IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

LAI: A MODEL FOR IDENTIFYING VARIOUS LUNG ABNORMALITIES

[1]Ms. DINLA O K, [2] HRIDYA RAJ P, [3]SAYANTH K,[4] SIVANTH P K,[5] VYSHAGH C

[1] Professor, [2] Student, [3] Student, [4] Student, [5] Student
[1] Department of Computer Science and Engineering
[1] St. Thomas College of Engineering and Technology, Kannur, Kerala, India

Abstract : This study introduces a novel automated multiclassification approach for identifying lung abnormalities through chest X-ray and CT scan images. It tackles key challenges in medical imaging such as class imbalance, computational complexity, and the necessity for explainable AI to aid clinical decisionmaking. The project makes several significant contributions: It employs data augmentation techniques, specifically VAE, to address class imbalance and enhance classification performance. Extensive image preprocessing methods are applied to improve image quality while preserving crucial diagnostic information. The modified VGG-19 model is developed and optimized for chest X-ray and CT scan datasets, demonstrating high accuracy and efficiency in detecting lung abnormalities. Comprehensive comparisons with transfer learning networks are provided to assess modified VGG-19's precision and training time. The results of the study showcase the effectiveness of the proposed framework in accurately identifying various lung diseases, including COVID19, Pneumonia, Emphysema, Fibrosis, Lung cancer, Tuberculosis across both imaging modalities. This demonstrates the system's potential to enhance diagnostic accuracy and facilitate timely interventions, ultimately contributing to improved patient outcomes

***Index Terms* - Artificial intelligence, lung disease identification, and real-time feedback.**

I. INTRODUCTION

The primary objective of this project is to automate the classification of lung abnormalities, including pneumonia, fibrosis, emphysema, lung cancer, tuberculosis, and COVID19, through the analysis of chest X-ray and CT images. In recent years, the increasing prevalence of lung diseases has underscored the need for efficient diagnostic tools. Traditional methods of diagnosis often rely on manual interpretation of medical images, which can be time-consuming and prone to human error. This project addresses these challenges by employing advanced machine learning techniques to enhance diagnostic accuracy and speed.The project stems from the pressing need for improved diagnostic tools in the field of medical imaging. With the rising incidence of lung diseases globally, including pneumonia, tuberculosis, and COVID-19, timely and accurate diagnosis is crucial for effective treatment and patient outcomes. Traditional diagnostic methods often rely on manual interpretation of chest X-rays and CT scans, which can be subjective and timeconsuming, leading to delays in care. This project aims to leverage advanced machine learning techniques to automate the classification of lung abnormalities, thereby enhancing diagnostic efficiency and accuracy. By utilizing a publicly accessible dataset and employing Variational Autoencoders (VAE) for data augmentation, the project addresses challenges related to insufficient and unbalanced datasets that can hinder model performance. The choice of a modified VGG19 model further enhances the system's capability to accurately identify a range of lung conditions. Ultimately, this project seeks to contribute to the healthcare sector by providing a reliable tool that can assist medical professionals in making quicker and more informed decisions regarding lung health. The integration of cutting-edge technology in medical diagnostics not only promises to improve patient care but also aims to set a precedent for future innovations in the field.

I. PROBLEM STATEMENT

One of the primary challenges is the insufficient and unbalanced datasets available for training classification models. This limitation can severely impact the performance of these models, leading to inaccurate results and unreliable diagnoses. When datasets lack diversity and adequate representation of various conditions, the model may struggle to generalize effectively, resulting in poor classification outcomes. The current system's focus is primarily on detecting COVID-19 and pneumonia, which restricts its applicability to a broader range of lung abnormalities. This narrow scope not only limits the utility of the diagnostic tool but also overlooks other critical conditions such as fibrosis, emphysema, lung cancer, and tuberculosis that require attention. The inability to identify these additional diseases can lead to missed diagnoses and inadequate patient care. Additionally, the absence of a suggestion or feedback mechanism within the system presents another significant issue. Without an interactive component that allows users to provide input or receive recommendations, the model lacks adaptability and may not evolve based on user experiences or new data. This limitation can hinder continuous improvement and user satisfaction, ultimately affecting the system's effectiveness in realworld applications. By addressing these challenges through innovative solutions such as Variational Autoencoders for data augmentation and employing a modified VGG-19 model for enhanced classification accuracy, this project aims to develop a comprehensive tool capable of identifying a wide array of lung abnormalities while ensuring robust performance and user engagement

