DEEP LEARNING-BASED SEMANTIC SEGMENTATION OF BRAIN TUMORS USING CNN AND MRI IMAGES

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ABSTRACT:

The brain tumor is a disease that affects or harms the brain with unwanted tissues. This is very difficult to detect brain tumor tissue from whole brain. Early detection of tumor is very important to save patient's life. Detection or segmentation techniques are used to detect and segment the brain-tumor region from the MRI images of brain and it is very useful method in recent days. In medical, magnetic-resonance-imaging is a tough field in image processing because accuracy percentage must be very high so doctors could get proper idea about diseases to save patient's life. Some MRI images have been taken as inputs data. The brain-tumor segmentation process is performed for separating brain-tumor tissues from brain MRI images, The MRI images should be filtering such as with the median filtering technique and skull stripping should be done in pre-processing, the thresholding process is being done on the given MRI images with using the watershed segmentation method. Then at last the segmented tumor region is obtained. And then in other phase features extracted by GLCM methods using MATLAB software. Then, the some images have been classified using support vector machine (SVM), this system obtained with the average accuracy of 93.05%. Which is quite better than other conventional models.

Keywords: SVM, GLCM, MRI, CNN, Deep learning, tumor.

I. INTRODUCTION

Brain tumor can be defined as a group of abnormal cells that grows inside or around the brain, in other words, a brain tumor is an uncontrolled growth of solid mass formed by undesired cells either located in one or more brain parts such as glial cells, neurons, lymphatic tissue, blood vessels, pituitary and pineal gland, skull, or spread from cancers mainly located in other organs. The type of tumor, its localization, its size and its evolution are among the most important factors occurring in the choice of the appropriate method for the treatment of a brain tumor. Brain tumors can be benign or malignant, benign tumors are non cancerous, they do not invade nearby tissue or spread to other parts of the body, sometimes they do not require treatment, unless symptoms indicate a serious problem.

Surgery is a common type of treatment for benign tumors; the goal is to remove the tumor without damaging surrounding tissues. Other types of treatment may include medication or radiation. In most cases, and after they were removed, they do not come back. Malignant tumors are cancerous, they spread rapidly invading other tissues of brain, sometimes cells move away from the original (primary) cancer site and spread to other organs or bones where they can continue to grow and form another tumor at that site. This is known as metastasis or secondary cancer. They are often resistant to treatment, and they sometimes recur after they were removed. Computer-Aided diagnostic technology has become a very important technological tool in the medical field, many medical problems have found a solution through the use of this technology, and the medical images processing has progressed immensely in recent years , it is one of the most encouraging areas of research, since it offers facilities for the diagnosis and treatment decisions of a large number of diseases such as cancer and in particular brain tumors.

Today, the study of this type of brain abnormalities using the medical images processing is becoming a very challenging task, several techniques and several methods have been proposed for the detection of their

existence, their exact location , Their size and their nature most of these methods are based on the processing of the MRI (Magnetic Resonance Image) brain images , this imaging modality is widely used by radiologists to visualize the internal structure of the human body, the level of information inside the image is surprising compared with any other imaging modality, today, it is becoming the most modality used to evaluate the patients who present signs indicating the existence of a cerebral anomaly especially brain tumors. In this study, a new neuronal approach is proposed for the classification of brain tumors from MR images.

The used database is composed of a set of MR images of brain tainted by several types of brain tumors and belonging to different persons. the three processing steps that compose the proposed system have been described, namely, the preprocessing step where we have showed that the size of the MR brain images must be normalized, features extraction step, where we have used the central moments of order 1, 2 and 3 of histograms of zones obtained after sliding a window of size 16×16 pixel on the image of the brain, and the classification step achieved using a multilayer perceptron

A Convolutional Neural Network (CNN) is a neural network that has one or more convolutional layers and are used mainly for image processing ,classification ,segmentation and also for other auto correlated data. A convolution is essentially sliding a filter over the input. One helpful way to think about convolutions is this Rather that looking at an entire image at once to find certain features it can be more effective to look at smaller portions of the image.

