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An Improved Automatic Brain Tumor Detection System

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Abstract— Brain tumor detection is well known research area for both medical as well as computer scientists. In last two decades there has been much research done on tumor detection, segmentation, & classification but still there is no complete automated system developed yet. As we know Brain Tumor is one of the deadliest diseases at present which is only curable in its early stages. The paper proposes an improved automatic brain tumor detection method by automatically detecting tumor location in MR images, & then tumor is segmented out from the MR image then after its features are extracted & then it's fed to an Artificial Neural Network (ANN) to classify the grade of tumor. All the techniques used here are almost researched individually for particular purposes & the paper combines them all to automate the tumor detection efficiently, with accuracy & less time consumption. Results shown in paper justifies that method used is automatic with good accuracy (95.30%) & it detects, classifies tumor correctly.

Keywords— MRI segmentation, Brain tumor detection, Tumor segmentation, Tumor classification, Medical Imaging, ANN

I. INTRODUCTION

Medical Imaging is technology that can be used to generate images of human body (or part of it). These images are processed or analyzed by experts who provide clinical prescription based on their observations. Ultrasonic, X-ray, Computerized Tomography, & Magnetic Resonance Imaging (MRI) are quite seen in daily life, through different sensory systems are individually applied [1]. In this paper we're only concerned about one of the application of Medical Imaging i.e. Brain Tumor Detection, Segmentation, & Classification.

A tumor develops if normal or abnormal cells multiply when they are not needed. A brain tumor is a mass of unnecessary cells growing in the brain or central spine canal. There are two basic kinds of brain tumors –primary brain tumors and metastatic brain tumors. Primary brain tumors start and tend to stay, in the brain. Metastatic brain tumors begin as cancer elsewhere in the body and spread to the brain [2]. About 160 out of 1 lack of the population are diagnosed with cancer every year in India alone. More than half of these cases suffer from the most aggressive type of cancer called glioblastoma multiforme (Grade IV) which is the other name for Brian tumour [3]. Each year more than 66,000 Americans are diagnosed with a primary brain tumor and more than twice that number are diagnosed with a metastatic tumor [2]. In the UK, around 9,400 people are diagnosed each year with a tumour that started in the brain, or elsewhere in the central nervous system (CNS) or within the skull (cranium) [4]. As per the above survey Brain Tumor must be diagnosed early to reduce the risk of death.

There are about 130 different types of brain tumours. They are generally named after the type of cell they developed from. Most brain tumours develop from the cells that support the nerve cells of the brain called glial cells. A tumour of glial cells is a glioma [5]. Tumors are diagnosed, and then named, based on a classification system. Most medical centers now use the World Health Organization (WHO) classification system for this purpose. The grade of a tumor indicates its degree of malignancy [2]. According to WHO Grading System Brain tumors are classified into four grades named as Grade (I – IV) among which Grade III & IV are most dangerous ([2],[5]) also known as Malignant(Cancerous).

Brain tumor detection & segmentation is not an easy task it takes a lot of experience & image analytical knowledge but in general most of the medical institutions still work on manual segmentation where expert clinician segment out the tumor manually thus it's time consuming as well as a slow process to work with ([8],[9]). To reduce these flaws till date many computer aided tumor segmentation methods were proposed using different terminologies but to achieve the same goal. Like Dina A. Dahab et al. [10] suggested a Probabilistic Neural Network approach to detect & classify tumor and differentiated it with the classical segmentation methods. M. Prastawa et al. [8] gave a tumor segmentation framework based on outlier detection which they detected abnormal regions using a registered brain atlas as a model for healthy brains. The drawback here was; it was atlas based which requires a huge dataset of healthy brain which in general is very hard to maintain as compared to the dataset of unhealthy brain. Although it was kind of dependent system approach where registered atlas dataset is very dependable from the source. Whereas M. Schmidt et al. [9] describes alignment based feature extraction & segmentation technique. Recently a Fast Bounding Box (FBB) [11] method was proposed to quickly detect brain tumor by locating a parallel-axis rectangle around the tumor which basically finds the most dissimilar region & bound it in a rectangular box called bounding box.

