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EfficientNet-B6 model-based transfer learning for the classification of brain tumors

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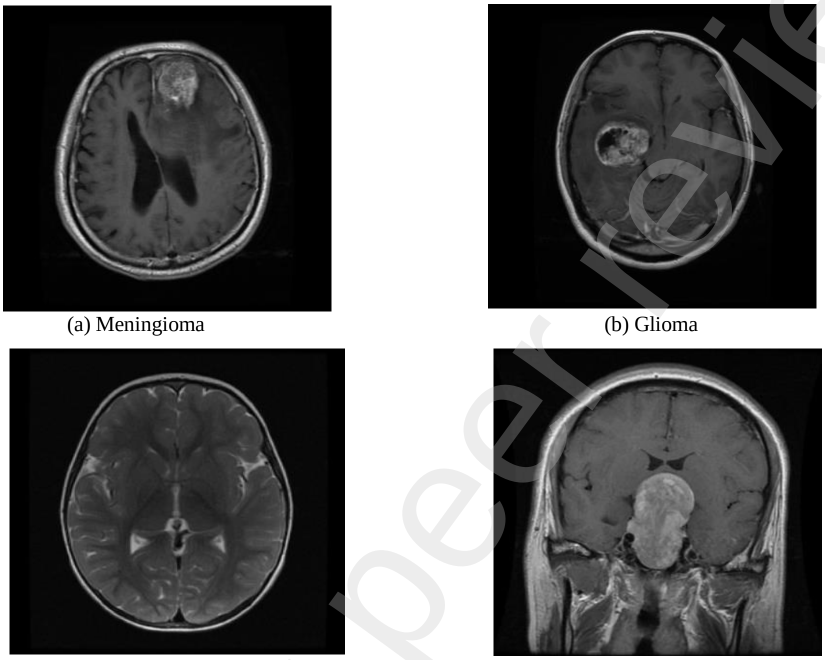
Abstract

One of the leading causes of death worldwide is brain tumor (BT). It is difficult to classify BTs using medical image processing. When abnormal brain growth occurs, it can have a negative impact on the functioning of the brain. Early diagnosis can help improve the prognosis and enable faster recovery for patients. A computer system that can help radiologists identify and categorise BTs using MRI scans can be beneficial. Unfortunately, manual classification techniques can lead to inaccurate and incomplete diagnoses. This is because the similarities and variations between normal tissues and tumors can affect the accuracy of the diagnosis. In recent studies, deep learning (DL) techniques have shown promising results when it comes to improving the accuracy of detecting and classifying BTs using MRI. The algorithm presented in this paper, uses Convolutional Neural Networks (CNN) in combination with transfer learning. This work utilized EfficientNet-B6, a transfer learning architecture, that achieved train accuracy, validation accuracy, test accuracy, precision, recall, and F1-score values of 100%, 99.34%, 99.61%,100%,99% and 100% on the MRI-large dataset. The proposed method is significantly better than current research literature, demonstrating that it can be utilized to accurately categorize brain tumors.

Keywords- Brain tumor, Deep learning techniques, EfficientNet-B6

1. Introduction

The brain is regarded as one of the most intricate organs in the body, as it controls the nervous system and billions of cells (Louis, David N., Arie Perry, etc.). Apart from its primary functions, it also controls various other regulatory actions within the body, such as vision, emotion, and memory. When a cell divides uncontrollably, it creates an abnormal region of the brain. The presence of this group of cells can disrupt the functioning of healthy brain cells. When certain types of tumors grow in the brain, they can make it problematic for the brain to work. The primary tumor is located in the brain tissue. On the other hand, the secondary tumor can spread to other parts of the body through the bloodstream (Mohsen, Heba,etc).Some of the most common symptoms of BTs are memory loss, headaches, and poor concentration. The size and shape of BTs can vary. The diagnosis of such tumor's using MRI has become a vital part of the field of medicine (Kumar, Sanjeev, etc.). Recent studies have revealed that this treatment could lead to the development of new and more effective cancer therapies. A computerized system that can accurately identify and classify a BT is needed for early detection. This method can help save the lives of patients and improve their quality of life. To make use of the system, researchers need to search for various techniques that can help distinguish the presence of BT from other types of cancer. The developments in deep learning in Artificial intelligence (AI) have made a huge impact in medicine, as they allow doctors to diagnose illnesses much earlier. CNNs are a widely used component of computer-aided diagnosis. These techniques require a lot of data in order to improve their accuracy, and finding and obtaining this information can be a challenge for medical professionals.



