

Brain Tumor Identification and Classification of MRI Images Using Deep Learning Techniques

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Abstract - Brain tumor detection from Magnetic Resonance Imaging (MRI) is a critical task in medical diagnosis, as early identification can significantly improve treatment outcomes. This paper presents a Brain Tumor Identification and Classification System using deep learning techniques implemented on a Raspberry Pi platform. A USB camera module is used to capture MRI scan images, which are then processed using a trained YOLO (You Only Look Once) deep learning model to detect the presence or absence of a brain tumor. The classification result is displayed on an LCD screen with visual and audio alerts provided via LEDs and a buzzer. The proposed system offers a compact, cost-effective, and portable solution for preliminary brain tumor screening, suitable for educational, research, and assistive diagnostic applications. The system achieved confidence scores of 0.93–0.94 for normal brain classification and approximately 0.73 for tumor detection.

Key Words: Brain Tumor Detection, MRI, Deep Learning, YOLO, Raspberry Pi, Real-Time Detection.

1. INTRODUCTION

Brain tumor detection from Magnetic Resonance Imaging (MRI) plays a vital role in modern medical diagnostics, as timely and accurate identification significantly enhances treatment planning and patient survival rates. MRI provides high-resolution images of brain tissues, enabling detailed analysis of abnormalities such as tumors. However, manual examination of MRI scans by radiologists can be time-consuming and subject to human error, especially when dealing with large volumes of medical data.

With the advancement of Artificial Intelligence (AI) and Deep Learning, automated systems have emerged as powerful tools for improving diagnostic accuracy and efficiency. YOLO (You Only Look Once) is a powerful real-time object detection algorithm capable of identifying and localizing abnormalities within images in a single forward pass. This project focuses on developing

a Brain Tumor Identification and Classification System using YOLO-based deep learning deployed on a Raspberry Pi platform, integrated with hardware components such as a camera module, LCD display, LEDs, and buzzer for real-time feedback.

2. LITERATURE SURVEY

Several studies have explored the application of deep learning for brain tumor detection and classification. A comprehensive 2025 review examined ML and DL approaches including CNNs, RNNs, GANs, vision transformers, and ensemble learning methods, highlighting the significant progress in automated brain tumor diagnosis. The review addressed evaluation metrics, preprocessing techniques, and publicly available datasets, and identified future research directions for robust AI-based solutions [1].

MRI-based brain tumor detection using convolutional deep learning and machine learning approaches was proposed in 2023, where multiple DL and ML models were evaluated for diagnosing three tumor types—glioma, meningioma, and pituitary tumors—alongside healthy brains, achieving high accuracy in early-stage detection [2].

A 2025 systematic review on deep learning-based brain tumor segmentation using MRI analyzed a wide range of DL models chronologically, discussed their strengths and limitations, and highlighted dataset details and simulation tools, providing a comprehensive reference for future research [3].

3. EXISTING SYSTEM

Existing brain tumor detection systems typically rely on manual MRI image analysis by radiologists or traditional image processing techniques. Classical approaches use basic CNNs, Support Vector Machines (SVM), and K-Nearest Neighbors (KNN). These methods require extensive preprocessing—including noise removal, skull stripping, resizing, normalization, and contrast

enhancement—followed by feature extraction before classification.

3.1 Disadvantages of Existing System

The major drawbacks include: (i) dependence on manual radiologist analysis leading to human error; (ii) slow multi-stage processing; (iii) high computational requirements; (iv) lower accuracy for complex or small tumors; (v) lack of real-time detection capability; and (vi) poor portability, restricting deployment on embedded devices.

4. PROPOSED SYSTEM

4.1 System Architecture

The proposed system uses a Raspberry Pi as the central processing unit to perform brain tumor identification and classification from MRI images using YOLO-based deep learning. The system architecture integrates the following components:

- Power Supply:** Provides regulated DC power to all components.
- Raspberry Pi:** Core controller running the pre-trained YOLO model. Features a Broadcom BCM2835 SoC with ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and 512 MB RAM.
- USB Web Camera:** Captures MRI images for real-time processing.
- YOLO Deep Learning Model:** Performs single-stage detection and classification with high speed and accuracy.
- I2C LCD Display (16x2):** Displays results ("Tumor Detected"/"No Tumor") with confidence scores.
- Green LED:** Illuminates when a brain tumor is detected

