A futuristic approach for analyzing the Brain Tumor using Computational Aided Diagnostics

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Abstract - Brain tumor is a treacherous and life threatening disease. Prognosis of cancer demands trained medical professionals and effective clinical trials. Imaging modalities such as Magnetic Resonance Imaging (MRI) is a valuable tool for diagnosis. To enhance the quality of life of brain tumor patients improved examinations with non invasive treatments are required. It is an emerging area of research in both field medical as well as engineering field. The primary purpose is to develop an efficient tool which could be helpful in early detection of tumor. This study proposed a futuristic technique of analyzing the detection of tumor by comparing it with the normal brain data through machine learning classifiers. This paper deals with comparative study of pattern recognition and feature extraction of tumor from the primary data of image in terms of intensities obtained from MRI modality. Our contribution to an existing scenario is to provide with an analyzed data mining evidence of different classifiers specifically targeting Solid cum Cystic Tumor. Computational analysis from the available dataset is done through machine learning tool. MRI images are represented in grey scale level image. Mean intensity, variance and combination of both are considered as a feature classifier. Classification accuracy of datasets of brain tumor with normal brain is analyzed via machine learning classifiers. Matlab is used for Intensity feature extraction and WEKA machine learning software is used for classification testing. The experimental results clearly show classification accuracy. Among mean and variance, later shows more reliable result testing different algorithm. Variance can be taken into account as a prominent feature extraction for tumor detection.

Keywords- Brain, MRI, Classifiers, tumor, intensity.

I. INTRODUCTION

Brain is a complex structured central body organ. Any abnormality in brain effects its normal functioning. Tumors are the result of abnormal growth of normal cells. Tumors are of two types. Malignant is a cancerous where as benign is non cancerous. Brain Tumor whether malignant or benign is fatal to human body. Patients’ treatment is highly dependent on the quality of clinical trials and equipments used. Decisions of Medical Professionals (Lab technicians, Doctors, Pathologists) plays very important role in disease diagnosis. Existence of semi automated system for tumor detection can cause error. There is a need of fully automated system to keep track on tumor analysis. Extensive research is required in Tumor early detection, its type, observing growth rate, pre and post surgery analysis. Biomedical engineering is an emerging field of technology. During recent years there is a great deal of work is accomplished in brain tumor. Magnetic Imaging Modality (MRI) and Computed Tomography (CT) are worthwhile imaging modalities for tumor examination. Brain development can be examined with high resolution images from MRI [1]. Digital image processing is a diverse discipline has almost applications in all areas, its application in medicine has opened new doors of research. Tumor segmentation is a very complicated task. All research encompasses to find a method which can automatically detect tumor. Computational analysis is yet another area which has great contribution to tumor study. Pattern recognition and feature extraction of tumors through machine learning tool are also beneficial for cancer investigations. It gives quantitative evaluations among classifiers to find accuracy with help of algorithms.

Our investigation represents a futuristic technique for classification of brain tumor by comparing with normal brain. MRI images are taken into consideration. Machine learning tool is used to find the accuracy level among different cases of normal and tumor brain. Brain tumors cases of solid, cystic and solid cum cystic are chosen for analysis. Our work will be helpful in programming a machine to distinguish between normal and brain with tumor. Our study is just a first step in modeling a computer assisted system or tool for tumor detection and classification. Intensity feature of MRI image is chosen for research. Images are analyzed through Matlab. The pixel value represented by image is actually its intensity. MRI images shows intensities on grey scale. As Brain Tumors are heterogeneous in nature. Heterogeneity involves its size, shape, texture and mainly its location. Effective pattern recognition and feature extraction is required in devising a tool. This paper has 5 sections: first briefs introduction of study, second discusses literature review, thirds deals with methods and materials used in research, fourth discussion of our study through tables and graphs and in the end conclusion followed by future work. This paper shows promising results as represented and supported by graphs under discussion section.

