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Tumor Detection and Extraction in the Human Brain

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Abstract: Images are useful means to convey different kinds of information, making different problems easy to understand. Amongst these are medical images where image-processing techniques are extensively used to identify defected areas in a human body. One such defect is brain tumor a benign or malignant growth of tissues in the brain that disrupt its proper function. Regardless of its type, a brain tumor may produce a symptom that varies according to where in the brain the tumor is detected. Different image processing techniques were developed, most of which use Magnetic Resonance Imaging (MRI) to assist automatic detection of brain tumor by computers. This research presents an approach to detect brain tumor based on image processing algorithms including image preprocessing, enhancement, segmentation, feature extraction and detection of the brain tumor. Further research is in progress to enhance these techniques, hence, to provide for accurate classification yet diagnoses of a brain tumor.

Key words: Brain tumor, morphological operations, MRI segmentation, algorithms, accurate classification, diagnoses

INTRODUCTION

At present, a brain tumor is one of the main causes of increasing the death among adults and children. The majority of the Western world has found that the number of people with brain tumors continues to increase to 300 per year over the past few decades (Isselmou *et al*., 2016). On the other hand, Magnetic Resonance Imaging (MRI) an advanced medical imaging technique used to produce high-quality images of the parts contained in the human body is often used in treating a brain tumor, ankle and foot (Rajesh and Bhalchandra, 2015).

Ramalakshmi and Chandran (2014) developed anisotropic filter where concurrent filtering is applied along with contrast stitching. The proposed filter implies choosing a diffusion constant relative to the noise gradient and a threshold value proper to filter with in order to 2 remove background noise and hence, keeping edge points in an MRI image.

Another approach was suggested by Priyanka and Balwinder (2013). They attempted to enhance MRI medical image using median filter. This filter was used to de-noising the salt and pepper noise as well as the poisson noise from the image. They suggested also to use bounding box method to localize the tumor in the brain image.

Yousuf and Nobi (2010) presented order static filter a technique that combines median filtering with mean filtering to assist removing rician noise that affects the accuracy of detecting brain tumor in the input MRI image.

Jaya *et al*. (2009) applied a weighted median filter to remove highly frequent components keeping edges undisrupted in MRI image. Filtering is applied for each pixel in a window of a certain size of neighboring pixels to extract and analyze the mean gray value of foreground, the mean value of background and the contrast value of the concerned pixels. To improve the accuracy of identifying brain tumor in MRI, SivaSankar *et al*. (2014) applied GLCM and gabor feature extraction algorithms with the aid of using k-means clustering segmentation to extract an optimal set of 9 features, contrast, correlation, homogeneity, entropy, shape, color, texture and intensity, hence, transforming input samples of image data into reduced representation set of feature “Feature vectors”, preparing for computer-based recognition of brain tumor. Bahadure *et al*. (2017) presented an integrated decision support system for clinical diagnosis by the radiologists or other specialists.

The research proposed a way to improve the accuracy of diagnosis of brain tumor by combining Berkeley Wavelet Transformation (BWT) and SVM classifier in an aim to extract certain features from the segmented tumor region and hence, to classify healthy and infected tissues for a set of sample medical images. This research presents an automated system

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for detecting brain tumor in Magnetic Resonance Imaging (MRI) scanned images. The system adopts various image-processing techniques integrated with a user-friendly interface that is created using GUI tool in MATLAB. The underlined working environment tends to facilitate physicians in detecting the tumor as well as extracting its geometrical features which in turn save the time needed for diagnosing brain tumor by doctors and pathologists.

MATERIALS AND METHODS

The phases to detect and extract the tumor region from the MRI image of the human brain are shown in Fig. 1. In this approach, the first step is to take the MRI image of the human brain and to proceed through the following phases.

Enhancement of brain image: The MRI image is enhanced to reduce the noise and to remove unwanted data, this is achieved using an average low-pass filter. This filter is used to smooth as well as enhace the MRI image. Figure 2 shows the effect of applying the average filter to the input MRI human brain image.

