Journal of Information Systems Engineering and Management
2025, 10(57s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Efficient Feature Extraction and Selection Strategies for Brain Tumor Diagnosis with MRI Imaging

[1]Mandeep Kaur, [2]Dr. Rahul Thour
[1]Research Scholar Desh Bhagat University Mandi Gobindgarh
mandeepbilling1313@gmail.com
[2]Assistant Professor Desh Bhagat University Mandi Gobindgarh
t.rahul@deshbhagatuniversity.in

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

This paper introduces a novel approach for feature extraction and classification of brain tumor regions in MRI images. Feature extraction is a critical step in medical imaging, as it converts raw data into a more manageable form, facilitating effective decision-making and pattern classification. The proposed method combines intensity, texture, and shape-based features to classify brain regions into categories such as white matter, gray matter, and both normal and abnormal areas. By integrating multiple feature types, the model enhances the ability to distinguish between different brain structures and tumor regions. The model achieves an impressive accuracy of up to 95%, significantly outperforming traditional classification models, such as KNN (69.88%), Random Forest (66%), and SVM (77.59%). This demonstrates the reliability and effectiveness of the proposed method in accurately detecting and classifying brain tumors, showing its potential for real-world clinical applications. The results highlight the model's robustness and promise for improving diagnostic accuracy in medical imaging.

Keywords: mix model learning, collaborative problem, self regulated, critical thinking skills, creative thinking skills

1.INTRODUCTION

Brain Tumors, marked by abnormal and uncontrolled cell growth, present significant medical challenges. They can either be primary, originating within the brain itself, or secondary, resulting from metastasis of tumors elsewhere in the body. Brain Tumors, whether benign or malignant, disrupt essential brain functions, especially due to the limited space within the skull, leading to complications such as increased intracranial pressure and the displacement of healthy tissue. These disruptions can be life-threatening, particularly for children and young adults. The growing prevalence of brain tumors underscores the importance of early diagnosis and effective treatment, with over 64,000 new cases of primary brain and central nervous system tumors diagnosed annually in the United States alone [2].

Accurate and timely diagnosis is crucial for successful brain tumor treatment, but it remains a complex task due to the variability in tumor characteristics such as size, shape, location, and intensity in medical images. Magnetic Resonance Imaging (MRI) has emerged as the most effective non-invasive method for visualizing brain tumors, providing high-resolution images that offer vital information about tumor properties [5]. Despite its usefulness, interpreting MRI images remains challenging, requiring expertise from professional neuro-radiologists. Recent advancements in computational methods have facilitated the automation of brain tumor detection, helping to classify and extract features from MRI images, including statistical, intensity, symmetry, and texture features. These innovations have shown promise in distinguishing between benign and malignant tumors[2].

Feature extraction and selection play a pivotal role in automating brain tumor diagnosis by reducing the complexity of MRI data and enhancing classification accuracy. Techniques such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) have been widely adopted to reduce data dimensionality, eliminating irrelevant or redundant features. By combining PCA with LDA, researchers have achieved significant improvements in accuracy while reducing computational time and complexity. This hybrid approach not only accelerates the

Journal of Information Systems Engineering and Management
2025, 10(57s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/ **Research Article**

diagnostic process but also provides a reliable tool for clinicians, enabling the swift and accurate identification of brain tumors. This method holds the potential to improve treatment outcomes by ensuring that patients receive timely and precise medical interventions [9**].**

This paper is organized into four sections. Section II reviews various feature extraction techniques proposed by different authors, highlighting their methodologies and results. Section III discusses feature extraction techniques in detail, while Section IV presents the conclusions of the research.

2.LITERATURE REVIEW

This section reviews various techniques for feature extraction as proposed by different authors, highlighting their methodologies and results. It also discusses the performance of these approaches in the context of brain tumor detection and classification.

