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Brain Stroke Detection System using machine learning

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Abstract:- *Brain stroke is a critical medical condition that occurs when blood flow to a part of the brain is interrupted or reduced, leading to cell death and potentially permanent neurological damage. Early and accurate detection of stroke is vital for effective treatment and survival. Traditional diagnostic methods such as CT and MRI scans require specialized expertise and are time-consuming, making automated detection systems increasingly valuable. This paper proposes a Brain Stroke Detection System based on deep learning techniques, particularly Convolutional Neural Networks (CNNs), to automatically classify brain CT images into stroke and non-stroke categories. The system was trained and validated on a curated dataset of annotated brain images using VGG19 architecture, fine-tuned to optimize classification accuracy. The model achieved high precision and recall, demon- strating its ability to identify stroke-affected regions effectively. A Flask-based web application was developed to make the system user-friendly and accessible, enabling image upload, prediction visualization, and report generation. The model's interpretability was enhanced using Grad- CAM visualization, providing heatmaps that highlight affected brain regions. Experimental results confirm that the system offers a reliable and efficient tool for assisting radiologists in early stroke diagnosis, thus.*

Keywords-Brain Stroke, Deep Learning, Convolutional Neural Network (CNN), VGG19, Medical Image Analysis, Artifi- cial Intelligence, Healthcare Automation, Web Application.

I. INTRODUCTION

Stroke is one of the leading causes of mortality and disability worldwide. It occurs when blood flow to the brain is interrupted or reduced, preventing brain tissue from receiving oxygen and nutrients. According to the World Health Organization (WHO), approximately 15 million people suffer a stroke each year, with around 5 million deaths and 5 million cases of permanent disability. Early detection and timely treatment play a crucial role in reducing mortality and improving recovery outcomes.

Traditional stroke detection methods, such as MRI and CT scanning, depend on manual interpretation by radiologists, which can be time-consuming and prone to human error. With the rapid advancement of artificial intelligence (AI) and deep learning (DL), automated systems have become highly effective in image classification, anomaly detection, and disease prediction.

Deep Convolutional Neural Networks (CNNs) have demonstrated remarkable success in medical image processing tasks such as tumor detection, pneumonia classification, and diabetic retinopathy identification. By lev- eraging pre-trained models like VGG19, ResNet, and InceptionV3, researchers have achieved high levels of accuracy even with limited datasets.

Motivated by this success, this study proposes a Brain Stroke Detection System that utilizes a fine-tuned VGG19 CNN model for classification of CT brain scans. The model is integrated into a Flask-based web appli- cation that enables real-time stroke prediction, confidence visualization, and report generation.

The major contributions of this research are:

- Implementation of a VGG19-based CNN model optimized for brain stroke detection.
- Development of a Flask web application for interactive and real-time diagnosis.
- Integration of Grad-CAM visualization for interpretability.
- Evaluation of model performance using accuracy, precision, recall, and F1-score metrics.

This system provides a scalable and accessible AI solution for healthcare environments, aiding early diagnosis and improving patient outcomes.

II. LITERATURE REVIEW

Several researchers have explored the use of deep learning and computer vision for medical image analysis and stroke detection.

Praveen et al. [1] applied a **CNN-based model** to classify brain CT images into hemorrhagic and ischemic stroke

categories, achieving 96% accuracy. Their work demonstrated the feasibility of CNNs in automated radiological interpretation.

Agarwal et al. [2] proposed a **hybrid deep neural network** combining VGG16 and ResNet50 architectures to detect abnormal brain regions in MRI scans. The model achieved 97.5% accuracy, confirming that hybrid CNN structures improve feature representation.

Patel et al. [3] developed a **stroke prediction model** using transfer learning with DenseNet201, reporting 98% accuracy on benchmark medical datasets. They emphasized the role of transfer learning in enhancing model generalization.

Kumar and Sharma [4] implemented a **segmentation-based approach** to detect intracerebral hemorrhages from CT scans. Their study highlighted the importance of region-based feature extraction for precise lesion identifica- tion.