(a) Meningioma (b) Glioma

(c) Pituitary (d) No Tumor

Fig. 1. MRI image of BTs (a) Meningioma,(b) Glioma,(c) Pituitary,(d) No Tumor

This problem can be solved by developing an automatic Computer-aided diagnosis (CAD) system that can detect dangerous diseases such as cancer (Deepak, S., and P. M. Ameer). The paper proposes a method using a DL system to analyse and improve the performance of MRI scans on the brain. A new DL system that utilizes state-of-the-art frameworks like EfficientNet-B6 is proposed here. It is based on a transfer learning approach that uses MRI scans of BTs.

2. Related work

Although CNN is widely used in various applications, its performance in imaging is still good. Over the past few years, various methods for detecting the presence of BT have been developed using DL. Most of these focus on the binary classification of the tumors. Table 1 summarizes the various DL methods that were utilized by researchers in the past.

Table 1. A list of DL Methods to find and classify BTs.

year	References	Approach	Accuracy
2016	Liu, Renhao,etc.	pretrained deep neural networks	95.45%
2019	Das, Sunanda,etc.	CNN model	94.39%
2020	Joshi, Ranjana,etc.	VGG-19	99.30%
2021	Mantha, Tejakrishna, and B. Eswara Reddy	EfficientNet-B3	99.35%
2021	Saleh, Abdulrazak Yahya,etc.	ResNet	94%
2021	Hossain, Md Farhad,etc.	CNN	96.90 %
2021	Arbane, Mohamed,etc.	CNN	98.24%
2022	Çınar, Necip,etc	VGG19	97.2%.
2022	Ahmad, S. and Choudhury	VGG19	99.39%
2022	Shah, Hasnain Ali,etc.	EfficientNet-B0	98.87%
2022	Mishra, Shailendra Kumar,etc.	EfficientNet	98.78%
2022	Behera, Tanmay Kumar,etc	Superpixel-Based Deep Transfer Learning	98.33%
2022	Bandagale, Ajinkya,etc.	CNN model	98.70%
2022	Sheergojri, Aadil Rashid,etc.	Hybrid CNN-ELM Algorithm	97.14%
2022	lahmood HAMEED, Fakhri,etc.	CNN	92.78
2022	S. Nidaan Khofiya, Y. Nur Fu'adah,etc.	AlexNet	93%
2023	Sankaranarayaanan, R., M. Senthil Kumar,etc.	VGG16 model	92%
2023	Pillai, Rudresh,etc.	VGG16	91.58%
2023	Cobilla, Ramil,etc.	Xception Model.	96%
2023	Mathur, Parimal,etc.	DenseNet-121	97.47%

3. Proposed Work

The implementation of the suggested work and materials is covered in this section. Section 3.1 provides an overview of the MR image data sets that are utilized in the training and testing of the proposed methods. Section 3.2 explores CNN's proposed structure. Finally, Section 3.3 explores the setup and validation procedures.

3.1. Dataset:

The training model developed by using MRI scans of the brain taken from Kaggle (Masoud Nickparvar), (A. Hamada) which had 7023 slices. The four types of tumors featured in the images are pituitary, glioma, meningioma, and no tumor. In total, there were 7023 images of BT. 5712 images were utilized to fix the training set's misbalance. These were limited to 1311 images because the minimum set for these 4 classes was observed in the training set. The resolution of the images was initially 512x512 pixels. The resolution of the image has been reduced to 224 x 224 pixels, which makes it very convenient to use. The dataset's details are presented in the following Figure 2, which shows the splitting of the data. The training, validation and test sets are made from the entire dataset. About 90% of the collected data is used for training, 5% for validation, and 5% for testing.

