Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(12):456-463

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Segmentation and classification of brain tumor computed tomography (CT) images using watershed segmentation for early diagnosis

S. Krishnakumar*[1], J. Bethanney Janney[1], J. Jerisha[1], P. Nayaki Ashmi[1] and V. Dooslin Mercy Bai[2]

[1]*Faculty of Bio and Chemical Engineering, Department of Biomedical Engineering, Sathyabama University, Chennai, Tamilnadu, India*
[2]*Department of Biomedical Engineering, Rajiv Ganthi College of Enginnering and Technology, Puducherry, India*

ABSTRACT

A computer software system is designed for segmentation and classification of benign and malignant tumor slices in brain computed tomography (CT) images. The objective of the present study is to develop software and to achieve auto-segmentation and detection of brain tumor. Therefore the algorithm has been designed and developed for analysis of medical images based on hybridization of synergistic and statistical approaches using watershed segmentation and morphological operation. This algorithm performs segmentation and classification is done in human vision system, which recognizes objects, perceives depth, identifies different textures, curved surfaces or a surface inclination by texture information and brightness. The analysis of medical image is directly based on four steps: 1) image filtering, 2) segmentation, 3) feature extraction and 4) analysis of extracted features by pattern recognition system or classifier. In proposed method an attempt has been made to present an approach for segmentation and detection of brain computed tomography images. The present approaches are threshold segmentation, color conversion, filter fft, Image enhancement, watershed segmentation and morphological operation. The algorithms itself scan the whole image and perform the segmentation and classification in unsupervised mode.

Key words: image-processing, brain tumor, CT image

INTRODUCTION

A tumor is a mass of tissue formed by an accumulation of uncontrolled proliferation of cells. The tumor cell losses cell regulation leads to continue to grow as more and more cells to form undifferentiated mass. The most common types of adult brain tumors are gliomas and astrocytic tumors. These tumors form from astrocytes and other types of glial cells. The second most common type of adult brain tumors are meningeal tumors formed from the meninges by thin layer of tissues cover the brain and spinal cord. To diagnose a brain tumor the patients are subjected to undertake imaging studies such as a CT scan or MRI scan images of brain. Angiogram or MRA have been taken using dye and pass X rays on blood vessels of brain to detect the signs of tumor or abnormal blood vessels. Once the brine tumor has been diagnosed the patient is undergone for surgery. After surgery chemotherapy or radiation therapy is used to kill the left out cancer cells. However some tumors can't be surgically removed because of their location in the brain. In such cases, both chemotherapy and radiation therapies are in practice to kill or shrink the tumor cells. Tumors are located in deep brain which is difficult to reach radiation might be treated with Gamma Knife therapy (GKT). Treatment of brain tumor could damage nearby healthy tissue is the adverse risk to the patient.

Image processing is a technique in which the data from an image is digitized and various mathematical operations are applied in order to create an enhanced image. Enhanced images are more useful to perform some of the

interpretation and recognition tasks performed by human [1]. Image processing has extensive array of applications including astronomy, medicine, industrial robotics and remote sensing by satellites, manipulating data in the form of an image through several possible techniques. The requirements for image processing are the images must be available in digitized form with arrays of finite length binary words. Before processing of an image it must be converted into a digital form [2].The digitized image is processed by the computer to display a digital image is first converted into analog signal, which is scanned onto display. For capturing the brain image Computed Tomography (CT) is used. CT is more preferred for brain imaging than the MRI [3]. The technique subjected to apply for image processing is threshold segmentation, color conversion, filter fft, watershed segmentation and morphological operation. Segmentation is one of the most important problems in image processing. It consists of constructing a symbolic representation of the image and the image is described as homogeneous areas according to one or several priori attributes. The purpose of this study is to adapt a new method for image segmentation using the topological gradient approach and the watershed transformation. These methods are used for detecting a tumor region from brain CT image. Initially the image obtained from the patient is preprocessed and the noise is removed using high pass filter and median filter attenuate the low frequency noise and salt and pepper noise respectively. In watershed segmentation distance transforms, gradient operator and super imposed gradient operator also applied to get correct segmented region of brain CT image. Finally the morphological operation is applied in the segmented brain CT image to get desired region output.

