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Review on Brain Tumor Detection and Classification with MRI Images using Deep Learning Techniques

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Abstract

Segmentation allows visualizing size and position of tumor within the brain which is used for comparison of tumor images before and after surgery. Clinical Experts performs this task manually. As clinical data is increasing day by day, the manual segmentation methods may not be always accurate and may lead to errors for different types of brain tumors. The image data has various attributes which are case specific and the distinction and interdependence of these attributes plays a significant role in classification and detection. Analyzing the data for its better understanding as per the required format finally allows us to better detect and classify the tumor. As there is variations in the appearance of tumor tissues among different patients, manual Segmentation is a challenging process,. Researchers are working in this area for many years and they has presented the results which are found to be useful. However, there is a scope for further improvement in the area of classification and detection with respect to various quality parameters associated with the process. Inthe clinical practice, accuracy of tumor detection is highly dependent on the operator's experience. In the present study, Magnetic Resonance Imaging (MRI) images of different types of brain tumors shall be considered. Automatic segmentation and classification of brain tumor using Deep neural network is proposed in this study. The network shall be trained on publicly available fig-share brain tumor dataset also the MRI images collected from Tata Memorial Hospital, Mumbai.

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Keywords: *MRI, Deep Neural Network, Segmentation*

1. Introduction

Cancer can be defined as the growth of cells in an unusual way which tend to multiply in an uncontrolled way and, in some cases, it spreads to other parts of the body. A brain tumor is a mass or growth of abnormal cells in the brain. Early diagnosis can be an important factor in the outcome of tumors in the brain which provides better treatment options for the patient. Brain tumors are of two main types: cancerous tumors and benign tumors. Depending on their initial origin, Cancerous tumors can be divided into primary tumors, which start within the brain, and secondary tumors, which have spread from elsewhere, known as brain metastasis tumors. The most common primary brain tumors are gliomas, meningioma and pituitary types of brain tumors

A glioma type of tumor starts to grow in the gluey supportive cells that surrounds nerve cells. Gliomas constitute 33% of all brain tumors. A strocytoma is considered as high gradeglioma. The main focus of current brain tumor segmentation research is Gliomas type of brain tumor. Gliomas vary in their aggressiveness, or malignancy. Surgery, chemotherapy and radiotherapy are the techniques used, usually in combination, to treat gliomas. Meningioma is a slow-growing tumor that forms from the meninges which are the three membranous envelopes that surround the brain and spinal cord. Pituitary adenomas are tumors that start to grow in the pituitary gland situated in the brain. Pituitary adenomas are benign tumors that comprise 15% of primary brain tumors.

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Once the brain tumor is seen by the doctor, radiological evaluation is necessary to evaluate the tumor for its size and location in the brain also to evaluate its influence on the surrounding areas. On the basis of this information various treatments like surgery, radiation, or chemotherapy are decided by the oncologists. Tumor grading is done as per the growth rate of the cancerous cells. World Health organization (WHO) categorizes the tumor grades as I ,II ,III, IV from low to high growth rate. According to WHO, Stage (0,1,2,3,4) of the disease is decided on the basis of its progression. It is proved that the lives of a tumor bearing patient can be saved if the tumor is detected accurately in its early stage. It is very difficult to treat cancer in its higher stage. As a result, radiological evaluation of brain tumors using imaging modalities has gained importance in clinical practice. The various imaging modalities are useful for the radiologists to observe disease advancement and surgical treatment planning. The physical examination of brain i.e. scanning using imaging modalities like Computed tomography (CT) or MRI is a noninvasive approach. Whereas traditional method like biopsy is invasive approach of diagnosis where a surgical cut is done in the skin to collect tumor sample which is used to observe tumor cells under microscope to confirm malignancy.

Brain tumor segmentation involves diagnosing, describing and separating tumor tissues from normal brain tissues which includes Gray Matter (GM), White Matter (WM) and CSF. In current clinical practice, this task includes manual explanation and bisection of MRI images. However, since manual segmentation is a very time taking procedure that may prone to human errors, there is a need of development of robust automatic segmentation method, to provide efficient and reliable segmentation in a very less time, became an interesting and popular research area in recent years. Nowadays, deep learning techniques are providing good performance and exciting solutions in the process of segmentation.

2. Review of Literature

Zacharaki et al propsedrCBV mapsclassification method[2]. The method classifies brain tumor in to meningioma ,glioma in to grades II, III, IV, and metastasis tumors. In this study 102 MRI Brains images were used.In this method, linear SVM model was used extracting feature characteristicslike tumor shape, image intensity, and Gabor features from Images. Images were preprocessed and region of interest was extracted from the brain images. Various selection algorithms like ranking based were used for feature reduction. Lastly, SVM was applied for classification. They got 91.7 accuracy for classifying metastasis tumors. They found difficulty in identifying grade II and grade III gliomas.

