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Review of MRI Image Classification Techniques

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Abstract: *MRI is an important medical diagnosis tool for the detection of tumors in brain as it provides the detailed information associated to the anatomical structures of the brain.MR images helps the radiologist to find the presence of abnormal cell growths or tissues (if any) which we call as tumors. The MRI image analysis is performed under the sequence of operations such as Image Acquistion, Preprocessing, Feature Extraction, Feature Reduction and Image Classification. In this paper, an effort was put to review the existing MRI image processing techniques used in the brain tumor detection and their performances are studied.*

Keywords: *Wavelet Transform, Support Vector Machine (SVM), Principle Component Analysis (PCA), Artificial Neural Network (ANN), Gray Level Co-occurrence Matrix (GLCM).*

1. INTRODUCTION

A brain tumor is a very serious-type among all life threatening diseases which is increasing drastically among the humans. A brain tumor is a mass of tissue formed by an unregulated growth of the abnormal cells in the brain. A trigger in a single cell's genes causes a change and makes it to divide out of control. Generally a primary brain tumor originates in the brain, the brain's coverings, or its nerves. Most brain tumors identified in the children are primary tumors .In adults the brain tumors are stated as metastatic or secondary tumors which means the cancer has spread to the brain from the breast, lung, or other parts of the body. Nearly 1 in 4 people with cancer is affected by secondary brain tumor. People with secondary brain tumors were expected to survive only several weeks after diagnosis. Brain tumors are classified as benign or malignant. Benign tumors are noncancerous cells and malignant tumors are cancerous cells. The first types do not invade brain or other tissues. But they need to be treated because they might harm the neighboring tissues or other vital organs. A malignant brain tumor invades normal tissue or contains cancerous cells either from the brain or other parts of the body. These types of tumors are life-threatening, as they can spread throughout the brain or to the spinal cord. So patients with either benign or malignant tumors, needs immediate recovery treatment after the diagnosis. The choice of the recovery treatment depends on the type of brain tumor and the patient's health state.

U.S News reports say that more than 180,000 brain tumors (malignant and benign) are diagnosed each year. Of those, about 36,000 comprise primary brain tumors. Brain tumors can occur in adults between the ages of 40 - 70 years and in children between 3-12 years. Primary brain tumors account for only 2-3 percent of all new cancer cases in adults. In children, however, brain tumors account for 25 percent of all cancers. About 2,900 children [below 20 years] diagnosed with brain tumors each year in the United States. The Office for National statistics, UK reports that in the last 32 years, brain cancer occurrence rates have increased by 23% to 25%. In 2010, the rate was 8 new cases per one lakh men and 5 new cases per one lakh women. This regards to nearly 2,300 newly diagnosed cases in men and just fewer than 1,700 in women. The research people still investigates basis for the increased occurrence of this rare cancer .The news report from the Indian Express said that in India the Brain tumor comprises 1-2 per cent of all cancers. It is the second most

common cancer among children and is 70 per cent curable. In adults though, it is more challenging considering diverse demographics, socio-economic system, delivery of care, etc.

2. MRI IMAGE ANALYSIS

The patients who suffer from the symptoms of brain tumor should start the earlier course of diagnosis undergoing some physical tests, mental tests and the neurological examinations such as brain scans. An analysis of the brain tissue gives the established manifest of the presence of brain tumor. The analysis helps the doctors to classify the tumor from either least aggressive (benign) or the most aggressive (malignant). In most cases, a brain tumor is named based on the cell type of origin or its location in the brain.

A brain scan is a picture of the internal anatomy of the brain. Most commonly used scans are MRI (Magnetic Resonance Imaging), CT or CAT scan (Computed Tomography) and PET scan (Positron Emission Tomography) are used to discover the presence of brain tumor. The information obtained from the above mentioned scans will exert significance on the treatment given to a patient. The most extensively used clinical diagnostic and research technique is MRI. Its working is based on the principal of nuclear magnetic resonance (NMR).

As the process of separation of cells and their nuclei separation is very important, much attention is needed in the development of the expert diagnosis system for image segmentation & features extraction. In studying human brain, magnetic resonance imaging (MRI) plays an important role in progressive researches. Magnetic resonance (MR) imaging was introduced into clinical medicine and has ever since assumed an unparalleled role of importance in brain imaging. Magnetic resonance imaging is an advanced medical imaging technique that has proven to be an effective tool in the study of the human brain. The rich information that MR images provide about the soft tissue anatomy has dramatically improved the quality of brain pathology diagnosis and treatment.