The main objective of the present study is to implement computer software to detect the benign and malignant brain tumor diagnosis using watershed segmentation. The tumor image is directly analyzed and characterized by the following steps *viz;* image filtering, segmentation, feature extraction and analysis of extracted features by pattern recognition system to identify the accurate region of tumor from the brain CT image. The proposed method by using texture statistics could able to classify brain tumor into benign and malignant tumor.

EXPERIMENTAL SECTION

The techniques to be applied in the present study are threshold segmentation, color conversion, filter fft, watershed segmentation and morphological operation. These algorithms are used to detect the tumor region from brain CT image. The block diagram of the present study deals with CT image is depicted in fig. 1. Initially the brain CT image is preprocessed and the noise has been removed. Threshold is applied for the image to get a binary image for further classification. Erosion and Dilation are the two methods which are used to improve the quality of the input image. Disk based segmentation is applied for the segmentation of the tumor region. After completing this process filter fft is applied for getting a good quality image with noise removal. Then the watershed segmentation is used for segmenting a tumor region separately. In watershed segmentation distance transforms, gradient operator and super imposed gradient operator is applied to obtain correct segment region of brain CT image. Finally the morphological operations are applied in the processed brain CT image to get desired region output.

Image Processing

An image is usually interpreted as a two-dimensional array of brightness values represented by photographic print. An image could be digitalized to reduce into a series of numbers that can be manipulated by the computer. Each number representing the brightness value of the image at a particular location is called a picture element or pixel. A typical digitized image may have roughly 2, 50,000 pixels although much larger images are becoming common. Once the image has been digitized, there are three basic operations that could be performed in the computer. These operations could be taken singly or in combinations are the means by which the image is enhanced, restored, or compressed. The value of every pixel in the noisy image is recorded along with the values of its nearest eight neighbours. The nine numbers are then ordered according to size and the median is selected as the value for the pixel in the new image. As the 3 × 3 window is moved one pixel at a time across the noisy image then the filtered image is formed [4].

Digitization

Digitization includes sampling of image and quantification of sampled values. After converting the image into bit information the processing technique might be followed by Image enhancement, Image reconstruction, and Image compression.

Image enhancement

It refers to accentuation or sharpening of image features such as boundaries or contrast to make a graphic display more useful for display and analysis. This process does not increase the inherent information content in data. It includes gray level, contrast manipulation, noise reduction, edge christening, sharpening, filtering, interpolation, magnification and pseudo coloring.

Image compression

Compression is a way of representing an image by fewer numbers, mean while minimizing the degradation of the information contained in the image. Compression is important because of the large quantities of digital imagery stored electronically. Once the image is compressed for storage or transmission it must be uncompressed for use by the inverse of the compression operations. High compression rates are acceptable where high image quality must be preserved as in diagnostic medical image.

Image enhancement techniques

Image enhancement techniques are instigated for making satellite image more informative and helping to achieve the goal of image interpretation. As an image enhancement technique often drastically alters the original numeric data it is normally used only for visual (manual) interpretation and not for further numeric analysis. Common enhancements include image reduction, image rectification, image magnification transect extraction, contrast adjustments, band rationings, spatial filtering, fourier transformations, principal component analysis and texture transformation. The image enhancement techniques are applied either to single-band images or separately to the individual bands of a multiband image set.

MATLAB

MATLAB is a high level language and interactive environment for numerical computation, visualization and programming. Using MATLAB the data has been analyzed, develop algorithms and create models for variety of applications. MATLAB products provide medical device engineers and researchers with the tools for analyzing and visualizing medical images for developing advanced imaging algorithms used in a wide range of diagnostic and therapeutic medical devices with topographic (MRI, CT, PT), ultrasound, intravascular and endoscopic imaging modalities. In the present research MATLAB is used to process the brain CT image for early diagnosis of malignant tumor.

