



Innovations in Stroke Identification: A Machine Learning-Based Diagnostic Model Using Neuroimages

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Abstract: Stroke diagnosis is a time-sensitive and critical healthcare process that requires rapid and accurate detection to ensure effective treatment and improved patient outcomes. Stroke is one of the leading causes of mortality, neurological disorders, and long-term disability worldwide, creating a significant burden on healthcare systems. Conventional diagnostic methods such as Computed Tomography (CT) scans and Magnetic Resonance Imaging (MRI) depend heavily on expert radiological analysis, which may lead to delays during emergency situations where immediate medical intervention is essential. To overcome these limitations, this research presents a machine learning and deep learning-based stroke diagnosis system using neuroimaging data. The proposed framework utilizes advanced Deep Learning architectures, including Convolutional Neural Networks (CNN), Inception V3, and MobileNet, for efficient analysis and classification of brain neuroimages. The CNN model performs automated feature extraction from medical images, while Inception V3 enhances detection accuracy by capturing complex spatial and visual patterns through deep convolutional layers. Additionally, MobileNet provides a lightweight and computationally efficient architecture, enabling faster processing and suitability for real-time clinical applications. The integration of these models ensures both high diagnostic accuracy and reduced computational complexity. The system was trained and tested on neuroimaging datasets containing both stroke-affected and healthy brain scans. Experimental evaluation demonstrated superior performance in terms of accuracy, precision, sensitivity, and reliability for stroke prediction and classification. The proposed intelligent diagnostic model assists healthcare professionals in achieving faster stroke detection, early diagnosis, and timely treatment planning. By incorporating Artificial Intelligence (AI), Medical Image Processing, and Machine Learning techniques into the healthcare workflow, the system can significantly reduce diagnosis time, improve patient care quality, minimize human error, and decrease the economic burden associated with stroke management and rehabilitation.

Keywords: Stroke Diagnosis, Machine Learning, Deep Learning, Convolutional Neural Network (CNN), Inception V3, MobileNet, Neuroimaging, Medical Image Processing, Artificial Intelligence (AI), Brain Stroke Detection, CT Scan, MRI Scan, Healthcare Analytics, Stroke Prediction, Real-Time Diagnosis, Clinical Decision Support System.

I. INTRODUCTION

Stroke is one of the most serious and life-threatening neurological disorders affecting millions of people worldwide. It occurs when the blood supply to the brain is interrupted or reduced, preventing brain tissues from receiving oxygen and essential nutrients. As a result, brain cells begin to die within minutes, making stroke a medical emergency that requires immediate diagnosis and treatment. According to global healthcare reports, stroke is among the leading causes of death and long-term disability, significantly affecting the quality of life of patients and creating a major burden on healthcare systems. Early detection and rapid medical intervention are essential to reduce mortality rates and improve patient recovery. Traditional stroke diagnosis methods mainly rely on medical imaging techniques such as Computed Tomography (CT) scans and Magnetic Resonance Imaging (MRI). These neuroimaging methods help medical experts analyze brain abnormalities and identify stroke conditions. However, the diagnosis process often requires experienced radiologists and neurologists to carefully examine the medical images, which can consume valuable time during emergency situations. Delays in diagnosis may lead to severe brain damage, permanent disability, or even death. Therefore, there is a growing need for intelligent and automated diagnostic systems that can assist healthcare professionals in making faster and more accurate decisions. Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) have revolutionized the healthcare sector by enabling automated disease detection and medical image analysis. Deep learning models, especially Convolutional Neural Networks (CNNs), have shown remarkable performance in extracting complex features from medical images and identifying disease patterns with high accuracy. These technologies reduce human effort and improve diagnostic efficiency by learning from large datasets and performing automated classification tasks. As a result, AI-driven healthcare systems are becoming increasingly important in modern medical research and



