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Neuro Vision: Deep Learning-Based Brain Tumor Identification

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Abstract

Early and accurate identification of brain tumours from MRI images is essential to prevent severe and life-threatening conditions. The complex nature of brain tissues makes tumour detection, segmentation, and classification a challenging process. Tumour differ in size, shape, texture, and position, which reduces the accuracy of traditional detection methods. In this paper, a deep learning-based system is introduced using Convolutional Neural Networks (CNNs) for automatic brain tumour analysis. Image enhancement techniques such as Denoising Wavelet Transform (DWT) and Diffusion Tensor Imaging (DTI) are applied to improve image clarity and feature extraction. The use of multimodal MRI scans provides detailed structural information, leading to better tumour segmentation and classification. The proposed system improves diagnostic accuracy and supports doctors in making faster and more dependable clinical decisions.

Keywords: Convolutional Neural Networks; Tumor Cells; Denoising Wavelet Transform; Diffusion Tensor Imaging; Naive Bayes Classifier.

How to Cite This Article

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Introduction

In today's healthcare system, early and correct diagnosis plays a very important role in providing effective treatment and improving patient survival. Among many serious diseases, brain tumors are one of the most critical and challenging medical conditions. They are complex in nature and can become life-threatening if not detected at the right time, making accurate diagnosis extremely important. Brain tumors can be of different types, ranging from non-cancerous (benign) to highly cancerous (malignant). Each type requires a different treatment approach. Any delay in detection or incorrect classification of the tumor may lead to serious complications and can negatively affect the patient's recovery and overall health condition. With the advancement of technology, the combination of medical science and artificial intelligence has created new opportunities to improve brain tumor diagnosis. Deep learning, which is a part of artificial intelligence, has shown excellent performance in analyzing medical images. Convolutional Neural Networks (CNNs), in particular, are highly effective in processing MRI images and identifying important patterns that may not be easily visible to the human eye.

This paper focuses on using deep learning techniques to detect brain tumors at an early stage using medical imaging data. By designing and training a CNN-based model specifically for brain MRI images, the system aims to automatically identify the presence of tumors with high accuracy. The main objective of this project is to develop a fast, reliable, and accurate brain tumor detection system that can assist doctors in early diagnosis, speed up treatment decisions, improve patient outcomes, and reduce the workload on healthcare professionals.

Literature Review

Lakshmi & Rao (2023) conducted a comprehensive study on brain tumor detection and classification using intelligent techniques based on MRI images. Their approach mainly focused on the use of Convolutional Neural Networks (CNNs) for automatic tumor classification. The process included several stages such as image preprocessing to remove noise and improve image quality, feature extraction to identify important tumor characteristics, and classification of tumors into different categories. The model was trained and evaluated using standard publicly available MRI datasets, which helped in validating the effectiveness of the approach. The results demonstrated that CNN-based methods provide better accuracy compared to traditional techniques.

Asiri, Toufique Ahmed Soomro, Ahmed Ali Shah, et al. (2024) proposed an optimized dual-module approach for brain tumor detection using MRI images. The first module focuses on MRI image enhancement to improve image quality and highlight tumor regions, which helps in better feature extraction. In the second module, the enhanced images are classified using a Support Vector Machine (SVM) to identify the presence and type of brain tumor. The proposed method showed improved classification performance due to effective image enhancement. However, the system requires high computational resources, which may limit its practical implementation. Additionally, the approach depends on standardized MRI datasets for consistent performance, and the accuracy of SVM classification may decrease when tumors have irregular shapes or complex boundaries.

Ayesha Jabbar et al. (2023) proposed a hybrid deep learning model called Caps-VGGNet for brain tumor detection and multi-grade segmentation. This model combines the strengths of Capsule Networks (CapsNet) and VGGNet to improve the accuracy of tumor detection and classification. The study used MRI images from the BraTS-2019 and BraTS-2020 datasets. Before training the model, several preprocessing steps were applied, including image normalization, skull stripping, and data augmentation to enhance image quality and increase dataset diversity. The hybrid model showed improved performance in tumor detection and segmentation. However, the approach requires high computational time and resources. Additionally, it depends on large, well-annotated datasets for effective real-world application and may face challenges in detecting very small tumors or rare tumor categories.

