



Performance Analysis of Various Deep Learning Models for Brain Tumor Segmentation and Classification: Comparative Approach

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Abstract: Detecting the brain tumors in their early stage is crucial, as this allows physicians and experts to develop better treatment strategies and improves patients' chances to overcome any dangers pertaining with tumors. The primary objective is to precisely map out the tumor region. There have been several approaches to brain tumor segmentation. In this study, various strategies are evaluated and explained. They are thoroughly investigated and addressed in this work. The early segment of this paper involves reviewing previous research which utilized deep learning to categorize and detect brain cancers. The second segment of the paper is presented with the proposed methods performance analysis in detailed manner. The paper intends to offer future researchers with an in-depth review of current research developments and the effectiveness of various deep learning approaches. We believe that this study will significantly broaden our knowledge of brain cancers detection methods.

Keywords: Brain tumor segmentation, deep learning, Convolutional neural networks, image classification.

1. INTRODUCTION:

Tumors are collections of cells that develop into abnormal growths or tissue within the human body. Tumors can range in size from very small to very large. A tumor is classified as malignant or benign based on whether or not the growth is damaging and has the potential to spread to cells in the surrounding area [1]. It's extremely important for determining whether or not an anomaly exists in the tissue, this is because accurate segmentation has a direct bearing on the ability to detect disease at an early stage, which in turn increases the likelihood that therapy will be effective [2]. When it comes to analysis and diagnosis, the segmentation of medical images is of the utmost importance [3]. Without appropriate and effective medical image segmentations, Researchers are unable to carry out the analysis of medical images. In the field of pathology, accurate segmentation has a direct bearing on the ability to detect disease at an early stage, which in turn increases the likelihood that therapy will be effective [2]. Deep learning and computer vision have brought about revolutionary breakthroughs in a number of fields in recent years. Among these, deep learning is notable for its exceptional ability to manage enormous datasets, which is transforming several industries, including the biomedical one. With remarkable results, its abilities have been specifically applied to the field of brain tumor detection using MRI scans. Research has been conducted in a variety of biological image processing fields, including the detection of brain cancers. Improving the detection of brain tumor patterns is the main goal of the investigation of image processing methods. Therefore, medical image segmentation has received extensive attention from researchers and clinicians [4]. Having the findings of the segmentation has made it feasible to perform shape analysis, detect volume changes, and make therapy decisions with greater precision [2]. With the help of this crucial information, it is simple to carry out duties like

assessing anatomical structures, tracking the development of diseases, and forecasting patient outcomes. Deep learning methods have become a potent instrument in medical image analysis in recent years, bringing about a paradigm shift in the interpretation of medical pictures [5]. With an emphasis on the developments and difficulties related to the tumor, this study attempts to do a thorough evaluation of the deep learning methods currently used in brain tumor segmentation.

2. LITERATURE REVIEW:

There have been several deep learning methods emerging as there has not been one particular method for segmentation of brain tumors. The brain tissue form, location, density, depth varies person to person. It arises one of the most significant problems to models which needs to train on extensive dataset that presents with various forms, locations and densities of the patients, so that the model can segment accurately. To overcome this CNNs have been meticulously used to give accurate segmentation and classification of brain tumors [6]. In [7] the authors proposed a model that uses deep learning and stats modelling. They used non local mean filters to preprocess the medical images. Which in return reduced the noise. After which a Deep Autoencoder (DAE) grounded in the Jaya optimization algorithm (JOA) that has SoftMax regression. The DWT (discrete wavelet transform) technology that combined 4 different MRI modalities into one MRI, this method makes it easier to create fused sequence that customized every patient data. Then CNN is trained using ensemble method [8]. In the research [9], ResNet50 architecture is used with the UNet framework. This gave amazing result of 98.14% accuracy. They used preprocessing techniques and augmentation on dataset. In paper [10], where authors used VGG-SCNet model on BraTS 2015,2017,2019 datasets, which gave amazing results with the highest being the 91% and precisely categorizing. In paper [11], the authors used their model on Kaggle dataset. In which SVM classifier was used and this model was used on the 2D MRIs which categorized the tumors into four classes. [12] Presents ADAS optimization and AI algorithm that segments the brain tumor in MRIs. To get accurate results first they pre-processed the dataset and then used deep learning algorithms. Similarly, [13], the authors proposed a novel method UNet++DSM. That uses deep supervision mechanism using UNet++. This method has shown excellent results for the low labelled dataset. In the paper [14], a convolutional based hybrid model is presented which enhanced the accuracy by focusing on the region of interests. The model used BraTS dataset. Work by authors [15], proposed method that utilizes a transformer network to correlate among the features. This solved the drawback of integrating multimodal MRI data.