Block Diagram

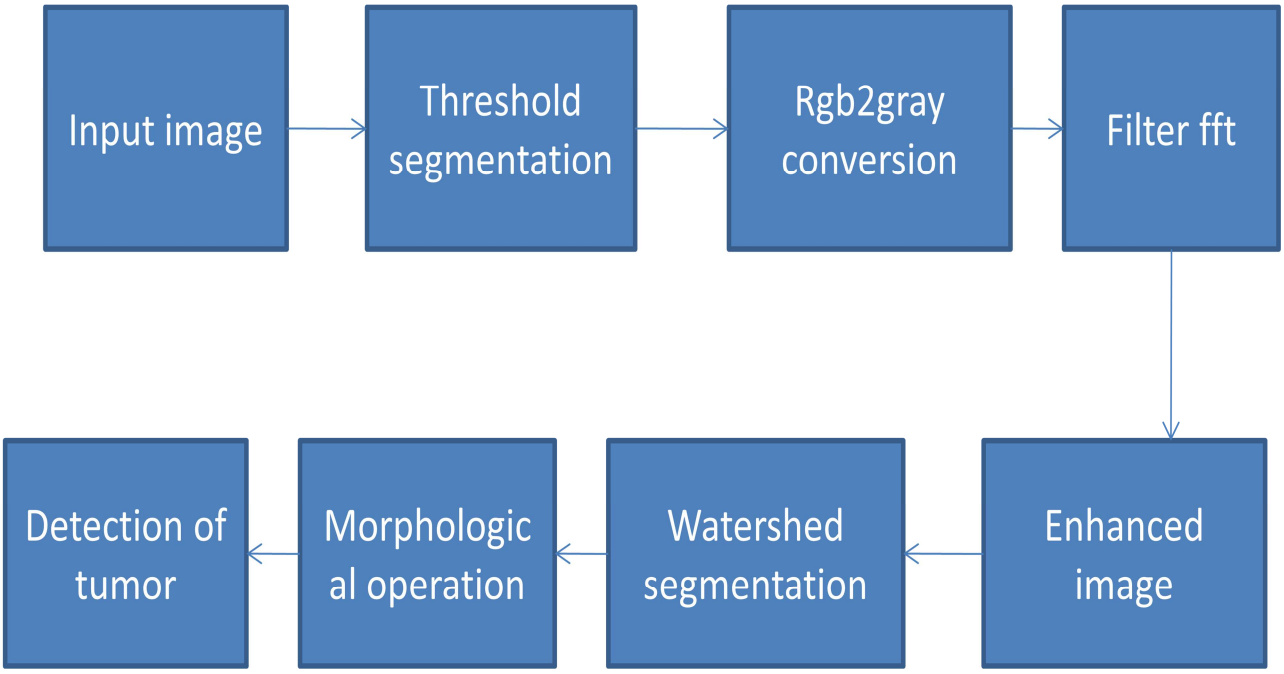

Fig. 1 Block diagram of brain CT image processing

Image Acquisition

Prior to image processing an image must be captured by a camera and converted into a manageable entity. The general goal for image acquisition and processing is to bring the picture into the computer domain. Where they can be manipulated and altered for enhancement to display the images. The following processes such as input, display, manipulation and output are involved in image acquisition. The transformation of optical image into an array of numerical data may be manipulation by the computer to achieve machine version.

Preprocessing

Preprocessing of the image was performed using high pass filter (HPF) and median filter (MF) to remove the noise. HPF passes high frequencies and attenuate frequencies lower than the cut off frequency. The input signal initially goes to the capacitor. The high frequency AC signals pass through the capacitor while the slower frequency signals tend to be blocked through it. The resistor voltage separates and the voltage distinction across the resistor turns into the output signal. The median filter is a nonlinear digital filtering technique used to remove noise to improve the results of later processing of edge detection of an image.

Segmentation of tumor region

Watershed segmentation was used for the segmentation of the tumor region. Watershed is the recent segmentation technique which gives better performance than other techniques. First the image must be converted into grayscale and use a morphological top-hat operator with a disk shaped structuring element to smooth out the uneven illumination. Second a new function called gray threshold was used to determine a good threshold for converting the image into binary. Finally compute the distance transform of the complemented binary image and modify into force the background to its own catchment basin. Compute the watershed transform, since the light areas are already fairly well separated by dark lines [5].

Feature extraction and feature selection

Texture analysis is a quantitative method could be used to quantify and detect structural abnormalities in different tissues. Features are extracted from the two level wavelet approximation tumor image of each slices grey level co-occurrence matrix and take the average of all the features extracted from four grey level co-occurrence matrices. Feature selection is the process of reducing the dimension of feature vector. Significant features are selected by the calculation of mean values for every feature in benign tumor class and malignant tumor class.

Threshold segmentation

Threshold technique is one of the important techniques in image segmentation. Threshold technique is computationally simple and never fails to define disjoints regions with closed boundaries. Threshold technique converts a colored image or gray scale image into binary or bimodal image. The RBG image has been segmented through threshold techniques. Segmentation algorithms are based on one of two basic properties of intensity value discontinuity and similarity.

