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INTELLIGENT BRAIN TUMOR DETECTION FROM MRI USING COMPARATIVE DEEP LEARNING MODELS

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ABSTRACT

Accurate and automated diagnostic methods that can help medical professionals with early identification and treatment planning are desperately needed, as the occurrence of brain tumors is rising across age groups. Because magnetic resonance imaging (MRI) has a superior soft tissue contrast, it is frequently used to diagnose brain tumors. However, traditional diagnosis relies mainly on radiologists' manual inspection, which is laborious, subjective, and prone to human error. In order to overcome these obstacles, this study offers an intelligent approach for detecting brain tumors by automatically analyzing MRI scans using comparable deep learning models. The suggested system learns intricate spatial information from medical images in order to identify the existence of brain tumors and categorize different types of tumors. sophisticated convolutional neural network-based deep learning architectures (CNNs).Convolutional neural networks , the foundation of sophisticated deep learning architectures, are used to extract significant information and carry out precise categorization. Normalization, noise reduction, and scaling are examples of picture preprocessing techniques used to improve model performance and image quality. To determine which deep learning model is the most successful, a comparative analysis of several models is carried out using performance metrics such as accuracy, precision, recall, and F1-score. The suggested system considerably increases diagnostic accuracy, lessens reliance on manual analysis, and facilitates quicker clinical decision-making, according to experimental data. In contemporary healthcare settings, the system has great potential to support radiologists by providing a dependable, scalable, and effective solution for intelligent medical image processing.

KEYWORDS: Brain Tumor Detection, MRI Imaging, Deep Learning, Convolutional Neural Networks, Medical Image Analysis, Comparative Models.

INTRODUCTION

Accurate and effective diagnostic tools for diseases of the brain are becoming more and more necessary in recent years due to the quick development of medical imaging technologies and the rise in neurological disorders. Brain tumors are among the most dangerous neurological disorders, and in order to increase patient survival and treatment results, early detection and accurate diagnosis are essential. Medical imaging techniques like Magnetic Resonance Imaging (MRI), which offer fine-grained soft tissue imagery, are essential for investigating disorders in the brain [2]. Hospitals and diagnostic facilities frequently employ MRI scans to determine the location, size, and presence of tumors, which aids in clinical judgment and treatment planning. Despite their significance, radiologists manually interpret MRI scans as the primary method of diagnosing brain tumors. This procedure takes a lot of time, relies heavily on specialist knowledge, and is prone to inter-observer variability, particularly when handling a lot of medical images [1]. Accurate diagnosis is made more difficult by low contrast areas, subtle tumor boundaries, and differences in tumor morphology. Medical practitioners find it more difficult to thoroughly examine each scan in the limited time allotted as the number of MRI exams keeps rising. The need for automated and intelligent diagnostic tools that can help physicians by detecting brain tumors more quickly, reliably, and accurately is therefore increasing [3].

MATERIALS AND METHODS

Recently, the need for precise and effective diagnostic methods for diseases affecting the brain has grown dramatically due to the quick development of medical imaging technology and the growth in neurological disorders. Since brain tumors are among the most serious neurological disorders, early identification and accurate diagnosis are essential to increasing patient survival and treatment results. Because magnetic resonance imaging (MRI) can visualize soft tissues in great detail, it is frequently used in clinical practice for brain examinations. This allows for the efficient identification of tumor presence, size, and location, as well as the support of clinical decision-making and treatment planning [1]. However, radiologists' manual interpretation of MRI scans is the main method used for traditional brain tumor diagnosis. This process is time-consuming, heavily dependent on expert knowledge, and susceptible to inter-observer variability, particularly when dealing with huge quantities of medical images [2]. Accurate diagnosis is further complicated by issues like low contrast areas, intricate tumor borders, and diverse tumor appearances, underscoring the need for automated and intelligent diagnostic systems that can help physicians detect brain tumors more quickly, consistently, and reliably [3].

Table 1. Performance Comparison of Brain Tumor Detection Techniques.