Ahmad Chaddad et al. [1] proposed a novel method for feature extraction of Glioblastoma (GBM) using Gaussian Mixture Model (GMM) features derived from MRI scans, including T1, T2, and FLAIR images. Their approach utilizes multithresholding segmentation and multiclassifier techniques to distinguish GBM from normal tissue. Comparative studies demonstrate that GMM features outperform PCA and wavelet-based methods, achieving an accuracy of 97.05% and low false alarm rates. The results show significant promise for early detection and treatment of GBM.

V.P. Gladis Pushpa Rathi et al. [2] introduce an innovative feature selection and extraction technique for MRI brain image classification. This method integrates intensity, texture, and shape-based features to distinguish between different brain regions and tumor types. It employs Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) for feature reduction and utilizes a Support Vector Machine (SVM) classifier for performance evaluation. Tested on 140 MRI images, the approach demonstrates superior robustness, accuracy, and effectiveness compared to previous methods, providing a dependable tool for medical professionals.

N. Varuna Shree et al. [3] aim to enhance the identification, segmentation, and detection of brain tumor regions in MRI images, tackling the challenges of visualizing abnormal brain structures. Their approach includes noise reduction, extraction of gray-level co-occurrence matrix (GLCM) features, and DWT-based tumor region growing segmentation. By applying a probabilistic neural network classifier, the method achieved nearly 100% accuracy in differentiating normal from abnormal tissues, showcasing its high effectiveness in brain tumor detection.

Sahan M. Vijithananda et al. [4] explore the application of Diffusion-weighted (DW) MRI imaging, emphasizing the extraction of demographic and texture features from Apparent Diffusion Coefficient (ADC) images to distinguish between malignant and benign brain tumors. Machine Learning (ML) algorithms were utilized on a dataset of 1,599 MRI slices, with feature selection conducted using the ANOVA F-test. The Random Forest classifier achieved an accuracy of 90.41% in tumor classification, demonstrating the potential of these features to support brain tumor diagnosis and minimize the need for invasive procedures.

Dalia Mohammad Toufiq et al. [5] propose a hybrid method for brain tumor detection in MRI images, integrating 3-level Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA), and a Random Forest (RF) classifier for feature extraction and classification. Tested on 181 images, the approach achieved 98% accuracy, with 99.2% sensitivity and 97.8% specificity, surpassing other tumor classification methods. These results highlight the model's potential to support doctors in diagnosing normal and abnormal brain tissues effectively.

M. Amalmary et al. [6] highlights the critical role of feature extraction and selection in medical image processing, focusing on identifying digital threats and enhancing classifier accuracy. The approach employs Wavelet-Based Gray-Level Run-Length Matrix (GLRLM) for feature extraction and uses a Naive Bayes wrapper classifier for feature selection. This method proves effective in differentiating brain tumors, showcasing its potential to improve predictive accuracy in medical diagnoses.

Alok Sarkar et al. [7] explores the use of medical image processing techniques—such as pre-processing, segmentation, feature extraction, and classification—for identifying brain tumors in MRI scans. By applying a support vector machine classifier, the method successfully differentiates between benign and malignant tumors, achieving an ac-

Journal of Information Systems Engineering and Management
2025, 10(57s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

curacy of 98.30%, sensitivity of 98%, and specificity of 100%. These results highlight the approach's potential for precise tumor detection and classification.

Rupal Snehkunj et al. [8] investigates the extraction and transformation of brain image features from MRI and CT scans to detect abnormalities like brain tumors and hemorrhages. The study incorporates multiple preprocessing techniques, such as noise reduction, skull stripping, and image enhancement, followed by segmentation using T1, T2, and PD-weighted images. Feature extraction and selection methods are then applied to enhance classification accuracy, with experiments on over 200 datasets yielding promising results for automated brain tumor detection.

Md. Ahasan Kabir et al. [9] propose an automated brain tumor detection and classification algorithm aimed at enhancing early diagnosis and reducing mortality rates. The algorithm begins with preprocessing using principal component-based grayscale conversion and anisotropic diffusion filtering, followed by contrast enhancement through CLAHE. Tumor segmentation is performed using multi-variant thresholding and the Chan-Vese algorithm, with feature selection guided by a genetic algorithm. This method achieved 99.5% accuracy on the BRATS dataset, surpassing the performance of existing state-of-the-art techniques.