clinical applications. In this study, a machine learning-based stroke diagnosis system is proposed using advanced deep learning architectures such as Convolutional Neural Networks (CNN), Inception V3, and MobileNet. The CNN model is used for automated feature extraction from neuroimages, while Inception V3 enhances classification performance through deep convolutional layers capable of capturing complex image patterns. MobileNet is integrated due to its lightweight and computationally efficient structure, which supports faster processing and real-time applications. The combination of these architectures helps achieve both high accuracy and reduced computational complexity in stroke detection. The proposed system is trained and evaluated using neuroimaging datasets containing both healthy and stroke-affected brain scans. Various preprocessing and feature extraction techniques are applied to improve the quality of medical images and optimize model performance. Experimental results demonstrate that the proposed model can accurately identify stroke conditions and assist healthcare professionals in rapid diagnosis and clinical decision-making. The use of deep learning techniques significantly improves prediction performance compared to conventional methods. The integration of machine learning and medical image processing into stroke diagnosis has the potential to transform modern healthcare systems. The proposed intelligent diagnostic model can reduce diagnosis time, support early medical intervention, minimize human error, and improve patient care quality. Additionally, automated stroke detection systems can help reduce healthcare costs and the economic burden associated with long-term stroke treatment and rehabilitation. Therefore, the application of AI and deep learning in stroke diagnosis represents an important step toward developing efficient, reliable, and real-time healthcare solutions.

II. LITERATURE REVIEW

1. Muhammad Asim Saleem, Ashir Javeed, and Wasan Akarathanawat proposed a machine learning-based diagnostic model for stroke identification using neuroimages. The study utilized advanced deep learning techniques such as Convolutional Neural Networks (CNN), Inception V3, and MobileNet to improve the accuracy and speed of stroke diagnosis. Their research focused on analyzing CT and MRI brain scans to identify stroke conditions efficiently. Experimental results demonstrated high classification accuracy and highlighted the importance of AI-driven systems in supporting real-time clinical diagnosis and early medical intervention. [1]
2. L. Ali, A. Javeed, A. Noor, H. T. Rauf, S. Kadry, and A. H. Gandomi presented a Parkinson's disease detection system using L1-regularized Support Vector Machine (SVM) and Deep Neural Networks (DNN). The proposed framework performed feature refinement and selection to improve classification performance and reduce unnecessary data complexity. Their study achieved significant accuracy in detecting Parkinson's disease, proving that machine learning and neural network approaches can support early diagnosis and assist healthcare professionals in neurological disorder prediction. [2]
3. A. Javeed, P. Anderberg, A. N. Ghazi, A. Noor, S. Elmståhl, and J. S. Berglund developed a hybrid statistical and machine learning-based system for dementia prediction. The research combined statistical analysis with machine learning algorithms to identify dementia-related risk factors and predict disease occurrence effectively. Their model improved prediction accuracy and demonstrated the capability of AI-based healthcare systems in assisting clinicians with early-stage dementia diagnosis and patient monitoring. [3]
4. A. Javeed, J. S. Berglund, A. L. Dallora, M. A. Saleem, and P. Anderberg proposed an XGBoost-BiLSTM-based machine learning model for accurate sleep apnea detection using electronic health records. The hybrid model combined XGBoost for feature selection and BiLSTM for sequential data analysis, enhancing predictive performance. Their work highlighted the effectiveness of combining deep learning and machine learning techniques in healthcare diagnostics and disease prediction systems. [4]
5. A. Javeed, A. L. Dallora, J. S. Berglund, A. Ali, P. Anderberg, and L. Ali conducted research on predicting dementia risk factors using feature selection and neural network models. The study analyzed medical and demographic data to identify important factors associated with dementia. Their neural network-based framework achieved improved prediction accuracy and demonstrated the importance of AI-driven predictive analytics in modern healthcare applications. [5]
6. E. Rasool, M. J. Anwar, B. Shaker, M. H. Hashmi, K. U. Rehman, and Y. Seed proposed deep transfer learning approaches for breast microcalcification detection in digital mammograms. The study applied pretrained deep learning models to classify mammographic images and detect cancer-related abnormalities with improved accuracy. Their work emphasized the significance of transfer learning in medical image analysis and early cancer diagnosis. [6]
7. A. Tursynova, B. Omarov, N. Tukenova, I. Salgozha, O. Khaaval, R. Ramazanov, and B. Ospanov developed a deep learning-based brain stroke classification system using computed tomography (CT) images. The proposed framework utilized convolutional neural networks to analyze brain scans and classify stroke conditions automatically. Experimental outcomes showed enhanced performance in stroke detection and demonstrated the efficiency of deep learning methods in neuroimaging analysis. [7]
8. M. Gupta, P. Meghana, K. H. Reddy, and P. Supraja proposed an IoT-enabled deep learning and machine learning framework for brain stroke prediction. Their system integrated Internet of Things (IoT) devices with AI-based



