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Utilization of Machine Learning in Brain Tumor Classification

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ABSTRACT

Abnormal formation of mass of cells may result in formation of brain tumor. Brain tumor type if not diagnosed precisely, may affect the survival rate. Biopsy report is gold standard in defining tumor type and its grade. However biopsy report may contain sampling and subjectivity errors which may results in inaccurate diagnosis.Inaccurate diagnosis results in the wrong treatment management, hence affecting the overall survival rate of a patient. This motivated the clinicians and scientists of cross disciplinary area to develop non-invasive machine learning methods in detecting brain tumor types and grading. The presented paper was divided in three sections. Introduction discusses the importance, need of brain tumor classifications with the help of noninvasive machine learning methods. Related work discusses the various machine learning approaches which were developed inorder to classify the tumor types or grades. A summary of implemented machine learning classifiers reported in literature along with their reported accuracy were also presented in this section. The conclusion section concludes the paper and helps in finding the relevant challenges which needs further exploration.

Keywords: Brain tumor, Biopsy, Magnetic Resonance Imaging, Machine Learning, Feature Selections

I. INTRODUCTION

Brain is among the one of the complex organ of the human body. Brain tumor occur when there is abnormal formation of cells within tissues takes place. This abnormal formation of cells may push the normal tissues within the brain and can cause deformation of normal anatomy of the brain. This may also affect the normal functioning of the brain. Brain tumors can be formed in two ways. Abnormal formation of cells may start within the brain itself. Such type of brain tumors are known as primary brain tumors. When source of formation cell mass that causes tumor belongs to some other organ of the body, such type of tumors are known as secondary brain tumors. Secondary brain tumors are also known as metastasis tumors.

Brain tumors majorly falls into two categories i.e. benign tumors and malignant tumors. Benign tumors are non-cancerous and malignant tumors are cancerous in nature [1]. Early detection of tumor may improve the survival and quality of suffering patient [1-22]. Exact reasons that causes brain tumors are unknown till today.Some of the symptoms of brain tumors are: Headache, difficulty in speaking, imbalance, double vision, weakness etc. [2-10]. Clinician observe the symptoms and may ask for further examinations such as scans or biopsy. Conducting these additional examinations helps

clinicians to get details of tumor such as what is the size, type and grade of tumor and which part it is affecting most etc. General investigation starts with imaging which includes magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET), PET-CT etc. [1-5]. MR imaging is considered to be better choice as per clinicians over other imaging techniques because of its better soft tissue contrast and non-invasiveness. Once tumor is confirmed with the help of imaging procedure, clinician may ask for biopsy procedure. If possible, depending on the size and location of tumor, clinician may conduct surgery inorder to remove the tumor cells completely. The cells which were resected during the tumor procedure are sent to pathology where it is strained with chemicals in order to detect tumor grade or type. Sometime it is very difficult to conduct the surgery which may be due to size, shape and location of brain tumor. In that case clinician may conduct the stereotactic biopsy to collect the tumor tissues so that tumor type and gradecan be decided. Once tumor grade and type is diagnosed precisely, clinician may plan the futher treatment such as chemotherapy, radiotherapy or combination of these. Biopsy, whether it is conducted normally or stereotactically, is invasive in nature and time consuming. Biopsy report may contain errors which may be due to sampling of collected tissues or may be due to subjectivity. The errors in biopsy report may cause the inaccurate grading and type's detection which futher affect treatment planning and survival rates of suffering patients. These all factors motivated clinicians and engineering scientists of various domains such as computer, maths, biomedical, information sciences, bioinformatics, electrical etc. to collaborate inorder to find some non-invasive method using MR imaging to precisely detect the type and grade of brain tumor hence improving the treatment planning and increasing the survival rate.

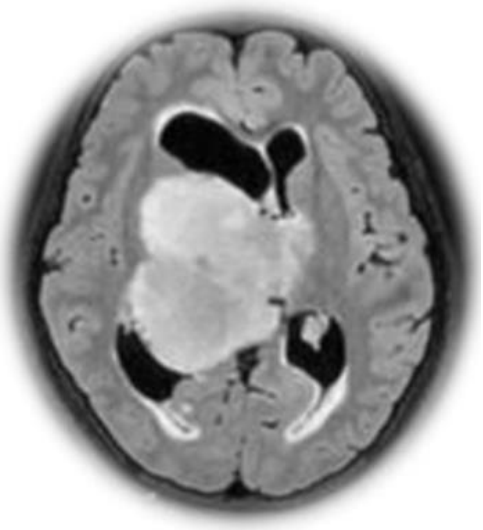

Fig 1. MRI FLAIR image showing the tumor mass (white in color) pushing the CSF inside the brain.

To make the procedure fast without being explicitly programmed, role of machine learning, deep learning and transfer learning in tumor classification are exploring now a day's by the clinicians and scientists.

The aim of this paper is to present the overview of brain tumor and application of machine learning approaches in diagnosing brain tumors grades and types. The whole paper is organized in three major sections i.e. introduction, related work, conclusion and future research directions.

