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Brain Tumor Detection with Advanced Deep Convolutional Neural Networks

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Abstract
Identifying brain tumors at an early stage is important because early diagnosis and treatment can greatly improve the chances of a successful outcome. Brain tumors can grow and spread rapidly, and the longer they are undiagnosed and untreated, the more difficult they can be to treat. Early detection can also help to prevent or minimize the potential complications of a brain tumor, such as brain damage, seizures, and headaches. Additionally, diagnosis can also help to reduce the risk of the tumor spreading to other parts of the body, which can improve the prognosis for patients. So, transfer learning-based deep learning methods are analyzed and use a number of traditional classifiers to detect the brain tumor. Among all, the EfficientNet-B7 base model is fine-tuned with our proposed layers that efficiently classify and detects brain tumor images. The results show that the proposed Advanced Fine-tuned EfficientNet-B7 outperforms other DCNN models in achieving the highest classification accuracy values surpassing other state-of-the-art models.

Keywords: EfficientNet-B7, Adam, Root Mean Squared Propagation, Stochastic Gradient Descent, sigmoid, Rectified Linear Activation Function.

Introduction

An abnormal growth of cells is called a tumor, which has no purpose. The benign tumors which do not invade surrounding tissues and grow in a contained area are non-cancerous. However, if the tumors grow nearer to a vital area, then they can still cause trouble. The other type of tumor is called a malignant tumor, which can grow and spread in such a manner that can cause life-threatening cancerous disease. Whenever the maximum number of cells get damaged or old, they have to be removed or replaced with new cells. If the damaged or old cells are not removed then it may several problems, sometimes even death The development of a large amount of tissue, which refers to the growth or tumor is often the result of the creation of additional cells. The identification of a brain tumor is a challenging task due to its size, shape, position, location, and form of the tumor in the brain. The lack of precise information about the tumor's size results from the low-resolution image of brain tumor areas which causes difficulty in the early-stage brain tumor diagnosis. If the formation of brain tumors is detected early, then it can cause the patients to be treated in a good way and helps to save the patient's life. With the proper classification, brain tumor treatment is highly dependent on the timely diagnosis of the tumor. For the diagnosis of brain tumors, there are several medical imaging technologies, which can be used like Magnetic Resonance Imaging (MRI) scan, Computerised Tomography (CT) scan, Ultrasound, Simple Photon Emission Computed Tomography (SPECT), Positron Emission Tomography(PET) and X-ray. When compared to other medical imaging technologies, the MRI is the most commonly used medical imaging technology because identifying the brain

tumor from the MR images can offer better contrast images of the brain tumor. Recently machine learning (ML) based approaches are gained much popularity as they can give quite accurate and precise detection results. Especially, transfer learning technique has been demonstrated in several investigations, where the knowledge learned from a task can be reused for another similar task to reach achieve improved performance in classification on a target dataset [1].

To train a deep Convolutional Neural Network model using a large or massive dataset the chances for computational complexity are quite high. So, the learning procedure can be simplified by reusing the model weights from the previously trained models. Then the trained model is to be employed in a new model to get it trained with a new data set of interest. Then by using this procedure, the training time and generalization errors are significantly reduced. It is necessary to be selected the best-performing model in the target application, so a detailed study of different traditional deep transfer learning models is needed. Then an effective deep transfer learning system is identified which can detect and classify the brain tumor with great accuracy even in the presence of the lower dataset. The proposed pre-trained deep CNNs are used for MR Images to extract the necessary features and they are further categorized with 10-fold cross-validation finally detailed comparative results are computed which are in the presence of different performance matrices [2].

Literature Survey

In this author, the proposed method for classification of brain tumors using a Classifier and Neural Network uses segmentation algorithms which include Skull Striping along with morphological operation aiming that pre- processing, Anisotropic Diffusion Filtering which is used for noise removal and smoothing with edge detection locating the boundaries anatomically of the image [3]. This author proposed a brain tumor detection model using a Convolutional neural network. Here, they used many methods like Densely Connected Convolutional Networks-169(DenseNet-169) and ResNeXt-50, ShuffleNetV2, and Mobile neural architecture search Network (Mnas Net). These Deep features are a good choice in case the size of the MRI dataset is larger [4]. In this, the author uses methods like the combination of Le-Net and U-Net known as the Lu-Net model to detect Brain abnormality. The proposed method gives the best accuracy. It is a low-layered and less complex U-Net model [5]. In this, the author proposed the methods like Template-based K-means (TK) and Principal Component Analysis (PCA) to detect Brain Tumor MR Images using superpixels principal component analysis and template-based K- means clustering algorithm. By using these methods, brain tumors are detected accurately [6].