Pankaj Sapra, Rupinderpal Singh, and Shivani Khurana (2023) presented a neural network-based approach for brain tumor detection using MRI images. In their method, image segmentation techniques were applied to identify the tumor region from MRI scans. After segmentation, a neural network model was used to classify the tumor by learning patterns from the extracted image features. The approach demonstrated effective tumor detection when clear MRI images were used. However, the model's performance was highly dependent on the quality of preprocessing, and the presence of noise significantly reduced accuracy. Additionally, the method performed well mainly on high-contrast MRI images and showed limited robustness for low-quality scans. Due to the use of a small dataset, the model's accuracy may not generalize well to real-world clinical environments.

Methodology

The proposed methodology for Neuro Vision: Deep Learning-Based Brain Tumor Identification is based on a deep learning framework that utilizes Convolutional Neural Networks (CNNs) for automated brain tumor detection and classification from MRI images. Initially, MRI scans are collected and subjected to preprocessing techniques to improve image quality and enhance important structural details. Denoising

Wavelet Transform (DWT) is applied to remove noise and preserve critical image information, while Diffusion Tensor Imaging (DTI) improves tissue representation and supports better feature extraction. The preprocessed multimodal MRI images are then passed through the CNN model to automatically learn tumor-related features and identify complex patterns associated with brain abnormalities. Feature extraction enables effective differentiation between normal and tumor regions, followed by classification to determine tumor presence. The developed system generates prediction outputs through an analysis interface, supporting faster and more reliable diagnosis for clinical decision-making while improving detection accuracy and reducing manual intervention.

System architecture

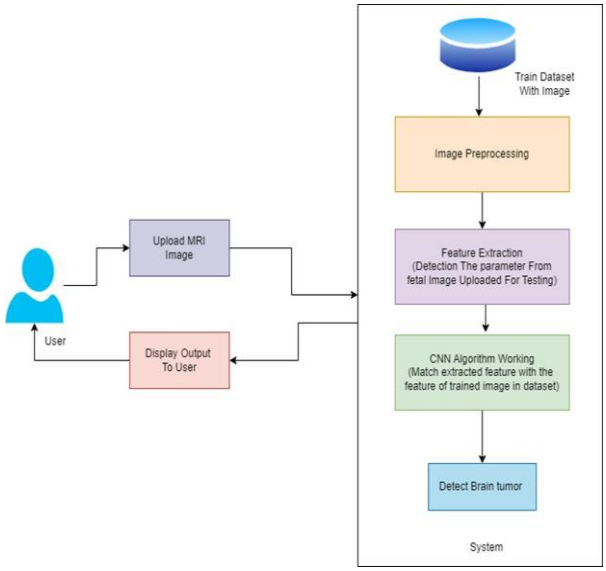

Fig 1. *System Architecture*

Result

The proposed Neuro Vision system was evaluated using MRI images to identify and classify brain tumors through a CNN-based detection framework. The implemented model successfully processed uploaded MRI scans through multiple stages including image selection, preprocessing, feature extraction, and final prediction generation. The preprocessing stage improved image clarity and reduced noise, enabling more accurate feature learning during classification. The developed interface demonstrated successful operation through login, registration, image upload, and prediction modules. During analysis, the system produced three possible outputs: Tumor Detect, No Tumor, and Invalid Data, depending on the uploaded MRI image quality and classification outcome. The CNN model effectively identified tumor regions from MRI scans and demonstrated improved detection capability by utilizing enhanced imaging inputs. The obtained results indicate that the proposed framework supports automated and reliable brain tumor identification, reduces manual diagnostic effort, and assists healthcare professionals in making faster and more informed clinical decisions.