healthcare analytics to monitor patient health data and predict stroke occurrence. The research highlighted the role of smart healthcare technologies in improving remote patient monitoring, early diagnosis, and sustainable healthcare management. [8]

9. L. Cortés-Ferre, M. A. Gutiérrez-Naranjo, J. J. Egea-Guerrero, S. Pérez-Sánchez, and M. Balcerzyk applied deep learning techniques for intracranial hemorrhage detection using medical imaging data. The study focused on automated hemorrhage identification from CT scans using convolutional neural networks. Their findings demonstrated high diagnostic accuracy and showed the potential of deep learning in assisting emergency medical diagnosis and reducing human error. [9]
10. A. Javeed, L. Ali, A. M. Seid, A. Ali, D. Khan, and Y. Imrana proposed a Clinical Decision Support System (CDSS) for unbiased prediction of caesarean section procedures. The framework used feature extraction and optimized classification algorithms to support clinical decision-making processes. Their study demonstrated that machine learning-based CDSS systems can improve healthcare efficiency, reduce bias in predictions, and assist medical professionals in accurate treatment planning. [10]

III. PROPOSED SYSTEM

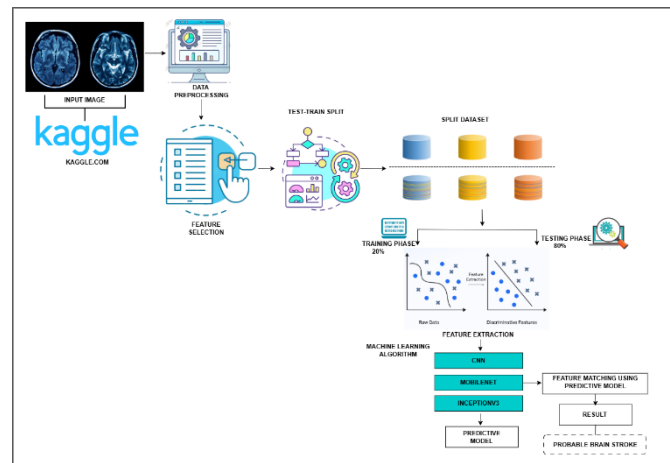


Fig. 1: System Architecture

As shown in Fig. 1, the proposed system for Innovations in Stroke Identification focuses on the development of a machine learning and deep learning-based diagnostic model using neuroimages. The system utilizes advanced algorithms such as Convolutional Neural Networks (CNN), Inception V3, and MobileNet to accurately detect and classify stroke conditions from MRI and CT scan images of the brain. These algorithms enable automated medical image analysis and assist healthcare professionals in rapid and reliable stroke diagnosis. Inception V3 is employed due to its deep convolutional architecture, which provides efficient feature extraction and improved image classification performance. The model can capture complex spatial patterns and hidden characteristics present in neuroimages, enhancing the overall diagnostic accuracy. MobileNet is integrated into the system because of its lightweight and computationally efficient structure, making it suitable for real-time applications and resource-constrained environments such as mobile healthcare systems. The CNN model plays a significant role in identifying important image features and detecting abnormalities associated with stroke conditions. The proposed framework is trained using a large dataset of labeled neuroimages containing both healthy and stroke-affected brain scans. Various preprocessing techniques are applied to improve image quality and optimize model performance. The system aims to support early stroke detection and clinical decision-making by providing accurate and automated analysis of medical images. Early diagnosis can help reduce treatment delays, improve patient recovery, and