II. LITERATURE SURVEY

A literature review is a piece of academic writing demonstrating knowledge and understanding of the academic literature on a specific topic placed in context. Usually a literature review forms a section or part of a dissertation, research project or long essay. However, it can also be set and assessed as a standalone piece of work. We picked three articles for survey:

- Deep Learning Techniques for Identification of Pneumonia: A CNN Approach.
- InstaCovNet-19: A deep learning classification model for the detection of COVID19 patients using Chest X-ray.
- Fast and Efficient Lung Abnormality Identification With Explainable AI: A Comprehensive Framework for Chest CT Scan and X-Ray Images.

A. Deep Learning Techniques for Identification of Pneumonia: A Cnn Approach

The paper presents a novel approach to pneumonia detection using deep learning, focusing on the implementation of Convolutional Neural Networks (CNNs). The goal is to develop an autonomous system capable of accurately identifying pneumonia from chest X-ray (CXR) images. This innovation seeks to address the challenges of traditional diagnostic methods, such as subjective interpretation and variability among healthcare professionals. By employing the VGG-19 architecture, a wellestablished CNN model known for its effectiveness in image classification tasks, the study aims to enhance diagnostic efficiency and reliability.

efficiency and reliability. The dataset used in this research was sourced from Kaggle, specifically curated for pneumonia detection. It is divided into three segments: training, testing, and validation, with each segment containing images categorized as normal or pneumonia cases. The training set comprises 1,342 normal and 3,876 pneumonia images, while the testing set includes 234 normal and 390 pneumonia images. The validation set, used to fine-tune the model, contains 9 images from each category. This structured dataset ensures the model is trained on a substantial amount of data while maintaining separate sets for evaluation and validation to accurately assess its performance.

Data preprocessing was a crucial aspect of the study, preparing the images for effective CNN training. Since the original images varied in pixel sizes, they were resized to a uniform dimension of 224 × 224 pixels to ensure consistency. To further enhance the model's robustness, data augmentation techniques such as rotation, scaling, normalization, and the introduction of random noise and blurring were employed. These strategies increased the diversity of the dataset, helping to mitigate overfitting and enabling the model to generalize effectively to unseen data.

effectively to unseen data. The VGG-19 architecture was selected for its proven success in image classification tasks. The model was trained on both original and augmented datasets to maximize learning from diverse image scenarios. Preprocessing steps, including normalization and batch normalization, were applied to standardize pixel values across images. These techniques ensured that all features contributed equally to the learning process and improved the model's efficiency during training. By employing these advanced methods, the study aimed to optimize the model's performance and reduce overfitting.

The proposed system achieved a high classification accuracy of 95%, demonstrating its effectiveness in detecting pneumonia from chest X-ray images. This performance highlights the value of integrating deep learning techniques with carefully structured datasets and advanced preprocessing methods. The model's accuracy indicates its potential for real-world application, particularly in resource-limited settings where access to expert radiologists may be constrained.

B. INSTACOVNET-19: A Deep Learning Classification Model for The Detection of Covid-19 Patients Using Chest X-ray

The paper introduces **InstaCovNet-19**, an integrated stacked deep learning model developed to detect COVID-19 using chest X-ray images. This model addresses the urgent need for fast, accurate, and cost-effective diagnostic tools during the COVID-19 pandemic, where traditional testing methods like RT-PCR can be both time-consuming and expensive. To overcome the challenges posed by limited training data, InstaCovNet-19 leverages multiple pre-trained convolutional neural networks (CNNs), including **ResNet101, Xception, InceptionV3, MobileNet**, and **NASNet**.

The primary objective of InstaCovNet-19 is to classify chest X-ray images into three categories: **COVID-19, pneumonia, and normal**. By employing a stacking ensemble technique, the model effectively integrates features extracted from the different CNN architectures, leading to improved classification performance. The model achieves an impressive **accuracy of 99.08% for binary classification** (COVID vs. non-COVID) and also demonstrates high precision and recall, highlighting its reliability for use in clinical settings.