3. METHODOLOGY:

The survey was carried out collecting various paper that include mostly from journal articles. This research employed a strategic analysis of already available work on brain tumor detection and classification using deep learning methods. The main objective is to understand the approaches related to brain detection and classification in this domain. This also includes in depth information about the deep learning models used like UNets, SEGNetS or RESNets. The papers were collected from 2020 year to 2024 year. In 2020, various technical studies were conducted, which shows that deep learning algorithms continued to give state of art results across the domain [16]. In early 2021, a substantial amount of research was conducted in 2021 where deep learning was used as the main technique. In late 2022, where deep learning became the primary tool in the methods. In year 2023 and 2024, research highlights the importance of U-Net's contribution to the development of medical image analysis and its crucial role in contribution to enhancing the results of brain tumor segmentation [17]. From this it is evident that from 2020 to 2024, the algorithms have been concentrating on enhancing the deep learning algorithms that is extensively for MRI segmentation and classification.

4. PERFORMAMCE ANALYSIS:

The performance of various methods is compared in terms of evaluation metrics. Which can

Be observed from the Table 1. This table is giving the understanding of the performance metrics and respective model architecture.

Table 1. Performance analysis of various deep learning methods

REFERENCE NUMBER	ARCHITECTURE USED	PERFORMANCE RESULTS	KEY FINDINGS
[7]	JOA(Java optimization algorithm) based on deep autoencoders & SoftMax regression.	Accuracy: 98.5%.	Feature extracting is difficult.
[8]	DWT used for feature extracting and the CNN is used for classification.	Accuracy: 98%.	The parameters are more, which increased the complexity.
[9]	RESNet50 Model inculcated with UNet.	Accuracy: 95%.	Training time for the model is very high as the complexity is of the model is more.
[10]	VGG-SCNet model is used to classify the tumors.	Accuracy: 99.2%, Precision: 99.2%, Recall: 99.1%, and F1 scores: 99.2%.	The dataset used is less and data pre-processing is not done.
[11]	CNN model classified the tumors in four categories.	Accuracy: 99%.	CNNs cannot learn important features.
[12]	ADAS optimization with AI algorithm.	Accuracy: 94%.	Dataset used is less.
[13]	U-Net++ with DSM architecture.	Sensitivity: 98.59%, Specificity: 98.64%, Accuracy: 98.64 % and Dice Score: 98.02 %.	Good accuracy using less labelled data.
[14]	Convolution neural network-Based Model	Dice Scores: 92.80 %.	High accuracy achieved.
[15]	Multimodal model	Classification	

5. CONCLUSION:

Assessing the strengths and limitations of these models is crucial for choosing the best approach in clinical settings. This review offers valuable guidance to researchers in selecting models based on segmentation accuracy, efficiency, and adaptability. Different deep learning architecture methods for brain tumor segmentation were examined. The papers published between 2020 and 2024 were carefully examined. CNNs and UNets have demonstrated strong accuracy and effective feature detection. However, transformer models now lead in accuracy across various tasks. Transformer models, while U-Net structures offer effective feature extraction. Despite this, optimizing models remains crucial for practical applications. Fine-tuning these architectures can enhance real-world performance. Balancing accuracy and efficiency ensure usability in deployment. A well-informed choice ensures improved performance in medical imaging applications. By comparing various architectures, researchers can optimize methods for practical use. These insights contribute to advancements in healthcare technology.

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