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Study of Machine Learning vs Deep Learning Algorithms for Detection of Tumor in Human Brain

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Abstract**—** Modern medical imaging research faces the challenge of detecting brain tumor through Magnetic Resonance Images (MRI). Brain tumor is an abnormal mass of tissue in which some cells grow and multiply uncontrollably, apparently unregulated by the mechanisms that control normal cells. There are three types of tumor that are commonly observed viz. Benign, Pre-Malignant, and Malignant. Many supervised and unsupervised classification algorithms are used for detection of tumor as benign or malignant. Usually lighter datasets are used for image classification in application field where as comparatively larger and heavier datasets are used in case of medical field. Many parameters chosen during training play a very important role in measuring the performance and accuracy of the system. Thus an attempt has been made to clearly show how accuracy of the algorithm varies based on the parameters chosen for detection of brain tumor in human brain for an MRI image.

Keywords**—** CNN, Transfer Learning, Medical Imaging, Glioma, Image Classification, Machine Learning, Deep Learning.

I. INTRODUCTION

Medical image processing is the most challenging and emerging field today. Today's modern medical imaging research faces the challenge of detecting brain tumor through Magnetic Resonance Images (MRI). Normally, to produce images of soft tissue of human body, MRI images are used by experts. It is used for analysis of human organs to replace surgery [14].

The word tumor is a synonym for a word neoplasm which is formed by an abnormal growth of cells [7].Brain tumor is an abnormal mass of tissue[11] in which some cells grow and multiply uncontrollably, apparently unregulated by the mechanisms that control normal cells. The growth of a tumor takes up space within the skull and interferes with normal brain activity. So detection of the tumor is very important in earlier stages. Various techniques [7] were developed for detection of tumor in brain. There are three types of tumor that are commonly observed viz. Benign, Pre-Malignant, Malignant [8].

Glioma is a general term used to describe any tumor that arises from the supportive (―glueyǁ) tissue of the brain. This tissue, called ―glia,ǁ helps to keep the neurons in place and functioning well. There are three types of normal glial cells that can produce tumors. An astrocyte will produce astrocytomas (including glioblastomas), an oligodendrocyte will produce oligodendroglioma, and ependymomas come from ependymal cells. Tumors that display a mixture of these different cells are called mixed glioma.

Glioma is also classified by the type of cells they affect. The types of Glioma are:

- Astrocytoma — develop in the connective tissue cells, called astrocytes
- Brainstem Glioma — develop in the brain stem
- Ependymoma — develop from ependymal cells
- Mixed Glioma — develop from more than one type of glial cell
- Oligodendroglioma — develop in the supportive tissue cells of the brain, called oliogendroctyes
- Optic nerve Glioma — develop in or around the optic nerve

Image Classification is an important task within the field of computer vision. Image classification refers to the labeling of images into one of a number of predefined categories. Classification includes image sensors, image pre-processing, object detection, object segmentation, feature extraction and object classification. Image classification is an important and challenging task in various application domains, including biomedical imaging, biometry, video surveillance, vehicle navigation, industrial visual inspection, robot navigation, and remote sensing.

Motivation:
Brain tumor, which is one of the most common brain diseases, has affected and devastated many lives. According to International Agency for Research on Cancer (IARC) approximately, more than 126000 people are diagnosed for brain tumor per year around the world, with more than 97000 mortality rate in 2017 [9]. Brain and other nervous system cancer is the 10th leading cause of death for men and women. It is estimated recently that 17,760 adults (9,910 men and 7,850 women) will die from primary cancerous brain and CNS tumors. Despite consistent efforts to overcome the problems of brain tumors, statistics still shows low survival rate of brain tumor patients. To combat this, recently, researchers are using multi-disciplinary approach involving knowledge in medicine, mathematics and computer science to better understand the disease and find more effective treatment methods. Magnetic resonance Imaging (MRI) and computer tomography (CT) scanning of the brain are the two most common tests undertaken to confirm the presence of brain tumor and to identify its location for selected specialist treatment options. The choice for the treatment options depends on the size, type, and grade of the tumor. It also dependents on whether or not the tumor is putting pressure on vital parts of the brain. Whether the tumor has spread to other parts of the central nervous system (CNS) or body, and possible side effects on the patient concerning treatment preferences and overall health [10] are important considerations when deciding the treatment options.