In this, they introduced a model to detect Brain diagnosis in the early stage by using Deep Convolutional Neural Network. This model has no adverse effect on classification and gives good accuracy. This system runs on the Tensor flow [7]. This author proposed a brain tumor classification method using the ensemble of deep features from pre-trained deep convolutional neural networks with ML classifiers. These deep features can help improve performance significantly [8]. This author used a method like Deep Convolutional Neural Network with Visual Geometry Group-16 to detect the brain tumor based on Deep Convolutional Neural Network. This model achieved an overall classification accuracy of 96%. This network operates particularly well in detecting tumors [9]. In this paper, the author proposed a new approach for brain tumor image classification based on transfer learning and fine-tuning using EfficientNet-B3.The proposed system obtained an accuracy of 94.8%. This may be used to develop a classification system for other body organ MRI images and other medical imaging domains [10].

In this paper, the author introduced Hybrid intelligence techniques for MRI brain images classification using Discrete Wavelet Transform(DWT), Principal Component Analysis (PCA), False Positive Artificial Neural Networks(FP-ANN), and K-Nearest Neighbors (k-NN). The

proposed hybrid technique consists of three stages, namely, feature extraction, dimensionality reduction, and classification. The classifiers have been used to classify subjects as normal or abnormal MRI human images [11]. This paper is about Brain tumor detection using the Deep CNN method. In this, we achieved the training accuracy of maximum levels. The method shown in this paper is a very basic image classification method of Le-net architecture [12]. This author proposed a Brain Tumor Detection Using Artificial Neural Networks. Magnetic Resonance Imaging (MRI) is one of the best technologies currently being used for diagnosing brain tumors and it creates more detailed pictures. It was observed that the Elman network was used during the recognition process, and the duration time and accuracy level were high [13]. In this, the proposed system utilizes wavelet, curvelet, and shearlet transformations, coupled with textural features from MR brain images. Various texture and entropy features are selected using a Particle Swarm Optimization-Support Vector Machine (PSO– SVM) combination. Shearlet transform-based features outperform other techniques in terms of performance parameters [14].

This paper is about Brain Tumor Identification and Classification of MRI images using deep learning techniques. CNN is considered one of the best techniques for analyzing the image dataset. The CNN predicts by reducing the image size without losing the information needed for making predictions [15]. This author proposed Brain Tumor Segmentation from MRI Images using Hybrid Convolutional Neural Networks. He used methods like U-Net, U-Net, Semantic Segmentation model(SegNet), and Residual Neural Network-18(ResNet-18). These methods are designed for the reliable automatic segmentation of brain tumors [16]. This paper is about Very Deep Convolutional Networks. For Large-Scale Image Recognition and investigates the effect of the convolutional network depth on its accuracy in the large-scale image recognition setting. It demonstrated that the representation depth is beneficial for classification accuracy and that state-of-the-art performance on the ImageNet challenge [17]. This paper is about the Classification of MR images using transfer learning and Fine-tuning. The method used in this paper is Deep Convolutional Neural Networks(DCNN). The traditional machine learning techniques for classification focus only on low-level or high-level features. Here, using the pre-trained deep CNN model and proposing a blockwise fine-tuning strategy based on transfer learning [18].

In this, the author proposed Brain tumor detection using the SVM method. SVM is used for pattern mapping and pattern matching processes. In this the images get pre-processed and skull masking is done here. After skull masking, fatty tissues and other unwanted details get smoothen. Pre-processed image is segmented with the K-Mean segmentation [19]. This author proposed Brain tumor detection with the help of using a BRAMSIT which is a resource for possible use by the MRI analysis research community. The projected MRI database is termed BRAMSIT, characterized by an attempt to offer a group of normal and malignant brain tumor images [20]. In this, the author proposed a system that is trained with pre-processed MRI brain images that then classifies newly input images as tumorous or normal based on features extracted during the training of the data [21]. In this, the author proposed a brain tumor segmentation and classification method for multi-modality magnetic resonance imaging scans. The data from the multimodal brain tumor segmentation challenge (MICCAI BraTS 2013) are utilized which are co-registered and skull-stripped, and the histogram matching is performed with a reference volume of high contrast [22].