II. Related Work

This section presents the related work done in the domain of brain tumor classification using machine learning approaches. In study [1], the authors compared different feature selection and machine learning approaches in gliomas classifications. For conducting this carried out study, 210 high grade gliomas and 75 low grade gliomas cases were considered. As per findings support vector machine and multilayer perceptron achieves the better accuracy when compared to other 13 classifiers considered. Reported accuracy in classifying LGG from HGG when SVM was used as a classification method, equal to 94.4%. In study [2], authors presented survey which includes the literature

review of year 2018 and year 2019. As per their findings, SVM was the most used machine learning algorithm in gliomas classification. In study [3], authors considered the BraTS 2018 data set to conduct their study. SVM model was developed to classify the LGG cases from HGG. K-fold (K=5) cross validation was used to validate the developed model. For C= 1 and kernel=linear, model achieved the classifier performance equal to 88.4%. In study [4], authors used CNN to classify HGG from LGG. For enhancing tumor regions, saliency strategy was used. Using CNN approach, developed CNN model achieves the accuracy equal to 89.74%. In study [5], author used the concept of DT to classify the HGG from LGG. Study was conducted using BraTS 2013 dataset, using texture as input features. Reported accuracy using decision tree as classifier was equal to 96.6%. In study [6], authors used deep neural network to distinguish high grade glioma from low grade glioma. The developed model was cross validated with the help of leave-one-out strategy.

In study [7], authors developed models to classify the tumors into five classes' i.e. Central neuro cytoma, GBM, glioma, Intra Ventricular Malignant Mass and metastasis. Three models i.e. K-nearest neighbor, SVM (support vector machine), BPNN (back propagation neural network) were developed. Out of these three developed models, BPNN achieved the better accuracy which was equal to 97.0%. In study [8], authors presented a survey which gives an overview of deep learning techniques in tumor segmentation and classifications. In study [9] authors implemented four classifiers i.e. KNN, random forest (RF), SVM and decision tree (DT) using REMBRANDT dataset. As per their findings SVM produced the best classifier accuracy over other implemented classifier i.e. equal to 90%. In study [10], authors developed a deep learning model in order to classify T1 MR images into three categories i.e. glioma, meningioma and pituitary. The reported accuracy on test data set was equal to 95%. For developing their deep leaning CNN model, auto-keras library was used. In study [11], author developed CNN model to detect brain tumor. The developed model achieved accuracy equal to 91% in detecting brain tumor.

In study [12], authors developed a hybrid model which were based on concept of PSO (particle swarm optimization) and SVM to classify the tumor into benign or malignant. For conducting their studies, they have used the BraTS 2015 dataset. The developed hybrid classifier achieves the accuracy equal to 91%. In study [13], authors developed method for detecting the tumor. For carrying out their proposed task, model based on the concept of boosting technique (Adaboost) was used. With the help of developedmodel, reported accuracy was equal to 89.90%. In study [14], authors developed model which was based on RELM (regularized extreme learning concept) to classify brain tumors into three classes. Hybrid feature extraction method was used to extract the features. With the help of developed model they have achieved the accuracy equal to 94.233%. In study [19], authors developed three classifier inorder to classify the cases into normal or abnormal. Three classifiers were based on the concept of CNN, artificial neural network (ANN) and SVM respectively. These three concepts were further used to develop the three more classifier which can classify the cases into benign and malignant class. The model which was developed based on the concept of CNN performed better when compared to other two developed classifier.

Table-I: Summary of implemented machine learning classifiers reported in literature along with their reported accuracy

Reference	No. of considered cases	ML classifier	Reported Accuracy
[1]	LGG = 75 HGG = 210	SVM, Multilayer perceptron, other13 classifiers	Accuracy = 94.4% in case of SVM
[3]	LGG = 75 HGG = 210	SVM	Accuracy = 88.4%
[4]	LGG = 75 HGG = 210	CNN	Accuracy = 89.74%
[5]	LGG = 20 HGG = 10	DT	Accuracy = 96.6%
[6]	LGG = 20 HGG = 10	DNN	Accuracy = 93.3%
[7]	Central Neuro Cytoma =30, GBM =30, Glioma=30, Intra Ventricular Malignant Mass =30, Metastasis = 30	Gabor-Wavelet + CVM + BPNN	Accuracy = 97.0%
[9]	REMBRANDT	KNN, RF, DT,SVM	Accuracy (SVM) = 90%
[10]	Meningioma = 708	CNN	Accuracy = 95%

III. Conclusion & Future Research Direction

This paper over view the role of machine learning techniques in classifying different types of brain tumors.The paper presented was organized in three major sections. In introduction part importance of developing non-invasive methods in diagnosing brain tumors was established. In related work, different machine learning approaches discussed in various studies available in literature were discussed. The relevance of this section gives overview to its readers about the related work done and accuracy achieved on sample size considered. The accuracy achieved on considered patient cohort (sample size) helps in evaluating the approach considered in diagnosis. The table I represents the summary of machine learning classifier implemented and accuracy achieved. Although lots of machine learning approaches were discussed in literature which shows promising results in classifying brain tumors but needs validation on larger data set. It was well established in literature

that due to lack of common datasets and large datasets, comparison of various approaches seems difficult and opens door for further research in this directions.

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