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# Optimized Brain Tumor Detection using Machine Learning: A Review

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**ABSTRACT:** Brain tumors present a serious threat to human life, and early detection significantly impacts treatment success. This research proposes a dual-module approach for efficient and accurate brain tumor detection using MRI images. The first module enhances image quality using adaptive Wiener filtering, Radial Basis Function (RBF) neural networks, and Independent Component Analysis (ICA). The second module classifies tumors using Support Vector Machine (SVM) models based on the enhanced images. The method achieves high accuracy (0.989), sensitivity (0.991), and Dice Score (0.981), while processing images in under 0.5 seconds. This approach shows strong potential to support medical professionals in making quicker and more precise diagnoses.

**KEYWORDS:** Brain Tumor, MRI, Image Enhancement, Wiener Filtering, Neural Networks, Independent Component Analysis (ICA), Support Vector Machine (SVM), Classification, Segmentation.

## I. INTRODUCTION

Magnetic Resonance Imaging (MRI) has become the gold standard in identifying brain abnormalities due to its ability to produce high-resolution images of soft tissues. However, analyzing these images manually is time-consuming and error-prone, especially due to low contrast and noise. Hence, there's a growing need for automated systems to assist radiologists in brain tumor detection.

Brain tumors, both malignant and benign, present unique challenges due to their unpredictable growth and locations. Conventional biopsy methods are invasive, while imaging methods like MRI offer a non-invasive route. Unfortunately, raw MRI images often contain artifacts, noise, and contrast variability, which hinders accurate segmentation and classification.

This research proposes a comprehensive dual-module system. The first module enhances MRI image quality using advanced filtering and learning algorithms. The second module uses a machine learning classifier to segment and identify tumor types. This approach aims to deliver reliable results with minimal processing time, bridging the gap between image acquisition and clinical diagnosis.

### Motivation

Brain tumor mortality is increasing globally, and early, accurate detection is critical. Manual assessment of MRI scans is prone to errors and delays. Existing automated solutions lack reliability in real-world scenarios due to noise, contrast variability, and poor generalization. Therefore, developing a robust, high-performance, dual-stage detection system can drastically improve outcomes and reduce the workload on radiologists.

## II. LITERATURE REVIEW

1.Z. Khazaei, E. Goodarzi, V. Borhaninejad, F. Iranmanesh, H. Mirshekar pour, B. Mirzaei, H. Naemi, S. M. Bechashk, I. Darvishi, R. E. Sarabi, and A. Naghibzadeh-Tahami:-This is an ecological study. The data on cancer incidence and cancer mortality was extracted from the World Bank for Cancer in 2018 (GLOBOCAN 2018). The incidence, mortality rate, and brain cancer distribution maps were drawn for different countries. We used correlation and regression tests to examine the association of incidence and mortality rates of brain cancer with HDI. The statistical analysis was carried out by Stata-14 and a significance level of 0.05 was considered.

2. W.Deng,Q.Shi,K.Luo,Y.Yang,andN.Ning:-Accurate and reliable brain tumor segmentation is a critical component in cancer diagnosis. According to deep learning model, a novel brain tumor segmentation method is developed by integrating fully convolutional neural networks (FCNN) and dense micro-block difference feature (DMDF) into a unified framework so as to obtain segmentation results with appearance and spatial consistency.

3. M.Hssayeni:-After traumatic brain injury (TBI), intracranial hemorrhage (ICH) may occur that could lead to death or disability if it is not accurately diagnosed and treated in a time-sensitive procedure. Currently, Computerized Tomography (CT) scans are examined by radiologists to diagnose intracranial hemorrhage to localize affected regions. In this work, we collected a dataset of 82 CT scans of patients with traumatic brain injury. Intracranial hemorrhage regions in these scans were delineated in each slice by two radiologists. The radiologists also annotated each CT slice for the presence of different types of intracranial hemorrhage and fracture. The CT scans of 75 subjects in NIfTI format are made public in this dataset.