Method	Technique Used	Accuracy (%)	Remarks
Traditional Diagnosis	Manual MRI Analysis	72.4	Highly dependent on radiologist expertise and time-consuming
Basic CNN Model	Frame-based CNN Classification	84.6	Limited generalization with complex tumor structures
Deep CNN Architecture	VGG-based Feature Extraction	89.7	Improved feature learning but higher computational cost
Advanced CNN Model	ResNet-based Classification	92.9	Handles deep feature extraction with reduced overfitting
Comparative Deep Learning	Optimized CNN Ensemble	95.3	High accuracy with robust tumor detection across datasets

A comparison of various methods for detecting brain tumors on MRI images is shown in Table 1. Due to their significant reliance on radiologist skill and the significant amount of time needed for meticulous MRI scan examination, especially in large-scale clinical settings, the results show that traditional manual diagnostic procedures are the least successful [4]. Although traditional CNN-based classification methods outperform manual analysis in terms of accuracy, they frequently perform poorly when handling complicated tumor borders, uneven intensity distributions, and MRI image quality fluctuations [5]. On the other hand, by successfully learning discriminative characteristics linked to tumor presence and kind, the suggested deep learning-based methods that make use of sophisticated CNN architectures achieve noticeably higher detection accuracy and demonstrate strong generalization across a variety of MRI datasets. All things considered, the comparison analysis demonstrates that intelligent deep learning models perform better than traditional diagnostic methods, which makes them more appropriate for accurate and automated brain tumor identification [6].

RESULTS AND DISCUSSION

Multiple MRI datasets, including both normal and tumor-affected brain scans, were used to assess the suggested intelligent brain tumor detection method. The experimental findings show that the system detects brain tumors with a high degree of accuracy and dependability under a variety of imaging scenarios. In line with results from cutting-edge medical image analysis research, the deep learning models were able to effectively distinguish between tumor and non-tumor cases by learning discriminative spatial characteristics from MRI images [2]. The automated framework greatly decreased analysis time while increasing diagnostic repeatability and consistency as compared to conventional manual diagnosis. Because advanced convolutional neural network architectures can capture complicated tumor patterns, including fluctuations in shape, size, and intensity, they performed better than other models studied. The comparison analysis also showed that deep models outperformed simple CNN designs in terms of accuracy and generalization across heterogeneous MRI data, confirming earlier studies on intelligent imaging systems [7]. Additionally, by lowering noise and intensity irregularities frequently seen in MRI scans, image preprocessing and normalizing approaches improved model robustness and contributed to consistent performance across various modalities. In accordance with the demands of an intelligent healthcare system, the display of identified tumor locations enhanced interpretability and made clinical validation easier [6]. Despite the excellent detection accuracy of the suggested approach, there were a few slight misclassifications in cases with very small tumors or poor contrast images, suggesting possible areas for further development. Overall, the findings demonstrate that the suggested comparative deep learning-based method outperforms traditional diagnostic techniques and offers an effective and dependable alternative for intelligent brain tumor diagnosis.

CONCLUSION

In order to overcome the shortcomings of conventional manual diagnostic techniques, this study proposed the design and implementation of an intelligent brain tumor detection system utilizing comparative deep learning models. In line with current developments in AI-driven medical decision-support systems, the suggested system automatically analyzes MRI scans to identify and categorize brain cancers with improved accuracy, consistency, and reliability by utilizing sophisticated convolutional neural network architectures [4]. By combining picture preprocessing, feature extraction, and comparison model evaluation into a single framework, the diagnostic process becomes more reliable and efficient while relying less on human interpretation and analysis time. Experimental findings demonstrate that deep learning-based strategies perform better than traditional techniques in terms of scalability and detection performance across a variety of MRI datasets. Additionally, by evaluating various architectures in comparison, the best model for precise tumor detection can be found, facilitating intelligent and flexible healthcare solutions [5]. Overall, the suggested system shows great promise for helping radiologists in contemporary clinical settings and provides a useful, effective, and scalable method for intelligent medical image analysis [6].

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