Skull stripping in MRI image: The human brain surrounded by a bone area called the skull that protects the brain from external effects. This phase attempts to isolate the skull area from the background of the human brain image as illustrated in Fig. 3. This technique allows reducing the testing area and the possibility of errors, since, it puts all the background areas aside from the examination. The following steps achieved this process.

Step 1: Take the MRI image of the human brain and then store it in a two dimensions matrix.

Step 2: Start scanning the image from the left-top side to the right-bottom.

Step 3: Detect the threshold value based on selecting the peak threshold value for each side.

Step 4: If the intensity value for the left side is less than the threshold value and then set these values to zero. This step ensures the detection of the left side of the skull was achieved.

Step 5: Repeat the above steps to detect the right, top and bottom portions of the MRI skull image.

Step 6: Repeat the above steps to detect the right and top skull portion of the MRI image.

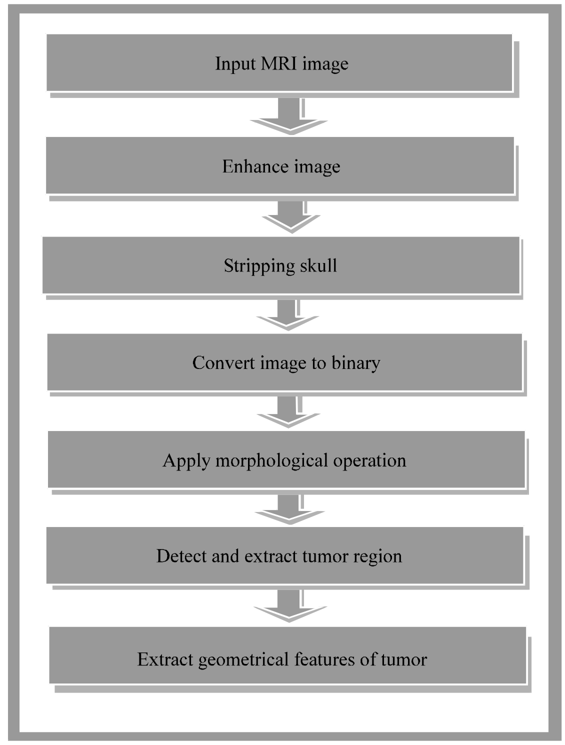

Fig. 1: Image processing steps for brain tumor detection

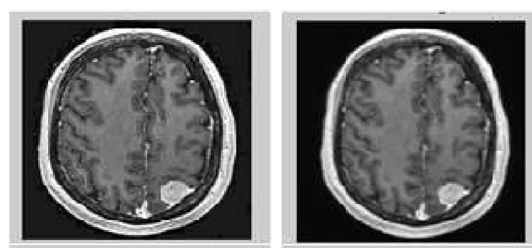

Fig. 2: Applying average filter to the input MRI brain image

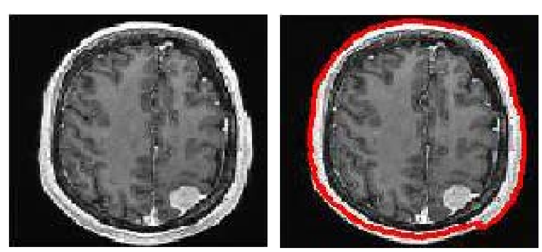

Fig. 3 : Skull stripping in MRI brain image

Conversion of MRI image to binary: This phase converts the enhanced MRI image to binary image. This process is applied to the thresholding image