Threshold techniques

Threshold technique is the important techniques in image segmentation. This technique can be expressed as: T=T[x, y, p(x, y), f(x, y]

Where: T is the threshold value. x, y are the coordinates of the threshold value point. p(x, y) ,f(x, y) are points the gray level image pixels.

Watershed segmentation

Any grayscale image can be viewed as a topographic surface where high intensity denotes peaks and hills while low intensity denotes valleys. As the water rises depending on the peaks (gradients) nearby, water from different valleys will start to merge.

Watershed Segmentation process

Segmentation is one of the most important problems in image processing. It consists of constructing a symbolic representation of the image is described as homogeneous area. According to the literature, we could find various segmentation algorithms. The first method appeared during the sixties and then different algorithms have been constantly developed. The purpose of the present study is to adapt a new method for image segmentation using the topological gradient approach [6] and the watershed transformation [7].Watershed Segmentation gets its name from the manner in which the algorithm segment regions into Catchment basins.

Morphological operation

Erosion and Dilation are the two processes in Morphological operations. It will improve the quality of an image and the output of an image has to be improved to obtaining a better input image which gives the segmentation of tumor region effectively.

Erosion and Dilation

Erosion is the process of deleting the unwanted things from the segmented image. Dilation is the process of adding the required things with the segmented images.

Morphological Reconstruction (MR)
Morphological reconstruction is a morphological transform involving two images and a structuring element. One image, the marker, contains the starting points for the transformation. The other image, the mask, constrains the transformation. The structuring element is used to define connectivity.

Border cleaning
The extraction of objects from an image for subsequent shape analysis is a fundamental task in automated image processing. An algorithm for removing objects that touch the border is useful. We have developed a border cleaning procedure based on morphological reconstruction by original image as the mask and the following marker image.

$F(x, y) = I(x, y)$ if (x, y) is on the border of I

The border- cleaning algorithm first computes the morphological reconstruction $R_I^D(F)$, which extracts the objects touching the border and then computes the difference.

$X= I- R_I^D(F)$

Texture Feature for Morphological Operation
Texture is another feature that can help to segment images into regions of interest and to classify those regions. In some images it can be the dining characteristic of regions and critical for obtaining a correct analysis. Texture gives us information about the spatial arrangement of the colors or intensities in an image. Suppose that the histogram of a region tells us that it has 50% white pixels and 50% black pixels [8].

Probabilistic Neural Network (PNN)
Probabilistic neural networks (PNN) can be used for classification problems. When an input is presented the first layer computes distances from the input vector produces whose elements indicate close proximity to a training input. The second layer sums these contributions for each class of inputs to produce as its net output vector of probabilities. Finally, a complete transfer function on the output of the second layer picks the maximum of these probabilities, and produces 1 for that class and 0 for the other classes.

RESULTS AND DISCUSSION

Brain tumor is treatable and curable if it has been identified in the earliest stages of the disease. Untreated or malignant brain tumor would disseminate inward because the skull will not let the brain tumor expand outward. This will put excessive pressure on the brain causing increased intracranial pressure and can cause permanent brain damage and eventually death may occur. Only invasive techniques such as biopsy and spinal tap methods could determine whether the brain tumor is malignant or non malignant. But the algorithm specifically designed in this method helps in classifying cancerous and non cancerous brain tumors automatically by PNN classifier [9]. Basically PNN consists of an input layer, which represents the input pattern or feature vector. The input layer is fully interconnected with the hidden layer, which consists of the example vectors. Finally an output layer represents each of the possible classes in which the input data can be classified. The example nodes for a given class connect only to that class output node and none other [10]. In the present study there are two types of training models such as back propagation method (BPM) and perceptron was used in order to train the PNN network. The algorithm itself scans the whole image and performs the segmentation and classification in unsupervised mode. The percentage of accuracy of classification using PNN is found to be nearly centum. Based on the experimental results PNN is considered to have major advantages over conventional neural networks. Because PNN learns from the training processes and classify the CT brain images into normal, benign and malignant, based on their texture features. This will helps the Physicians to proceeds the further treatment process well advance.

A Computer Software System (CSS) is designed in order to differentiate the Benign and malignant tumor from the brain CT images. The preprocessed brain tumor CT images are displayed in fig. 2.

