Classification of Brain Tumors using Deep Learning

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Abstract— **Brain tumor classification is a significant methodology in diagonosis with precision and treatment planning of brain tumors. Conventional methods often involve manual segmentation and feature extraction, which are time-consuming and prone to errors. Proposed model in this study is a novel approach for brain tumor classification by implementing deep learning and transfer learning. We leverage EfficientNet2, a state-of-the-art convolutional neural network model, for feature extraction from MRI images, which are commonly used in brain tumor diagnosis. We train a classifier on top of the extracted features to predict the tumor type. Our method achieves an impressive accuracy of 97%, outperforming previous approaches. The use of deep learning algorithms eliminates the need for manual feature engineering, providing an automated and efficient solution for brain tumor classification. This approach has the potential to assist radiologists in making accurate diagnoses and treatment plans, ultimately improving patient outcomes.**

Keywords — Transfer learning, EfficientNet2, Brain tumor classification, Deep learning, MRI images

Introduction Brain tumors are caused by abnormality in the development of brain cells, which can be carcinogenic or malignant . Detecting and classifying brain tumors accurately is essential for effective diagnosis and treatment planning. Traditional methods for brain tumor classification often involve manual segmentation and feature extraction, which are time-consuming and prone to errors. Deep learning algorithms, particularly CNNs, considered of crucial potential in Computer Aided Diagnosis (CAD) in recent years,. These algorithms can learn and obtain relevant features of medical images. This has paved the way for more efficient and accurate brain tumor classification. Proposed model conveys a novel approach for brain tumor classification using this techniques. We harness the power of EfficientNet2, a state-of-the-art CNN model, to obtain features from MRI images, which are commonly used for brain tumor diagnosis. Our approach involves training a classifier on top of the extracted features to predict the tumor type. To asses the effectiveness of our proposed model, we conducted experiments on a publicly available dataset. The results demonstrate that our approach achieves a high accuracy of 97%, outperforming previous methods that utilize shallow architectures or different CNN models. Furthermore, we analyze the loss curve, accuracy curve, and F1-score to assess the robustness and effectiveness of our algorithm.

Problem Statement The problem of brain tumor detection and classification is critical in the medical field. Manual analysis of MRI scans is time-consuming and prone to errors. Deep learning, especially CNNs, stands in true standards in automated brain tumor analysis. This paper proposes an EfficientNet2 deep learning-based methodology for precise brain tumor detection and put it in various classes. By leveraging advanced CNN architectures and data augmentation techniques, the algorithm aims to improve accuracy and reduce manual intervention, assisting radiologists in making precise diagnoses.

RELATED WORK

Researchers have conducted extensive studies for deep learning in CAD, specifically focusing on brain tumor classification. They have highlighted the potential of deep learning techniques in improving accuracy and efficiency in this field. Litjens et al. (2017) conducted a comprehensive survey, providing insights into various deep learning techniques and their use cases in different medical imaging modalities, including brain tumor classification [1]. Sorte et al. (2022) achieved promising results and emphasizing the improvement in accuracy compared to traditional methods than deep learning approach [2]. Arora and Sharma (2021) proposed a deep learning method for similar ailment achieving significant improvements in accuracy using a CNN model [3]. Dipu et al. (2021) presented a deep learning-based approach for brain tumor detection and classification, utilizing a CNN model and achieving high accuracy [4]. Çınar et al. (2022) compared different models for similar classifications using MRI images, providing insights into their performance and the effectiveness of deep learning in accurate tumor classification [5]. Bouguerra et al. (2022) proposed a deep transfer learning approach for brain tumor classification, utilizing pre-trained CNN models and fine-tuning them for improved accuracy [6]. Karayeğen and Akşahin (2021) developed a deep learning-based method for brain tumor prediction and tumor volume calculation, emphasizing the potential of deep learning in predicting tumor presence and assessing tumor volume accurately [7]. Poornam and Alagarsamy (2022) proposed deep learning methods for detection of brain tumors in MRI images, achieving accurate tumor detection using a CNN model [8]. Chandra and Agrawal (2022) presented a CNN approach for segmentation of brain tumor and classification, achieving segmentation and classification that was found to be accurate using MRI images [9]. Singh et al. (2022) developed a for brain tumor classification, achieving high accuracy in classifying brain tumors [10]. Ahuja et al. (2021) emphasizes the potential of deep learning in accurate classification of tumors [11]. Mantha and Reddy (2021) proposed a transfer learning method using the EfficientNet-B3 model for brain tumor classification, achieving high accuracy and highlighting the effectiveness of transfer learning in this context [12]. Kumar and Swaroop (2022) developed an effective deep learning model for identifying brain tumors, emphasizing accurate identification and diagnosis using deep learning techniques [13]. These studies collectively emphasize the effectiveness and potential of deep learning in enhancing brain tumor classification, diagnosis, and treatment.