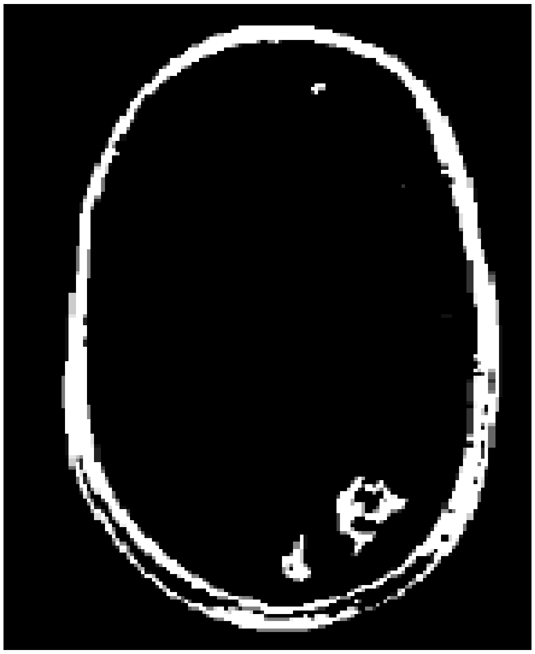

Fig. 4: Application of threshold and binarization to the filtered image

(Al-Khalidi *et al*., 2015). Binarization the threshold image is used to detect the boundary of the patient brain as shown in Fig. 4.

Extraction of brain region: The brain region is detected and extracted as an elliptical area from the binarized image to reduce the scanning area for the tumor detection. In order to cover the filtered images by elliptical area (Al-Khalidi *et al*., 2015) the location and size of the ellipse are determined as in the following steps.

Step 1: Calculate the center value (x_0, y_0) of the ellipse where x_0 represents the center value between the highest (x max) and lowest (x min) pixel location of the brain boundary, respectively in the vertical direction and y_0 represents the center between highest (y max) and lowest (y min) pixel location of the brain boundary, respectively in the horizontal direction.

Step 2: Apply the ellipse Eq. 1 is used to detect the ellipse location in the human brain:

$$\frac{(x_i - x_0)^2}{a^2} + \frac{(y_i - y_0)^2}{b^2} = 1 \quad (1)$$

The values of a and b in the Eq. 1 are calculated from x max and y max to x_0 and y_0, respectively. Figure 5 shows the detection of the human brain as an elliptical area from the background.

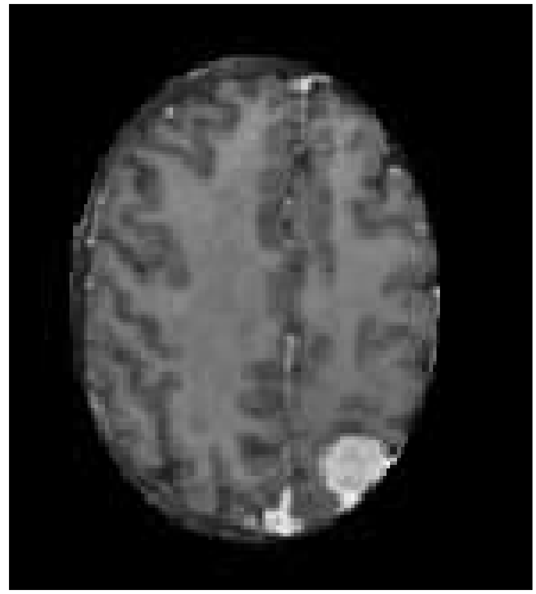

Fig. 5: Extraction of human brain as elliptical area

Step 3: Extract this current area from the original image. Figure 5 illustrates the extraction of the human brain as elliptical area (Yousuf and Nobi, 2010).

Apply morphological operation: At this phase, the binary image is indexed into regions and each region is compared with the neighborhoods. Structural pixels are called the morphological technique which is used to test a small shape or template. The structuring pixels are placed in all probable locations in the image and then matched to the identical neighborhood of pixels. The process then starts to exam the pixel if it is “fit” with in the neighborhood or else it “hits” or intersects the neighborhood. The regions are labeled by numbers to allow subsequent detection of the one with the greatest intensity where this represents the tumor region.

Detection and extraction of tumor region: The tumor region is detected and extracted in the MRI image based on the determination of the high-intensity region in the image. Figure 6 illustrates the detection and extraction of tumor region in the human brain.

