Segmentation of Brain Tumor in MRI Images Using Artificial Neural Networks

Sajith.P.V. 1, Sathyabalaji.N 2

1 Final year M.E. (CSE), JKK Munirajah College of Technology, T.N Palayam, TamilNadu.

2Assistant Professor, Department of Computer Science & Engineering, JKK Munirajah College of Technology, T.N Palayam, TamilNadu.

Abstract- A Brain Tumor is very serious disease causing deaths of many individuals. The detection and classification system must be available so that it can be diagnosed at early stages. Tumor classification has been one of the most challenging tasks in clinical diagnosis. At present tumor classification is done mainly by looking through the cells’ morphological differences, which do not always give a clear distinction of tumor subtypes. Unfortunately, this may have a significant impact on the final outcome of whether a patient could be cured effectively or not. This paper deals with such a system which uses computer based procedures to detect tumor blocks and classify the type of tumor using Artificial Neural Network Algorithm for MRI images of different patients. Different image processing techniques such as histogram equalization, image segmentation, image enhancement, morphological operations and feature extraction are used for detection of the brain tumor in the MRI images of the tumor affected patients.

Index Terms – Artificial Neural Network, Brain Tumor, Detection technique for Tumor, Magnetic Resonance Image.

1. INTRODUCTION

Imaging is an essential tool of medical science to visualize the anatomical structures of the human body. Several new complex medical imaging techniques, such as X-ray, magnetic resonance imaging (MRI), and ultrasound, strongly depend on computer technology to generate or display digital images. MRI is especially true to classify brain tissues whether it is the tumorous or not. A tumor is a mass of tissue that grows out of control of the normal forces that regulates growth. Manual classification of magnetic resonance (MR) brain tumor images is a challenging and time-consuming task. The most important advantage of MR imaging is that it is non-invasive technique. Presently available systems can only detect location and size of tumor but do not provide any knowledge about the type of tumor. Many tumor forms can only be diagnosed after a sample of suspicious tissue has been removed and tested. Pathologists view pathologic tissues, typically with brig field microscopes, to determine the degree of normalcy versus disease. This process is time consuming, and fatiguing. It is very necessary to diagnose the patients properly and exactly. The algorithm must be divided into various stages and accordingly the algorithm has to train also. The tumor diagnosis must be fully automatic with zero error is essential as it directly related with human being. With computer techniques, multidimensional digital images of physiological structures can be processed and manipulated to help visualize hidden diagnostic features that are otherwise difficult or impossible to identify using planar imaging methods. The use of computer technology in medical decision support is now widespread across a wide range of medical area, such as tumor research, heart diseases, brain tumors etc.

Different body parts MRI image needs different type of segmentation. The most common class of methods is statistical classification using multi-parameter images. These methods are highly intensity based and hence the accuracy is very low. Warfield et al. combined elastic atlas registration with statistical classification. Marcel Prastawa used a modified spatial atlas for classification which includes prior probabilities for tumor and edema. Another group of researchers highly depend on computational intelligence for MR brain tumor classification which guarantees high accuracy. Zumray et.al elaborates the inferior results of multilayer perceptron for the biomedical image classification problem. The Self Organizing Feature Map (SOFM) ANN based algorithms shows excellent results in the classification of brain tumor images. Hopfield neural networks (HNN) prove to be efficient for unsupervised pattern classification of medical images, particularly in the detection of abnormal tissues.

2. METHODOLOGY

The work carried out involves processing of MRI images of brain tumor affected patients from the local TUMOR Research Hospital, for detection and Classification on different types of brain tumors. The image processing techniques like histogram equalization, image segmentation, image enhancement and then extracting the features for Detection of tumor. Extracted feature are stored in the knowledge base of ANN. A suitable Nero Fuzzy classifier is developed to recognize the different
types of brain tumors. The system is designed to be user friendly by creating proper Graphical User Interface (GUI).

Fig.1. Components of an Image Analysis System

A. Image Pre-Processing

Image pre-processing can be the first step in image understanding. Generally pre-processing techniques try to reduce the artifacts introduced by the imaging modality. Two pre-processing techniques applicable to image segmentation in general are noise removal and contrast enhancement. In this work, the converted gray scale MR images are median filtered to reduce noise and artifacts.

B. Feature Extraction

MR Image segmentation is based on a set of measurable features which are extracted or computed from the images. Features themselves can be classified as pixel intensity-based features, calculated pixel intensity-based features and edge and texture-based features. Intensity values can be from a single image, a volume data set, a multispectral data set, or a multimodal image set. In this process of tumor detection, pixel intensity-based features are extracted.