A key strength of this work lies in its emphasis on developing a **minimally human-dependent and economically viable** diagnostic system. The ability to detect COVID-19 through widely available chest X-rays can significantly reduce the burden on healthcare professionals, especially in resource-limited environments. Additionally, the paper underscores the importance of **preprocessing techniques and robust training strategies**, which contribute to the model's generalization and stability across varying datasets. Overall, InstaCovNet-19 showcases the potential of deep learning in revolutionizing medical diagnostics and offers a valuable tool for early and effective COVID-19 detection.

C. Fast And Efficient Lung Abnormality Identification With Explainable Ai: A Comprehensive Framework for Chest Ct Scan and X-ray Images

The paper presents a comprehensive framework designed for the fast and efficient identification of lung abnormalities using chest X-ray and CT scan images. Given that respiratory disorders are among the leading causes of mortality worldwide, early and accurate diagnosis is essential for improving patient outcomes. Traditional imaging techniques such as chest radiography and computed tomography (CT) play a crucial role in diagnosing lung conditions. While chest X-rays are quick and widely available, they can be challenging to interpret, especially for non-specialists. On the other hand, CT scans offer detailed insights into lung structures but come with higher costs and increased radiation exposure. This study aims to bridge the diagnostic gap between these two modalities by applying advanced deep learning techniques to improve diagnostic accuracy across both image types.

The proposed method introduces an automated multi-classification approach that tackles common challenges in medical imaging datasets, including class imbalance and limited labeled data. To address these, the authors employ Generative Adversarial

Networks (GANs) for data augmentation, enriching the training data and enhancing model performance. At the core of the framework is the Compact Convolutional Transformer (CCT) model, selected for its ability to process both X-ray and CT images efficiently. An ablation study is conducted to fine-tune the model and determine the most effective configurations for achieving high classification accuracy. This careful optimization enables the framework to deliver strong performance across different imaging modalities while significantly reducing training times compared to conventional models.

Beyond performance optimization, the study underscores the importance of explainable AI in medical diagnostics. By integrating Grad-CAM visualization techniques, the framework provides interpretability by highlighting the regions in the medical images that influence the model's decisions. This transparency is critical for clinical acceptance, as it helps healthcare professionals understand and trust the outputs of AI-driven systems. The results of the research are promising, with the framework achieving an accuracy rate of 99.77% and maintaining robust performance even with smaller datasets. Overall, this paper offers valuable contributions to the application of deep learning in medical imaging, aiming to support healthcare professionals in the early detection and management of lung abnormalities and ultimately enhance respiratory healthcare delivery

III. PROPOSED SYSTEM

Our system proposes an automated multi-classification approach to detect a variety of lung abnormalities, including pneumonia, fibrosis, emphysema, lung cancer, tuberculosis, and COVID-19, using chest X-ray and CT images. This innovative framework addresses key challenges such as limited and imbalanced datasets by incorporating Variational Autoencoders (VAE) for data augmentation and leveraging a modified VGG-19 model for classification. The inclusion of a user-friendly application allows users to upload images and receive prompt diagnostic results, enhancing accessibility and efficiency. This comprehensive approach aims to improve diagnostic accuracy and reliability in identifying lung-related conditions.

Variational Autoencoders (VAE) play a critical role in our system by tackling the limitations of small and unbalanced datasets. Unlike traditional autoencoders, VAEs use a probabilistic approach to learn complex data distributions. They encode input data into a latent space defined by a mean and variance, capturing the variability within the dataset. This probabilistic representation enables the generation of synthetic images that resemble real data while introducing variability. The architecture of VAEs includes an encoder that maps data into a latent space distribution and a decoder that reconstructs the data from this space. By optimizing with techniques like the reparameterization trick, VAEs ensure effective training. This capability is particularly beneficial in medical imaging, where obtaining labeled data is challenging. By generating diverse and realistic synthetic images, VAEs enhance dataset balance and improve the robustness of the classification model.