Extraction of geometrical features of tumor region: Geometrical features are calculated for the tumor region.These features include the following.

Mean: This is the first statistical feature to extract from the tumor region by adding up all pixels values and dividing the result by the number of pixels in the image (region of tumor) as indicated by Eq. 2:

Fig. 6: Detection and extraction of tumor region in human brain

$$g(x, y) = 1/N \sum_{(x, y)\in S} f(x, y) \tag{2}$$

Where:

g(x, y) = The filtered image
f(x, y) = The original image before being filtered
S = The Set of coordinating pixels in the neighbourhood of pixel
(x, y) = Including the pixel (x, y) itself
N = The total number of pixels in the neighbourhood

All pixels included in the filter size are added up and the result is divided by the number of pixels (Gonzales *et al*., 2004) (Fig. 6).

Standard deviation: This is the second central moment that describes the probability distribution of observant population and can be used as a measure of heterogeneity. The higher value indicates a better intensity level and a high contrast to the edges of the image. This can be indicated by Eq. 3:

$$SD = \sqrt{\left(\frac{1}{m\times n}\sum_{x=0}^{m-1}\sum_{y=0}^{n-1}\left(f(x, y)-M\right)^2\right)} \tag{3}$$

Variance: The variance value can be obtained by taking the differences between each number in the group and the mean, taking into account differences (to make them positive) and dividing the sum of squares by the number of values in the group X, the individual data point:

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N} \tag{4}$$

The variance (σ^2) is defined as the sum of the squared distances of each term in the distribution from the mean (μ), divided by the number of terms in the distribution (N).

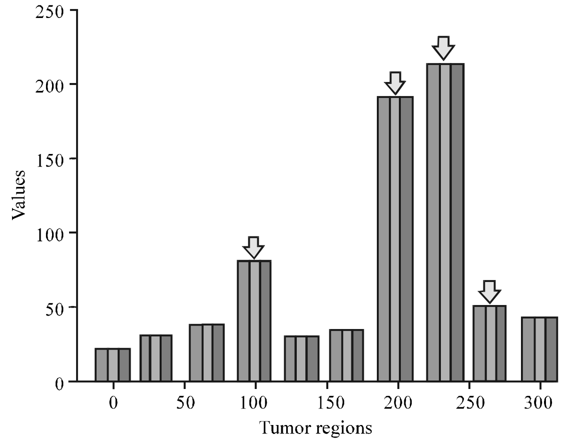

Fig. 7: Histogram for tumor region

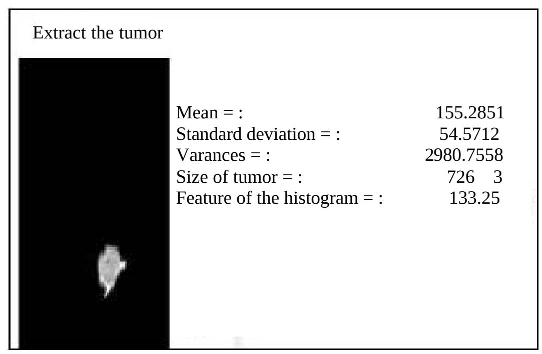

Fig. 8: Tumor region with features

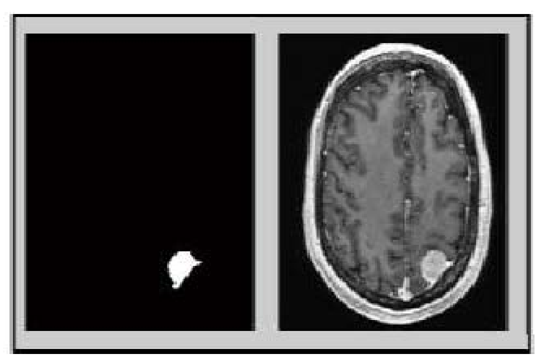

Fig. 9: Manual extraction of the tumor region

The histogram: This is the third feature to extract from the tumor region. It takes the average of the four highest values for the frequencies in the histogram of the ROI. The four highest peaks are more affecting to the tumor than others during the diagnosis process. Figure 7 illustrates the histogram for the tumor region in Fig. 6-9.