1.Start-Image

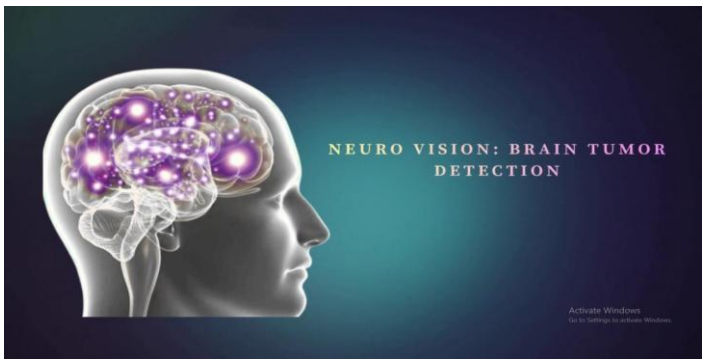

Fig. 2. *Start Image*

2. Login/Sign-Up Page

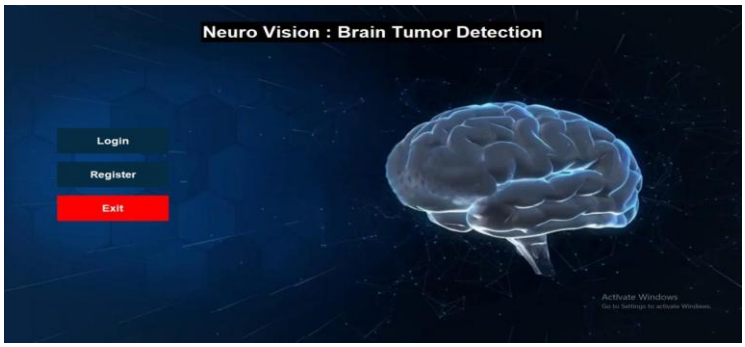

Fig. 3. *Login/Sign-Up Page*

3. Login Page

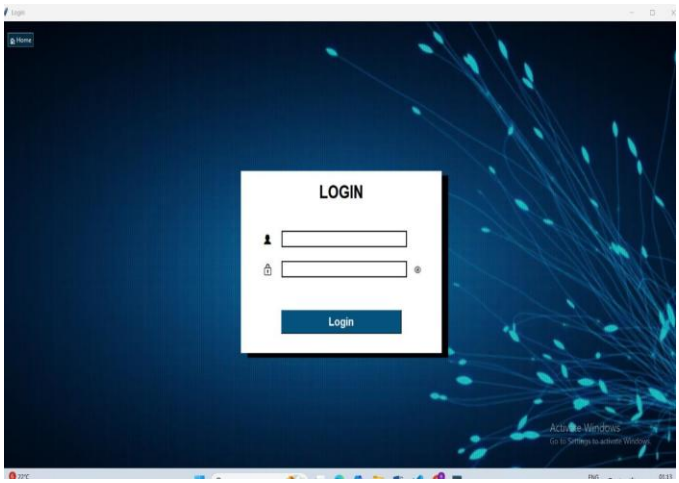

Fig. 4. *Login Page*

4. Register Page

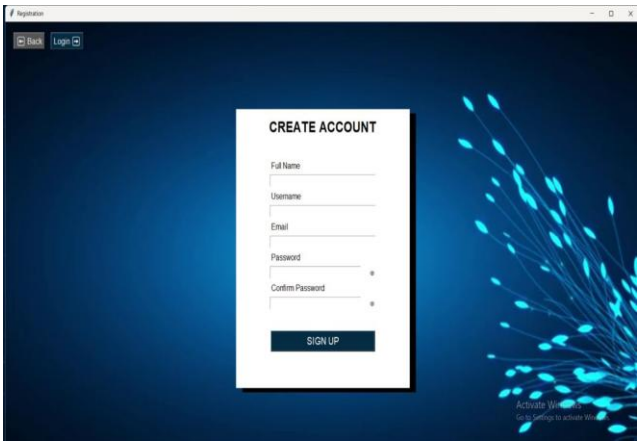

Fig. 5. *Register Page*

5. Prediction/Analysis Page

a. Selecting Image

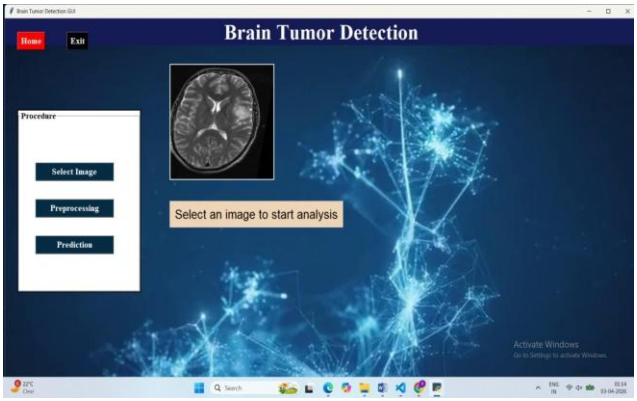

Fig. 6. *Prediction and Analysis Page*

b. Pre-processing Image

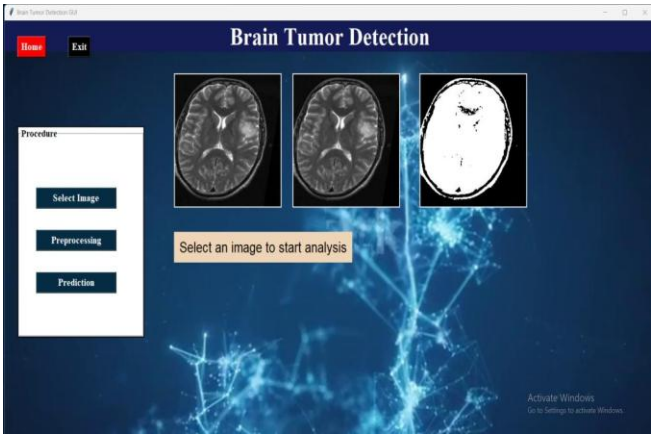

Fig. 7. *Image Selection Module*

c. Result

Tumor Detect

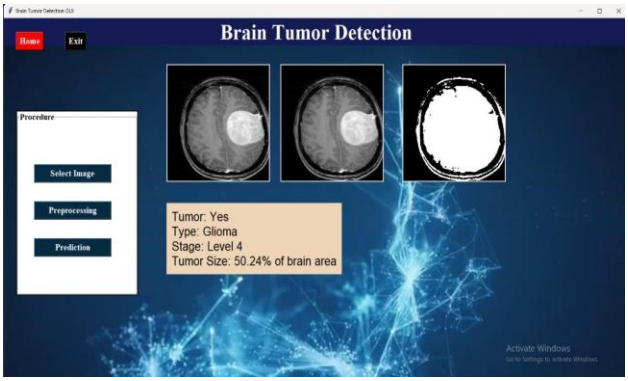

Fig. 8. *Image Preprocessing Output*

No Tumor

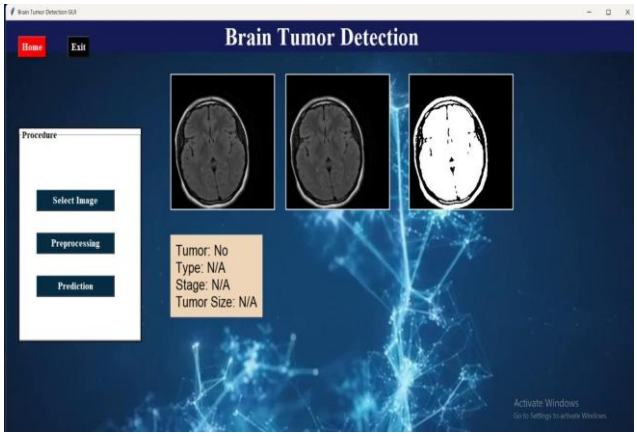

Fig. 9. *Tumor Detection Result (No Tumor)*

Invalid Data

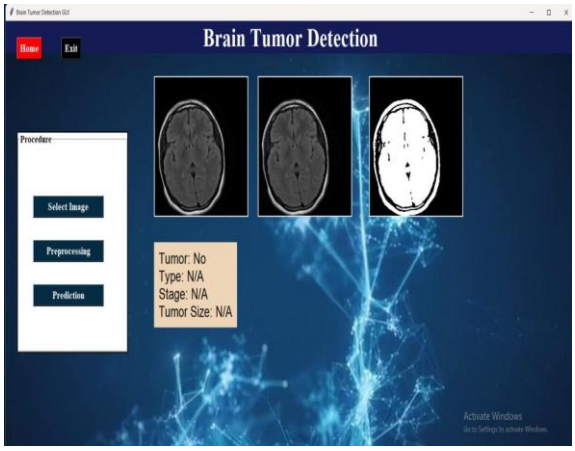

Fig. 9. *Tumor Detection Result (Invalid Data Output)*

Conclusion and future work

This system presents a CNN-based approach for brain tumor detection, which classifies tumors into three regions: whole tumor, core tumor, and enhancing tumor. It extracts important features such as intensity, intensity difference, neighborhood information, and wavelet features from multi-modal MRI scans, which helps the model learn more accurately. The CNN classifier has improved detection and classification performance, achieving results that are comparable to or better than existing methods. For future improvements, the model can combine multiple imaging modalities like MRI, CT, and functional scans to increase accuracy, use transfer learning to benefit from pre-trained models on large datasets, and implement techniques to make the model's decisions more explainable for clinicians. Additionally, automated and precise tumor segmentation can be developed to delineate tumor boundaries better, while optimizing the system for real-time processing and edge devices can make diagnosis faster and more accessible. Integrating the system with electronic health records can provide a holistic patient history, supporting better-informed diagnosis and treatment planning, ultimately making brain tumor detection more accurate, efficient, and reliable

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