C. Segmentation

Image segmentation groups pixels into regions, and hence defines object regions. Segmentation uses the features extracted from the image(s); therefore, good feature selection greatly influences segmentation results. MRI segmentation methods use either a single 2D or 3D image or a series of multispectral or multimodal images. Common segmentation approaches to MR images are thresholding, edge detecting, clustering, genetic algorithms, neural networks, and probabilistic techniques. In this work, thresholding and neural networks have been used for segmentation.

The Complete process of the tumour detection is given as a flow chart in Fig.2

D. Classification

During segmentation, a pixel, based on features, is assigned to a particular class. However, some methods make no connection between the segmentation classes and the tissue classes. They simply group like pixels or regions together. Strictly speaking, this is truly segmentation.

3. PREVIOUS IMPLEMENTATIONS

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. This new approach to computing also provides.

3.1 Analogy to the Brain

The exact workings of the human brain are still a mystery. Yet, some aspects of this amazing processor are known. In
particular, the most basic element of the human brain is a specific type of cell which, unlike the rest of the body, doesn't appear to regenerate. Because this type of cell is the only part of the body that isn't slowly replaced, it is assumed that these cells are what provide us with our abilities to remember, think, and apply previous experiences to our every action.

3.2 Brain Tumor

The body is made up of many cells which have their own special function. Most of the cells in the body grow and divide to form a new cell of the same kind as they are needed for the proper functioning of the human body. When these cells lose control and grow in an uncontrollable way. It gives rise to a mass of unwanted tissue forming a tumor. Brain tumor is a mass of tissue which cells grow and multiply uncontrollably. These brain tumors may be embedded in the regions of the brain that makes the sensitive functioning of the body to be disabled.

3.3 Risk Factors of Brain Tumor

Various risk factors of brain tumor are,

Ionizing Radiation: Ionizing radiation from high dose x-rays (such as radiation therapy from a large machine aimed at the head) and other sources can cause cell damage that leads to a tumor. People exposed to ionizing radiation may have an increased risk of a brain tumor, such as meningioma or glioma.

Family History: It is rare for brain tumors to run in a family. Only a very small number of families have several members with brain tumors.

4. SYSTEM IMPLEMENTATION

Image Segmentation

Image segmentation refers to the process of partitioning a digital image into multiple segments i.e. set of pixels, pixels in a region are similar according to some homogeneity criteria such as color, intensity or texture, so as to locate and identify objects and boundaries in an image. Practical application of image segmentation range from filtering of noisy images, medical applications (Locate tumors and other pathologies, Measure tissue volumes, Computer guided surgery, Diagnosis, Treatment planning, study of anatomical structure), Locate objects in satellite images (roads, forests, etc.), Face Recognition, Finger print Recognition, etc.

Thousands of different segmentation techniques are present in the literature, but there is not a single method which can be considered good for different images, all methods are not equally good for a particular type of image.

Detecting Discontinuities: It means to partition an image based on abrupt changes in intensity, this includes image segmentation algorithms like edge detection.

Detecting Similarities: It means to partition an image into regions that are similar according to a set of predefined criterion; this includes image segmentation algorithms like thresholding, region growing, region splitting and merging.

Segmentation Based on Edge Detection

This method attempts to resolve image segmentation by detecting the edges or pixels between different regions that have rapid transition in intensity are extracted and linked to form closed object boundaries. The result is a binary image. Based on theory there are two main edge based segmentation methods- gray Histogram and Gradient Based Method.

Image segmentation by thresholding is a simple but powerful approach for segmenting images having light objects on dark background. Thresholding technique is based on image space regions i.e. on characteristics of image. Thresholding operation convert a multilevel image into a binary image i.e., it choose a proper threshold T, to divide image pixels into several regions and separate objects from background. Any pixel (x, y) is considered as a part of object if its intensity is greater than or equal to threshold value i.e., f(x, y) ≥T, else pixel belong to background. As per the selection of thresholding value, two types of thresholding methods are in existence, global and local thresholding. When T is constant, the approach is called global thresholding otherwise it is called local thresholding.

Segmentation Based on Clustering

Clustering is an unsupervised learning task, where one needs to identify a finite set of categories known as clusters to classify pixels. Clustering use no training stages rather train themselves.
using available data. Clustering is mainly used when classes are known in advance. A similarity criteria is defined between pixels, and then similar pixels are grouped together to form clusters. The grouping of pixels into clusters is based on the principle of maximizing the intra class similarity and maximizing the interclass similarity.