4.M. Sharif, J. Amin, M. Raza, M. Yasmin, and S. C. Satapathy:-The publicly available complex brain datasets such as RIDER and BRATS 2018 Challenge are utilized for evaluation of method and attained 99% maximum accuracy. The results are also compared with existing methods which evident that the presented technique provided improved outcomes which are clear proof of its effectiveness and novelty.

5. A. Rehman, S. Naz, M. I. Razzak, F. Akram, and M. Imran:-The misdiagnosis of brain tumors will result in wrong medical intercession and reduce chance of survival of patients. The accurate diagnosis of brain tumor is a key point to make a proper treatment planning to cure and improve the existence of patients with brain tumors disease. The computer-aided tumor detection systems and convolutional neural networks provided success stories and have made important strides in the field of machine learning.

6. N. Abiwinanda, M. Hanif, S. T. Hesaputra, A. Handayani, and T. R. Mengko:-In this study, we attempted to train a Convolutional Neural Network (CNN) to recognize the three most common types of brain tumors, i.e. the Glioma, Meningioma, and Pituitary. We implemented the simplest possible architecture of CNN; i.e. one each of convolution, max-pooling, and flattening layers, followed by a full connection from one hidden layer

7.A. Gumaei, M. M. Hassan, M. R. Hassan, A. Alelaiwi, and G. Fortino:- In this paper, we propose a hybrid feature extraction method with regularized extreme learning machine for developing an accurate brain tumor classification approach. The approach starts by extracting the features from brain images using the hybrid feature extraction method; then, computing the covariance matrix of these features to project them into a new significant set of features using principle component analysis (PCA).

8.A. Gumaei, M. M. Hassan, M. R. Hassan, A. Alelaiwi, and G. Fortino:-To overcome the problems of automated brain tumor classification, a novel approach is proposed based on long short-term memory (LSTM) model using magnetic resonance images (MRI). First, N4ITK and Gaussian filters having size  $5 \times 5$  are used to boost the of multi-sequence MRI quality. The presented deep LSTM model having four layers is utilized for classification.

### III. EXISTING SYSTEM

In current medical imaging workflows, the detection and classification of brain tumors using MRI scans largely rely on manual interpretation or basic machine learning algorithms. Techniques such as CNN-based classifiers like VGG16, AlexNet, and GoogLeNet have been widely adopted in research, but they often struggle with issues like overfitting, high false positive rates, and poor performance on low-contrast or noisy images. Most existing systems use a single-stage approach where raw MRI images are directly input into classification models without substantial preprocessing or enhancement. Additionally, many of these methods lack robustness when dealing with the natural variability found in real-world medical imaging datasets. As a result, their reliability in clinical settings remains limited. Furthermore, these systems are typically computationally expensive and do not prioritize real-time performance, which restricts their practical deployment in time-sensitive medical environments.

#### IV. PROPOSED SYSTEM

The proposed system introduces a novel two-module approach designed to improve both the quality of MRI brain images and the accuracy of brain tumor classification. The first module focuses on image enhancement and preprocessing using a combination of adaptive Wiener filtering to suppress noise, Radial Basis Function (RBF) neural networks to normalize image contrast, and Independent Component Analysis (ICA) to extract meaningful features and improve image consistency. This results in clear, well-contrasted, and noise-free images, which are crucial for effective diagnosis. The second module employs a Support Vector Machine (SVM) classifier to detect and classify tumor regions based on the enhanced images. This modular approach ensures that only high-quality input is used in the classification stage, significantly improving accuracy, sensitivity, and computational speed. Validated on a large CE-MRI dataset, the system achieves impressive performance metrics, including a 0.989 accuracy and an average processing time of 0.43 seconds, highlighting its potential for real-world clinical application.

#### V. CONCLUSION

This dual-module system effectively enhances MRI brain images and classifies tumor types with high accuracy. The approach significantly improves processing time (0.43 seconds per image) and yields superior results in terms of Dice Score, accuracy, sensitivity, and specificity. It overcomes limitations of existing methods by integrating preprocessing, enhancement, and classification into a seamless pipeline.

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