In recent times, the introduction of information technology and e-health care system in the medical field helps clinical experts to provide better health care to the patient. Brain tumors affect the humans badly, because of the abnormal growth of cells within the brain. It can disrupt proper brain function and be life-threatening. Two types of brain tumors have been identified as benign tumors and malignant tumors. Benign tumors are less harmful than malignant tumors as malignant are fast developing and harmful while benign are slow growing and less harmful. The various types of medical imaging technologies based on noninvasive approach like; MRI, CT scan, Ultrasound, SPECT, PET and X-ray. When compared to other medical imaging techniques, Magnetic Resonance Imaging (MRI) is majorly used and it provides greater contrast images of the brain and cancerous tissues.

Therefore, brain tumor identification can be done through MRI images. The focuses on the identification of brain tumor using image processing techniques. The detection of a brain tumor at an early stage is a key issue for providing improved treatment. Once a brain tumor is clinically suspected, radiological evaluation is required to determine its location, its size, and impact on the surrounding areas. On the basis of this information the best therapy, surgery, radiation, or chemotherapy, is decided. It is evident that the chances of survival of a tumor-infected patient can be increased significantly if the tumor is detected accurately in its early stage. As a result, the study of brain tumors using imaging modalities has gained importance in the radiology department. In this paper the brain tumor identification is done by an image processing.

II. LITERATURE REVIEW

1. Salim Ouchtati, Jean Sequeira., "Brain Tumors Classification from MR images Using a Neural Network and the Central Moments "

The study is based on the proposal of a novel method for the classification of brain tumours from MRI brain images; the used feature vector is composed of parameters obtained by applying the central moments method.

2. N. Varuna Shree, T. N. R. Kumar., "Identification and classification of brain tumor MRI images with feature extraction

using DWT and probabilistic neural network"

The identification, segmentation and detection of infecting area in brain tumor MRI images are a tedious and time consuming task. The different anatomy structure of human body can be visualized by an image processing concepts.

It is very difficult to have vision about the abnormal structures of human brain using simple imaging techniques. Magnetic resonance imaging technique distinguishes and clarifies the neural architecture of human brain. MRI technique contains many imaging modalities that scans and capture the internal structure of human brain.

3. "Automatic Human Brain Tumor Detection in MRI Image Using Template-Based K Means and Improved Fuzzy C Means Clustering Algorithm"

The Human Brain Tumor, firstly, the template-based K-means algorithm is used to initialize segmentation significantly through the perfect selection of a template, based on gray-level intensity of image; secondly, the updated membership is determined by the distances from cluster centroid to cluster data points using the fuzzy C-means (FCM) algorithm while it contacts its best result, and finally

The improved FCM clustering algorithm is used for detecting tumor position by updating membership function that is obtained based on the different features of tumor image including Contrast, Energy, Dissimilarity, Homogeneity, Entropy, and Correlation. Simulation results show that the proposed algorithm achieves better detection of abnormal and normal tissues in the human brain under small detachment of gray-level intensity. In addition, this algorithm detects human brain tumors within a very short time—in seconds compared to minutes with other algorithms

4. "Brain Tumor Image Classification and Grading Using Convolutional Neural Network and Particle Swarm Optimization Algorithm"

Brain tumor defines the aggregation of abnormal cells in certain tissues of the brain area. The earlier identification of brain tumor plays a significant part in the treatment and recovery of the patient. The identification of a brain tumor and its grade is generally a difficult and time consuming task. For effective classification and grading of brain tumor images, in this paper, we present a convolutional neural network (CNN) and particle swarm optimization (PSO) algorithm of Glioma by the use of magnetic resonance imaging (MRI). The presented CNNPSO model make use of PSO algorithm to select the deep neural network architecture which are generally depends on trial and error or by employed fixed structures. A detailed experimentation of the CNN-PSO method is carried out on several benchmark MRI brain images and verified its effectiveness on the applied test images with respect to different classification measures.