minimize the risk of severe neurological damage. To evaluate the effectiveness of the proposed models, several performance metrics such as accuracy, precision, recall, F1-score, and Area Under the Receiver Operating Characteristic Curve (AUC-ROC) are used. Cross-validation techniques are employed to ensure model generalization and reduce the possibility of overfitting. Hyperparameter tuning is also performed to optimize the performance and efficiency of the algorithms. Since CNN-based architectures require intensive computation and large-scale data processing, powerful GPU systems are utilized during the training phase. A comparative analysis of CNN, Inception V3, and MobileNet is conducted to identify the most accurate and reliable model for stroke diagnosis. Among these models, CNN demonstrates superior capability in capturing spatial image patterns and extracting relevant medical features. However, all models contribute valuable insights and collectively improve the overall diagnostic performance of the system. This multi-algorithmic approach creates a robust, efficient, and intelligent diagnostic framework for stroke identification using neuroimages.



A. Methodology

The methodology of the proposed stroke identification system involves collecting neuroimaging datasets containing MRI and CT scan images of both healthy and stroke-affected patients. The acquired images undergo preprocessing techniques such as resizing, normalization, noise removal, and image enhancement to improve data quality and model performance. After preprocessing, the dataset is divided into training and testing sets for model development and evaluation. Advanced deep learning algorithms, including Convolutional Neural Networks (CNN), Inception V3, and MobileNet, are implemented to extract important image features and classify stroke conditions accurately. The models are trained using labeled neuroimages and optimized through hyperparameter tuning and cross-validation techniques to reduce overfitting and improve generalization. Performance evaluation is carried out using metrics such as accuracy, precision, recall, F1-score, and AUC-ROC to determine the effectiveness of the proposed system in detecting and diagnosing strokes efficiently.

IV. RESULTS

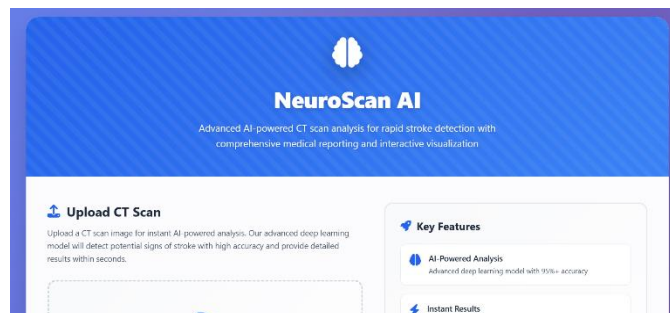


Fig 2: NeuroScan AI – Stroke Detection System Interface

Figure 2 shows the user interface of the proposed “NeuroScan AI” system designed for AI-powered stroke detection using CT scan images. The interface provides an upload section where users can submit CT scan images for instant analysis. The system utilizes advanced Deep Learning techniques to identify potential signs of stroke with high accuracy and generate rapid diagnostic results. The interface also highlights important features such as AI-powered analysis, instant result generation, and interactive medical reporting, making the system suitable for efficient and user-friendly healthcare applications.