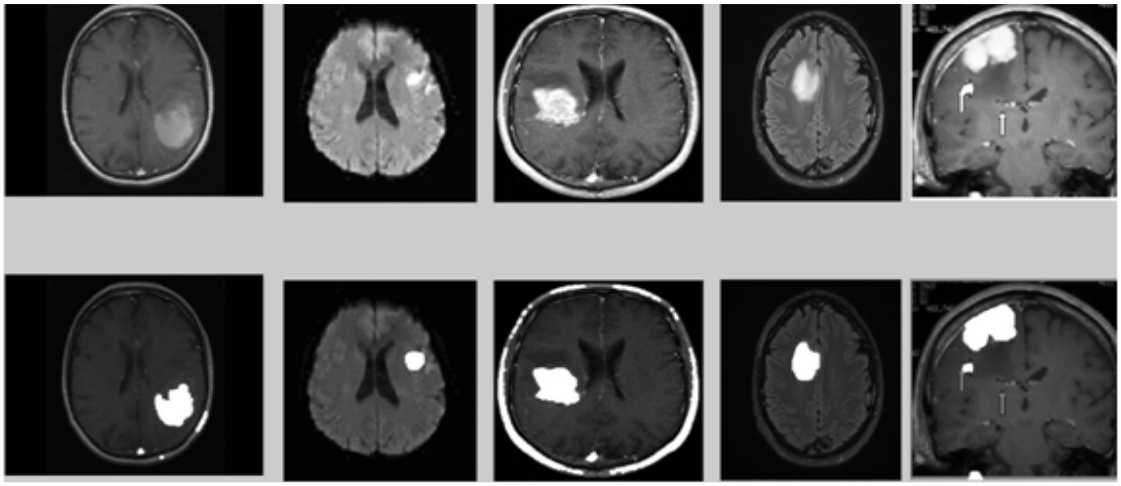

Fig. 2 Preprocessed brain tumor CT images

Once the image has been taken from the patient is subjected to preprocessing to remove the noise leads to proper identification of image. After preprocessing the image is subjected to perform segmentation process of threshold segmentation and watershed segmentation in order to get the better segmentation output. A processed brain tumor CT image with watershed segmentation is shown in fig.3.The Segmentation rate and Classification rate of brain CT images using Watershed Segmentation is high compared with other methods like Genetic Algorithm (GA) and Support Vector Machine (SVM) method [11]. The accuracy obtained by Watershed segmentation and Morphological operations are high compared to Piecewise Linear Discriminant Method (PLDM) Genetic Algorithm (GA) and Support Vector Machine [12].

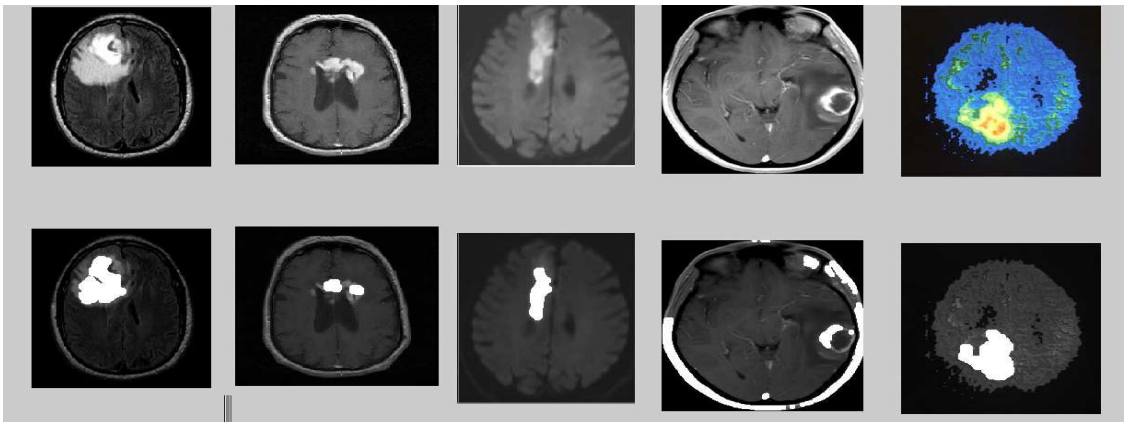

Fig. 3 Processed brain tumor CT images with watershed segmentation

In image processing different watershed lines might be computed followed by morphological operation will be performed to deals the texture feature. Texture feature can help to segment the images into regions of interest and to classify those regions by dining characteristic of regions and critically obtaining a correct analysis. Texture gives us information about the spatial arrangement of the colors or intensity of an image. Morphological operation was performed by erosion and dilation. Erosion deals with deleting the unwanted things and dilation deals with adding of required parts of the segmented image are shown in fig. 4.