Why Image Processing?
Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Why MRI for bio-medical Imaging?
Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. It includes the analysis, enhancement and display of images captured via X-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies.

Magnetic resonance imaging (MRI)[12] is important imaging technique used in the detection of brain tumor. Brain tumor is one of the most dangerous diseases occurring among the human beings. Brain MRI plays a very important role for radiologists to diagnose and treat brain tumor patients. Study of the medical image by the radiologist is a time consuming process and also the accuracy depends upon their experience. Thus, the computer aided systems becomes very necessary as they overcome these limitations. Several automated methods are available, but automating this process is very difficult because of different appearance of the tumor among the different patients.

Most tumors develop from the supporting cells of the brain known as the glial cells. They may be named after the type of cell that they are made up of, or after the part of the brain where they are found such as a brain stem glioma. More than half of all primary brain tumors are glioma. How serious a glioma is depends on its grade. Glioma are classified by whether they are low-grade (I or II) — slow or relatively slow growing, or high-grade (III or IV) – malignant, with fast growth and spread into normal brain tissue.

Rest of the paper is organized as follows, Section II contain the related work of different algorithms with advent of technology in image classification, Section III contains the generic methodology used by most of the researchers to perform comparative analysis of different algorithms and devise a better algorithm to obtain better accuracy based on the features, section IV concludes research work with future directions.

II. RELATED WORK

Depending on the imaging technique and what diagnosis is being considered, image processing and analysis can be used to determine the parameters that decide the performance of the algorithms for classification of tumor into its grades.

In this paper, a detailed survey about the methods and the data sets used for classification of tumor has been carried out and the accuracy obtained has been recorded as below.

V.P. GladisPushpa Rathi et.al [1] proposed innovative way of feature extraction and selection. This method focuses on using many shapes, texture and many more feature of tumor as white matter, gray matter, CSF, abnormal and normal area.

Methods used: The author has used Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) and also Support Vector Machines (SVM) in this method. Comparison of linear techniques and non-linear techniques are done by SVM. PCA and LDA are used in dimension reduction. The architecture of our proposed work is as follows

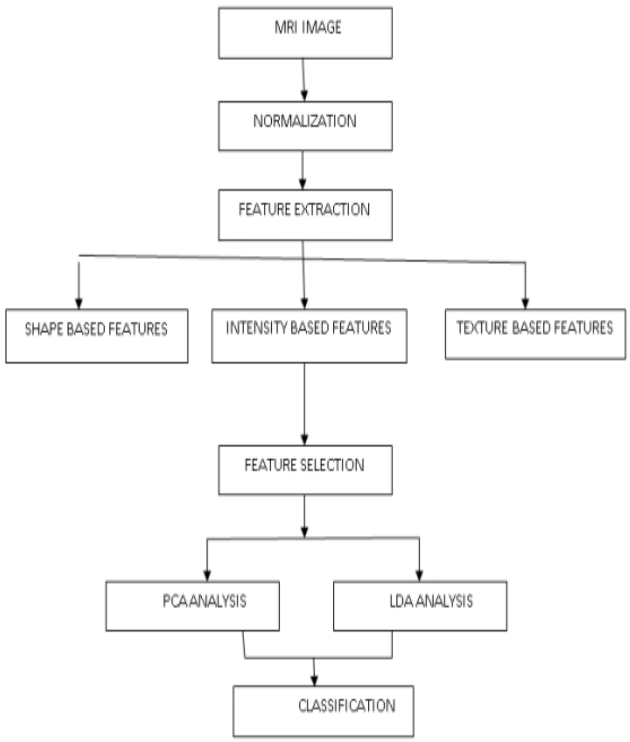

Fig 1: Architecture proposed by [1]

Images are taken from different patients with Glioma. 24 slices in axial plain with 5 mm slice thickness in each volume. MR imaging was done in 3T Siemens devices. MRI image dataset is done as shown in the following (normalization done in range of 0-255).Normalization is done by converting the images to gray levels of 0-1 and features extraction is done.

