory (LSTM) networks are highly impactful in disease classification, particularly for sequential or time-dependent medical data. They analyze ordered datasets like CT or MRI slices while retaining critical temporal context. When combined with CNNs, LSTMs capture spatial-temporal patterns, enabling precise detection of progressive diseases, tracking changes over time, and improving diagnostic accuracy and treatment strategies.

E. Performance Evaluation

We had provided additional information about LAM disease, including its symptoms and behavior, in this module. We examined the performance of CNN and LSTM models on a dataset of patients diagnosed with LAM. The analysis revealed that LSTM models achieved an impressive accuracy range of 85% to 95%, while CNN models performed slightly lower, with an accuracy of 80%. These results highlight the potential of deep learning techniques to enhance diagnostic accuracy, allowing for more timely detection and personalized treatment of LAM, thereby improving patient outcomes.



[Fig.4: Accuracy Part and Loss Part]

VII. CONCLUSION

The project's main goal is to create a fully automated organization and make it possible for transaction details to keep records using employees. As a result, the proposed system has been constructed with sufficient adaptability without sacrificing response time. The entire system will be computerized, resulting in greater accuracy and a significant reduction in clerical work. Reports can be produced quickly, clearly and without ambiguity. Incorporated data set plan and simplicity of upkeep is a significant benefit of the framework. The system stands out for its ease of use. As a result, by designing a system that is easy to use, many users can use the system without prior computer experience or training.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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REFERENCES

1. Alexa. E,Chloe Steveson,"Ultra low dose CT with Silver filter and deep learning reconstruction significantly reduces radiation and retain quantitative information in the investigation and monitoring of Lymphangioleiomyomatosis" European Radiology [2024]. DOI: https://doi.org/10.1007/s00330-024-10649-z
2. Anushka K palipana, Emra Gecili," Predicting Indualized lung disease progression in treatment naïve patient with Lymphangioleiomyomatosis(LAM)" Epub [2023]. DOI: https://doi.org/10.1016/j.chest.2022.12.027
3. Eileen Wang-koheler ,Adina.R "Complications of lymphangioleiomyomatosis(LAM) in pregnancy" Elsevier [2024]. DOI: https://doi.org/10.1016/j.xagr.2024.100309
4. Xiang jia,Chen Qiantong , "Study on diffuse cystic lung disease based on deep learning."Journal of Science direct[2024]. https://openurl.ebsco.com/EPDB%3Agcd%3A14%3A2656526/detailv2?sid=ebsco%3Aplink%3Ascholar&id=ebsco%3Agcd%3A180445423&crl=c&link_origin=scholar.google.co.in
5. Eun Min lee, Ju hee kim"Uterine lymphangioleiomyomatosis (LAM) in a premenopausal woman with tuberous sclerosis"Elsevier[2024]. DOI: https://doi.org/10.1016/j.crwh.2024.e00650
6. Claire.E, Lawrence .A "Unsupervised Exercise in Interstital Lung Disease"CHEST journal [2024]. https://journal.chestnet.org/action/showPdf?pii=S0012-3692%2824%2904613-0
7. David rudilla, Maria Molina,"A study on the Psychological profile and coping with the disease in patients with Lymphangioleiomyomatosis(LAM)", Elsevier[2024]. DOI: https://doi.org/10.1016/j.opresp.2024.100327
8. Kundu .N, Holz MK "Lymphangioleiomyomatosis (LAM): a metastanic lung disease"AM J physiol cell [2023]. DOI: https://doi.org/10.1152/ajpcell.00202.2022
9. McCormack FX, Inoue Y "Efcacy and safety of sirolimus LAM"[2011]. DOI: https://doi.org/10.1056/NEJMoa1100391
10. Rudilla D, Beceiro MJ, Alonso T, Oliver A, Soriano J, Valenzuela C, et al. Psychological profile of patients diagnosed with idiopathic pulmonary fibrosis. Arch Bronconeumol. 2022;58:191– 3, http://dx.doi.org/10.1016/j.arbres.2021.04.025
11. Yeom JA, Kim KU, Hwang M et al (2022) Emphysema quantifcation using ultra-low-dose chest CT: efcacy of deep learning-based image recon- struction. Medicina (Kaunas) 58:939. DOI: https://doi.org/10.3390/medicina58070939
12. Pouw T, de Man-van Ginkel J, Hardeman JA, Mager JJ, Trapman L, Jaarsma T, et al. The association of resilience with self-care and quality of life in people with chronic obstructive pulmonary disease: a cross-sectional study. Nurs Open. 2023;10:7738–48, http://dx.doi.org/10.1002/nop2.2015
13. Pollok J, van Agteren JE, Esterman AJ, Carson- Chahhoud KV. Psychological therapies for the treatment of depression in chronic obstructive pulmonary disease. Cochrane Database Syst Rev. 2019;3:CD012347, http://dx.doi.org/10.1002/14651858.CD012347.pub2
14. Araujo MS, Baldi BG, Freitas CS, Albuquerque AL, Marques da Silva CC, Kairalla RA, et al. Pulmonary rehabilitation in lymphangioleiomyomatosis: a controlled clinical trial. Eur Respir J. 2016. DOI: https://doi.org/10.1183/13993003.01683-2015
15. Cottin V, Archer F, Leroux C, Mornex JF, Cordier JF. Milestones in lymphangioleiomyomatosis research. Eur Respir Rev. 2011;20:3–6, http://dx.doi.org/10.1183/09059180.00000311