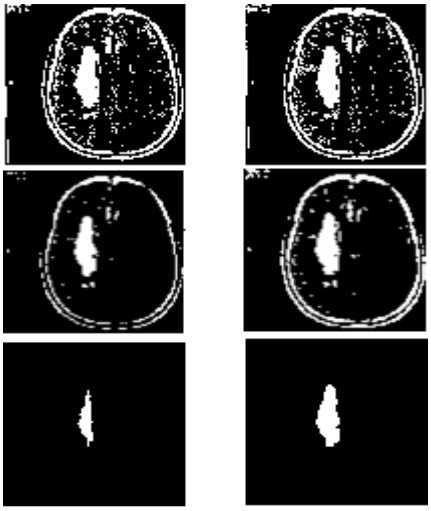

Fig 4 Morphological Erosion and Dilation of brain CT image

Finally a complete transfer function on the output of the second layer picks the maximum of these probabilities and produces 1 for that class and 0 for the other classes. The output of the morphological operation of brain tumor CT image is portrayed in fig. 5. Thus the tumor will be classified either as Benign or Malignant.

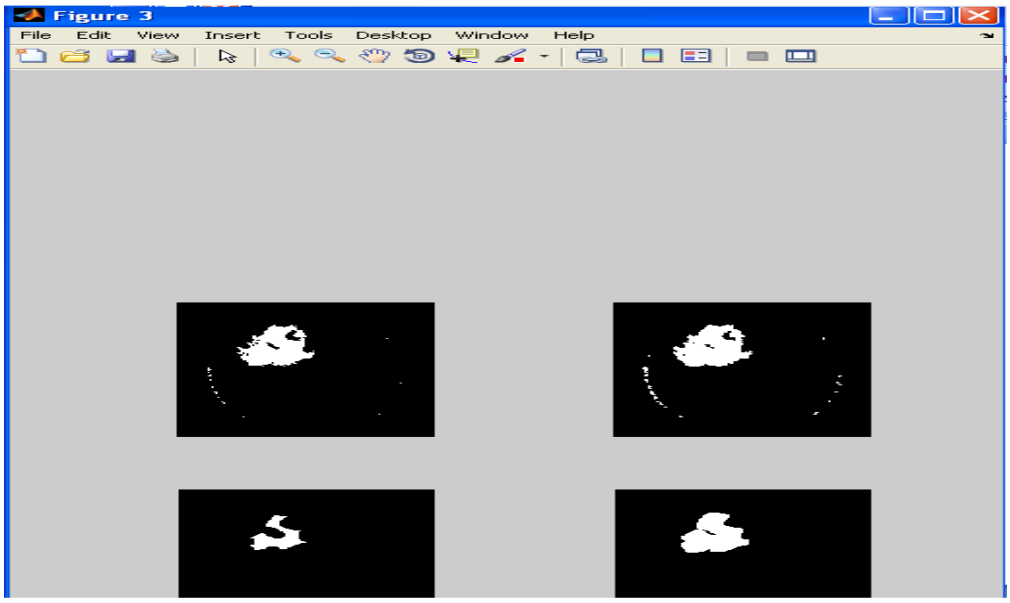

Fig. 5 Morphological operation of brain tumor CT image output

Threshold is one of the widely used methods for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted into binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest. The advantage of obtaining binary image is to reduce the complexity of the data and simplifies the process of recognition and classification. The most common way to convert a gray-level image to a binary image is to select a single threshold value (T). Values below T will be classified as black denoted as 0, and those above T will be white denoted as 1[13]. Rajendran and Madheswaran [14] reported that the MARI (Mining Association Rule in Image database) algorithm and Spatial Gray Level Dependent Features (SGLDF) can be used for the segmentation of brain images. They used the CT technique for imaging and they obtained the result on prediagnosed database of brain images showed 96% and 93% sensitivity and accuracy respectively. Padma and Sukanesh [15] used the SGLDM method for feature extraction, Region of Interest (ROI) for feature selection and SVM is used for feature classification of CT images. Average accuracy rate of 97% was obtained using this classification and segmentation. Janney et. al., [16] carried out image fusion technique for magnetic resonance imaging (MRI) and positron emission tomography (PET) using Haar wavelet transform and Pillar K-mean clustering algorithm. Comparison and improvement of wavelet based image fusion is done using GUI (Graphical User Interface). They observed that the