Feature Extracted:
Here feature extraction is done based on shape, intensity and texture. Shape Features – shape being circular, regularity, Area .Intensity features – Mean of the data, distortion , standard deviation etc.. features –Contrast, information measure, uniformity, cluster attributes like shades, sum of standard deviation.Feature selection is done where the extracted images with least dimensions are taken and the rest are discarded. It is done for the data to run on the algorithms smoothly.

Forward Selection starts with no variables and iteratively adds one by one which makes least errors. We use simple rank-based selection criterion, which compares two distributions.

Results obtained:
The classification phase is divided into training and testing phase. Efficiency of training determines the accuracy of the classification.

This method's accuracy is as tabulated below

Table 1: Feature values of various data sets

Features	T1	T2	FLAIR	TOTAL
Intensity	6	5	11	22
Shape	1	1	3	5
Texture	8	5	20	33
Total	10	20	30	60

Limitations:
Redundant values can be selected but not preferably. Feature ranking method can be used to choose more discriminative feature.

Conclusion:
Backward Selection starts with all variables and deletes them iteratively until any other removal increases error significantly. This is done to reduce over fitting. To optimize the classification performance support vector machine recursive feature elimination algorithm is used. Backward selection makes SVM based error bound smallest.
Classification is done by PCA and LDA. Frequencies within class which are unequal are tested on randomly selected test data. Variance between classes and within are maximised in this method.

OmidReyhani-Galangashi et.al [2] proposed brain tumor segmentation method based on the Random Forest algorithm. The method proposed is applied to the part of the images of brain magnetic resonance and a high performance indices like Dice Similarity Coefficient (DSC) as well as algorithm accuracy (ACC) are calculated which are 98.38% and 97.65%, respectively. The result which obtained, showed that the proposed model can have a good performance when compared to the other segmentation methods.

Advantages:
In order to find the exact area of the brain tumors, a cohesion-based self-merging (CSM) algorithm for the division of the brain MRI data is proposed. CSM attracts a lot of attention because it has more favorable results than that of other integration processes.

Results:
After doing diagnosis, clustering methods and boundaries were used to extract the exact tumor area and above 99% accuracy was obtained for diagnosis—according to the authors' claim. The author's approach was to manipulate machine learning and customize an innovative learning algorithm known as Random Forest (RF) in a way to handle larger datasets.

Limitation:
Performance analysis showed that the qualitative results of the proposed model are similar to those obtained with other

two models. Choosing the right control parameters to obtain better results from the algorithm is challenging.

Conclusion:
In the proposed work, the noise effect is greatly reduced to increase the chance of finding the exact area of the tumor, so that the calculation time is also a lot lower since the algorithm proposed is simple and therefore computes with less complexity. So a particle swarm optimization (PSO) algorithm which is based on clustering is proposed and identifies the center of mass of clusters. Each cluster contains the brain tumor patterns obtained by MRI in a group. The results of the three different performance measurements were compared with the results obtained by Support Vector Machine (SVM) and Adaptive Boosting (AdaBoost) methods. In this regard, after presenting the mathematical modeling of the RF concept, the author suggested a work flow to implement the segmentation process on tumors for MRI data.

LinaChato et.al [3] proposed various Machine Learning methods such as K-Nearest Neighbors, Support Machine Vector, Tree, Ensemble, Linear Discriminant, and Logistic Regression were used to develop the prediction model for classification. Many feature extraction methods were used such as Statistical and Intensity Texture, Volumetric and Location, 2D Deep Feature, and Histogram Distribution. The first order features includes Correlation, Energy, Standard Deviation, Smoothness, Entropy, Root Mean Square, Contrast, Homogeneity, Inverse Difference Moment, and Mean. The best prediction accuracy based on classification is achieved by using deep learning features extracted by a pre-trained Convolutional Neural Network and was trained by a linear discriminant.

Results:
Glioma is considered as the aggressive type of brain tumor and overall survival rate doesn't exceed two years and they represent 74.6% of all malignant tumors. The sample contained patient's age, MRI brain images, and the overall survival time in days. The dataset was labeled according to the survival rate i.e. short-term survivors (less than 6 months), mid-term survivors (ranging from 10-15 months), and long-term survivors (more than 15 months).

Limitations:
The dataset considered was already divided into two groups, higher grade glioma and lower grade glioma and four sequences of MRI modalities were provided.

Conclusion:
Multimodal brain tumor segmentation 2017 challenge dataset was used, which has 163 samples. The author obtained an accuracy of 68.5%.