III. PROPOSED SYSTEM

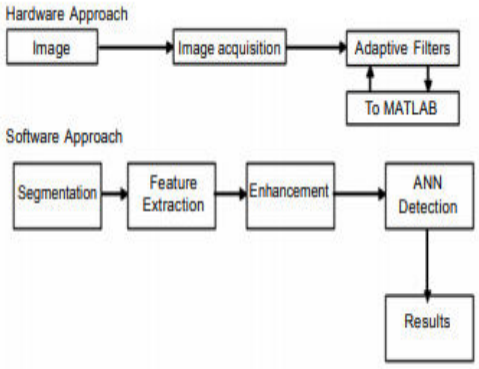


Figure No:1. Scheme of Proposed System for Brain Tumor Detection

The resizing of the Image is performed to convenient size so that processing and analyzing can be carried out effectively. The Adaptive Filter is applied to remove the spurious signals present in the image. Then the segmentation and the feature extraction of region of interest (ROI) is obtained so that enhancement of required section can be done through software. The next block of the system is neural network control. The neural network is trained for the detection of tumor present in human brain. After testing and successful implementation of the proposed scheme with Neural network using Math lab, the real time operation can be performed on

the MR Brain Images for the detection of Brain Tumor.

Pre-Processing

It is very difficult to process an image. Before any image is processed, it is very significant to remove unnecessary items it may hold. After removing unnecessary artifacts, the image can be processed successfully. The initial step of image processing is Image Pre-Processing Pre Processing involves processes like conversion to grayscale image, noise removal and image reconstruction. Conversion to grey scale image is the most common pre-processing practice. After the image is converted to grayscale, then remove excess noise using different filtering methods.

Median Filter

This most common technique which used for noise elimination. It is a „non-linear" filtering technique. This is used to eliminate „Salt and Pepper noise" form the grayscale image . Median filter is based on average value of pixels. The advantages of median filter are efficient in reducing Salt and Pepper noise and Speckle noise. Also, the edges and boundaries are preserved. The main disadvantages are complexity and time consumption as compared to mean filter.

In our proposed work we are going to use median filter for less computation complexity and better smoothing of images. However, it is better in preserving useful detail in the image than the mean filter. Like the mean filter, the median filter considers each pixel in the image and replaces it with the median of the neighborhood pixel values. The median filter has two main advantages over the mean filter It is a more robust estimation than the mean. A single unrepresentative pixel in a neighborhood will not affect the median significantly. It does not create new unrealistic pixel values, since the median must actually be the value of one of the pixels in the neighborhood.

Segmentation

Segmentation of images is important as large numbers of images are generated during the scan and it is unlikely for clinical experts to manually divide these images in a reasonable time. Image segmentation refers to segregation of given image into multiple non-overlapping regions. Segmentation represents the image into sets of pixels that are more significant and easier for analysis. It is applied to approximately locate the boundaries or objects in an image and the resulting segments collectively cover the complete image. The segmentation algorithms works on one of the two basic characteristics of image intensity; similarity and discontinuity.

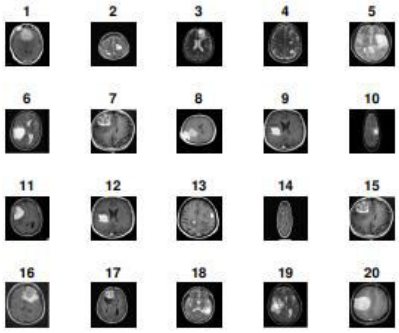
Segmentation has a significant part in clinical diagnosis and can be useful in pre-surgical planning and computer assisted surgery. Therefore, numerous segmentation techniques are available which can be used widely, such as threshold based segmentation, histogram based methods, region-based (region growing, splitting and merging methods), edge based and clustering methods (expectation maximization, k-means, FCM and mean shift). Clustering methods are most promising technique for processing the medical images. Cluster analysis can be set out as a pre-processing stage for other methods, namely classifiers that would then run on selected clusters. Therefore in our system, we have used clustering segmentation techniques for diagnosis of tumor and calculating tumor area in MRI images.