method effectively retains the basic information and details of original image and enhances information carries of fused image. Plant et.al., [17] has been used the Gaussian Bayes Classifier for classification of MRI image by automated detection of brain atrophy patterns based on MRI for the prediction of Alzheimer's disease. They obtained the better recognition rate compared to other methods. The present study clearly indicates that, Watershed Segmentation and Morphological Operation algorithm helps us to detect the exact tumor affected region present in the brain CT images. This will made the Physicians to proceed further with proper treatment process. The present study might help the tumor patient for the early diagnosis of brain tumor and opens a new avenue in biomedical engineering.

CONCLUSION

This investigation project presents an efficient method of classifying CT brain images into normal, benign and malignant tumor using a probabilistic neural network. The proposed approach gives very promising results in classifying CT images data instantaneously. This speed of learning gives the PNN the capability of adapting its learning in real time. Most of the existing methods can detect and classify CT brain images into normal and abnormal. Whereas the proposed method with the help of the texture statistics able to classify brain tumor into benign and malignant. The percentage of accuracy of classification using PNN is found to be nearly hundred per cent. Based on the experimental results, PNN is considered to have major advantages over conventional neural networks. Because PNN learns from the training processes and classify the CT brain images into normal, benign and malignant, based on their texture features. This will helps the Physicians to proceeds the further treatment process in advance to treat tumor patients.

Acknowledgment
Authors are grateful to the management of Sathyabama University, Faculty of Bio and Chemical Engineering, Department of Biomedical Engineering, Chennai, India for providing required facilities to complete the research successfully.

REFERENCES

[1] SY Shin; DH Jang; HK Park, *J. Software Engg and Its Appl.*, **2013**, 7(6), 175-184.
[2] K Suzuki; H Abe; H MacMahon; K Doi, *IEEE Trans. Med. Imag.*, **2000,** 25(4), 406–416.
[3] S Laughlin; W Montanera, *Postgraduate Medicine*, **1998**, 104(5), 73–88.
[4] I El-Naqa; Y Yang; MN Wernick; NP Galatsanos; RM Nishikawa, *IEEE Trans. Med. Imag.*, **2002,** 21, 1552-1563.
[5] P Arbelaez; L Cohen, *CVPR*, **2008**,
[6] D Auroux; LD Cohen; Masmoudi, *J. Biomed. Imag.*, **2011,** (4), 1-20.
[7] JBTM Roerdink; A Meijster, *Fundamenta Informaticae*, **2001,** 41, 187-228.
[8] T Xiaoou, *IEEE Transaction on Image Processing*, **1998,** 7, 234-243.
[9] MC Clark; LO Hall; MS Silbiger, *IEEE Trans. Med. Imag.*, **1998,** 17, 187-192.
[10] FZ Brill; DE Brown; WN Martin, *IEEE Trans on Neural Networks*, **1992,** 3, 324-328.
[11] A Kharrat; MB Messaoud; N Benamrane; M Abid, *IEEE International Conference on Signals, Circuits and Systems*, **2009**.
[12] M Ambard; S Rotter, *Front. Comput. Neurosci.*, **2012,** 6, 78.
[13] Q Hu; G Qian; A Aziz; WL Nowinski, *IEEE Eng. Medi.and Biol. Soc.*, **2005**, 6, 3375-3378.
[14] P Rajendran; M Madheswaran, *(IJCSIS) Int. J. Comp.Sci. and Info. Secu.*, **2009,** 6(3), 107-116.
[15] A Padma; R Sukanesh, (IJACSA) *Int. J. Adv. Comp. Sci.and Appl.*, **2011**, 2(10), 53-59.
[16] JB Janney; S Krishnakumar; PS Sruthi, *Res. J. Pharm. Biol. Chem. Sci.*, **2015,** 6(1),
[17] SJ Plant; A Teipel; C Oswald; T Bohm; J Meindl; AW Mourao-Miranda; H Bokde; Hampel; M Ewers, *NeuroImage*, **2010,** 50,162–174.