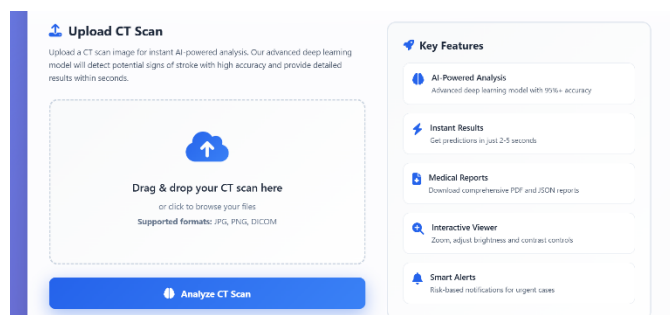


Fig 3: CT Scan Upload and Analysis Module of NeuroScan AI

Figure 3 illustrates the CT scan upload and analysis module of the proposed “NeuroScan AI” system for stroke detection. The interface allows users to upload CT scan images in formats such as JPG, PNG, and DICOM through a drag-and-drop feature or file browser. After uploading, the “Analyze CT Scan” button processes the neuroimage using advanced Deep Learning algorithms to detect potential stroke conditions. The interface also highlights key features of the system, including AI-powered analysis, instant result generation, medical report creation, interactive image viewing, and smart alert notifications for urgent cases. This module improves the efficiency, accessibility, and usability of automated stroke diagnosis in healthcare applications.

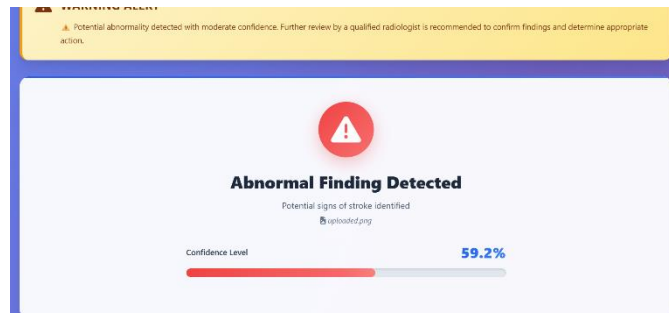


Fig 4: Abnormal Stroke Detection Result in NeuroScan AI

Fig 4 displays the diagnostic result interface of the proposed “NeuroScan AI” stroke detection system after analyzing a CT scan image. The system identifies an abnormal finding and indicates potential signs of stroke with a confidence level of 59.2%. A warning alert is generated to notify users that further medical review by a qualified radiologist is recommended for confirmation and appropriate treatment planning. The interface visually represents the prediction confidence through a progress bar, helping healthcare professionals quickly understand the severity and reliability of the diagnostic result. This feature enhances early stroke detection and supports faster clinical decision-making using AI-powered medical analysis.

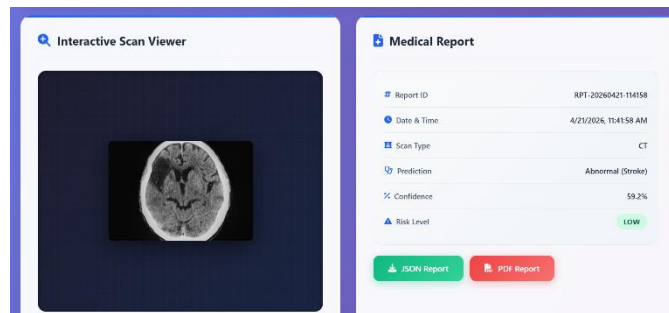


Fig 5: Interactive Scan Viewer and Medical Report Generation Module

The fig 5 illustrates the interactive scan viewer and medical report generation module of the proposed “NeuroScan AI” system. The left section displays the uploaded CT brain scan through an interactive viewer that allows healthcare professionals to examine neuroimages more effectively. The right section presents a detailed medical report containing information such as report ID, date and time, scan type, prediction result, confidence level, and risk assessment generated by the AI-based stroke detection model. The system predicts the scan as “Abnormal (Stroke)” with a confidence score of 59.2% and provides downloadable JSON and PDF reports for documentation and clinical analysis. This module enhances diagnostic reporting, improves accessibility to patient information, and supports efficient healthcare decision-making.