Reference Number	Title	Methodology Used	Observation	Limitations
[3]	Classification and Segmentation of Brain Tumor Using	Adaboost classifier	Adaboost classifier is used to classify brain images into Tumor vs Nontumors.	Data imbalance that leads to the decrease in classification

	Adaboost Classifier			accuracy.
[4]	Detection of tumors on brain MRI images using the hybrid convolutional neural network architecture.	Densely Connected Convolutional Networks-169, InceptionV3,and ResNeXt-50.	The ensemble of the deep features is a good choice in case the size of MRI dataset is large.	Needs to reduce the size of the model to deploy on a real-time medical diagnosis system.
[5]	Detection of brain abnormality by a novel Lu-Net deep neural CNN model from MR images.	Combination of Le-Net and U-Net known As Lu-Net Model	It provides the best accuracy rate but it also outperforms other deep neural models.	The classification accuracy and computational as well as structural complexity contains limitations.
[6]	Brain tumor detection in MRimage using superpixels, principal component analysis and template based K-means clustering algorithm.	Template- based K-means(TK) and Principal Component Analysis (PCA)	It is better than other existing detection schemes better when compared to other existing detection schemes.	The enhancement for the accuracy of detection and classification with stage identification of tumor.
[7]	Early tumor diagnosis in brain MR images via deep convolutional neural network model.	*Deep Convolutional Neural Networks*(DCNN)	Achieved higher accuracy and attained good detection outcomes including case of abnormality.	It needs to reduce the parameter space without affecting classification accuracy.
[8]	MRI-based brain tumor classification using ensemble of deep features and machine learning classifiers.	Densely Connected Convolutional Networks169,Inception V,ResNeXt-50, Shuffle Net V2, Mobile neural architecture search Network(MnasNet)	This model is used in case of very large and very small datasets.	Further research needs to be done to reduce the size of the model.
[9]	Deep convolutional neural networks model-based brain tumor detection in brain MRI images.	Deep Convolutional Neural Network(DCNN) with Visual Geometry Group-16(VGG-16)	The model was trained for faster and effective training using a pre-trained VGG-16 network	Our work is expected to expand with 3D brain scans in the future.
[10]	Brain Tumor Classification for MR Images Using Transfer Learning and EfficientNetB3.	EfficientNet-B3	The use of the CNN Efficient Net – B3 model to classify MR images of braintumors	This research still has Limitations like efficiency and accuracy in the use of different datasets.
[11]	Hybrid intelligent techniques for MRI brain images classification.	Discrete Wavelet Transform(DWT), Principal Component Analysis(PCA), False Positive Artificial Neural Networks(FP-ANN), and K-Nearest Neighbors (k-NN).	The proposed models that we have built gave very promising results in classifying the healthy and brain patient.	This work requires fresh training each time whenever there is an increase in image database.
[12]	Brain Cancer Detection From MRI: A Machine Learning Approach (TENSORFLOW).	Detection From MRI: A Machine Learning Approach (TENSORFLOW).	The dataset out of which 900 were cancerous and 900 were non- cancerous are identified with CNN.	The training accuracy was found to be 99% and validation accuracy was 98.6% in 35 epochs,but this system is still in