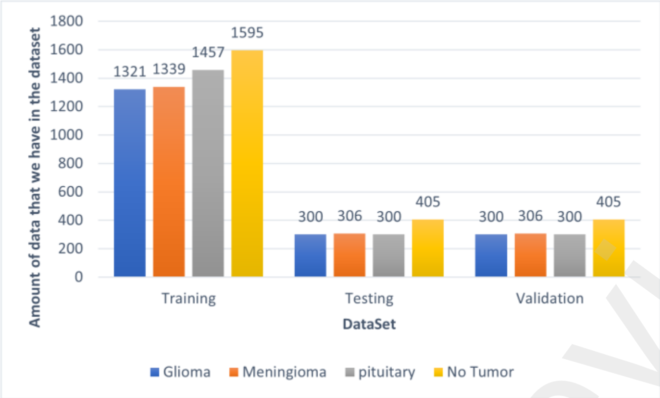


Fig. 2. Dataset splitting in graphical form.

3.2. Proposed approach:

The EfficientNet framework is a set of image classification tools that are designed to provide high-quality and accurate image classification. They are also smaller and faster than previous models (Tan, Mingxing, and Quoc Le). While other frameworks focus on computational efficiency, EfficientNet considers both performance and efficiency. The Softmax activation method is used in the frameworks. The EfficientNet-B6 framework is a case study that considers transfer learning. In Figure 3, you can see how the suggested model is put together. It introduces some new layers and freezes the top ones. Fine-tuning then takes place, and batch normalization and dropout layers are introduced to minimize overfitting. Figure 4 shows the flow of the layers during the batch normalization process. In the first dense layer, 256 neurons are used, and ReLU is the activation function. In the final layer, which is the dense layer, and the top layer that predicts output, the activation function is SoftMax. These tumors are classified into four groups: meningioma, glioma, pituitary.
and no-tumor. The training processes for the suggested model have been carried out over 40 epochs. It yielded the best results.

3.3. Validation processes for the experimental setup:

Validation of the model was carried out using images that weren't used in the initial training sessions. The results of the evaluation were then used to generate a confusion matrix. The activation factor used is ReLU. The last dense layer is the top layer that predicts output. This is where SoftMax is used to classify the various types of tumors. The training of the model was carried out over 40 epochs. It produced the best results. However, after three changes in the learning rate, the training was stopped at epoch 28. The elapsed time of the training was 6 hours, 53 minutes.

4. Experimental Results

The experiments are performed on an Anaconda Navigator with 12th-generation (8-MT/4-ST) Intel Core i7 processors. Each epoch, 115 steps used, and the batch size was 40. It is then decreased to a lower learning rate through the Reduce LR On-Plate-au technique. The suggested model able to achieve an overall test accuracy of 99.61% when compared to a training batch and accuracy graphs in the study.

