AUTOMATIC BRAIN TUMOR DETECTION AND CLASSIFICATION USING SVM CLASSIFIER

[1]SONU SUHAG, [2]LALIT MOHAN SAINI

[1,2]School of Biomedical Engineering, National Institute of Technology,
Kurukshetra, Haryana - 136119, INDIA
E-mail: [1]sonusuhag001@gmail.com, [2]lmsaini@gmail.com

Abstract— Tumor is unwanted growth of unhealthy cell which increase intracranial pressure within skull. Medical image processing is the most challenging and innovative field specially MRI imaging modalities. The strategy presented in this paper involves preprocessing, segmentation, feature extraction, detection of tumor and its classification from MRI scanned brain images. Magnetic Resonance Imaging (MRI) is a non-invasive imaging modalities which is best suited for the detection of brain tumor. The segmentation method proposed in this paper is fuzzy c-means (FCM) which can improve medical image segmentation. The algorithm is easy to handle and identification of tumor and its classification in scanned region has been done accurately. A user friendly environment has been created by using GUI in MATLAB resulting in an automated brain tumor detection system for MRI scanned images. By using the GUI tool, the physician and other practitioners are facilitated in detecting the tumor and its geometrical feature extraction. Multi-SVM has used to classify the various type of tumors like Gliomas, Metastasis, Astrocytoma etc. In this work, Multi Support Vector Machines (m-SVMs) has been proposed and applied to brain scanned image slices classification using features derived from slices. This work helps in recognition of tumor which in turn saves the precious time of medical diagnostic to diagnose the tumor automatically in short span of time.

Keywords— Image Classification, Medical Diagnosis, Tumors.

I. INTRODUCTION

Medical image processing specially MRI imaging modalities is the most challenging and innovative field. MRI is a 3-d non-invasive imaging modality, which is best suited for soft tissue abnormality detection. The MRI imaging technique is the best for detection of brain tumors due to its high resolution and ability to show clear brain structures, tumor's size and location. From MRI brain image, the useful information is obtained for the detection of tumors. Nowadays there are several methodologies for classifying MRI images, viz. fuzzy methods, region growing method, neural networks, knowledge based methods, watershed segmentation methods and various other segmentation methods. MRI consists of T1 weighted, T2 weighted and proton density (PD) weighted images. Main part of brain contains tissue with high fat content and appears bright; whereas, compartments filled with water appears dark. So, T1 weighted images are best suited for high resolution and clarity [2].

Brain tumor is unwanted growth of diseased/abnormal cell in brain in uncoordinated fashion. Brain tumor rises the intracranial pressure within the skull which affects the region of white matter (WM), Gray matter (GM), Cerebrospinal fluid (CSF). Brain is the CPU of world's most complicated bio-computing machinery, which act as the center of thoughts, emotions, wisdom, communication, coordination of muscular movements from sense organ (pain, taste, sight, hear, touch etc.). The brain tumor has various properties like tumor size, type and location. Tumor can affect any part of brain. Brain tumors are of two type, either Benign or Malignant. Benign tumors are non-cancerous cells, which do not invade in surrounding healthy tissues. The growth is very slow and the periphery or edge of benign tumor can be clearly visualized [1]. Benign brain tumors are sometimes life threatening when it press the sensitive region of brain [2]. Malignant tumors are cancerous cells, which invade in surrounding healthy tissues and spread to other part of brain or spine. This type of tumor grows very fast and more fatal than benign tumor. The edge is not clearly visualized due to penetration in nearby cells [1, 2]. Thus, tumor can be either benign or malignant. To determine the exact type of tumor, a diagnostic has to examine patient biopsy sample [3]. Growth and development of brain tumor depends on various factors:

- Size and origin location
- Biological characteristic and type of tissue affected
- Spread of tumor within brain or spinal cord
- Primary and secondary (Metastasis) tumor

A. Classification of Tumors

Brain tumors are basically categorized on the basis of origin, location, area of tumor and biological characteristics of tissue. Various type of brain tumors are [3]:

- GLIOMAS : Glioma develop from Glial cells which are supporting cells in the brain
- METASTSIS: are secondary type of tumors. They spread to other part through blood stream.
- ASTOCYTOMA: Slow growing, rarely spreads to other parts of the central nervous system (CNS), Borders not well defined. At

any stage of age, cystic formation may occur.