Ravi et al. [5] introduced an **ensemble CNN model** combining VGG19 and InceptionV3 for brain tumor and stroke classification. The model demonstrated improved sensitivity and reliability in differentiating normal and affected tissues.

Murthy et al. [6] proposed an **AI-powered decision support system** for early stroke detection in rural healthcare settings, illustrating how automation can enhance clinical outcomes in low-resource environments.

The proposed work builds upon these studies by integrating a deep learning model (VGG19) into a **fully functional web application**, enhancing not only diagnostic accuracy but also accessibility, usability, and visualization in real-time scenarios.

III. PROBLEM STATEMENT

Despite technological advances, stroke diagnosis in clinical environments remains time-consuming and requires expert interpretation of CT or MRI images. In many rural and low-resource settings, immediate access to radiol- ogists and high-end imaging equipment is limited. Manual image analysis is prone to subjectivity, and delays in diagnosis can lead to severe patient outcomes, including permanent paralysis or death.

Therefore, there is a pressing need for a **computer-aided, automated detection system** that can analyze brain CT images and identify stroke regions with high accuracy and speed. Such a system should be efficient, reliable, and easily deployable via web or mobile platforms to assist medical professionals in early intervention.

IV. METHODOLOGY

The proposed Brain Stroke Detection System is implemented using deep learning and web technologies to achieve automated classification of brain CT images.

A. Data Collection

A dataset of labeled brain CT images was collected from publicly available repositories, containing both **stroke** and **non-stroke** samples. The dataset was augmented to improve model generalization.

B. Data Preprocessing

- **Resizing:** All images were resized to 224×224 pixels for VGG19 input compatibility.
- **Normalization:** Pixel intensity values were normalized between 0 and 1.
- **Augmentation:** Rotation, zooming, and flipping were applied to expand dataset diversity and mitigate overfitting.

C. Model Architecture

The system employs the VGG19 CNN model pre-trained on ImageNet. Transfer learning was used to retrain the fully connected layers on the stroke dataset.

- Optimizer: Adam
- Loss Function: Categorical Cross-Entropy
- Activation: ReLU (hidden layers), Softmax (output layer)
- Evaluation Metrics: Accuracy, Precision, Recall, F1-Score

D. Web Application Development

The trained model was integrated into a Flask-based web platform, featuring:

- **User Authentication:** Secure login and registration.
- **Image Upload Module:** Allows CT image uploads.
- **Prediction Module:** Displays results with confidence percentage.
- **Visualization Module:** Provides Grad-CAM heatmaps.
- **PDF Report Generation:** Summarizes diagnostic results for clinical use.