M Malathi and P Sinthia (2019)[4] proposed convolutional neural network based automatic brain tumor segmentation method. In this study BRATS 2015 database was used which contains high grade brain images of Gliomas. Segmentation was carried out by using tensor flow. The research work was mainly targeted on classification of tumor in to edema, non-enhancing, enhancing and necrotic tumor. The performance parameters like dice similarity co-efficient and the sensitivity were used for evaluation.

Abhishek Anil et al.(2019)[5] presented a method which consist of a classification network which classifies the input MR images into two classes one with tumor and the second without tumor. In this research work , detection of brain tumor was done by retraining the classifier using the transfer learning via classification. Three different CNN networks i.e Alexnet,VGG16 and VGG19 aretrained on pre-trained Image-net dataset and concluded that VGG19 was the best detector among the three.

For automatic brain tumor segmentation, M.Thaha et al.(2019)[6] proposed Enhanced Convolutional Neural Networks (ECNN) with loss function optimization by BAT algorithm. MRI images were pre-processed by using Skull stripping and image

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enhancement algorithms. The method gives better performance in terms of accuracy, precision and recall.

Jijja et al. (2019)[7] segmented and detected the brain tumor from MRI images using Convolutional Neural Network based method. Water cycle algorithm which is based on actual water cycle process was applied to CNN that plays an important role in detecting and classifying images of tumor.

Badisaat et al.(2019)[8] presented two major novel approaches for analyzing tumor-bearing brain images in an automatic way. To segment healthy and tumorous brain tissues, Multi-modal tissue classification with integrated regularization technique was used for segmentation which includes sub-compartments to provide quantitative volumetric information. The brain tumor severity is estimated using Convolutional neural network.

Sobhaninia et al.(2019) [9] proposed single link-net and multiple link net convolutional neural network for different angles of MRI image for tumor segmentation. The segmentation results are evaluated using Dice criterion. The Dice coefficient, metric for validation of medical image segmentation. The lowest Dice score was 0.71 which is related to the images from the axial view of the head.

Sajid et al. (2019)[10] proposed hybrid convolutional neural network architecture which combine the efficiency of two-stream parallel network with three-path network .It uses patch-based approach which considers both local and contextual information,for predicting output label. This improves efficiency of tumor segmentation.

Li Sunet al. (2019) [11] ensembles three different 3D CNN architectures for strong performance through voting (majority rule). This rule was used to extract tumoral region from MRI scan. Then various features of tumors like volume, shape, density, location and intensity are extracted and to predict overall survival of tumor bearing patient, various tumoral features combined with clinical features to predict overall survival.

S. Deepak et al. (2019) [12] proposed brain tumor classification framework. The proposed algorithm uses modified and fine-tuned GoogLeNet to learn the features of brain MRI images with tumors. When SVM or KNN was used in place of the classification layer within the transfer learned model then accuracy was increased. Misclassification of samples was observed from the class meningioma. The problem of overfitting with smaller training data was identified.

M..Talo et al. (2018)[13] uses deep transfer learning based approach to automatically classify normal and abnormal brain MR images. In This work, ResNet34 model was used as a deep learning model. To classify the brain tumor images, transfer learning with the pre-trained CNN ResNet34 architecture was used.

Selvy et al. (2019) [14] proposed the tactic to detect the neoplasm classify the glioma using resonance Imaging (MRI). Histogram Equalization (HE) technique was used for preprocessing. Then Gray Level Co- occurrence Matrix (GLCM) is employed for feature extraction. The obtained feature is given to Probabilistic Neural Network (PNN) classifier that's wont to train and test the performance accuracy within the interpretation of tumor location in brain MRI images.

Gupta et al. (2019) [15] presented CAD system that uses different segmentation schemes for various pulse sequences, fusion of texture features and ensemble classifier to perform three levels of classification. Once the tumor is detected at the primary level of classification, its location is analyzed using tentorium of brain and it's classified into superatentorial or infratentorial within the next level. supported the morphological and inherent

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characteristics of tumor (area, perimeter, solidity, and orientation),the system identifies tumor type at the third level of classification. The system gives average accuracy of 97.76% on JMCD (a dataset collected from local medical college) and 97.13% on BRATS datasets at the primary level of classification.