Figure 8 illustrates GUI of the proposed system presenting the shape of the extracted tumor region in the human brain together with the extracted geometrical (statistical) features.

Manual segmentation technique: This technique is commonly used in the medical field for its simplicity and ease of implementation. This type of segmentation forces the user to select the interesting part of an image manually. This method is based on visual observation of the required area and the complexity of the shapes for the segmentation process (Banik *et al*., 2009). Figure 9 shows the results of manual extraction of the tumor region. To measure the accuracy of detection of brain tumor a comparison is conducted between the results gained automatically by the proposed system with that gained by manual selection of the region of interest (tumor region).

RESULTS AND DISCUSSION

The proposed system design is implemented by building a program using the MATLAB Software. Tasks are accomplished from within a user-friendly working environment provided by the GUI (Guide) that the system offers. As shown in Fig. 10 the GUI allows users to load the human brain image and then to detect the defected tumor region via. the extracted features mentioned earlier. System's performance is verified by applying the tracking method for the tumor-brain to 350 sample images. The approach succeeds in detecting and extracting the tumor regions for 342 images. Results are then compared to that of calculated by either missing false detecting the tumor part according to in Eq. 5 shown (Fig. 11):

$$E = M+F \tag{5}$$

Where:

E = Overall Error
M = Missed tumor regions
F = False parts detected 7

The percentage of error for this approach is calculated by Eq. 6:

$$\text{Percentage of error} = \frac{E}{T}\times 100 \tag{6}$$

where, T Total number of tested images. The percentage of error recorded for the proposed approach is 2.3%.