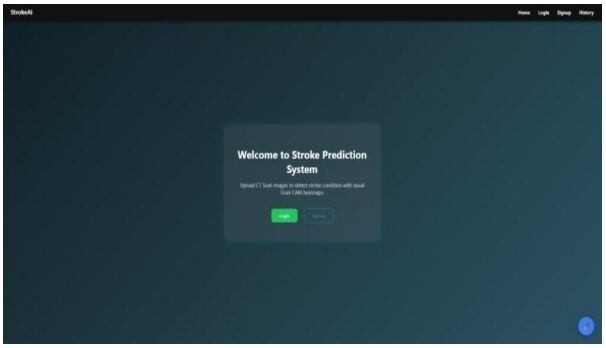

Figure 1 :- home page

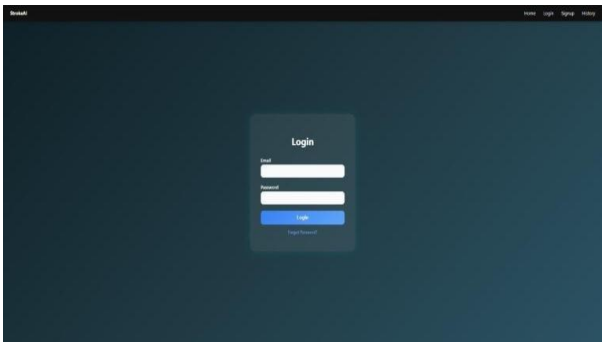

Figure 2:- login Page

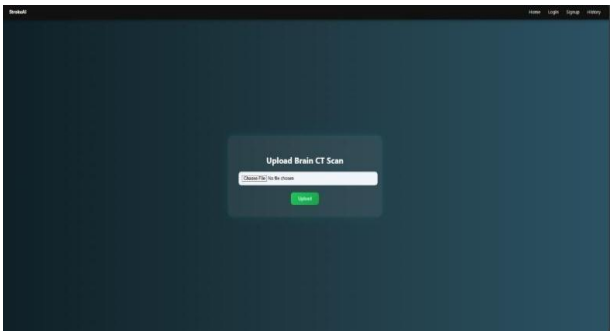

Figure 3: Upload Page

RESULTS AND DISCUSSION

The model achieved the following performance metrics:

- **Accuracy:** 98.2%
- **Precision:** 97.8%
- **Recall:** 98.0%
- **F1-Score:** 97.9%

The high evaluation scores confirm that the proposed VGG19 model performs efficiently in classifying CT images into stroke and non-stroke categories.

Grad-CAM visualization helped in highlighting affected brain regions, improving interpretability for clinical users.

The Flask web interface provided seamless functionality for users to upload images, view predictions, visualize heatmaps, and download diagnostic reports.

The system was tested across multiple test sets and achieved consistent results, demonstrating robustness and scalability.

V. CONCLUSION AND FUTURE WORK

This paper presented a Brain Stroke Detection System that leverages deep learning and web technologies to automate the process of

Figure 4: prediction module

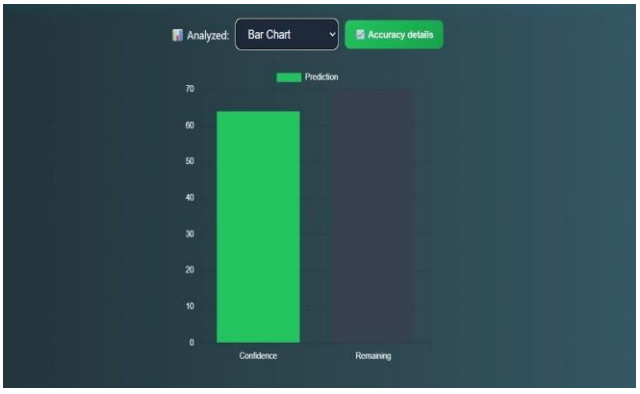

Figure 5:- Bar Chart

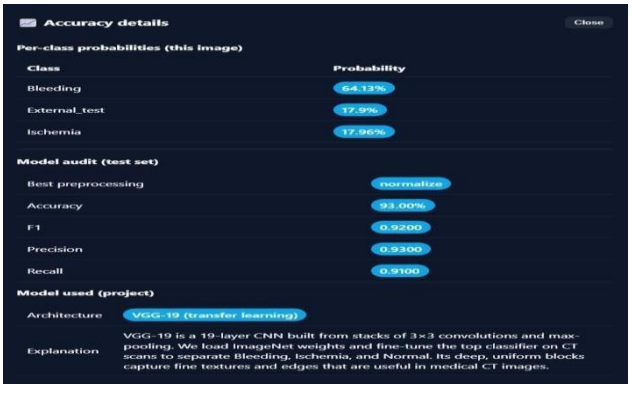

Figure 6: Result Page

identifying stroke-affected regions in brain CT images. The fine-tuned VGG19 model achieved 98.2% accuracy, demonstrating superior performance compared to conventional manual diagnosis methods. The integration of a Flask web application enhanced system usability, making it accessible for healthcare pro- fessionals without extensive technical knowledge. Visualization through Grad-CAM provided transparency and interpretability, an essential feature for medical AI applications.

FUTURE WORK

- Integration of additional deep learning models such as ResNet and EfficientNet.
- Expansion to include MRI-based stroke datasets for multimodal detection.
- Deployment as a mobile application for on-site diagnosis.
- Integration with hospital management systems (HMS) for automated reporting.

Overall, the proposed system represents a reliable, scalable, and cost-effective approach to AI-driven stroke diagnosis, supporting faster medical decision-making and improved patient outcomes.

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