Fig 4: Example for Clustering

**K-Means Clustering Algorithm** A cluster is a collection of objects which are similar between them and are dissimilar to the objects belonging to other clusters. Clustering is an unsupervised learning method which deals with finding a structure in a collection of unlabelled data. A loose description of clustering could be the process of organizing objects into groups whose members are similar in some way. K-means clustering is an algorithm to group objects based on attributes/features into k number of groups where k is a positive integer. Fuzzy clustering algorithms include FCM (Fuzzy C means)algorithm, GK (Gustafson-Kessel), GMD (Gaussian Mixture Decomposition), FCV (Fuzzy C Varieties), AFC, FCS, FCSS,FCQS, FCRS algorithm and etc, among all the FCM is the most accepted method since it can preserve much more information than other approaches.

**Algorithm Implementation K-means Algorithm**

Step 1: Decide on a value for K, the number of clusters.

Step 2: Initialize the K cluster (randomly, if necessary).

Step 3: Decide the class memberships of the N objects by assigning them to the nearest cluster center.

Step 4: Re-estimate the K cluster centers, by assuming the memberships found above are correct.

Step 5: Repeat 3 and 4 until none of the N objects changed membership in the last iteration.

**5. TRAINING & TESTING PHASE OF ANN**

ANN always works on Training Phase and Testing Phase. In Training Phase the ANN is trained for recognition of different types of brain tumor. The known MRI images of tumor affected patients are first processed through various image processing steps and then textural features are extracted using Gray Level Co-occurrence Matrix. The features extracted are used in the Knowledge Base for algorithm which helps in successful classification of unknown Images. The extracted features are compared with the features of Unknown sample Image for classification. Texture features or more precisely, Gray Level Co-occurrence Matrix (GLCM) features are used to distinguish between normal and abnormal brain tumors. Five co-occurrence matrices are constructed in four spatial orientations horizontal, right diagonal, vertical and left diagonal (0, 45, 90, and 135). A fifth matrix is constructed as the mean of the preceding four matrices.

ANN’s are networks are usually having nodes. The input of a specific node is the weighted sum of the output of all the nodes to which it is connected. The output value of a node is, a non-linear function of its input provided. The multiplying weighing factor between the input node j and the output node i is called the weight wji. ANN is a system whose parameters are changed during operation, normally during Training phase. After the training phase the Artificial Neural Network parameters are fixed and then testing phase is done. Presentation of output of the neural network is compared to the desired output and an error is computed. This error is then fed back as feedback input) to the Artificial Neural Network and used to adjust the weights such that the error must be decreased at each iteration and the neural model gets closer and closer to producing the desired output. This process is known as Training.

Fig 5: The architecture of used ANN

The Training of these networks consists in finding a mapping between a set of input values and a set of output values. The mapping is adjusting the value of the weights wji; using a learning algorithm, the most popular of which is the generalized delta rule. After the weights are adjusted on the training set, their value is fixed and the ANN's are used to classify unknown input images.

\[
E_p = \frac{1}{2} \sum_j (t_{pj} - o_{pj})^2
\]
Where,

\[ p \] - One input vector
\[ tp \] - target output vector
\[ op \] - observed output vectors

6. EXPERIMENTAL RESULTS

A set of MRI images both normal and tumorous are acquired for the project. Each original image contained a header with information regarding the patient, scanning facility and scanning parameters. This header is removed prior to filtering and segmenting. Only pixel information is given to the neural networks for processing.

A. Image Resizing

The images acquired after removing the header are of various sizes. In order to be able to perform matrix arithmetics on the images it is necessary for the images to be square matrix. Therefore all the images procured after removing the header are resized to a standard dimension of 512x512 pixels. The resizing of the images is done in MATLAB. Fig.4 represents the normal MR image, Fig. 6(a) and Fig.6(b) are the original and resized images. Similarly Fig.5 represents tumorous MR image. The original and resized image are shown in Fig.7(a) and 7(b). The images are resized using inbuilt MATLAB function ‘imresize’. The is read using ‘imread’ and then converted to datatype double. Then the image is resized from its original size to 512x512.
The resized images are then input to a pulse coupled neural network. This stage therefore performs steps to enable the image to be ANN compatible.

B. Image Enhancement Using ANN

The images produced from the resizing stage are then input one by one to a ANN algorithm. Fig. 8(a) is the resized normal input image and Fig. 8(b) is the output image after enhancement.

Fig. 8. Image Enhancement of Normal MR Image Using ANN

The network reads the images in the form of a matrix. The matrix elements are between 0 and 1 since the image is in grayscale.

7. CONCLUSION

The system has been tested only with the above sample images. The system can be designed to classify other types of tumors as well with few modifications. The scope of the system can further be improved by using other types (e.g. PET, MRS, CTS) of Images. It is essential to use large number of patient’s data which will improve the accuracy of the system. More features that could be added to the system include metabolic and genetic data as well as anatomical attributes of the brain.
8. REFERENCES


