Brain Tumor Detection Using ML

[1]Prof. Mrs. Swati Ambi, [2]Amarjeet Pawar, [3]Rajat Salokhe, [4]Satyam Hindule, [5]Aqib Naikwade

Department of Computer Science,

D. Y. Patil College of Engineering and Technology, Kasaba Bawada, Kolhapur, Maharashtra, India

Abstract:

This research presents a machine learning-based system for automated brain tumor detection using MRI scans. Utilizing deep learning, specifically Convolutional Neural Networks (CNNs), the system enhances diagnostic accuracy through image preprocessing, feature extraction, and classification. Designed to assist healthcare professionals, it improves efficiency, reduces manual errors, and facilitates early intervention. Performance is evaluated using key metrics, demonstrating high accuracy. Future enhancements include improved classification, dataset expansion.

1. INTRODUCTION:

The human body is composed of billions of cells, which typically grow and divide in a regulated manner. However, when this growth becomes uncontrollable, an abnormal mass of cells forms, leading to the development of tumors. While CT and MRI scans aid in diagnosis, manual analysis can be time-consuming and error-prone. This study proposes a machine learning-based system for automated brain tumor detection and classification, utilizing medical image processing, pattern analysis, and computer vision techniques. By applying preprocessing, segmentation, and feature extraction, the system enhances diagnostic accuracy, sensitivity, and specificity. It aims to reduce healthcare costs by minimizing the need for invasive procedures like biopsies. Leveraging state-of-the-art machine learning, this research contributes to improving automated medical diagnostics and advancing brain tumor detection techniques.

2. OBJECTIVE:

The primary objective of this research is to develop an automated system for brain tumor detection that focuses on enhancement, segmentation, and classification of tumors using advanced computational techniques. Designed for clinical applications, the system aims to assist neurosurgeons and healthcare specialists by providing specialized functionalities that enhance diagnostic precision and efficiency. By integrating image processing, pattern analysis, and computer vision techniques, the proposed system is expected to improve the sensitivity, specificity, and overall accuracy of brain tumor screening. This will not only aid in early detection but also reduce the need for invasive diagnostic procedures, ultimately contributing to better patient outcomes and optimized healthcare processes.

3. PROBLEM STATEMENT:

The study aims to develop an automated system for detecting and classifying brain tumors using MRI scans and system will also identify the presence of tumors and accurately classify them as either malignant or benign, thus aiding in early diagnosis and treatment planning.

4. LITERATURE REVIEW:

[1] M. J. Lakshmi and S. N. Rao (2021) investigated the use of deep learning for brain tumor classification. Their study highlights that supervised learning methods can generate feature maps by applying kernels to MRI images. While deep learning models enable automatic feature extraction, they require complex model architectures, hyperparameter tuning, large datasets, and significant computational resources. To address data limitations, researchers have employed augmentation techniques such as resizing, rotation,

scaling, and transformation. Additionally, transfer learning, which uses pre-trained neural networks, has been found useful in extracting relevant features from specialized datasets.

[2] Munagalapalli Thanuj and Panidapu Ravi Teja (2021) emphasized the importance of early brain tumor detection in improving patient outcomes. Their research explored deep learning approaches, particularly Convolutional Neural Networks (CNNs), to analyze medical images efficiently. The study evaluated the performance of different models on various datasets and demonstrated that deep learning can assist radiologists in accurately diagnosing brain tumors. This approach supports timely treatment planning and enhances clinical decision-making.

[3] Shubhangi Solanki and Uday Pratap Singh (2021) discussed the challenges of brain tumor detection,

including variations in tumor location, size, and structure. Their study reviewed the role of computational intelligence and statistical image

processing in identifying brain tumors using MRI scans. The authors provided an overview of various machine learning (ML), deep learning (DL), and transfer learning (TL) models. The paper also covered different dataset types, augmentation techniques, and feature extraction methods. The study concluded with an analysis of the advantages, limitations, and future trends in tumor detection research.

[4] Agarwal et al. (2021) proposed an automated system for early brain tumor diagnosis and classification. Their model included an Auto Contrast Enhancer to improve MRI image quality, followed by a tumor detection and classification module. The system used deep transfer learning, incorporating a pre-trained Inception V3 model for enhanced accuracy. Compared to models such as AlexNet, VGG-16, DenseNet-201, VGG-19, GoogLeNet, and ResNet-50, the proposed system achieved a high accuracy of 98.89% on MRI datasets with varying contrast and brightness. The study demonstrated the effectiveness of deep learning in achieving precise tumor detection and classification.

5. METHODOLOGY:

The proposed methodology for brain tumor detection and classification using machine learning consists of multiple stages, including data acquisition, preprocessing, feature extraction, model training, and evaluation. The system is designed to enhance diagnostic accuracy and efficiency by leveraging advanced image processing and deep learning techniques.