The proposed architecture includes the following key components working in an integrated manner:

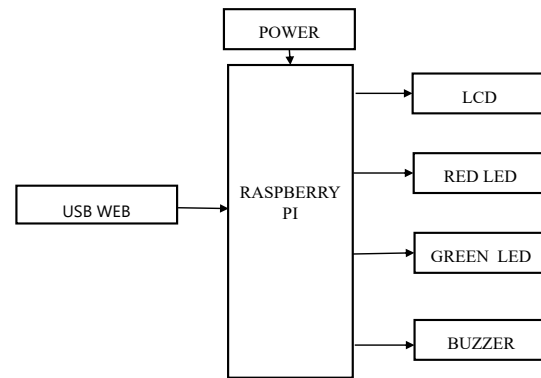


Fig .4.1: Block Diagram of Proposed System

The proposed system is designed to automatically detect and classify brain tumors from MRI images using deep learning techniques. It utilizes a Raspberry Pi as the central processing unit, making the system compact, portable, and cost-effective. The system integrates both hardware and software components to provide real-time and accurate results. An MPU camera module is connected to the Raspberry Pi to capture MRI images, while stored images can also be used for analysis. The captured or loaded image undergoes preprocessing steps such as resizing and normalization to make it suitable for the deep learning model.

The system employs a YOLO (You Only Look Once) deep learning algorithm, which is capable of detecting and classifying tumor regions in real time. The model analyzes the MRI image and identifies whether a tumor is present or not, along with confidence scores.

The output of the system is displayed on a 16×2 LCD screen, providing clear information such as “Tumor Detected” or “No Tumor.” For better user interaction, the system includes an alert mechanism using LEDs and a buzzer. A green LED glows when a tumor is detected, while a red LED indicates normal condition, and a buzzer provides an alert for immediate attention.

The entire process is automated, requiring minimal human intervention. The system ensures quick response time, making it suitable for real-time applications. Due to its portability and low cost, it can be used in remote areas where advanced medical facilities are not easily available.

Overall, the proposed system combines deep learning, computer vision, and embedded systems to provide an efficient, accurate, and user-friendly solution for preliminary brain tumor detection.



Fig. 4.2: Working Model of the Proposed System

The working model of the proposed system explains the complete process of brain tumor detection using both hardware and software components. Initially, the system is powered on, and the Raspberry Pi initializes all connected components such as the camera module, LCD display, LEDs, and buzzer. At the same time, the trained YOLO deep learning model is loaded into the system memory to prepare for image analysis.

Once the system is initialized, MRI images are acquired either by capturing them through the camera module or by loading pre-stored images from the system. The acquired image is then passed to the preprocessing stage, where it is resized, normalized, and converted into a suitable format required by the deep learning model. This step ensures that the input image is consistent and improves the accuracy of the detection process.

After preprocessing, the image is fed into the YOLO deep learning model, which analyzes the image to detect the presence of a brain tumor. The model identifies abnormal regions by drawing bounding boxes and provides confidence scores indicating the probability of tumor presence. Based on this analysis, the system classifies the image as either "Tumor Detected" or "No Tumor."

Following the classification, the result is displayed on the LCD screen in a clear and user-friendly format. If a tumor is detected, the system activates the green LED and triggers the buzzer to alert the user. If no tumor is detected, the red LED glows, indicating a normal condition, and the buzzer remains inactive.

The entire process is automated and operates in real time, allowing the system to continuously analyze new images if required. This integration of deep learning with embedded hardware ensures fast, accurate, and efficient brain tumor detection, making the system suitable for practical healthcare applications, especially in remote and resource-limited areas.

ADVANTAGES

- Accurate
- Portable
- Automated
- Efficient

APPLICATIONS

- Hospitals
- Clinics
- Telemedicine
- Research
- Training

5. RESULTS AND DISCUSSIONS

The implementation integrates Raspberry Pi, camera module, LCD display, LEDs, and buzzer with the YOLO model. The system supports both live image capture and file-based MRI input. Python scripts manage image acquisition, preprocessing, model inference, and output control through GPIO pins. Software tools used: Python (core programming), OpenCV (image processing), YOLO Ultralytics (object detection), Raspberry Pi OS tools (hardware interfacing), and VS Code (development environment). Performance parameters evaluated include: Accuracy (correct detection of tumor presence), Processing Time (time taken for detection), Response Time (speed of alert generation), System Efficiency (overall performance on Raspberry Pi), and False Detection Rate (incorrect predictions).