II. LITERATURE REVIEW

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Digital image processing plays a vital role in cancer treatment. [2] Discusses basic steps of image processing in tumor detection. Segmentation is the core step of DIP. Automated Segmentation of solid cum cystic brain tumor is represented via using MATLAB through MRI images [3, 4]. 2D and 3D Reconstruction of human body or organ can be done with the help of MR. [5] discussed the reconstruction of brain tumor in 3D. Artificial intelligence with digital image processing has embraced many applications in medicine. From speech recognition to almost all medical areas. Even emotions can be distinguished with its help [6, 7]. Artificial intelligence (AI) has great position in research of brain tumor detection. A great deal of study is done in this area. Literature review shows that machine learning scheme is used to classify brain tumor type with its severity grade [8]. This study focuses texture and shape. Investigating the grade of tumor required highly experienced pathologists. Research plays a vital role in this area.

Computer aided diagnosis has revolutionized the digital world. [9] presents a details survey of historical evolution in this area from 1987 to 2008. Digital image processing helps in segmentation of tumor which is a tedious and core task. Automatic Brain tumor detection from MRI images is very difficult task. There are many different types of MRI such as T1, T2, T1 Flair, Structured MRI, Functional MRI and 3D MRI. [10] Presents detection of asymmetrical deviation of brain tissues from 3D MRI images. They proved the validity of method on 17 different cases. [11] Discusses the detection of small tumors, which often form early primary neoplastic or metastatic disease. 3D image convolution using multi-scale LoG filters to extract blobby structure. An asymmetrical blobbing nature of brain tumor makes the task challenging. Ed-Edily Mohd. Azhari [12] proposed histogram clustering and morphological operation for tumor segmentation. A training set of 21 features is developed including the blob shape, compactness, and asymmetry and intensity statistics. Techniques Sequential Forward Selection, Quadratic Discriminant Analysis classifier are performed. The average sensitivity is found to be 97.5% (+4.7). BRATS (Multimodal Brain Tumor Image Segmentation Benchmark) [13] is a state of art collection of 20 algorithms capable of producing 65 comparable scans using image simulation software. The cases consist of many types of brain tumors. There are many machine learning techniques which are discussed in [14] for tumor detection. Luke Macyzyn [14] identifies the relation between MRI features and survival in patients by applying machine learning technique. Their study based on, as MRI can be used to develop non invasive biomarkers cellular/molecular characteristics. So the knowledge MRI image can be used as link between link molecular and imaging diagnostics. Mu Zhou [15] discusses survival rate with the use imbalanced data set (skewed distribution) of multi modal MRI. They proposed Synthetic Minority Over-sampling Technique and a predictive linear regression model, tested on 42 patients with Glioblastoma Multiforme (GBM) tumors. The results showed 95.24% accuracy. [16] Support vector machine classification for brain metastasis is proposed on texture based MRI. The GBM and metastasis physically appear same on images which can lead to misdiagnosis and wrong clinical treatment. Yang G. has proposed a semi automated method to discriminate between GBM and solitary MET. He used diffusion tensor [17] for segmentation and morphological feature extraction and pattern recognition for tumor classification. Proposed method has produced an accuracy of 97% with cross validation with previous methods. Mustasem K [18] proposed hybridization of Fuzzy C-Means and Artificial Bee Colony Algorithm for segmentation of brain tumor. He claimed his approach to be more reliable than traditional Fuzzy C mean algorithm and effective against noise.

Literature review shows that no work has been done on solid cum cystic brain tumor with machine learning tool. Although, some work is present with Solid cum Cystic Tumor in other region of human body or either solid or cyst solely. Early detection of solid lesion or cyst breast tumor is presented by automated approach using feature extraction. It employed diverse algorithms for classification into benign and malignant tumor. Pancreatic neuroendocrine tumors detection is also discussed [19] with the fusion of diffusion-weighted images (DWI), T1-weighted and T2-weighted (T2) MR images with calculation of Apparent diffusion coefficients (ADC) of tumor and adjacent pancreas were measured. One case with cystic tumor shows low ADC otherwise the fusion of images work well for other cases. They classify their mechanism into three grades; no lesion, uncertain lesion and certain lesion. The malignancy or benign ovarian cancer is found to be difficult [20]. Segmentation of solid type of brain tumor is detected through image processing with region growing algorithm [21]. Fourth order partial differential equation for denoising images. The accuracy is 99%. Diagnosing of human brain tumors (Astrocytoma tumors) with Type-II fuzzy expert system with use of T1-weighted Magnetic Resonance Images with contrast is presented with accurate results [22]. Mostly the research is being done on glioma or either on all types of tumors. Our study revolves around specifically around solid cum cystic type of brain tumor.