MuhammedTalo et.al [4] proposed CNN based ResNet34 model. The author has used deep learning techniques such as data augmentation, optimal learning ratefinder and fine-tuning in order to train the model.

Results:
The proposed model achieved 5-fold classification and the author claims that the accuracy obtained was of 100% when the dataset consisting of 613 MR images was used for classification. Abnormalities like Alzheimer's disease, stroke, Parkinson's disease and autism were classified by ResNet34.

Table 2: ResNet34 model particulars.

Layer type	Input shape	Output shape	#parameters
ResNet34	3,128,128	64,64,64	9408

Here previously trained model that have been learned how to solve a similar classification problem. The ResNet34 architecture is trained on ImageNet database which contains more than one million images that belong to 1000 categories.

Conclusion:
The author proposes that ResNet34 architecture converges faster when compared to other pre-trained models such as VGG and inception. The ResNet34 architectureis very simple to use in various datasets when compared to other pre-trained models suchas inception andVGG.

Heba Mohsen et.al[5] proposed Deep Neural Network classifier which is one of the DL architectures for classifying into four different classes .Brain tumor usually occurs whenever abnormal or uncontrolled division of brain cells within the brain is observed. Brain Tumors are of two types namely malignant and benign. Benign tumors do not spread whereas malignant tumors are cancerous as they grow with undefined boundaries very fast.

Algorithm Used:
The author has applied the deep learning concept to perform brain tumors classification using brain magnetic resonance images and measure the performance. The major agenda of the method proposed is to differentiate between normal brain and brain affected by tumors of different types. The following method uses a set of features extracted aided by the discrete wavelet transform (DWT), to train the DNN classifier for classification of brain tumors. Out of various Deep Learning architectures, the author has preferred to use convolutional neural networks (CNN) that can perform numerous sorts of complex operations using convolution filters. After the extraction of the features, the classification step using deep neural network is performed on the obtained feature vector.

Results:
A dataset of 66 brain MRIs were considered .Classification is done by DNN containing 7 hidden layers structure. The author claims to have obtained the accuracy of 96.97%.

Conclusion:
The author claims that the good results that were obtained using the DWT could be employed with the Convolutional Neural Network in the future.
Angel Cruz-Roaa et.al [6] proposed the approach of transfer learning for image classification.

Algorithms used:
In transfer learning, no dataset containing the images to be classified is used as such. Instead we make use of the pre-trained models which are used either as conventional features or as a weight initialization strategy for a neural network which is retrained for a different task. AlexNet, Visual Geometry Group (VGG) and Over feat are the most popular pre-trained CNN models that are publicly available and have won the ImageNet challenge, held every year from 2012 onward. The ImageNet dataset contains millions of annotated images that has its place in over one thousand different categories. Medulloblastoma is a type of malignant brain tumors, it comprises around 25 percent of all brain tumors observed in children. Depending on the subtype of medulloblastomai.e, anaplastic or non-anaplastic,the predicted course of tumor tends to differ, the anaplastic tumor typically last longer.

Limitation:
A decision support tool for pathologists to help differentiate the anaplastic from the non-anaplastic tumor.

Results:
The approach followed by the author is to compare two different CNN models VGG-CNN and IBCa-CNN, that were previously trained in two different domains namely, natural and histopathology images. VGG-CNN is a CNN model trained to classify natural images in 1,000 categories. This CNN has around 138 million of parameters distributed in16 layers where 13 layers are convolutional-pooling layers, 2 are fully-connected layers and 1 layer is softmax classification layer. IBCa-CNN is a CNN model trained to classify histopathology images between invasive or non-invasive breast cancer. IBCa-CNN has 3 layers: one convolutional-pooling layer, one fully-connected layer and one softmax classification layer.The author claims that VGG-CNN trained model could not classify histopathology images of medulloblastoma images whereas in IBCa-CNN trained model, the average classification accuracy was 89.8%, with a standard deviation of 5.6%.

Conclusion:
Both CNNs are used as feature extractors to represent the content of the histopathology image regions for both the anaplastic and non-anaplastic medulloblastoma tumors from whole-slide images. Result showed that IBCa-CNN outperformed VGG-CNN, despite being a smaller architecture.