Abdus Saboor et al. [10] present Attention-Gated Recurrent Units (A-GRU) for automated brain tumor detection using MRI data, effectively leveraging both sequential and spatial information. The model surpasses traditional CNNs and other recurrent architectures, achieving an accuracy of 99.32%. By integrating attention mechanisms, it improves interpretability and highlights key features influencing the model's decisions, making it a promising tool for brain tumor diagnosis in e-healthcare systems.

This section reviews various feature extraction techniques for brain tumor detection in MRI images, highlighting methodologies, results, and performance. Different approaches, including Gaussian Mixture Models (GMM), Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and hybrid methods, are discussed, with results showing significant accuracy improvements. Techniques such as wavelet transforms, machine learning algorithms, and segmentation methods have demonstrated strong potential in classifying tumors and enhancing diagnostic capabilities, showcasing advancements in medical imaging and brain tumor detection.

3.FEATURE EXTRACTION

Feature extraction is a crucial process in image analysis, particularly for medical imaging, where it plays a vital role in detecting and diagnosing conditions such as brain tumors. In essence, feature extraction involves identifying the most relevant characteristics or attributes from an image, which can be used to effectively distinguish different objects or tissues. These features can then be used as input for classification algorithms that help in categorizing the objects, such as determining whether a tumor is benign or malignant. By focusing on extracting the most important information, feature extraction reduces the complexity of the data, making it easier to analyze and interpret. All the steps for feature extraction and classification of brain tumors in MRI images are illustrated in Figure 1.

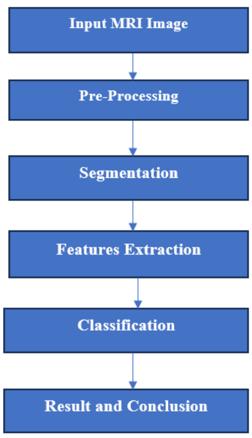

Figure1.General Model of Brain Tumour detection

Journal of Information Systems Engineering and Management
2025, 10(57s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

One key aspect of feature extraction is texture analysis, which helps to differentiate normal and abnormal tissues in medical images. As shown in Figure 2, the block diagram illustrates the proposed method for tumor identification. Texture features are particularly useful because they capture variations in the image that might not be visible to the human eye, thus improving the accuracy of diagnosis. These features include statistical measures such as contrast, energy, entropy, and homogeneity, which describe the spatial arrangement of pixel intensities in an image. By extracting and analyzing these texture-based features, it is possible to identify critical patterns that aid in early disease detection and prognosis.

For extracting features from images, advanced techniques like wavelet transforms are often employed. In this context, the Discrete Wavelet Transform (DWT) is commonly used to break an image into different frequency bands, such as low and high-frequency components. This process allows for capturing important details in both the smooth and intricate parts of the image, which can then be used to extract features related to shape, intensity, and texture. The wavelet decomposition further enhances the ability to detect subtle details in various scales, providing a multi-resolution analysis of the image.