We have searched for classifiers literature. Classifications of data have application almost in all fields which involves large amount of data analysis. Discussed only those which are used in this paper. Regression algorithm mostly used for software defect estimation [23]. This paper discusses regression via classification to make prediction for software defects. Classification also applicable by using only part of the dataset. [24] Discussed part classifier by moving window for image recognition focusing off-line images. Random forest [25] classification and regression is discussed with application in
Ensembles of Nested Dichotomies [26] are discussed with application of multi class problems. [27] Discussed least square support vector machine (LS-SVM) and proximal support vector machine (PSVM) for binary classification.

III. MATERIAL AND METHOD

Magnetic Resonance imaging modality is considered in this research. The images are acquired from General Electric Signa HDx 1.5 Tesla. The cases are arranged from local University. All the images in all three planes are available: axial, coronal and sagittal. Each view has 19 slices. There are many types of MRI techniques of which images with T1, T2 weighted and T1 FLAIR images are available. All images are $512 \times 512$ in size. We used T2 weighted image. Cyst appears white on T2 image which makes its visibility more obvious where as in T1, appears dark merging with other parts of brain. Axial view of all the cases is selected. In this paper we considered 4 normal cases and 4 cases with brain tumor. Tumor type is solid cum cystic type. There is very rare research work for this type of tumor with machine learning tool. Literature review shows that dataset target all type of tumor. We considered specific type of tumor to produce affective results. 3 Slices of axial view T2 weighted image (1, 10, 19) is used from all the cases. All images are formatted to JPEG format. Features are extracted through Matlab. Mean Intensity and Variance is selected as features. Data set is converted to Attribute-Relation File Format (ARFF) and feature are tested on WEKA. The details of important steps are as under.

A Feature Extraction

Intensity and variance of an image is considered as features for classifications. Feature extraction is done through MATLAB platform. Mean intensity of each image is found out using command in MATLAB `mean(A (: ))`, whereas $A$ is an image. `mean (A)` returns the mean of columns in row form. By using `mean (A (: ))` it will find the mean of row also producing a single value. Total of 24 mean intensities of all slices are found. Similarly, variance of each slice is found out through Matlab with `var (A (: ))`.

B Machine Learning Classifiers

We used following classifiers. The brief explanation of all classifiers are as under:

i) Multi layer Perceptron (MLP)- MLP is the type of Artificial neural network. Simple neuron called perceptron are used in MLP network. Instead of single layer it deals with multiple layers. It produces a single output with many simple units are connected with weighted connections. The weights can be allocated with different algorithm.

ii) Classifier via Regression- Regression is used to predict and statistically finding an estimation among variable. It is
basically used to find relationship between dependent and independents variables. It is widely used classification.

*iii) Nested Dichotomies-* These are binary trees in which classes are defined randomly at root node. At node logistic regression is used. It is used in large scale classification data.

*iv) Rotation Forest-* It is method in which features set is split into K subsets. Principal Component Analysis (PCA) is applied to subset. Then the rotation along the K axis is performed to generate new features based on base classifier. As the decision trees are chosen on the rotation sensitivity. Thus it is named rotation forest. [28]

*v) Random Forest-* In decision trees, random forest adds an extra layer of randomness to bagging of trees. Each node is split by choosing randomly best among the subsets of predictors at that node.

*vi) Multiclass Classification-* It is the classification of more than two classes. Figure 1 shows the summary of methodology adopted in this paper.

IV. DISCUSSION & RESULTS

Classification of large number of dataset is an important aspect of research. Artificial intelligence has influenced almost all real world problems. We have suggested a unique application of Artificial Intelligence in medical engineering. Our work is just a primary step towards automatic detection of tumor. Brain is central organ of human body. Tumor of any type in brain is life threatening. In this paper we discussed classification of solid cum cystic tumor through MRI images. Many classifiers are tested.