There are many semi- automatic, automatic brain tumor detection proposals by many researchers till date, but Improved Automatic Brain Tumor Detection System (IABTDS) uses some improved techniques from literature & combine these in such an order to make an automated computer aided system. In order to make completely automated system one may need all the resources including MRI sensory machine & a good configuration PC & one assumption is that this proposal can be a first step towards completely automated tumor detection system.

The paper is synchronized in 4 parts, where Part I is just discussed containing Introduction, then Part II is about Proposed Method, then after Part III contains Results, & finally the Part IV Conclusion.

II. PROPOSED METHOD

The Proposed method works as per the block diagram shown in Fig. 1. which shows a sequential order involved in the system from pre-processing to the final classification of tumor, each phase is equally important for the system as output of upper phase is taken as an input of the lower phase & so on till the final result i.e. tumor extraction with its grade. The input for the system is a MR slice of patient's head.

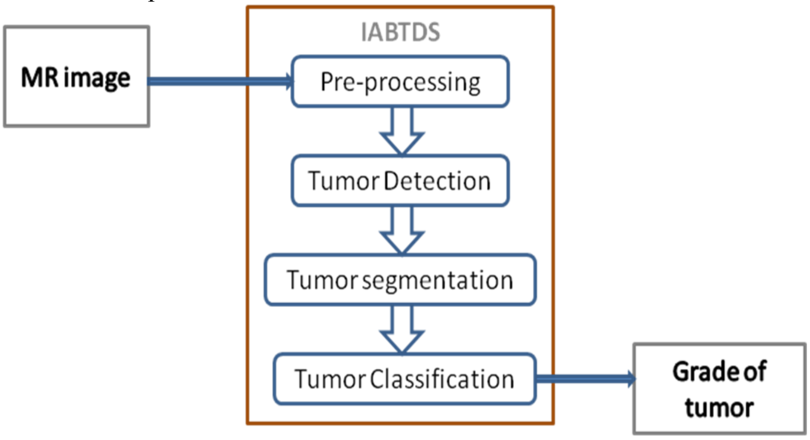
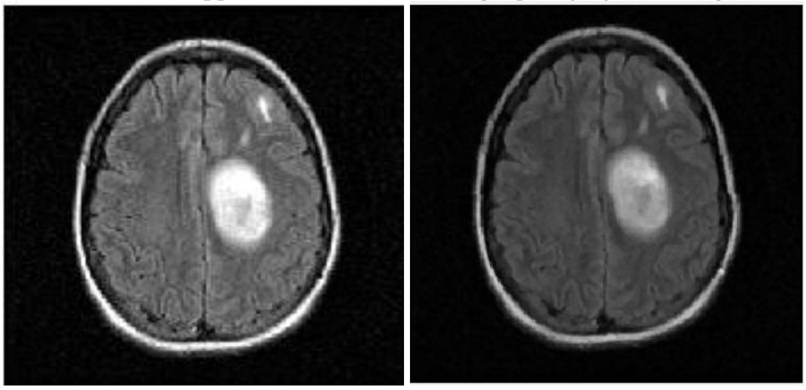


Fig. 1. Block diagram of proposed method

A. Pre-processing

This phase is used to remove all the present noise in the scanned MR image in order to enhance the image quality. Median filter is used to remove the salt & pepper noise also known as impulse noise generally found in MR image modality. Pre-processing is shown in Fig. 2. where original image (Fig. 2. a)) is enhanced using median filter (Fig. 2. b)).