Stefan Bauer et.al [13] proposed Support Vector Machine classification algorithm applying multispectral intensities and the pattern with the subsequent stratified regularization based on the Conditional Random fields to propose a fully automatic system for brain tissue classification and segmentation. The essential task to analyze a brain cancer is to delineate the tumor boundaries from MRI.

Results:
The prominent features for distinguishing healthy tissues and pathological and also their sub regions were extracted from the multispectral imaging data. The first order texture features such as energy, variance, mean, kurtosis, entropy and skewness were also used. Dice similarity coefficient was used to evaluate the results. For intra patient case, small sub regions were trained on the classifier and for inter patient case, leave-one-out cross-validation was performed.

Table 3: Results Obtained

	GTV	Necrotic	Active	Edema
Intrapatient Regularized	0.84±0.03	0.61±0.24	0.71±0.09	0.73±0.04
Intrapatient Unregularized	0.76±0.10	0.45±0.31	0.59±0.16	0.72±0.07
Interpatient Regularized	0.77±0.09	0.45±0.23	0.64±0.13	0.60±0.16
Interpatient Unregularized	0.67±0.13	0.30±0.24	0.46±0.12	0.63±0.16

Limitation:
To separate the tumor tissues and healthy tissues .Both the regions are sub classified into white matter, active, gray matter and necrotic, edema region and cerebrospinal fluid in a novel hierarchical way.

Conclusion:
This approach is fast and also adapted to standard clinical acquisition protocols. The author has considered the case of glioma, since it is the most aggressive type of brain tumors. The conditional random field approach makes the process very efficient but also maintains accuracy by considering the neighbor relationships.

III. METHODOLOGY

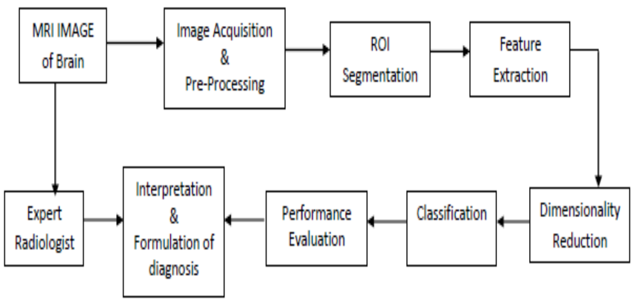

Fig 2: Generic Methodology for Tumor Classification

In the proposed work an attempt shall be made to to develop a fully automated computer aided diagnosis tool that incorporates different image processing techniques to give an accurate estimate of the features of the tumor in brain , then classify them based on the non parametric parameters using machine learning techniques and as well compare this with deep learning approach by identifying the ideal hyper parameters that are responsible for the classification of tumor as benign or malignant using the state-of-the-art techniques.
The features can be extracted as proposed by some of the techniques like forward selection and backward selection. Also some of the features extracted using machine and deep learning techniques can be compared with that of transfer learning techniques which does not have a predefined dataset to decide the kind of approach to be used to obtain the features.

IV. CONCLUSION AND FUTURE SCOPE

Various authors have proposed different techniques to extract features based on the kind of learning technique that has been implemented. In this paper stress has been made on the recent trending machine and deep learning algorithms to classify tumor as benign or malignant. There has been considerable results seen and accuracy obtained by various people on a fixed datasets only. Mostly the work carried out till now has been using various machine learning algorithms on different sizes of data and standard data sets only. Thus this work can be explored using the transfer learning approach and a detailed comparative analysis can be made against the varied sizes of data set and observe the behaviour of the algorithm and record their accuracy.

Thus in the proposed work an attempt shall be made to choose the right algorithm based on the size of the dataset to accurately diagnose the grade of the tumor present by applying deep learning methods optimally choosing the right hyper parameters involved for classification of sample into benign or malignant.

However there is scope for research to address the gaps identified from the detailed survey. A detailed comparative analysis of different machine learning algorithms can be carried out on a particular dataset for image classification. Also an attempt shall be made to scale the size of the dataset and apply the algorithm to check if the algorithm performs as predicted, this is considered as critical analysis of the algorithm. Suppose an algorithm does not provide the predicted accuracy, we tweak the parameters that led to the decrease in the accuracy; this is considered as optimization of algorithms.

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