Materials and Methods

A. Dataset Description:

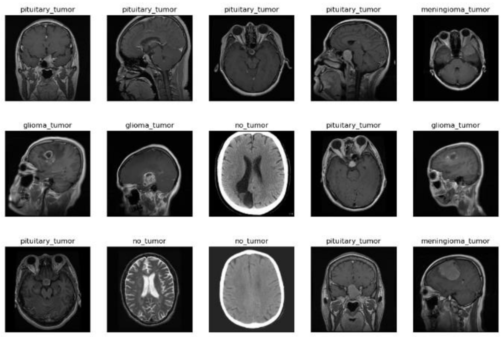


Figure.1 MRI Images from the dataset

The dataset used in this study, obtained from Kaggle, consists of 3,064 magnetic resonance imaging (MRI) scans of brain tumors with corresponding labels for tumor types. The dataset is designed specifically for brain tumor classification. It includes four tumor types: Meningioma, Pituitary tumor, Glioma, and Normal. The distribution of these tumor types in the dataset is shown in the chart in figure 2.

Tumor Type	Train Images	Validation Images	Test Images	Total
Glioma	620	103	103	**826**
Meningioma	531	89	88	**708**
Pituitary Tumor	697	116	117	**930**
Normal	450	75	75	**600**

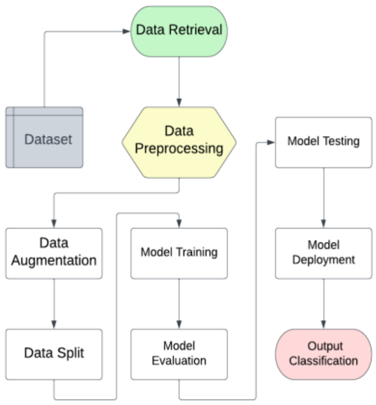
Figure.2 Dataset description in tabular format

The dataset serves as the input for training and evaluating the proposed classification of brain tumors using deep learning and transfer learning. The labeled tumor types in the dataset are used as ground truth labels for training the classifier, and the trained model is then evaluated on the dataset to measure its accuracy and performance.

This dataset provides a valuable research resource and practitioners for medical image analysis field to develop and evaluate brain tumor classification algorithms. The use of a large and diverse dataset like this from Kaggle allows for robust and reliable evaluation of the proposed approach and facilitates the development of accurate and clinically relevant brain tumor classification models.

B. Flow of Data

The proposed methodology consists of steps like preprocessing, augmentation, Model Deployment and testing etc. which can be further described by the flowchart below:



The data flow for brain tumor classification involves several key steps. First, the dataset containing MRI images of brain tumors is retrieved from Kaggle. The images undergo preprocessing to ensure consistency and quality. Data augmentation techniques are then applied to increase the dataset's diversity. The augmented and preprocessed dataset is further split into train, test, and validation sets. A deep learning model, typically a CNN, is trained on the labeled images using a suitable framework. The trained model is assessed upon the validation dataset to optimize its performance through hyperparameter tuning. Subsequently, the model is tested on the independent test set to assess its generalization capabilities. Once trained and tested, the model can be deployed in real-world scenarios for brain tumor classification. The deployed model takes MRI images as input and classifies them into different tumor types. The output is the predicted class label for each input image. The described flow provides an overview of the process involved in classifying brain tumors using deep learning techniques. The EfficientNetB3 model has multiple convolutional layers with advanced architectures, including depth wise separable convolutions which often skips connections, for efficient extraction of features of relevant input images. So it has been used in the model