A median filter of 3x3 window size is applied to enhance the image quality by removing noise from it.



a) b)

Fig. 2. Pre-processing a) Original Image b) Enhanced noise less image

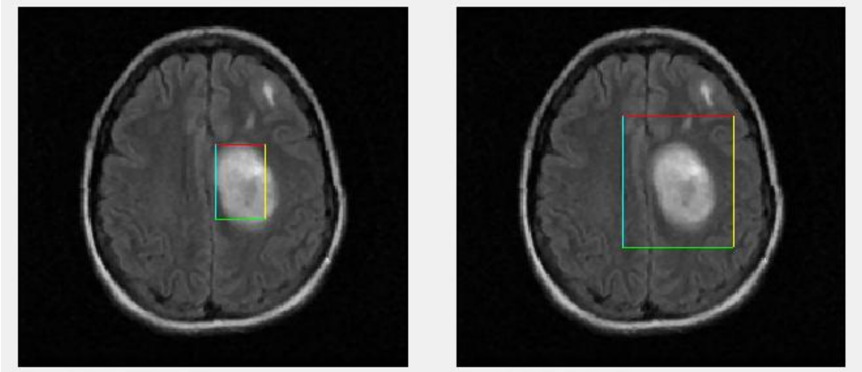
B. Tumor Detection

Brain Tumor is detected by using a novel boundary box method named as Fast Bounding Box (FBB) [11]. This method automatically locates the brain tumor or edema in any MR image slice of patient's head. This is used in the proposed method to find the most dissimilar region we mention it as Region of Interest (ROI) as it's the location of tumor. FBB uses a novel score function Bhattacharya's Coefficient (BC)[7] to detect the bounding box's parallel axes points which forms the box which inscribe the tumor portion & differentiate it with the other portion of the image.

It is found that FBB is detecting most dissimilar portion correctly but it somehow leaves some tumor's or edema's tissues which might be the part of tumor (Fig. 3.a)) that is easily visible, so to reduce this flaw we enhance ROI by scaling up the boundary box by 20 pixels which is Enhanced ROI(Fig. 3.b)). This means increasing the bonding box size by 20 pixels each side, which will increase the area & thus the left tumor part is also covered here by this process.

Steps involved in the phase are:

1) Locating tumor using FBB.
2) Enhancing ROI by scaling up bounding box got by FBB.



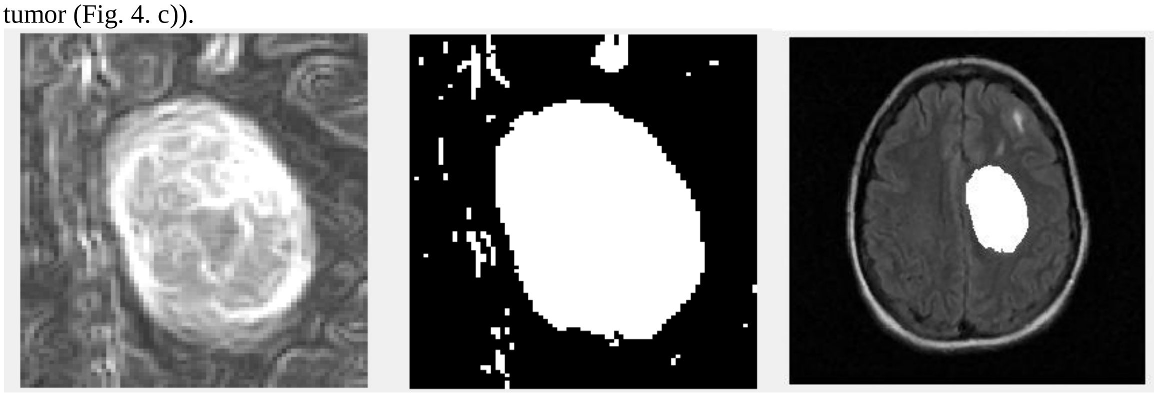
a) b)

Fig. 3. Tumor Detection to find ROI a) Boundary Box by FBB b) Enhanced ROI

C. Tumor Segmentation

After locating the tumor in MR image the tumor is segmented out here for extracting features. This phase is very important from both sides because on one side it gives the extracted tumor & from the other side it is used for feature extraction which further helps to classify the grade of tumor in the next phase i.e. Tumor Classification. Steps involved in the phase are:

1) The bonding box obtained from enhanced ROI is cropped out as Segmented region (Fig.4. a)).
2) An Optimal Threshold function is applied on the segmented region, where threshold value is mid of the two high intensity of histogram, the outcome is threshold applied image (Fig.4. b)).
3) After applying threshold the binary image obtained contains some other unwanted pixels among them largest Binary Large Object (BLOB) is selected & is again added to the original image in order to show the Extracted tumor (Fig. 4. c)).



a) b) c)

Fig. 4. Tumor Segmentation a) Segmented region b) Threshold applied c) Extracted tumor

D. Tumor Classification

Here tumor is classified by feeding the input matrix which contains the features which are matched from the training dataset of existing tumor grades samples. The 10 features considered here for training ANN & comparing data are:

1) Age
2) Sex
3) Entropy
4) Homogeneity
5) Contrast
6) Correlation
7) Energy
8) Dissimilarity
9) Inverse
10) Maximum probability

8 features in input matrix are GLCM [12] features & rest 2 features are just patients' identity based, where each feature plays an important role to classify grades individually. The input data matrix has 10x221 values which represent the features of 221 images. The target data matrix has 3x221 values which represent the grades of 221 images. In target matrix the 3 grades are Grade (II-IV). ANN used here is Feed Forward Back Propagation Network. Once the ANN is trained it is then ready to compare the input matrix for single image features & gives the output matrix containing values b/w 0 & 1 [0,1] showing the possible match value as *out* in Fig. 5. The 3 different values are the possibility of having Grade II, III & IV respectively. And the *ans =4* (encircled in orange color) is the grade value with the maximum possible matched features that means the example taken in the paper was of Grade IV tumor image.