The modified VGG-19 model is a refined version of the original VGG-19 architecture, optimized for medical image analysis. The original VGG-19 consists of 19 layers, including 16 convolutional layers, known for their ability to capture intricate image features. In our system, we enhance this architecture by adjusting the number of filters in the convolutional layers, enabling the model to learn features specific to various lung abnormalities. To further improve performance, dropout layers are introduced between fully connected layers to prevent overfitting, a common issue with limited medical datasets. Batch normalization is applied after convolutional layers to stabilize and accelerate training, leading to better convergence.

Additionally, the system utilizes transfer learning by initializing the modified VGG-19 with pre-trained weights from large datasets like ImageNet. This approach leverages transferable features, reducing the amount of data required for training while significantly enhancing classification accuracy. The output layer is customized with a softmax activation function to handle multi-class classification, providing probability distributions for each lung condition. These modifications make the model more robust and effective in identifying specific lung abnormalities from chest X-ray and CT images.

Overall, the combination of Variational Autoencoders for data augmentation and the modified VGG-19 model ensures a robust and accurate system for lung abnormality classification. By addressing key challenges and optimizing the framework for medical imaging, our system provides a reliable tool for improving diagnostic accuracy and efficiency in lung-related conditions.

IV. PROPOSED SYSTEM DESIGN

An architecture diagram visually represents the structure and interactions within a system. It provides a high-level view of the system's components, their relationships, and communication flows, offering insights into how the system functions and its scalability, resilience, and security. Architecture diagrams are essential for planning and aligning stakeholders, as they help developers, architects, and business teams understand both the overall design and specific aspects like data flow, integration points, and dependencies. They're also useful for troubleshooting, as they highlight possible bottlenecks and vulnerabilities in the system.

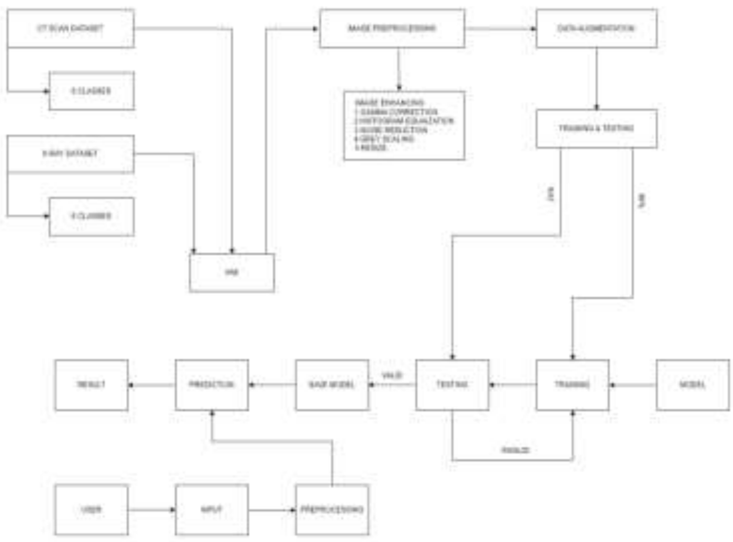

Fig.1. Architecture Diagram

a) **Data Input Layer:** The process begins with the data input layer , where users can upload chest X-ray or CT images. This interface is designed to be user-friendly, allowing for easy selection between the two imaging modalities, which is crucial for ensuring accessibility and usability.

b) **Image Preprocesssing:** Once the images are uploaded, they undergo image preprocessing. This step involves various techniques aimed at enhancing image quality and preparing the data for analysis. Common preprocessing methods may include normalization, resizing and noise reduction, which are essential to improve the accuracy of subsequent analyses.

c) **Data Augmentation with Variational Autoencoders (VAE):** To address the challenge of insufficient and unbalanced datasets, the architecture incorporates Variational Autoencoders (VAE) for data augmentation. This technique generates additional synthetic training samples, effectively balancing the dataset and increasing its diversity. By doing so, it enhances the model's ability to generalize and perform well on unseen data.

d) **Model Training with Modified VGG-19:** The augmented dataset is then fed into a modified VGG-19 model, which is employed for classifying various lung abnormalities. This deep learning model is known for its robustness and effectiveness in medical image classification tasks. The architecture leverages VGG 19's capabilities to accurately identify conditions such as pneumonia, fibrosis, emphysema, lung cancer, tuberculosis, and COVID-19.

e) **Classification Output:** After processing through the VGG-19 model, the system generates classification results based on the input images. This output provides users with valuable insights into the presence of lung abnormalities.

f) **Feedback Mechanism:** Finally, the architecture includes a feedback mechanism that allows users to receive identification results and potentially provide input on their experience. This interactive component is essential for refining the model based on real-world usage and enhancing user satisfaction. These key elements create a comprehensive framework that addresses existing challenges in lung abnormality detection, ultimately contributing to improved diagnostic accuracy and efficiency in healthcare settings.