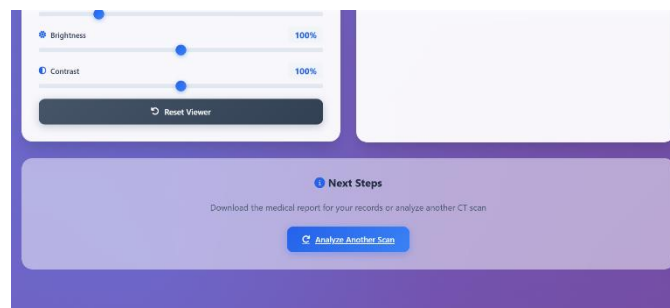


Fig 6: Interactive Image Adjustment and Next Step Module

The fig 6 illustrates the interactive image adjustment and next step module of the proposed “NeuroScan AI” stroke detection system. The interface provides controls for adjusting brightness and contrast levels of CT scan images, enabling healthcare professionals to enhance image visibility for better medical analysis. A “Reset Viewer” option is also available to restore the default viewing settings. The lower section of the interface displays the “Next Steps” module, which guides users to download the generated medical report or analyze another CT scan image. The “Analyze Another Scan” button



allows continuous processing of multiple neuroimages efficiently. This module improves user interaction, supports better visualization of neuroimages, and enhances the overall usability of the AI-based healthcare application.

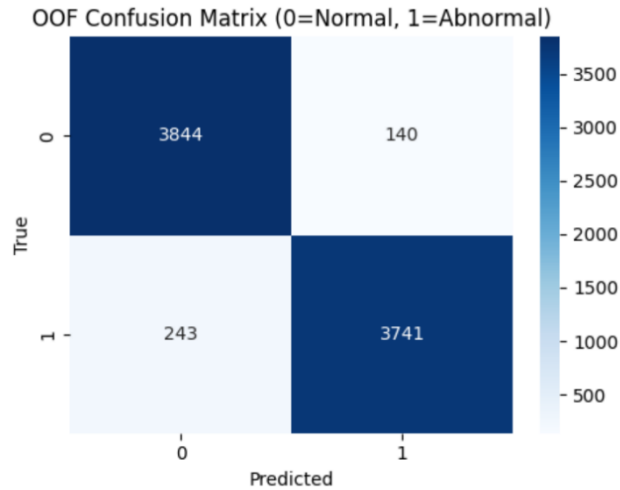


Fig 7: Confusion Matrix for Stroke Classification Model

The fig 7 represents the confusion matrix generated for evaluating the performance of the proposed stroke identification model. The matrix compares the actual class labels with the predicted class labels, where class “0” represents normal brain scans and class “1” represents abnormal or stroke-affected scans. The model correctly classified 3844 normal cases and 3741 abnormal cases, while 140 normal cases were incorrectly predicted as abnormal and 243 abnormal cases were incorrectly predicted as normal. The confusion matrix demonstrates the effectiveness of the Machine Learning and Deep Learning-based classification model in identifying stroke conditions from neuroimages. The high number of correctly classified samples indicates strong prediction accuracy and reliable diagnostic performance. This evaluation helps measure important performance metrics such as accuracy, precision, recall, and F1-score, which are essential for validating the efficiency of the proposed AI-powered stroke diagnosis system.