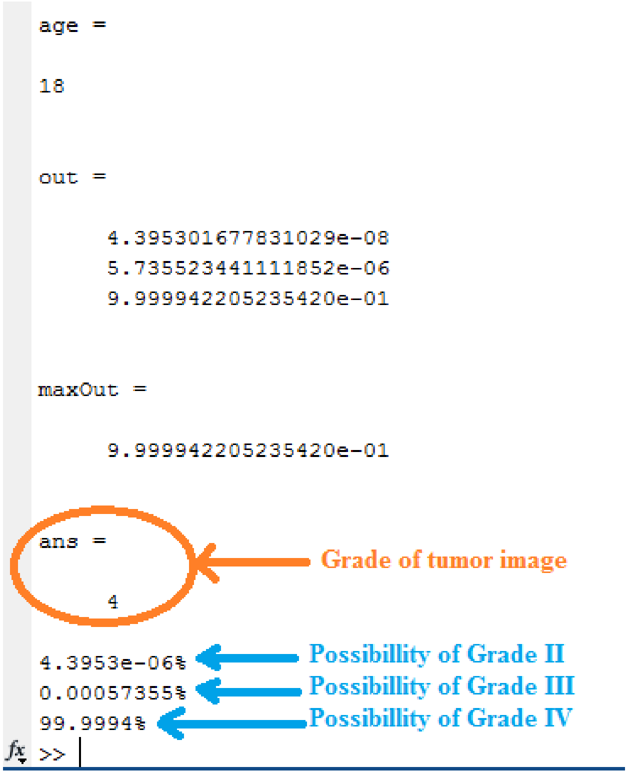


Fig. 5. Tumor Classification

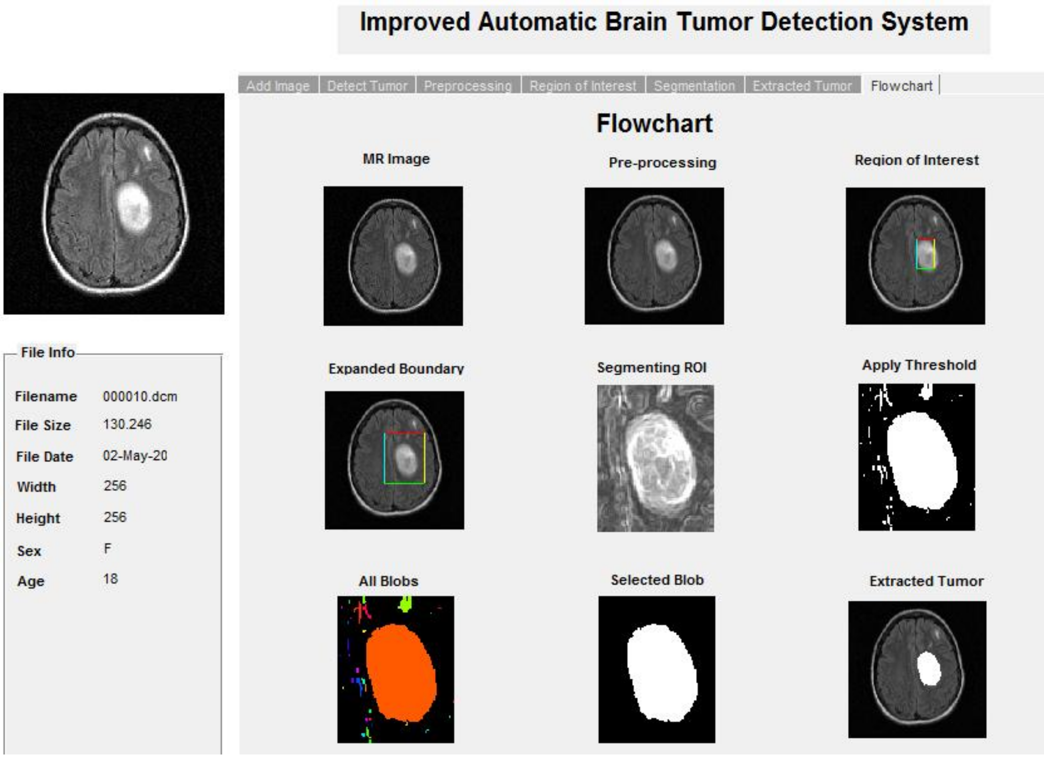


Fig. 6. Overall Flowchart of IABTDS

III. Results

The experimental results shown here is based on the 256x256 2D MR images taken from [6] which contain both low grade gloima & brain cancer in MR modality. Fig. 6. shows the overall flowchart of IABTDS.

A. Validation & Verification of Results

For validation & verification of results obtained by IABTDS, it was tested on 130 distinct MR images in which 33 images were Grade II images, 44 were Grade III images, & 53 were Grade IV images. All images were distinct in size, shape, & texture. In order to verify the grade the images used were taken of known grades to check the efficiency of ANN used in IABTDS which will validate the reliability of the system.

B. Results Obtained

Results obtained are shown in table I, by which the overall accuracy obtained by IABTDS on the tested images was 95.30% & per grade accuracy is also mentioned in table I.

Table I Results Obtained

Grade	No. of correct classified images	Accuracy
Grade II	31	93.93 %
Grade III	43	97.77 %
Grade IV	50	94.22 %

IV. CONCLUSION

The paper proposes an automated CAD system for brain tumor detection, segmentation & then classification. As discussed earlier it uses MR modality images as input & gives output in form of extracted tumor with its grade, example shown in the paper is of Grade IV tumor. Texture features are also extracted in order to classify the grade using ANN. IABTDS works fine & gives results with good accuracy & in very less time as per the results obtained.

There is future scope to improve the system by implementing it in medical institutions with the large dataset for training ANN & one can also increase the number of texture features. Also here only three grades are considered (Grade II - IV) due to lack of availability of data while one can improve system by adding the Grade I in the classification. This System can also be taken as a reference for future based 3D automated CAD system.

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