V. RESULT

The implementation of the lung abnormality detection system successfully provided a deep learning-based solution for identifying various lung diseases from CT scans and X-ray images. The system enhanced diagnostic accuracy through automated classification and real-time disease detection. The key results of the system's implementation are:

VI. IMPLEMENTATION

The implementation of LAI is structured into two main interfaces: the Admin Webpage and the User Mobile Application. These interfaces work together to provide a seamless and efficient lung disease identification.

A. **Admin Web Interface:** The purpose of the Admin Login Page in the LAI System is to provide a secure authentication gateway for administrators to access and manage the system. This page ensures that on authorized personnel can log in to oversee the application's functionalities, including user management, data analysis, andmonitoring lung disease identification processes.

Fig.2. Admin Web page Login

By requiring email and password authentication, the login page prevents unauthorized access, safeguarding sensitive medical data and system integrity. Additionally the Forgot Password option helps administrators recover their accounts if they forget their credentials.

The Admin Dashboard(Fig. 3) of the LAI System serves as the central control panel for administrators, providing an overview of the system and access to key functionalities. This page ensures that administrators can efficiently manage users, monitor system activities, and oversee feedback or doubts raised by users.At the top, the navigation bar includes essential options such as Home, Doubt, Feedback, User, and Logout, allowing administrators to navigate different sections of the system. The purpose of this page is to provide quick access to important administrative functions, such as managing user data, resolving queries, and reviewing feedback. Additionally, the Logout option ensures security by allowing administrators to safely exit the system when their tasks are completed. This dashboard acts as the primary interface for system management, ensuring smooth operation and user support within the LAI system.

Fig.3. Admin Dashboard

The purpose of this Feedback Management Page (Fig. 4) in the LAI Admin Web Interface is to allow administrators to view, manage, and respond to user feedback efficiently. This page provides a structured platform where users' comments and suggestions regarding the application are collected, helping administrators understand user experiences, identify issues, and improve the system accordingly. The search and filter options enable admins to find specific feedback based on date, making it easier to track user concerns over time. The reply functionality allows administrators to engage with users directly, addressing their feedback and ensuring better user satisfaction. Overall, this page plays a crucial role in maintaining user engagement and enhancing the quality of the LAI system through continuous feedback monitoring and response.

Fig.4. Feedback Page

The Doubt Management Page (Fig.5) in the LAI Admin Web Interface is designed to help administrators review and respond to user queries or doubts efficiently. This page serves as a centralized platform where users can submit their concerns, questions, or uncertainties regarding the system, and administrators can provide appropriate answers or clarifications. The structured table format ensures easy tracking of user doubts, along with relevant details such as submission date and user identity. The reply functionality allows admins to engage directly with users, offering resolutions and ensuring better user support. By addressing doubts in a timely manner, this page enhances user experience, promotes clarity, and improves overall system usability.

Fig.5. Doubt page

B. User Application: The LAI User App also allows users to upload CT or X ray images of their lungs to check for possible diseases. This feature helps in early detection by analyzing the images and providing insights, assisting users in monitoring their lung health effectively.

Fig.6. App Login

Fig.7. User Home

The User Login Page (Fig.6) in the LAI app serves as the entry point for users to access their accounts securely. It allows registered users to log in using their credentials, ensuring authorized access to app features. Additionally, it provides options for new users to register and existing users to recover their passwords if needed. The Home Page (Fig. 7) of the LAI app serves as a central hub for users to access key features conveniently. The main function is the image upload section, where users can tap to upload images like CT scans or X-rays to check for potential diseases. This feature helps in early detection and analysis of lung-related issues. Additionally, the page includes options to submit feedback, allowing users to share their experiences and suggestions to improve the app. There is also a Submit Doubt section where users can ask health-related questions and get guidance. The bottom navigation bar provides quick access to the Home and Profile sections, ensuring easy navigation for a smooth user experience.