B. Imaging Modalities to Diagnose Tumor

The following methods are used to diagnose tumor

- Magnetic Resonance Imaging (MRI) scan
- Computed Axial Tomography (CAT) scan
- Positron Emission Tomography (PET) scan
- Single Photon Emission computed Tomography (SPECT) scan
- BIOPSY (tissue sample analysis)

II. PROBLEM FORMULATION

Brain tumor detection is a serious issue in imaging science. Generally, the severity of disease is decided by the size and type of tumor. An important step in analysis of brain MRI scan image is to extract the boundary and region of tumor [4]. To solve the problem, the proposed work describes the strategy for detection, segmentation and feature extraction of brain tumor part using MATLAB software. This software based approach aims to introduce an algorithm for detecting and segmenting the brain tumor from normal brain using basic image processing operations (de-noising image, filtering), segmentation followed by feature extraction.

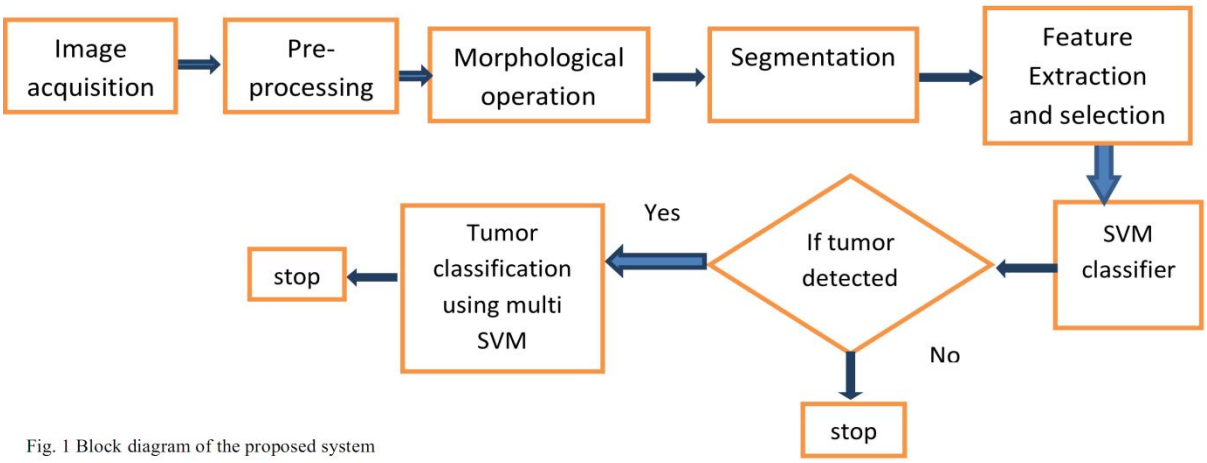

Fig. 1 Block diagram of the proposed system

A. PROPOSED SYSTEM

The proposed work performs processing of MRI brain images for detection and classification of tumor and non-tumor images by using a classifier. The image processing techniques like histogram equalization, image enhancement, image segmentation and then extracting the features for detection of tumor have been used.

Extracted features are stored in the knowledge base. An appropriate classifier is developed to recognize the brain tumors by selecting various features. The system is designed to be user friendly by using MATLAB GUI tool based on following steps.

Step 1: Obtain MRI brain scanned image of patients and respective medical diagnosis from medical practioner.

Step 2: Perform pre-processing and extract features. Store the features and respective diagnostic in a database. Divide the database into training and testing part

Step 3: Train SVM classifier with training data. If tumor is detected, then classify its type by multi-SVM.

Step 4: Classify testing data using steps 2 and 3.

If tumor is detected, appropriate treatment starts under medical supervision. Radiotherapy and chemotherapy are the best suited treatment therapy after confirmation of tumor through biopsy (benign or malignant).

B. IMAGE ACQUISITION

Image acquisition is the first step in the form of RGB image. The original MRI brain image has dimension 256*256*3 pixels and after conversion to gray scale image the dimension becomes 256*256 pixels. The steps are formulated in figure 1. After acquisition of image, convert to gray scale and the contrast is increased up to a certain level. Contrast image is partitioned into left and right hemisphere. Threshold / Binarization converts the image up to 256 gray level into black and white image as shown in figure 2.