Table 1 shows respective value of mean intensities. As it is mentioned earlier in this paper that three slices of axial plane MRI are selected. Keeping in mind that number of slices in each case is same which results in same cross section observation in all the cases. In following table the mean intensities and variance values of Case 1,2 and 4 are close to each other. In Case 3, the values variation in observation with difference of 10- 20 in grey level. The images are comparatively darker than other cases which is clearly visible. The inconsistency in reading of tumor cases is due to the fact that location and size of tumor is not same in all case. As we already mentioned in our introduction that this is our first attempt in this area of research. We start with selection of mean intensity and variance as features.

A comprehensive detail for performance evaluation of learning classifiers in terms of classification accuracy with possible combination of intensity based features of brain are shown in Table 2. . Out of all the classifiers used results of those are highlighted which comes out to be considerable.

Table 1. Mean Table

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Image 1</th>
<th>Image 10</th>
<th>Image 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 1</td>
<td>33</td>
<td>45</td>
<td>37</td>
</tr>
<tr>
<td>Case 2</td>
<td>37</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>Case 3</td>
<td>22</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Case 4</td>
<td>31</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Tumor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 1</td>
<td>30</td>
<td>43</td>
<td>46</td>
</tr>
<tr>
<td>Case 2</td>
<td>23</td>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>Case 3</td>
<td>23</td>
<td>36</td>
<td>27</td>
</tr>
<tr>
<td>Case 4</td>
<td>15</td>
<td>34</td>
<td>24</td>
</tr>
</tbody>
</table>

Mean intensity shows promising result of up to accuracy of 55% where as variance as standalone class doesn't show promising result. When a class of mean and variance together are considered, Multi Layer Perceptron and Rotation Forest shows effective result of 59%. Our findings are that variance is not a reliable feature for brain tumor classification. Mean is a sound feature and shows same accuracy level by classifiers. Highest time observed is 0.05 seconds with highest accuracy of 55% for mean intensity and 59% for mean intensity + variance together.

V. FUTURE WORK

This study includes only axial T2 weighted image with only three slices. Same work can be extended to (a) finding features of all axial slices, (b) feature of coronal and sagittal view can be taken, (c) exploring other classes, (d) testing classes on other machine learning software, (e) comparative study among different machine learning tools and (f) includes other types of tumors. The case 3 images can be made brightened for future
work. Image processing steps can be adopted. Classification of brain into its several parts can be made part of this research. Segmenting tumor or at least considering only tumor area through region of interest. Tumor detection can be further classified into solid and cystic part detection separately with its location mentioned. It is possible by comparing the tumor image with normal one. Literature review shows that there are supervised or semi supervised methodologies are recommended. Our aim is to introduce a fully automated system for tumor detection.

VI. REFERENCES

[1] Sudipta Roy, Samir K. Bandyopadhyay, "Detection and Quantification of Brain Tumor from MRI of Brain and it’s Symmetric Analysis International Journal of Information and Communication Technology Research", Volume 2 No. 6, pg:477-483, June 2012 ISSN 2223-4985


### Table 2. Classification accuracy of Machine Learning classifier on Brain Features

<table>
<thead>
<tr>
<th>Features</th>
<th>Classifier</th>
<th>Time to built model (sec)</th>
<th>Classification accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Multi layer Perceptron</td>
<td>0.04</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Classification Via Regression</td>
<td>0.12</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Nested Dichotomies</td>
<td>0</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Rotation Forest</td>
<td>0.02</td>
<td>55%</td>
</tr>
<tr>
<td>Variance</td>
<td>Multi layer Perceptron</td>
<td>0.06</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>Classification Via Regression</td>
<td>0.1</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Nested Dichotomies</td>
<td>0.01</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>Rotation Forest</td>
<td>0.03</td>
<td>33.33%</td>
</tr>
<tr>
<td>Mean &amp; Variance</td>
<td>Multi layer Perceptron</td>
<td>0.05</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Classification Via Regression</td>
<td>0.1</td>
<td>46%</td>
</tr>
<tr>
<td></td>
<td>Nested Dichotomies</td>
<td>0.01</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td>Rotation Forest</td>
<td>0.03</td>
<td>59%</td>
</tr>
</tbody>
</table>