IV. RESULTS EXPLANATION

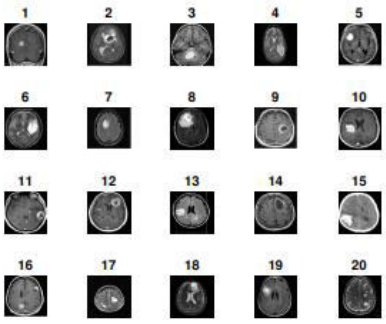
Data set: The dataset applied in this study are accessed from 4 online databases. The normal MRI are attained from the brain development website (IXI dataset) [18] which comprises of almost 600 MRI from normal subjects (without any lesion). MR images of Glioma tumors are gathered from the cancer imaging archive databases. REMBRANDT dataset holds the pre-surgical magnetic resonance multisequence images from 130 patients that suffer from low or high grade Gliomas. TCGA-GBM data collection has glioblastoma multiform brain MRI of around 200 patients and TCGA-LGG dataset contains low grade Gliomas data, gathered from 299 patients. The data gathered from the above said databases

are assumed as Case 1. Beside, the axial brain tumor images of Cheng et al. [19] are applied which contains a MRI with T1- weighted images from 233 patients with Meningioma, Glioma, and Pituitary brain tumor types. These images are assumed as Case 2. Fig. 4 shows the brain MRI of the normal person. Fig. 5 shows the MRI of 3 variant grades of Glioma tumor with gadolinium injection. And, Fig. 6 displays the instances of the three brain tumors images from Case II.

Simulation Results and Discussion A database of 40 brain tumor images is shown in Figure 2a,b where the first 20 images are shown in Figure 2a and the next 20 images are shown in Figure 2b. The database has been made by collecting different complex brain tumor images. We collected these images from [17–19] and pre-processed for the betterment of application in our algorithmic program. Then, we have processed these images by MATLAB 2016(a) and made the database for final use shown in Figure 2a,b. The tumors in these images are so critical that it is too hard for the common people to detect it so easily



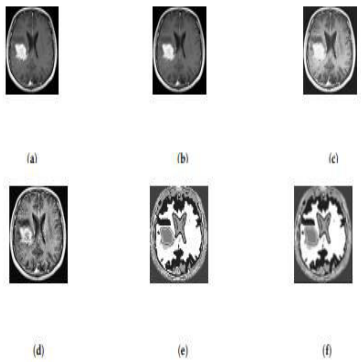
(a) Database 1



(b) Database 2

MR image pre-processing is very significant to ameliorate the visual effect of the image for further processing. Usually the collected images in the dataset are so poor in quality which requires filtering noise and sharpening the image. In pre-processing step, the acquired image in the dataset is converted into a two dimensional matrix and the image is converted into RGB image to gray scale image. To eliminate the noise in the image, a median filter is used. Then, the enhancement of the image is done by performing adjusted operation, histogram based operation and adaptive histogram based operation. Generally, enhancement of an image means improving the contrast of the image. After that different features are initially extracted implicitly. After that, different features are initially extracted implicitly. Every portion of the brain tumor must be selected even a small portion of the brain tumor are not avoided. At first, the input image is processed through some filter that are described in Figure 3. Then, in Figure 3e, there is initial segmentation of the image using template based K-means (TK) which is segmented on the basis of there gray level intensity and temper of color where k = 8. After that the tumor is filtered by median filter again. Then, the tumor is detected and marked it as red line using improved FCM algorithm based on the Euclidean distance from cluster centre to each data point which primarily depends on the different features. This could be important to grasp the importance of this changed and incorporated technique. Depending on the grey level intensity the improved FCM is performed for 13 clusters. Clustered image is defined as the image with its smallest gray level and separated from each other with their successive color intensity. For instance, many clustered images for input image no. 10 of database 2 are shown in Figure 4. Here, the tumor portion with different portion of the image are shown in individualize image and from this, depending on features the tumor is chosen. Here, the index no. 8 is chosen technically and marked as red line in Figure 5d. Figure 5 shows the input image no. 6, 11, 16 and 20 of database 1 and image no. 10 and 15 of database 2 are