Fig.8. User Doubt Page

Fig.9. User Feedback Page

The X-Ray Prediction Result page (Fig. 10) of the LAI app displays the analysis of an uploaded chest X-ray image. In this case, the app has detected Covid-19 based on the scanned X ray. The image at the top represents the chest X-ray that was analyzed, highlighting potential abnormalities associated with Covid-19, such as lung opacity or infection patterns. Below the image, the Prediction Result section clearly states the detected condition. This feature is designed to assist users and healthcare professionals in identifying possible lung diseases early. However, it is recommended to consult a doctor for further evaluation and confirmation of the diagnosis. The Back button allows users to return to the previous page for further actions. The CT Scan Prediction Result page (Fig. 11) of the LAI app displays the analysis of an uploaded CT scan image. In this case, the app has detected Cancer based on the scanned image. The image at the top represents the CT scan, which has been processed by the app's AI model to identify potential signs of cancer. Below the image, the Prediction Result section confirms the detection. This feature is designed to assist users and healthcare professionals in early diagnosis and further medical evaluation. However, it is important to note that this result is not a final diagnosis, and users should consult a medical professional for confirmation and further assessment. The Back button allows users to return to the previous screen.

Fig.10. Result For X-RAY Image

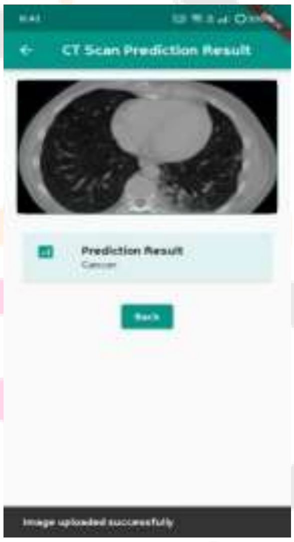

Fig.11. Result For CT Image

VII. CONCLUSION

The developed system introduces an automated multi classification approach for detecting lung abnormalities using chest X-ray and CT scan images. By addressing critical challenges such as class imbalance, computational complexity, and the need for explainable AI, the project enhances diagnostic accuracy and supports clinical decision-making. The use of Variational Autoencoder (VAE) for data augmentation effectively mitigates class imbalance, ensuring the model is well trained across diverse lung diseases. Additionally, extensive image preprocessing techniques improve image quality while preserving essential diagnostic details, optimizing the input for more accurate predictions. A modified VGG-19 model serves as the backbone of the classification system, specifically optimized for chest X-ray and CT scan datasets. The model demonstrates high efficiency and precision in detecting a wide range of lung diseases, including COVID-19, Pneumonia, Emphysema, Fibrosis, Lung Cancer, and Tuberculosis. Comparisons with standard transfer learning networks highlight the superior accuracy and reduced training time of the modified VGG-19 model. This ensures that the system not only provides reliable diagnostic predictions but also remains computationally efficient, making it practical for real-world medical applications. The integration of this model into a user-friendly web and mobile application further enhances accessibility and usability. The interface allows users to upload medical images, process them efficiently, and obtain instant diagnostic results. This functionality empowers healthcare professionals and patients alike by providing a fast and reliable preliminary diagnosis, reducing the dependency on manual interpretation. The explainable AI component ensures transparency, allowing medical experts to understand and trust the model's decision-making process.

The proposed framework significantly improves early detection and classification of lung diseases, facilitating timely interventions and better patient outcomes. By combining advanced AI techniques, optimized deep learning models, and a practical deployment strategy, the system has the potential to revolutionize lung disease diagnostics. Its ability to provide accurate and accessible predictions contributes to enhanced healthcare efficiency, enabling quicker medical responses and ultimately improving the quality of patient care.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to St. Thomas College of Engineering and Technology for their unwavering support and the resources provided, which were essential to the successful execution of this work.

REFERENCES

[1] Ali, A. 2001.Macroeconomic variables as common pervasive risk factors and the empirical content of the Arbitrage Pricing Theory. Journal of Empirical finance, 5(3): 221–240.