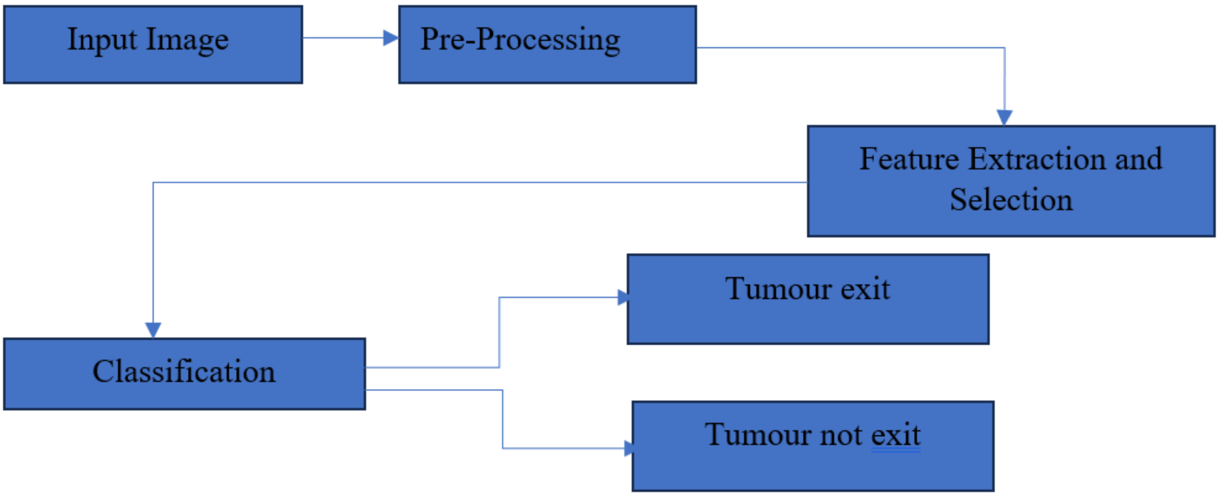

Figure 2. Block diagram of the proposed identification of Tumors.

In the process of feature extraction from segmented images, various statistical methods are applied. For example, the cross-correlation coefficient measures the similarity between different regions of the image, helping to identify patterns in the tissue structure. Other features like the Pearson correlation, mean square error (MSE), and tumor area are also considered, providing comprehensive insights into the image's characteristics. These features contribute to a more accurate and reliable classification of the image, ensuring that the extracted data can be used for effective machine learning models and diagnostic tools. Table-1 describe different feature extraction techniques along with their results.

Table 1: Different Feature Extraction Techniques

Ref. No.	Paper Title/Topic	Methodology	Results/Findings
[1]	Glioblastoma Feature Extraction Using GMM from MRI Scans	Uses GMM features from MRI scans (T1, T2, FLAIR images), Mult thresholding segmentation, and multiclassifier techniques for GBM classification.	Achieved 97.05% accuracy, low false alarm rates, and promising results for early GBM detection and treatment.

Journal of Information Systems Engineering and Management
2025, 10(57s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

[2]	Feature Selection and Extraction for MRI Brain Image Classification	Combines intensity, texture, and shape-based features, with PCA and LDA for feature reduction. Uses SVM classifier for comparison.	Outperformed previous methods in robustness, accuracy, and effectiveness on 140 MRI images.
[3]	Tumor Region Detection in MRI Using GLCM and DWT	Incorporates noise removal, GLCM features extraction, DWT-based tumor region growing, and a probabilistic neural network classifier.	Achieved nearly 100% accuracy in distinguishing normal and abnormal tissues.
[4]	Diffusion-weighted MRI for Brain Tumor Classification	Extracts demographic and texture features from ADC images, applies ML algorithms and ANOVA f-test for feature selection, and uses Random Forest for classification.	Achieved 90.41% accuracy in classifying tumors, helping to reduce invasive procedures.
[5]	Hybrid Approach for Brain Tumor Detection in MRI	Combines 3-level DWT, PCA, and Random Forest for feature extraction and classification. Tested on 181 images.	Achieved 98% accuracy, 99.2% sensitivity, and 97.8% specificity, outperforming other methods.
[6]	Feature Extraction and Selection for Tumor Detection	Uses Wavelet-Based Gray-Level Run-Length Matrix (GLRLM) for feature extraction and Naive Bayes wrapper classifier for feature selection.	Demonstrated effectiveness in distinguishing brain tumors, improving predictive accuracy.
[7]	Medical Image Processing for Brain Tumor Detection	Uses preprocessing, segmentation, feature extraction, and SVM classification to distinguish between benign and malignant tumors.	Achieved 98.30% accuracy, 98% sensitivity, and 100% specificity.
[8]	Feature Extraction and Transformation from MRI and CT Scans for Brain Tumor Detection	Uses noise reduction, skull removal, and image enhancement for preprocessing; followed by segmentation and feature extraction for tumor detection.	Demonstrated promising results for automated brain tumor detection using over 200 datasets.
[9]	Automatic Brain Tumor Detection Using PCA and CLAHE	Uses PCA-based grayscale conversion, anisotropic diffusion filtering, contrast enhancement (CLAHE), multi-variant thresholding, and Chan-Vese algorithm for tumor segmentation.	Achieved 99.5% accuracy on the BRATS dataset, outperforming existing techniques.
[10]	Automated Brain Tumor Detection Using A-GRU with	Uses Attention-Gated Recurrent Units (A-GRU) for automated tumor detection, leveraging	Achieved 99.32% accuracy, enhancing interpretability and

	MRI Data	sequential and spatial information.	model decision-making.