shown in Figure 5a and their outputs in Figure 5d respectively



We experimented on brain tumor MRI Images dataset by Navoneel [14]. The dataset is publicly available, consists of 253 real brain images developed by radiologists using data from real affected patients. Its available on Kaggle, a shared data platform used for machine learning competitions. We split our data into training, validation, and testing. There are 185 images for training, 48 images for validation, 20 for testing to evaluate our model accuracy. First, data augmentation is done to enhance our dataset by doing minor changes in our MRI images and extract these augmented images from our proposed CNN model. We trained the models for 15 epochs with a batch size of 32. The experiment is done using TensorFlow and Keras libraries in python on a CPU having a 2.3 GHz core i5 processor with 8 Gb of ram. Our proposed model showed 96% accuracy on our training data and 89% accuracy on our Validation dataset.

We calculated the Accuracy, Precision, Recall, and F1-Score of proposed CNN and other pre-trained models. Accuracy is the measurement of actual true classifications.

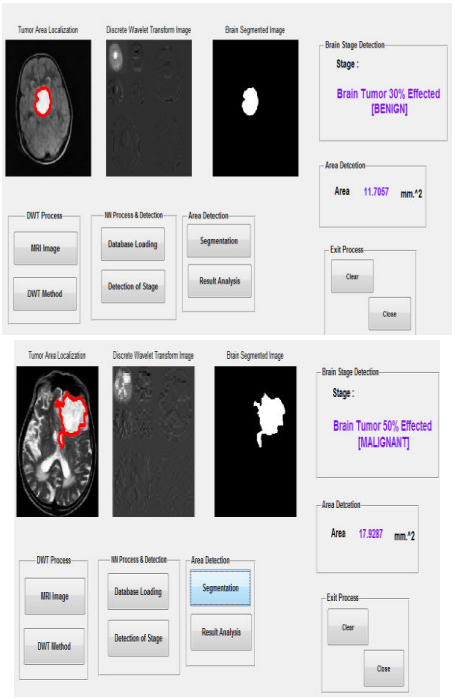
Accuracy = TruePositive(TP) + TrueNegative(TN)=(Total No o f S amples)

Precision estimates how many positive labels we had predicted.

Precision = TruePositive(TP)=(TruePositive(TP) + FalsePositive(FP))

Recall evaluates how many positive labels we had correctly predicted from our data.

Recall = TruePositive(TP)=(TruePositive(TP) + FalseNegative(FN))



Comparison of accuracy of existing method and proposed method

V. CONCLUSION

In this paper, a new approach was presented to classify brain tumor's. First, using the image edge detection technique, we find the region of interest in MRI images and cropped them then, we used the data augmentation technique for increasing the size of our training data. Second, we provide an efficient methodology for brain tumor classification by proposing a simple CNN network. For sophisticated and accurate results neural network requires a large amount of data to train on, but our experimental result shows that even on such a small dataset, we can attain full accuracy and our accuracy rate is very fine. So, our model needs less computational specifications as it takes less execution time.

Our proposed system can play a prognostic significance in the detection of tumors in brain tumor patients. To further boost the model efficiency, comprehensive hyper-parameter tuning and a better pre-processing technique can be conceived. Our proposed system is for binary classification problems, however, in future work, the proposed method can be

extended for categorical classification problems such as identification of brain tumor types such as Glioma, Meningioma, and Pituitary or may be used to detect other brain abnormalities. Also, our proposed system can play an effective role in the early diagnosis of dangerous disease in other clinical domains related to medical imaging, particularly lung cancer and breast cancer whose mortality rate is very high globally. We can prolong this approach in other scientific areas as well where there is a problem in the availability of large data or we can use the different transfer learning methods with the same proposed technique.

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