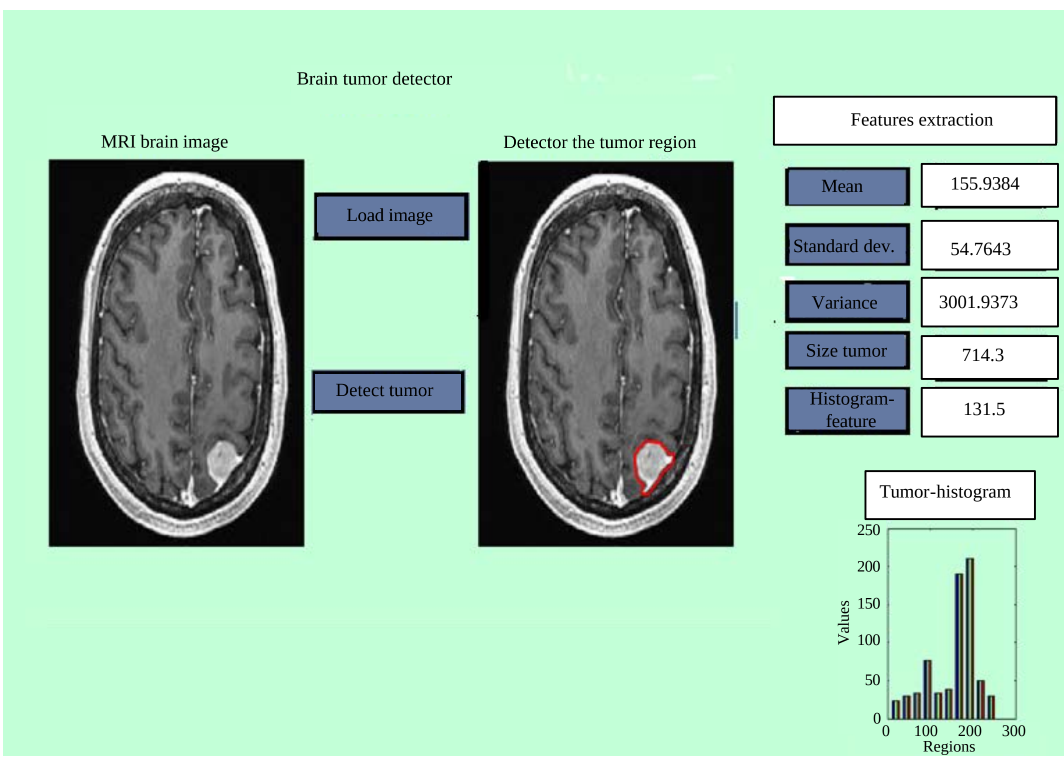

Fig. 10: GUI for proposed system

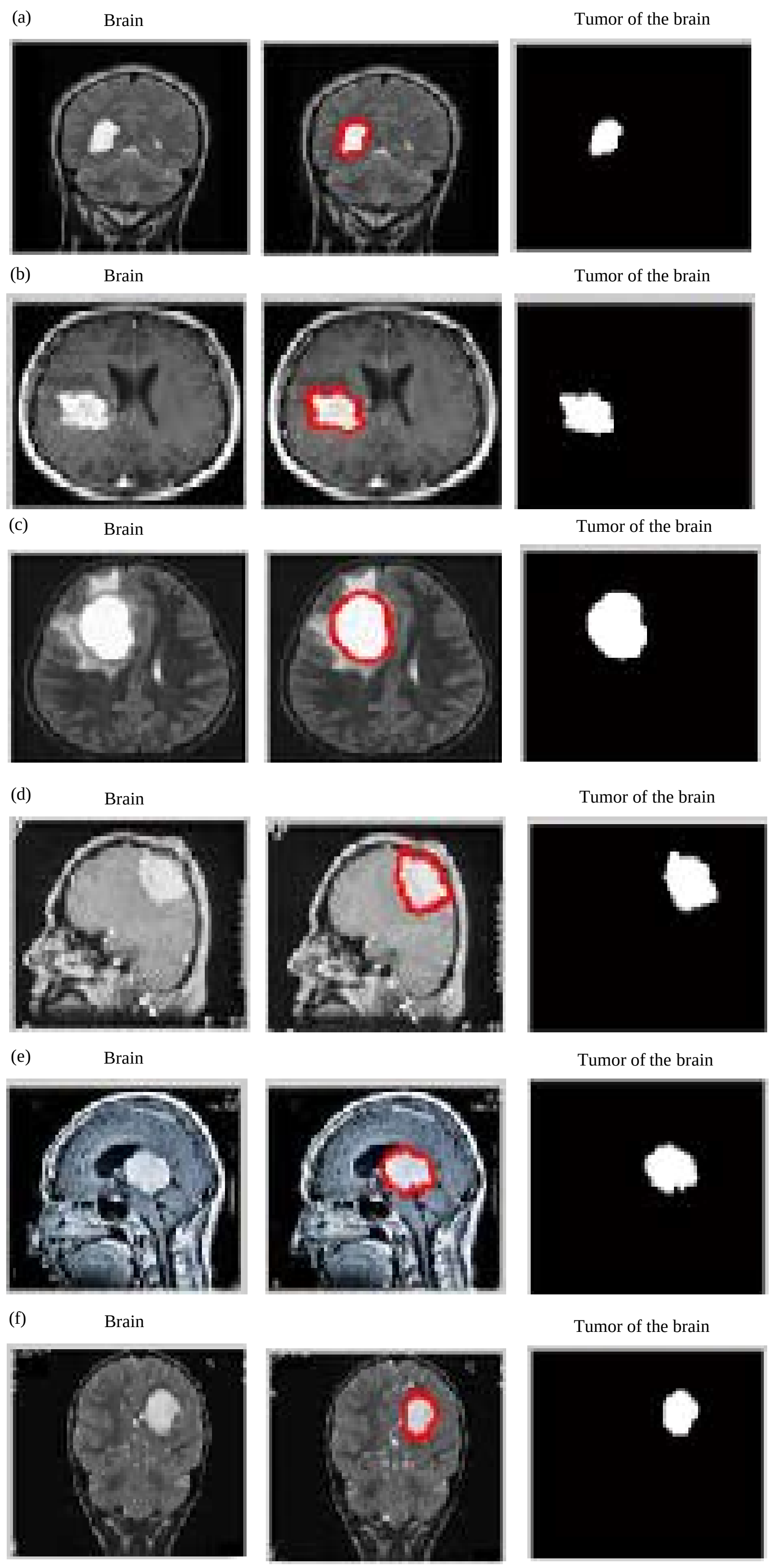

Fig. 11: a-f) Detection of tumor region in human brain

Figure 11 illustrates the accuracy yet, the advantages gained by this approach in detecting the tumor region in the human brain MRI images.

CONCLUSION

This research presented an approach to automatically detect and extract the tumor in human brain image using various medical image-techniques. The processes applied to MRI images. After the image was enhanced using an average-filter (LPF) and converted into a binary image using threshold technique, morphological operations were conducted to segment the image into regions and then to index these regions. Detecting and extracting the tumor region was based on measuring the intensity of each region. Numbers labeled the regions and detection proceeded by considering the region with the greatest intensity of the tumor region. Features of the tumor region were calculated which represent the size, average, standard deviation, variances and the histogram for the tumor region.

RECOMMENDATIONS

Further research involves expanding this approach to make it more comprehensive by creating a database for each patient and then examining the patient's sequences images to obtain a graph that helps in detecting and analyzing the growth in tumor region. Another expansion includes developing the features extraction from the tumor area to assist classification of tumor according to feature's types.

REFERENCES

Al-Khalidi, F., R. Saatchi, H. Elphick and D. Burke, 2015. Tracing the region of interest in thermal human face for respiration monitoring. Intl. J. Comput. Appl., 119: 42-46.