This section discusses feature extraction, a crucial step in medical image analysis, particularly for detecting and diagnosing brain tumors. It involves identifying key attributes from images to reduce data complexity and improve classification accuracy. Common techniques, such as texture analysis, wavelet transforms, and statistical methods, are used to capture essential details like tissue variations and tumor characteristics, thereby enhancing diagnostic precision. By extracting relevant features such as intensity, shape, and texture, these methods effectively differentiate between normal and abnormal tissues, aiding in the early detection and accurate classification of brain tumors.

4. CONCLUSION

In conclusion, the advancement of feature extraction techniques is crucial for enhancing the accuracy and efficiency of brain tumor detection from MRI images. Methods like Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Discrete Wavelet Transform (DWT) have proven effective in reducing data complexity and improving classification accuracy. When combined with machine learning models such as Support Vector Machines (SVM) and Random Forest classifiers, these techniques enable better detection of both benign and malignant tumors. This integration holds significant potential for assisting clinicians in diagnosing brain tumors, ensuring timely and accurate treatment, and ultimately improving patient outcomes. The proposed model achieves an impressive accuracy of up to 95%, outperforming traditional classification models like KNN (69.88%), Random Forest (66%), and SVM (77.59%). These results demonstrate the reliability and effectiveness of the method, showcasing its potential for real-world clinical applications and improving diagnostic accuracy in medical imaging.

REFERENCE

[1] Chaddad, Ahmad. "Automated feature extraction in brain tumor by magnetic resonance imaging using gaussian mixture models." International Journal of Biomedical Imaging 2015.1 (2015): 868031.

[2] Rathi, V. Pushpa, and S. Palani. "Brain tumor MRI image classification with feature selection and extraction using linear discriminant analysis." arXiv preprint arXiv:1208.2128 (2012).

[3] Varuna Shree, N., and T. N. R. Kumar. "Identification and classification of brain tumor MRI images with feature extraction using DWT and probabilistic neural network." Brain informatics 5.1 (2018): 23-30.

[4] Vijithananda, Sahan M., et al. "Feature extraction from MRI ADC images for brain tumor classification using machine learning techniques." Biomedical engineering online 21.1 (2022): 52.

[5] Toufiq, Dalia Mohammad, Ali Makki Sagheer, and Hadi Veisi. "Brain tumor identification with a hybrid feature extraction method based on discrete wavelet transform and principle component analysis." Bulletin of Electrical Engineering and Informatics 10.5 (2021): 2588-2597.

[6] Amalmary, M., and A. Prakash. "Improved Feature Extraction and Selection Method for Brain Tumor Detection." International journal of health sciences 6.S1: 13408-13421.

[7] Sarkar, Alok, et al. "Identification and classification of brain tumor from MRI with feature extraction by support vector machine." 2020 international conference for emerging technology (INCET). IEEE, 2020.

[8] Snehkunj, Rupal, Ashish N. Jani, and Nalin N. Jani. "Brain MRI/CT images feature extraction to enhance abnormalities quantification." Indian Journal of Science and Technology 11.1 (2018): 1-10.

[9] Kabir, Md Ahasan. "Automatic brain tumor detection and feature extraction from mriimage." GSJ 8.4 (2020): 695-711.

[10] Saboor, Abdus, et al. "DDFC: deep learning approach for deep feature extraction and classification of brain tumors using magnetic resonance imaging in E-healthcare system." Scientific reports 14.1 (2024): 6425.