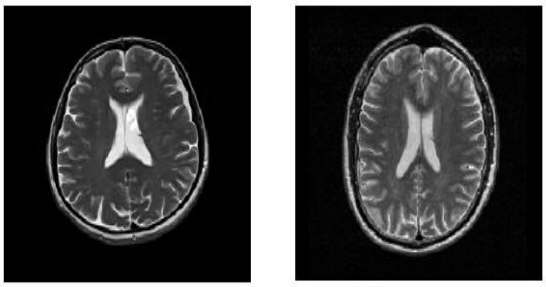

Fig. 1. *Normal MRI images*

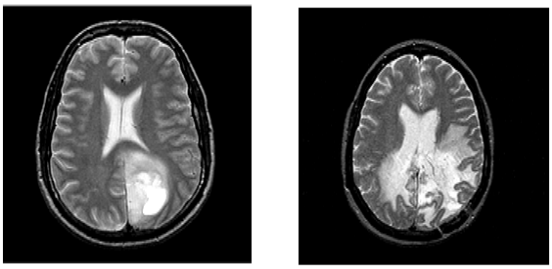

Fig. 2. *Abnormal MRI Images*

3. MRI ANALYSIS USING IMAGE PROCESSING

The Images obtained using MRI scanning is used in Machine intelligence for detection of diseases like brain tumor using image processing techniques. For this algorithms are to be developed so that the normal & abnormal MRI Images can be classified by machine or computer. The MRI Image undergoes series of following steps for analysis using image processing techniques.

3.1. Image Preprocessing and Segmentation techniques

Pre-processing of images includes two major steps a) Noise Removal and b) Image Enhancement. Noise Removal can be done by using filters like Median filters, Sobel filters, Robert and Prewitt filters, Laplacian filters etc., Image Enhancement improves the Image making it suitable for further image processing by modifying the image attributes. The Median filters remove certain types of noise (impulse noise) in which the individual pixel will have essential details [32].The performance of Median filters are better analyzed by authors [55-60]. In some cases segmentation is performed using Neural Network. The Feature vectors and selected regions are organized in the pattern matrix. Input vectors fed into the NN layers, the output represents the number of segmentation Classes [20]. [31] Introduces the threshold segmentation which provides an easiest way based on intensities or colors. Black pixels indicating background and white pixels representing foreground.

The author [47] uses weighted median filter (WMF) using Neural Network which reduces noise but preserves the image edges. The Point Spread Function (PSF) is used to remove the degradations like noise, blur and distortions during transmission of the image over the network. [35] Uses two filtering algorithms viz Weiner Filter and Wavelet Filter. The author proposes the Weiner Filter is optimal for Mean Square Errors and deblurring. The limitation of Weiner Filter is that it gives poor performances for the large noise which is overcome by the Wavelet Filter. Segmentation is important for healthy brain tissue differentiation [47].Pulse Coupling Neural Network proposed by [45] which is capable of robustness over noise and considers even minor intensity variations. Image Enhancement is followed by Image Restoration using Point Spread Function (PSF) which characterizes the image degradation process. The misclassified errors in the form of speckles can be removed using, a morphological filter which is proposed by an author [16].Speckles can be removed by using Adaptive weighted median filter (AWMF) [26].

3.2. Features Reduction

After Features extraction the dominant features are selected using Principal component analysis(PCA).The size of the dataset has been minimized from large to the most essential features in order to reduce the computational cost and time. One of the widely used techniques is PCA.

Table1. *Feature Reduction techniques*

METHODS	DESCRIPTION
Principal Component Analysis and kernel Support Vector Machine [54].	PCA has reduced 65536 to 1024 feature vectors. DWT+PCA+KSVM with GRB kernel achieved the best accurate classification result 99.38% than other HPOL and IPOL kernels.
Gray Level Co-occurrence Matrix, PCA and SVM using RBF kernel function [9].	Features Extracted by using GLCM and classified with RB-Kernel gives 100% classification accuracy better than PCA.
Discrete wavelet Transform (DWT), Principal component analysis (PCA), k-means clustering and k-nearest neighbor classifier [50].	Seven Statistical measures including skewness, Kurtosis, Specificity etc., are measured.
GLCM (Grey Level Co-occurrence Matrix) and SVM [32].	Texture based feature selection using GLCM and SVM classifier combination has proved to get accurate results but only for smaller dataset.
Wavelet based Principal component analysis with Fuzzy C-means Clustering [40].	PCA based Fuzzy C-means Clustering system yields more and accurate information about the abnormal tissues and WM through supportive visuals than conventional PCA.
Linear Discriminant Analysis, PCA and SVM [14].	LDA selects vital feature which are compared with PCA and SVM accuracy of 98.87%.
PCA and Supervised Learning Techniques (BPN, RBF and LVQ) [22].	PCA with BP has produced around 95- 96% recognition rate for 4-5 error images.
GLCM, KNN, ANN, PCA+LDA [37].	GLCM, PCA + LDA combination best reduces the dimensions reducing computational cost.

3.3. Image Classification

After dominant features vectors are selected, a classifier is to be selected for training &classification. Various schemes of classifiers are available. A Study performed over the literature

works of different authors.