				development.
[13]	Brain Tumor Detection Using Artificial Neural Networks.	ElmanNetwork, Artificial Neural Network(ANN)	The duration time and the accuracy level were high, compared with other ANNs systems.	The MR images dataset which is used here contains different modalities of MR images which increase the recognition difficulty for ANN
[14]	Application of Multiresolution Analysis for Automated Detection of Brain Abnormality Using MR Images.	Shearlet transform+ Texture + Particle Swarm Optimization-Support Vector Machine	It compares three efficient multiresolution analysis based image transformation techniques for the detection of brain abnormalities on MR images.	The other types of MR images, such as proton density and T1weighted Images need to develop.
[15]	Brain Tumor Identification and Classification of MRI images using deep learning techniques.	Fully Automatic Heterogeneous Segmentation using Support Vector Machine (FAHS-SVM)	The accuracy of this automated approach is similar to the values for manual segmentation inter-observer variability.	Tumor segmentation in conjunction with a semi supervised approach under a local and globalized accuracy system.
[16]	Brain Tumor Segmentation from MRI Images using Hybrid Convolutional Neural Networks.	U-Net,Semantic Segmentation model(SegNet), Residual Neural Network-18(ResNet-18)	It is designed for reliable automatic segmentation of the brain tumor from the MRI images with high accuracy.	The hybrid models can be improved by using different sizes of filters and modalities of the MRI images.
[17]	Very Deep Convolutional Networks For Large-Scale Image Recognition.	VeryDeepConvolutional Neural Networks(VDCNN)	ImageNet challenge dataset can be achieved using a conventional ConvNet architecture with substantially increased depth.	In wide range of tasks and datasets, matchings or outperforming more complex recognition pipelines built around less deep image representation.
[19]	Detection of Brain Tumor from MRI images by using Segmentation and SVM	K-means	This system is used for segmentation of brain MR Images for Detection and identification of brain tumor.	To find the size and type of tumor we should obtain the three dimensional image of brain.
[20]	BRAMSIT: A Database for Brain Tumor Diagnosis and Detection	BRAMSIT	It describes Screening Brain Tumor for the most recent database. Investigating brain tumor image analysis by using it as a resource.	Most brain tumor databases are not publicly available.
[21]	Deep Learning Approach for Brain Tumor Detection and Segmentation	*Deep Convolutional Neural Networks*(DCNN)	An efficient model for detection and segmentation of brain tumor is build which saves human efforts and time.	Images are not properly segmented where the tumor region is visible
[22]	Brain tumor	Final Value and brain	In this system	It contains high

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	classification from multi-modality MRI using wavelets and machine learning	tumor segmentation	intensity, intensity difference,neighborhood information and wavelet features are extracted and utilized on multi-modality MRI scans with various classifiers	computational complexity

Dataset Description

To analyze and evaluate the developed framework a publicly available and accessible MRI dataset from Kaggle [https://www.kaggle.com/navoneel/brain-mriimages-for-brain-tumor-detection] is used. The images are in two folders labelled as 'yes' and 'no' corresponding to the abnormal and normal brain images as shown in Fig.1 and Fig.2.

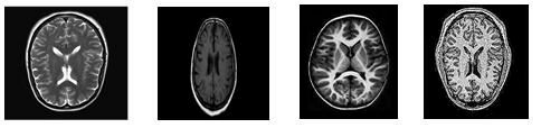

Fig 1. Brain Mri Images Without Tumors

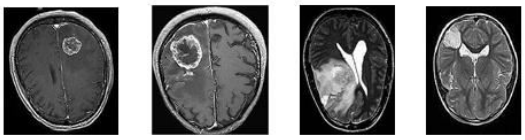

Fig 2. Brain Mri Images With Tumors

Proposed Methodology

EfficientNet-B7 is the largest and most accurate model in the efficient net family, with 7.8 million parameters. EfficientNet-B7 has been pre-trained on the ImageNet dataset and can be fine-tuned for other image classification tasks. It has been shown to achieve state-of-the-art results on a variety of image classification benchmarks and has been used in a number of applications such as object detection, semantic segmentation, and medical image analysis. The performance of the proposed CNN model experimented with 10 and 20 epochs. The optimizers used for the experiments are Adam, RMSProp and Stochastic Gradient Descent (SGD). The model named as Efficient net-B7. The pre-trained network is used to process the images. The efficiency of the framework is measured using accuracy which is calcuated in the following equation1.

TABLE 2. Ten folds classification results for precision, recall, F1-score and the highest accuracy obtained with the best pre-trained models

Optimizers	sigmoid		ReLu	
	Epoches	Accuracy	Epoches	Accuracy
adam	10 20	50 90	10 20	50 90
rmsprop	10 20	50 80	10 20	50 80
sgd	10 20	50 90	10 20	50 80

The above table 1 signifies that the proposed deep learning model gives better results for adam and sgd optimizers.

Conclusion

The proposed CNN model The several transfer learning-based deep learning methods are analyzed and corresponding results are compared to select a best-performing CNN model for the detection of brain tumors from MR Images. computed for all the pre-trained models with 10-fold cross-validation. The best-performing model is the EfficientNet-B7, which shows the highest accuracy among all the presented models. However, the presented model was not tested for different brain MRI modalities along with other imaging techniques. Also, the proposed technique can also be extended for the classification of tumor types like Glioma, Meningioma, and Pituitary using the MR image dataset. Above all, the use of a larger dataset and better GPU-based

processing can also improve the accuracy of results as well as the computational speed of presented models. We aim to highlight those issues as a part of future works.

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