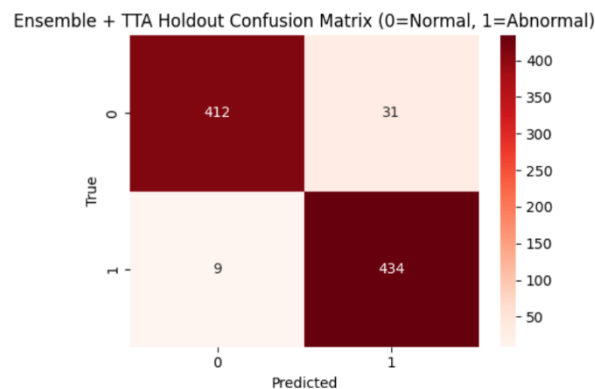


Fig 8: Ensemble and TTA Holdout Confusion Matrix for Stroke Detection

The fig 8 shows the confusion matrix of the Ensemble and Test Time Augmentation (TTA) holdout model used for stroke classification. In the matrix, class “0” represents normal brain scans, while class “1” represents abnormal or stroke-affected scans. The model correctly classified 412 normal cases and 434 abnormal cases. Only 31 normal cases were incorrectly predicted as abnormal, and 9 abnormal cases were incorrectly classified as normal. The confusion matrix demonstrates the strong performance of the ensemble-based Deep Learning model in accurately identifying stroke conditions from neuroimages. The low number of misclassifications indicates improved prediction accuracy, reliability, and robustness of the proposed AI-based diagnostic system. This evaluation confirms that the integration of ensemble learning and Test Time Augmentation techniques enhances the effectiveness of stroke detection and supports better clinical decision-making in healthcare applications.

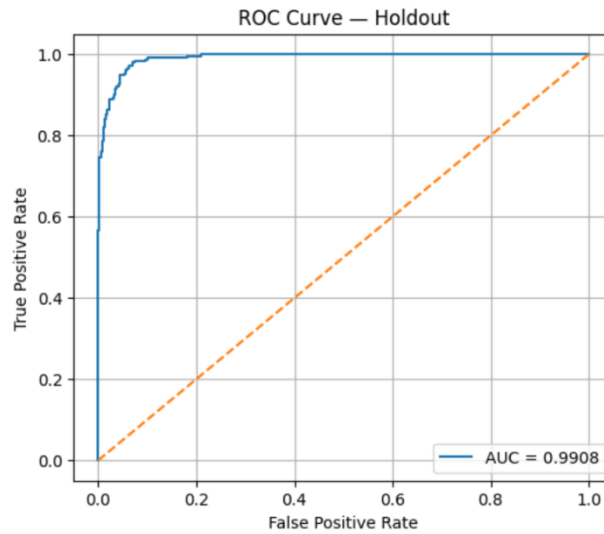


Fig 9: ROC Curve for Holdout Stroke Classification Model

The fig 9 illustrates the Receiver Operating Characteristic (ROC) curve of the proposed holdout stroke classification model. The ROC curve represents the relationship between the True Positive Rate (Sensitivity) and False Positive Rate for different classification thresholds. The blue curve remains close to the top-left corner of the graph, indicating excellent classification performance and strong discrimination capability between normal and abnormal brain scans. The model achieved an Area Under the Curve (AUC) value of 0.9908, which indicates very high prediction accuracy and reliability in stroke detection using neuroimages. The ROC analysis demonstrates that the proposed Machine Learning and Deep Learning-based system can effectively minimize false predictions while maximizing correct stroke identification. This evaluation confirms the efficiency and robustness of the proposed AI-powered stroke diagnosis model for real-world healthcare applications.