Bahadure, N.B., A.K. Ray and H.P. Thethi, 2017. Image analysis for MRI based brain Tumor detection and feature extraction using biologically inspired BWT and SVM. Intl. J. Biomed. Imaging, 2017: 1-12.

Banik, S., R.M. Rangayyan and G.S. Boag, 2009. Landmarking and Segmentation of 3D CT Images. Morgan & Claypool, San Rafael, California, ISBN:9781598292855, Pages: 170.

Gonzalez, R.C., R.E. Woods and S.L. Eddins, 2004. Digital Image Processing Using MATLAB. Prentice Hall, New Jersey, USA., ISBN-13: 9780982085400, pp: 609.

Isselmou, A.E.K., S. Zhang and G. Xu, 2016. A novel approach for brain tumor detection using MRI images. J. Biomed. Sci. Eng., 9: 44-52.

Jaya, J., K. Thanushkodi and M. Karnan, 2009. Tracking algorithm for de-noising of MR brain images. Int. J. Comput. Sci. Network Secur., 9: 262-267.

Priyanka and S. Balwinder, 2013. An improvement in brain Tumor detection using segmentation and bounding box. Intl. J. Comput. Sci. Mob. Comput., 2: 239-246.

Rajesh, C. and A.S. Bhalchandra, 2015. Brain Tumour extraction from MRI images using MATLAB. Intl. J. Electron. Commun. Soft Comput. Sci. Eng., 2: 38-41.

Ramalakshmi, C. and A.J. Chandran, 2014. Automatic brain Tumor detection in MR images using neural network based classification. Intl. J. Comput. Sci. Network Secur., 14: 1-4.

SivaSankari, S., M. Sindhu, R. Sangeetha and A.R. Shenbaga, 2014. Feature extraction of brain tumor using MRI. Intl. J. Innovative Res. Sci. Eng. Technol., 3: 10281-10286.

Yousuf, M.A. and M.N. Nobi, 2010. A new method to remove noise in magnetic resonance and ultrasound images. J. Sci. Res., 3: 81-89.