J. Seetha et al.(2018)[16] proposed five CNN architectures which uses hyper parameter within the learning process which accommodates two layers of convolution, activation (RELU) and maxpool followed by one hidden layer and 64 neuron for classification of Tumor.

Cui et al. (2018)[17] used cascaded neural network for tumor localization. Also Intra-tumor classification network (ITCN) was used for Tumor classification. The proposed approach was validated on (BRATS 2015) datasets, which contain 220 high-grade glioma (HGG) and 54 low-grade glioma (LGG) cases. The evaluation parameters Dice similarity coefficient (DSC), positive predictive value (PPV), and sensitivity were utilized in this study.

Kaldera et al. (2019) [18] proposed a Convolutional Neural Network (CNN), for classification and Faster Region based Convolutional Neural Network (Faster R-CNN) for segmentation with reduced number of computations with the next accuracy level. This research has used 218 images as training set. The system presented has a median accuracy Of 94% for all the classifiers.

Charron et al. (2018)[19]presented an existing 3D convolutional neural network (DeepMedic) to detect and segment brain metastases on MRI. Afshar et al (2019)[20] incorporated newly developed CapsNets for tumor classification. Accuracy obtained with this architecture was 90.89%. Architecture proposed during this work is used for interpretability in medical deciding. Moeskops et al.(2017)[21] proposed a way for the automated segmentation of MRI brain images into variety of tissue classes employing a convolutional neural network .and used patch based network for classification with average accuracy.

In current years, CNN's are more popular due to its outstanding performance and reliability. the most challenge in Computer Aided Diagnosis is to differentiate intensity of tumors , shape and therefore the variations in imaging modality. Convolutional Neural network (CNN) provides exciting solutions for learning complex tumor features and handling patch of infected tissues.

Recent Methods and Predictive Models

In current years, Deep learning methods are more popular because of its eye-catching performance, flexibility and reliability. Nowadays for image segmentation, there are various popular CNN architectures like CNN with Auto-Encoder, CNN with SVM for classification, CNN with K-Means algorithm; similarly there are various methods and architecture available for resolving the issues in medical domain.There are some CNN models available with different layers and structure, such as VGG ,AlexNet, GoogLeNet , ResNet , Highway nets, DenseNet , ResNext, SENets , NASNet , YOLO , GANs , U-net , V-net, and many

Summarized Findings from Literature Review

1. In Magnetic Resonance Imaging (MRI), the Experts requires quantification of the tumor in tumor diagnosis.

2. Researchers has got less accuracy for tumor grading. Hence, there is lot of scope in grade estimation of brain tumor.

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3. There is a scope for further improvement in the area of classification and detection with respect to various quality parameters associated with the process.
4. Feature Reduction without losing significant information is the main challenge in the process of classification.
5. Together with performance, Trustworthiness or interpretability of the model is also very important in deep learning models. Apart from this,making results more explanatory is very important in segmentation.

Research Motivation

Medical science as a boon to human kind at large, the success factor is always a dependent on the degree of diagnosis accuracy by a medical practitioner. Even with development in medical science field are reaching peak, unintentionally we are vulnerable towards diagnostic errors.These errors has harmed us in multiple ways[25]-

- Death
- Permeant organ damage
- Inappropriate treatment
- Financial losses
- Numerous social and occupational impairments

It can be concluded from the data available with various sources, that though the overall percentage of misdiagnosis varies between 5–10%, cancer related misdiagnosis are on higher side. Estimates shows cancer related misdiagnosed cases error varies between 10-20%. According to study, 40,000 patients die every year due to cancer related misdiagnosis, in US alone[24]. Looking at the world population, it is creating disastrous situation.
Technology, on the other hand, is known to assist all those professions and professionals where speed and accuracy is desired. An accurate automated system can minimize the diagnostics errors so that physician and patient can rely on the system and patient's life can be saved from the consequences of misdiagnosis. This research study uses MRI brain images, because of its high resolution and good quality.

Dataset

The network shall be trained on a brain tumor dataset publicly available via fig-share also the MRI images collected from Tata Memorial Hospital, Mumbai

Conclusion

The research paper is related with the review of current deep neural network techniques of segmentation and classification of brain tumor with MRI images. So the objective of this research work is to develop a Deep learning model which will provide faster, reliable and accurate segmentation and classification of infected brain tumor and to accurately detect stage of disease.

Future Scope

In medical domain as data is increasing day by day and datasets are changing due to increase in the diseases, various deep learning models are developed by the researchers to handle large datasets which provides good results.But, current deep learning models

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are trained with static inputs and are not trained to handle time. So to develop a model with considering time factor is future research point.

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