5.2 System Flowchart

The system flowchart represents the complete operational process: START → Initialize Components → Load YOLO Model → Select Input (PATH/LIVE) → Acquire Image → Preprocess → YOLO Detection → Decision (Tumor/No Tumor) → Output (Green/Red LED + Buzzer + LCD Display) → STOP. The system continuously loops for real-time monitoring.

5.3 Results

The results demonstrate that the proposed system effectively performs brain tumor detection and classification in real time. For normal brain MRI images, the system correctly classified the scan as "Normal" with a high confidence score of 0.93–

0.94, activating the red LED and displaying the result on the LCD. The buzzer provided audio notification to the user for brain tumor MRI images, the YOLO model successfully detected tumor-affected regions by drawing bounding boxes around suspected areas with confidence scores up to 0.73. Multiple bounding boxes were generated for different suspected regions within the same image. Upon detection, the green LED illuminated and the buzzer activated, while the LCD displayed "Brain Tumor" with the corresponding confidence value. The system demonstrated low latency from image input to result output, confirming the feasibility of deploying deep learning models on embedded systems. The integration of visual (LED) and audio (buzzer) alerts enhanced real-time usability, making the system particularly suitable for resource-constrained environments.

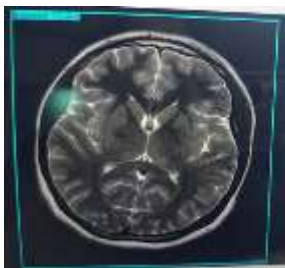


Fig. 5.1: Image for Normal Brain MRI.

Furthermore, the results confirm that the system operates with high accuracy, reliability, and efficiency. The ability to achieve accurate predictions on a compact device like Raspberry Pi highlights the feasibility of deploying deep learning models in embedded systems.



Fig. 5.2: Output Display for Normal Brain MRI

Overall, the obtained results validate that the proposed system is capable of performing automated, real-time brain tumor detection with high precision. It successfully combines artificial intelligence with embedded hardware to deliver a portable, cost-effective, and user-friendly solution, making it suitable for preliminary diagnosis and use in remote or resource-limited areas.

The results clearly demonstrate that the proposed system successfully detects the presence of a brain tumor using the YOLO-based deep learning model deployed on

the Raspberry Pi. The system efficiently processes the MRI image and accurately identifies abnormal regions associated with tumor growth.

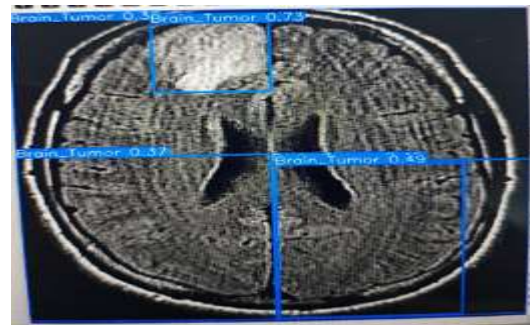


Fig. 5.3: Image for Brain Tumor MRI

6. CONCLUSION AND FUTURESCOPE

6.1 Conclusion

The Brain Tumor Identification and Classification System demonstrates the effective integration of Deep Learning with embedded hardware for automated MRI analysis. By deploying the YOLO model on a Raspberry Pi, the system proves that advanced medical image processing can be implemented on a compact, low-cost, and portable platform without compromising functional capability. The system is not intended to replace professional clinical diagnosis but serves as a valuable assistive tool for preliminary screening, educational purposes, and research applications.

6.2 Future Scope

Future enhancements include: (i) multi-class tumor classification to identify different tumor types (glioma, meningioma, pituitary); (ii) integration with cloud platforms and mobile/web-based interfaces for remote monitoring and telemedicine; (iii) GPU acceleration or edge AI devices for improved processing speed; (iv) 3D MRI analysis for volumetric tumor assessment; and (v) integration with hospital management systems with patient data management and automated report generation.

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