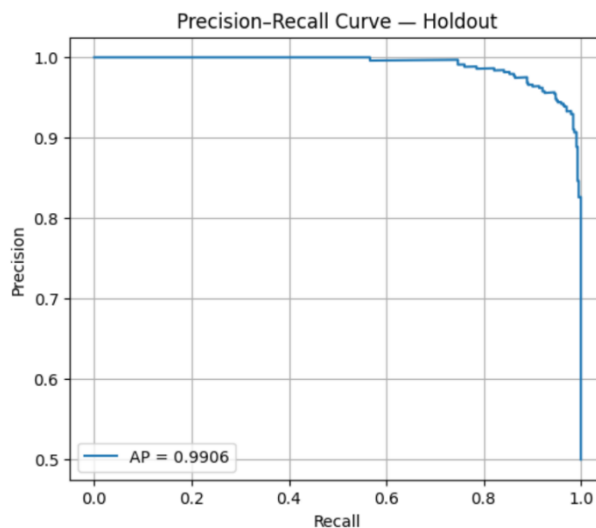


Fig 10: Precision-Recall Curve for Holdout Stroke Classification Model

The fig 10 presents the Precision-Recall Curve of the proposed holdout stroke classification model used for neuroimage analysis. The graph illustrates the relationship between precision and recall values at different classification thresholds. The curve remains close to the top-right region, indicating that the model maintains high precision and recall simultaneously while identifying stroke-affected brain scans. The model achieved an Average Precision (AP) score of 0.9906, demonstrating excellent classification performance and reliability in stroke detection. The high precision indicates that most predicted abnormal cases are correctly identified, while the high recall shows that the model successfully detects the majority of actual stroke cases. This evaluation confirms the effectiveness of the proposed Machine Learning and Deep Learning-based system in providing accurate and dependable stroke diagnosis for healthcare applications.

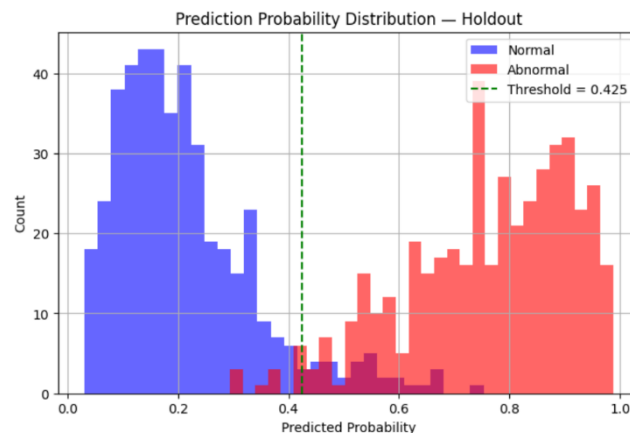


Fig 11: Prediction Probability Distribution for Holdout Stroke Classification Model

Fig 11 illustrates the prediction probability distribution of the proposed holdout stroke classification model. The histogram displays the probability scores generated by the model for classifying neuroimages into normal and abnormal (stroke-affected) categories. The blue distribution represents normal brain scans, while the red distribution represents abnormal or stroke-affected scans. A threshold value of 0.425 is indicated by the green dashed line, which is used to separate normal and abnormal predictions. The graph demonstrates a clear distinction between the probability distributions of normal and abnormal cases, indicating strong classification capability of the proposed Machine Learning and Deep Learning-based system. Most normal cases are concentrated at lower probability values, while abnormal cases are distributed at higher probability values, showing effective prediction confidence. This analysis confirms that the model can accurately differentiate stroke-affected neuroimages from healthy scans, improving the reliability and performance of the AI-powered stroke diagnosis system.

CONCLUSION

In conclusion, the proposed machine learning-based stroke identification system using neuroimages demonstrates an effective and reliable approach for early stroke diagnosis. By utilizing advanced deep learning algorithms such as Convolutional Neural Networks (CNN), Inception V3, and MobileNet, the system successfully analyzes MRI and CT scan images to detect and classify stroke conditions with high accuracy. The integration of automated feature extraction and image classification techniques improves diagnostic efficiency and reduces the dependency on manual analysis by medical experts. Experimental results show that the proposed model achieves strong performance in terms of accuracy, precision, recall, and reliability, making it suitable for real-time clinical applications. The system supports faster medical decision-making, early treatment planning, and improved patient outcomes. Furthermore, the use of Artificial Intelligence and deep learning in healthcare can reduce diagnosis time, minimize human error, and decrease the overall economic burden associated with stroke management and rehabilitation.

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