Table2. *Image Classification techniques*

METHODS	DESCRIPTION
Multi-Classification Support Vector Machine [23].	Multi- Classification SVM (MCSVM) extracted the boundaries of 7 kinds of encephalic tissues successfully and proved satisfactory generalization accuracy.
PCA and PNN assisted automated brain tumor classification [53].	Probabilistic Neural Network (PNN) with mathematical technique called Principal Component Analysis (PCA) is used to give more accurate and fast solution than the Conventional methods of brain tumor classification.
SVM–KNN: Discriminative Nearest Neighbor Classification for Visual Category Recognition [15].	A hybrid of these two methods which deals with the multiclass setting that can be applied to large, multiclass data's and with less complexity in computations both in training and at run time, and yields outstanding results.
Classification of tumor type and grade using SVM-RFE [11].	The binary SVM classification accuracy, sensitivity, and specificity are proved to be high for the discrimination of metastases from gliomas, and for discrimination of high grade from low grade neoplasm.
Texture features, Fuzzy weighting and SVM [51].	Fuzzy logic is used to assign weights to different feature values based on its discrimination capability. The multi class SVM provides better classification accuracy even if the features of different classes have overlapping boundaries.
Wavelet Transformation (WT), Principal Components Analysis (PCA), Feed forward - Back propagation Neural Network (FP-ANN) and k-Nearest Neighbors [10].	Sensitivity rate and Specificity rate for the Classifiers FP-ANN is 95.9% and 96%and k-NN obtained a success of 96% and 97% respectively.
Sphere-shaped support vector machine (SSVM) and Immune algorithm [33].	Optimal parameters selection is done using Immune Algorithm and SSVM classification is very much successful in classifying data with high irregularities.
Multiclass support vector machines (M-SVM) followed by KNN (K-nearest neighbor) [15].	The multiple image queries are supported by using M-SVM.
Least Squares Support Vector Machines (LS-SVM) compared with k-Nearest Neighbor, Multi layer Perceptron and Radial Basis Function Networks [39].	Analysis of the statistical features like sensitivity, specificity, and classification accuracy proved that LS-SVM yields better.
Multiresolution Independent Component Analysis (MICA) and SVM [41].	MICA based SVM classification accuracy has increased 2.5 times than other ICA based classifications
Spatial gray level dependence method (SGLDM), Genetic Algorithm (GA) and SVM [3].	A hybrid method using SGLDM for Feature extraction, GA for Feature Reduction and SVM classifier proves high statistical measures.
Texture feature coding method (TFCM) and Support Vector Machine [34].	Along with Cascade-Sliding-Window technique for automated target localization, this approach is applicable to mammograms with 88% accuracy.
Connected component labeling (CCL), Discrete Wavelet Transform (DWT) and SVM [36].	SVM works well with this combination proves to be robust and produces high quality results.
Feature ranking based Ensemble SVM classifiers [12].	Better results for nested feature set and thereby suitable for detecting Alzheimer's disease (AD) and autism spectrum disease (ASD).
Discrete wavelet Transform (DWT), Principal component analysis (PCA), k-means clustering and k-nearest neighbor classifier [50].	Segmentation using k-means Clustering. Seven Statistical measures including skewness, Kurtosis, Specificity etc., are measured and compared.
Content Based Image Retrieval (C.B.I.R.) and Support Vector Machine [1].	C.B.I.R based on texture retrieval along with SVM classifier suitable for detecting Multiple

	Sclerosis and tumors
Ripplet transforms Type-I (RT), PCA and Least Square (LS-SVM) [48].	Overcomes the drawbacks of DWT and NN and proves to be new successful combination as RT+LS-SVM.
Grey Level Co-occurrence Matrix (GLCM), Artificial Neural Network (ANN) and Back Propagation Network [46].	Achieves a balance between the net's memorization and generalization. Detects Astrocytoma type of tumors efficiently.
Artificial Neural Network (ANN), Grey Level Co-occurrence Matrix (GLCM), and Neuro Fuzzy Classifier [4].	Automated detection of Pathological tissue, without any need for the Pathological testing.
Back Propagation Network [BPN], Probabilistic Neural Network (PNN) and GLCM [22].	Histogram equalization is performed to avoid the dark edges.BPN based classifier produces 77.56% and PNN produces 98.07% of accuracy in tumor detection.
Modified Probabilistic Neural Network (PNN) model [30].	PNN Model based on Learning Vector Quantization (LVQ) performance is measured with 100% accuracy.
ANN,SVM, Fuzzy measures, Genetic Algorithms (GA), Fuzzy support Vector Machines (FSVM) and Genetic Algorithms with Neural Networks[38].	FSVM resolves unclassifiable regions caused by conventional SVM and genetic algorithm-based neural network outperforms gradient descent-based neural network.
PNN Classifier with Image Encryption [21].	Classification accuracy is about 100-85% and original content has been encrypted to avoid exploitation of the image.
Multimodal fuzzy image fusion [13].	Image quality is preserved even with blurs without any limitations. Best suitable for blurry images.
CA(Cellular Automata) based segmentation and ANN [27].	Seed based segmentation is reliable only for small set of data. Seed is selected using co-occurrence and Run-Length features.ANN provides high classification accuracy.

In this paper various automated brain tumor detection methods through MRI has been surveyed and compared. This is used to focus on the various combinations of techniques proposed by different people in medical image processing and their performances. This paper deals with the sequence of methods in image classification as i) Image Preprocessing and Segmentation ii) Feature Reduction and iii) Classification. Many algorithms have been proposed in the literature for each image processing stage. The results of various algorithms are discussed.

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