[2] Basu, S. 1997. The Investment Performance of Common Stocks in Relation to their Price to Earnings Ratio: A Test of the Efficient Markets Hypothesis. Journal of Finance, 33(3): 663-682.

[3] Bhatti, U. and Hanif. M. 2010. Validity of Capital Assets Pricing Model.Evidence from KSE-Pakistan.European Journal of Economics, Finance and Administrative Science, 3 (20).

[4] R. Ghavami Modegh et al., "Accurate and rapid diagnosis of COVID-19 pneumonia with batch effect removal of chest CT-scans and interpretable artificial intelligence," 2020, arXiv:2011.11736.

[5] M. Y. Kamil, "A deep learning framework to detect COVID-19 disease via chest X-ray and CT scan images," Int. J. Electr. Comput. Eng., vol. 11, no. 1, p. 844, Feb. 2021, doi: 10.11591/ijece.v11i1.pp844-850.

[6] MD. Zahid Hasan, Sidratul Montaha, Inam Ullah Khan, et al. (2024). Fast and Efficient Lung Abnormality Identification With Explainable AI: A Comprehensive Framework for Chest CT Scan and X-Ray Images. Retrieved from Fast and Efficient Lung Abnormality Identification.

[7] Sharmila Nageswaran, G. Arunkumar, et al. (2023). Lung Cancer Classi f ication and Prediction Using Machine Learning and Image Processing. International Journal of Computer Applications, 182(18), 1-7.

[8] K. U. Ahamed, M. Islam, A. Uddin, A. Akhter, B. K. Paul, M. A. Yousuf, S. Uddin, J. M. W. Quinn, and M. A. Moni, "A deep learning approach using effective preprocessing techniques to detect COVID-19 from chest CT-scan and X-ray images," Comput. Biol. Med., vol. 139, Dec. 2021, Art. no. 105014, doi: 10.1016/j.compbiomed.2021.105014.

[9] T. Mahmud, M. A. Rahman, and S. A. Fattah, "CovXNet: A multi dilation convolutional neural network for automatic COVID-19 and other pneumonia detection from chest X-ray images with transferable multi receptive feature optimization," Comput. Biol. Med., vol. 122, Jul. 2020, Art. no. 103869, doi: 10.1016/j.compbiomed.2020.103869.

[10] Gupta, A., Anjum, S., Gupta, S., & Katarya, R. (2021). InstaCovNet 19: A deep learning classification model for the detection of COVID 19 patients using Chest X-ray. Applied Soft Computing Journal, 99, 106859. https://doi.org/10.1016/j.asoc.2020.106859

[11] Bai, H., et al. (2020). Predicting COVID-19 Pneumonia: A Deep Learning Model Based on CT Scans and Clinical Data. Nature Medicine, 26(8), 1124-1128. https://doi.org/10.1038/s41591-020-0931-3.

[12] L. Wang, A. Wong, COVID-Net: A tailored deep convolutional neural network design for detection of COVID-19 cases from chest X-ray images, ArXiv (2020) 1–12, http://arxiv.org/abs/2003.09871.

[13] A. U. Ibrahim, M. Ozsoz, S. Serte, F. Al-Turjman, and P. S. Yakoi, "Pneumonia classification using deep learning from chest X-ray images during COVID-19," Cognitive Computation, pp. 1 13, 2021.

[14] K. U. Ahamed, M. Islam, A. Uddin, A. Akhter, B. K. Paul, M. A. Yousuf, S. Uddin, J. M. W. Quinn, and M. A. Moni, "A deep learning approach using effective preprocessing techniques to detect COVID-19 from chest CT-scan and X-ray images," Comput. Biol. Med., vol. 139, Dec. 2021, Art. no. 105014, doi: 10.1016/j.compbiomed.2021.105014.

[15] M. Arsenovic, S. Sladojevic, S. Orcic, A. Anderla, and M. Sladojevic, "Detection of COVID-19 cases by utilizing deep learning algorithms on X-ray images," in Proc. 18th Int. Sci. Conf. Ind. Syst. Ind. Innov. Digital Age, Jan. 2020, pp.