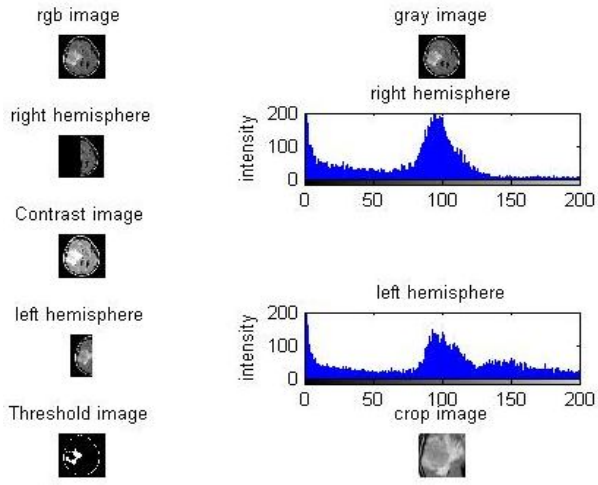

Fig. 2 Morphological operations on image

The final segmented image is then superimposed on the edge-boundary image which clearly distinguishes tumor images from non-tumor ones and the boundaries are detected. It becomes more visible when superimposed on the anatomical structure of image. From the superimposed image, the tumor part of image is extracted as shown in figure 3.

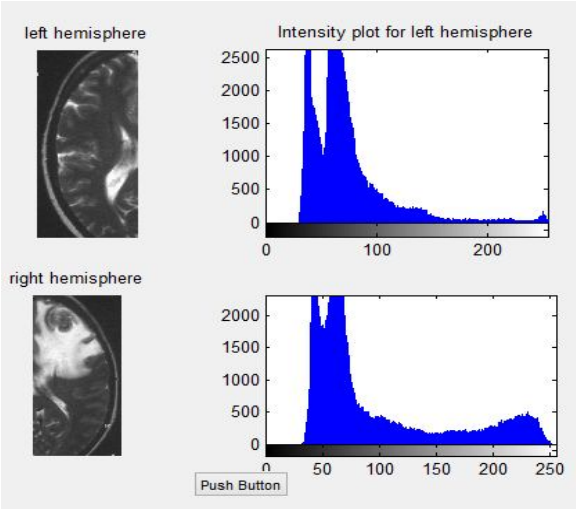

Fig. 3 Intensity plot of left and right hemisphere

From figure 3, it is evident that the histogram plotted for left and right hemisphere are not symmetrical. Right hemisphere has more variation in the intensity.

So there may be a chance of tumor on right side; because, the number of white pixels are more in right hemisphere. By implementing various morphological operations, the tumor can be detected on either side of hemisphere; but, the noise associated with the edge cannot be removed [5]. The noise is however removed by preprocessing.

C. PREPROCESSING

The pre-processing is done to de-noise the image and smoothing the edges using median filtering. After smoothening the image, the edges need to be isolated/extracted. The tumor need to be isolated from its background. So, the best suited segmentation like k-means, FCM has been used for this purpose.

D. SEGMENTATION

Segmentation in medical imaging is challenging and complicating task for the exact recognition of brain tumor. A number of clinical investigation/ trials are performed for the recognition of pattern of brain tumor. The main purpose of segmentation is to partition the image into multiple segments which makes more meaningful and easy to analyze. Each pixel assigning a label to the image so that pixel having same label show similar characteristics and properties. For the anatomical detailed information of brain images, mapping and identification of tumor clustering algorithm has been very effective. Various methods for image segmentation are:

- Edge detection methods
- Region growing methods
- Watershed segmentation
- Clustering segmentation

The best suited segmentation technique is clustering method for brain MRI scanned images; because, in other methods, the cancer cells near the surface of MRI image are very fat; thus, appear dark which is very confusing for the isolation of the edge or periphery for the tumor part and non-tumor part [6]. So Fuzzy C-means clustering has been used in this work (as shown in figure 4), in which every point has a degree of belongingness to cluster for a given dataset [7].

E. FEATURE EXTRACTION

For feature extraction GLCM technique has been used. A gray level co-occurrence matrix (GLCM) contains information about the positions of pixels having similar gray level values [9]. In feature extraction, relevant.

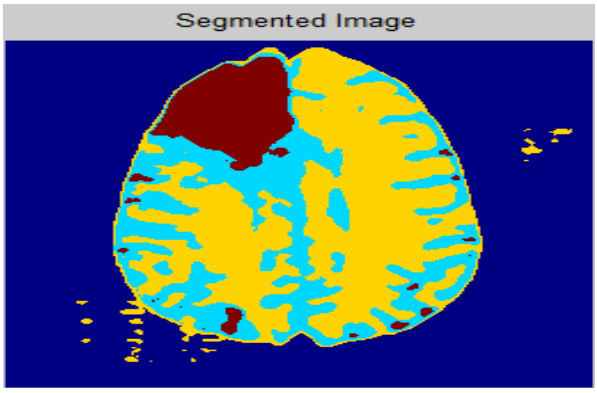

Fig. 4 FCM segmented image

information is extracted from input data. After feature extraction, a common method of selection is sequential forward selection (SFS). GLCM calculation of ten invariant features has been done which are as follows:

- Dissimilarity
- Homogeneity
- Contrast
- Correlation
- Entropy
- Energy
- Cluster shade
- Cluster prominence
- Maximum probability
- Autocorrelation

F. SVM and Multi-SVM CLASSSIFIER

This classifier is a part of machine learning that gives computers the ability to learn. It is a set of learning methods that analyze data pattern which is used for classification. In multi-SVM classifier, more than two classes are classified. Multi-SVM is used to classify various type of tumors like Gliomas, Metastasis,

Astrocytoma etc. SVM classifier has been used to determine whether it is normal or abnormal [11]. SVM is a binary classification method in which two classes for input data has been fixed. For normal case, symbol '0' has been taken; whereas, for abnormal '1' has been taken. the parameters from feature extraction have been used for classification [12].

III. RESULTS

A data set of hundred images has been taken for this study. For training phase, thirty nine abnormal images and fifteen normal images have been taken. The training classification results showed 100% accuracy. Abnormal images from three classes have been divided into three category viz. Gliomas, Metastasis and Astrocytoma. After accomplishment of training images set, the classifier was used for testing using thirty six abnormal and ten normal images. Accuracy of each type has been determined and given in table 1. The overall accuracy of this method was 91% when run on a dataset of hundred samples.

Table1
CLASSIFICATION OF NORMAL, ABNORMAL AND TYPE OF TUMOR

Images	No. of images for training phase	Testing phase		Overall correctly classified images	Overall classification accuracy (%)
		No. of images	Misclassified images		
Normal	15	10	0	25	100
Abnormal	39	36	1	74	98.6
Gliomas	15	7	3	19	86
Astrocytoma	4	3	1	6	83
Metastasis	20	25	4	41	92
Total	84	46	9	121	91

IV. GRAPHICAL USER INTERFACE (GUI)

GUI is the interactive tool that enables the user for graphical display. This application has self contained Matlab program with GUI [11]. GUI provides interactive tool for designing image processing morphological operation. This module of the GUI based automated segmentation and recognition of the brain tumor works to differentiate between healthy and non-healthy cells. A user need to click on different buttons in sequence to process a new MRI image of brain as shown in figure 5 and 6.

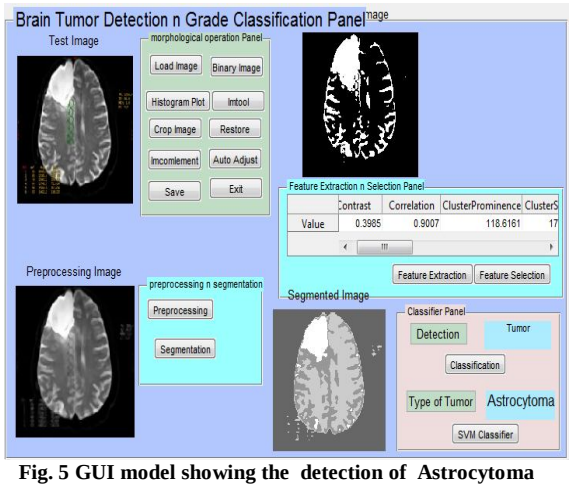

Fig. 5 GUI model showing the detection of Astrocytoma tumor.

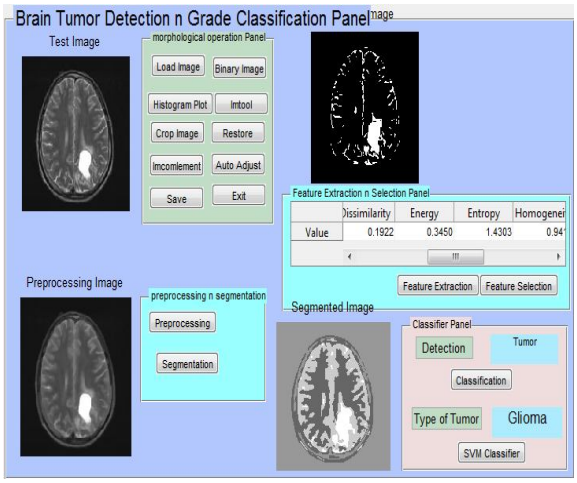

Fig. 6 GUI model showing the detection of Glioma tumor

CONCLUSION

In this paper an algorithm in Matlab GUI has been developed for the detection and classification of brain tumor from MRI scanned brain images based on various operation like preprocessing, Fuzzy C- means segmentation, feature extraction and by using SVM classifier. The accuracy of the method was 91% when run on a dataset of 100 images. This work helps in detection of tumor which in turn saves the precious time of doctor and pathologist to diagnose the tumor and its classification automatically in short span of time.

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