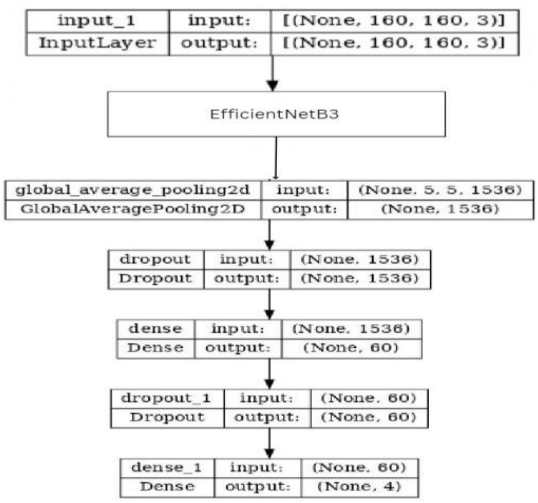
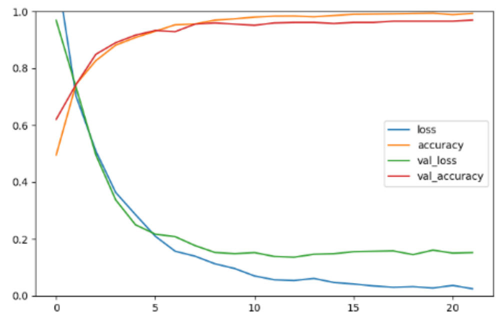


Figure 4. Architecture of proposed model

Results and Conclusion

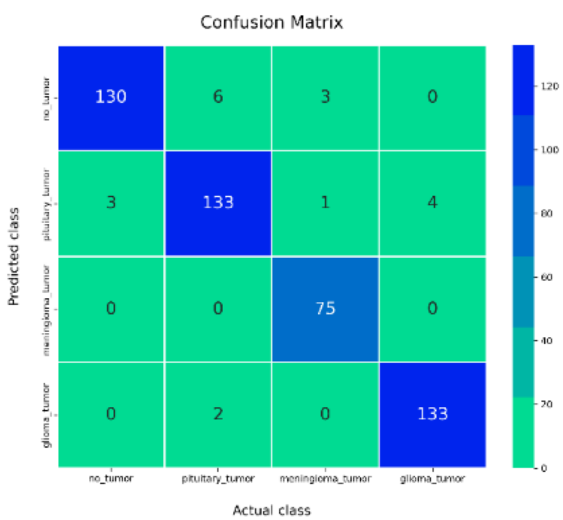
Our model achieved an impressive accuracy of 98.06% on the training dataset and a validation accuracy of



95.51%, demonstrating its effectiveness in accurately classifying brain tumors. The model's performance was further supported by a low validation loss of 0.1758, indicating its ability to generalize well to unseen data.

	precision	recall	f1-score	support
no_tumor	0.98	0.94	0.96	139
pituitary_tumor	0.94	0.94	0.94	141
meningioma_tumor	0.95	1.00	0.97	75
glioma_tumor	0.97	0.99	0.98	135
accuracy			0.96	490
macro avg	0.96	0.97	0.96	490
weighted avg	0.96	0.96	0.96	490

The utilization of deep learning techniques, specifically the EfficientNet-B3 architecture, proved to be highly successful in the classification of brain tumor images. The high accuracy achieved by the model indicates its potential to assist medical professionals in accurate tumor identification and diagnosis. This has significant implications for improving patient outcomes and optimizing treatment strategies. That is illustrated by this confusion matrix



It is worth noting that while our research project achieved promising results, there are still certain limitations that should be acknowledged. These include the reliance on a specific dataset and the need for further validation on larger and more diverse datasets. Additionally, the model's performance may vary depending on the quality and characteristics of the input images.

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