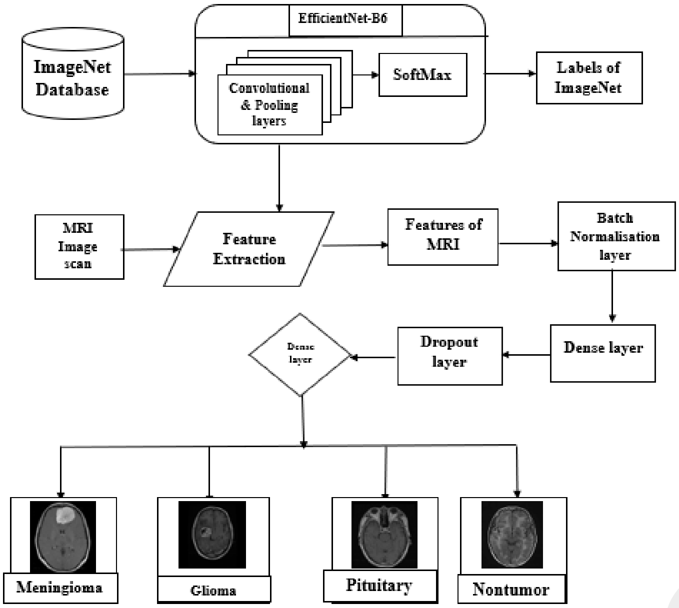


Fig. 3. The suggested model's structure

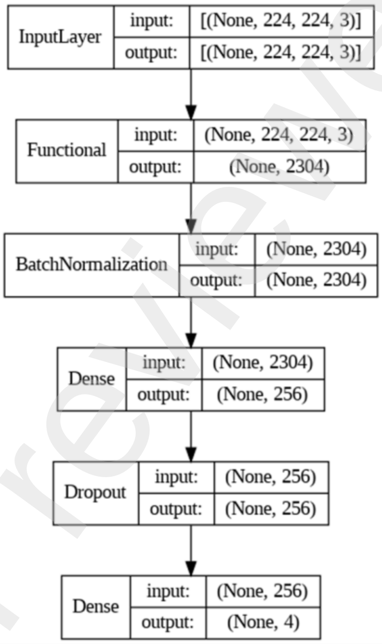


Fig. 4. The suggested layers' flow.

The training, validation, and testing accuracy percentages of the MR image dataset shown in Table 2. Figures 5 show the training and validation graphs for the promoted CNN model on a training dataset. Below are the metric formulas that can be figured out from the confusion matrix shown in the figure 7 for the proposed CNN model on a training dataset.

(a) Training & Validation Loss Graph (b) Training & Validation Accuracy Graph

Fig. 5. (a) Training & Validation Loss and Training & (b) Validation Accuracy graphs

Table 2. The accuracy of training, testing, and validation

Training	Validation	Testing
100%	99.34%	99.61%

Table 3 summarizes the comparative analysis of the literature survey's findings and the proposed model. It shows that the latter provides high accuracy and is better than the frameworks used in previous studies. Figure 6 represents the comparison between the proposed system and already established systems. The results of the evaluation indicate that the proposed architecture is more accurate when it comes to classifying BTs.

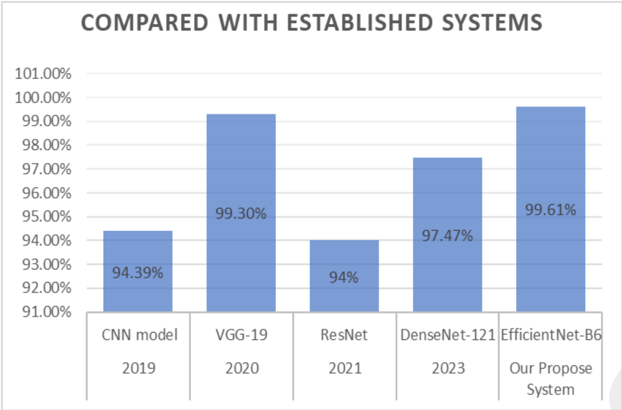


Fig. 6. Comparison graph of our model with some existing models.

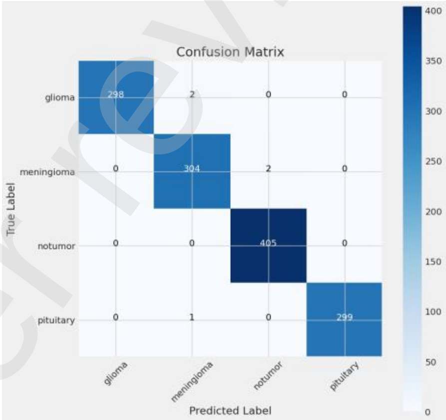


Fig. 7. Confusion Matrix

Table 3. New techniques are often compared with established ones.

year	References	Approach	Accuracy
2019	Das, Sunanda,etc.	CNN model	94.39%
2020	Joshi, Ranjana,etc.	VGG-19	99.30%
2021	Saleh, Abdulrazak Yahya,etc.	ResNet	94%
2023	Mathur, Parimal,etc.	DenseNet-121	97.47%
Proposed	**approach**	EfficientNet-B6	99.61%

5. Conclusion and Future Work

DL has helped solve various problems that previously impossible to accomplish, such as image classification. In this paper, a framework for improving the classification of BTs is proposed. The proposed method is based on the EfficientNet-B6 architecture, and it can be trained on MRI scans. The model able to achieve a 99.61% accuracy rate, a 99% recall rate, a 99% precision rate, and a 99% f1 score. It can also classify a given image class. This method can help improve the efficiency of BT diagnosis and reduce the time spent performing image analysis. The suggested method may be applied to other challenging biomedical problems.

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