1. **Data Acquisition** – MRI scan datasets are collected from publicly available sources and medical institutions. These datasets contain images labeled as benign or malignant, providing a foundation for training and validation.
2. **Preprocessing** – To improve image quality and ensure consistency, preprocessing techniques such as noise reduction, image resizing, normalization, and contrast enhancement are applied. Data augmentation methods like rotation, flipping, and scaling are used to increase dataset diversity.
3. **Segmentation** – Image segmentation techniques, including thresholding and region-based segmentation, are used to isolate the tumor region from the MRI scans. This step enhances the accuracy of tumor identification and feature extraction.
4. **Feature Extraction** – Convolutional Neural Networks (CNNs) are employed to automatically extract relevant features from MRI scans. These features include shape, texture, and intensity, which are critical for distinguishing between different tumor types.
5. **Classification** – A deep learning model, primarily based on CNN architecture, is trained to classify brain tumors as benign or malignant. The model undergoes iterative training using labeled MRI images, optimizing its parameters to improve classification accuracy.
6. **Evaluation and Performance Analysis** – The trained model is tested on a separate dataset to evaluate its performance using metrics such as accuracy, precision, recall, and F1-score. A confusion matrix is used to assess misclassification rates, ensuring the model's reliability in real-world applications.
7. **Deployment and Future Enhancements** – The developed system is designed for integration into clinical workflows, providing neurosurgeons and radiologists with an efficient diagnostic tool. Future improvements include refining model interpretability using explainable AI techniques, expanding datasets, and optimizing the user interface for better accessibility.

6. MODELING AND ANALYSIS

Model architecture

The proposed automated brain tumor detection and classification system is based on deep learning and medical imaging techniques to achieve high accuracy in tumor identification. The system utilizes VGG19, a deep convolutional neural network (CNN) known for its ability to extract detailed features from MRI scans. Along with this, Canny Edge Detection helps highlight tumor boundaries and improving model precision.

The input MRI images are first preprocessed using resizing, normalization, and augmentation techniques to enhance learning. The processed images are then fed into the VGG19 model, which extracts hierarchical features through multiple convolutional layers. The final fully connected layer classifies the images into malignant or benign cases, while a confidence score helps assess the need for further medical evaluation.

Training and Evaluation

The model was trained using a dataset containing over 1,400 brain tumor MRI images, ensuring a diverse set of cases. Adam optimizer was used to fine-tune model weights, and binary cross-entropy was employed as the loss function. The model was trained for 10 epochs, allowing it to generalize well to unseen cases.

Table 5.1 Values and Parameters

Parameter	Value
Dataset Size	1,400+ images
Model Used	VGG19
Training Epochs	10
Optimizer	Adam
Loss Function	Binary Cross-Entropy
Accuracy Achieved	98.83%

7. RESULTS AND DISCUSSION

The effectiveness of the proposed automated brain tumor detection system was evaluated using a dataset of over 1,400 MRI images, consisting of both malignant and benign cases. The system was trained for 10 epochs, ensuring that the model learned significant features for accurate classification.

Model Performance

The system was tested on unseen MRI scans, achieving an accuracy of 98.83% using VGG19. The model's high performance demonstrates its ability to detect tumors with minimal false positives and false negatives. To validate the results, comparisons were made with other models, including CNN (PyTorch), ResNet-50, and CNN (TensorFlow), where VGG19 consistently outperformed them in accuracy and robustness.

Table 2. Model Tested and Accuracy

Model	Accuracy (%)
CNN (PyTorch)	82.94
ResNet-50	96.25
CNN (TensorFlow)	96.44
VGG19	98.83

This study demonstrates that VGG19, in combination with preprocessing and texture analysis techniques, provides a highly effective approach for brain tumor detection and classification.

8. CONCLUSIONS:

The brain tumor detection system developed using machine learning demonstrates the effectiveness of deep learning models in medical image classification. By preprocessing MRI images and employing robust techniques like data augmentation and train-test splitting, the system achieves promising accuracy in distinguishing between healthy and tumor-affected images. The integration of PyTorch libraries for model development and training underscores the potential of modern machine learning frameworks in addressing critical healthcare challenges. This project highlights the importance of automation in medical diagnostics, offering a tool that can aid healthcare professionals in early detection and treatment planning.

9. FUTURE WORK:

1. **Improve Model Accuracy:**

Experiment with advanced pre-processing techniques, to enhance MRI image quality. Use data augmentation methods, like rotation, flipping, and noise injection, to increase dataset diversity and improve model generalization.

2. **Explainability of Predictions:**

Incorporate explainable AI techniques, to visualize the areas of the MRI image contributing to the model's decision-making.

3. **Dataset Expansion:**

Continuously update the dataset by integrating publicly available MRI datasets. Collecting datasets from healthcare institutes and labs and ensure data quality, compliance with regulations, and ethical handling.

10. REFERENCES:

[1] M. J. Lakshmi and S. N. Rao, ''Brain tumor magnetic resonance image classification: A deep learning approach,'' Soft Compute., vol. 26, no. 13, pp. 6245– 6253, Jul. 2022.

[2] Munagalapalli Thanuj; Panidapu Ravi Teja; Pallam John David Living Stun; K. Kranthi Kumar; R. Sudha Kishore Brain Tumor Detection Using Deep Learning Techniques 2023 5th International Conference on Inventive Research in Computing Applications (ICIRCA)

[3] Shubhangi Solanki; Uday Pratap Singh; Siddharth Singh Chouhan; Sanjeev Jain, Brain Tumor Detection and Classification Using Intelligence Techniques IEEE Access (Volume: 11) February 2023

[4] Monika Agarwal, Geeta Rani, Ambeshwar Kumar, P. Kumar K, R. Manikandan, Amir H. Gandomi, "Deep learning for enhanced brain Tumor Detection and classification" Result in Engineering 22 (2024) 102117 "www.sciencedirect.com/journal/results-in-engineering"