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Improved Brain Tumor Detection Technique Using Hybrid Roundness Metric, Region Growing and Cellular Automata Edge Detection

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Abstract: Brain tumor is one of the most life scowling diseases which need urgent and accurate detection. Various automated techniques have been designed to detect the tumor efficiently from MRI imaging. The aim of this paper is to propose a new and improved method for increasing the efficiency of tumor detection. The proposed technique involves the integration of Hybrid Roundness Metric with the existing techniques of segmentation called Modified Texture Based Region Growing and Cellular Automata Edge Detection. Hybrid Roundness Metric detects the circular objects thereby easing the detection of exact location of tumor. The two segmentation techniques perform well in collaboration but when Hybrid Roundness Metric is implemented along with the above two, results achieved are much more effectual. The detection of tumor is made easier and accurate with the proposed work.

Keywords: MRI; hybrid roundness metric; region growing; edge detection; tumor detection improved efficiency, parameters.

I. INTRODUCTION

A tumor is an abnormal growth of cells due to uncontrolled cell division within any region of the body and the brain tumor is that within the brain or central spinal canal. Any kind of brain tumor is serious and lethal due to its interfering and deteriorating nature that too in limited space of intracranial cavity. There are mainly three kinds of tumors namely.

Benign Tumor- is an inactive type of tumor, which does not expand in a crude manner which neither does affect it's surrounding healthy tissues nor it expands to its non-adjoining tissues. Moles are the most common examples of tumors.

Pre-malignant tumor: It is primarily considered as a pre-cancerous stage also called a disease whose improper treatment may lead to cancer.

Malignant tumor: The most serious type of tumor that cultivates with time and conclusively leads to a person's death is malignant tumor. The term malignant itself describes the meaning i.e. a disease that maturates with the progression of time.

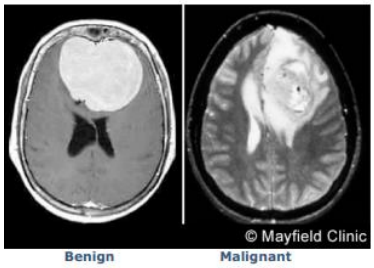

Fig.1: MRI scans of benign and malignant brain tumors

The level of threat produced by tumors depends upon multifarious factors like its location in brain, type of tumor, its size and development stage. The symptoms possibly exhibited by tumors are headache, variations in hearing, speech or vision, problem faced during walking or in balancing, nausea/ vomiting, mood swings, change in ability to concentrate, memory problem, seizures or convulsions, numbness in arms or legs. Medical science has not achieved any success in making out the reasons of brain tumor till date nor has it been able to find out the possible ways to prevent the brain tumors. People most prone to brain tumor are the ones whose body is exposed to high ionization radiations like high X-rays where the cells get damaged to large extent leading to brain tumor. The other class belongs to those who have multiple members down the generation in a family having brain tumor.

It is not sure that person undergoing the above mentioned symptoms is suffering from brain tumor. For proper detection and treatment one must visit a doctor as righteous treatment can only be provided by doctor. Some common tests conducted for tumor diagnosis are-

a. Physical Exam: It involves checking of general health signs by the health expert.
b. CT scan: The patient is given an injection of a certain medicine that helps to show up the brain more clearly in images taken by a computer linked X-ray machine which takes several images of the brain. Tumor can be detected through the same.
c. MRI: An exclusive dye is infused into the body of the patient which helps to differentiate among the tissues of brain, from the pictures taken by the magnet

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associated with a computer that takes elaborate pictures of inside of the body due to which detection of tumor is possible.

d. Angiogram: A dye is interjected into the blood stream that effuses into the blood vessels of brain making them show on X-ray. The presence of tumor is then identified in the X-ray.

e. Biopsy: a tissue is removed in search of tumor cells. This tissue when observed under the microscope shows the abnormal cells. It is capable of showing tissue changes that may result in cancer. The best way to diagnose brain tumor is biopsy.

Brain tumor detection is best performed through image processing techniques with emphasis on segmentation methods. Various brain tumor detection and segmentation techniques have been studied providing insight into their advantages and disadvantages of these methods on brain tumor detection [1], [2], [3]. Computer- based technique has been proposed that firstly classifies brain as healthy or one containing tumor and if tumor is detected, it is classified as benign or malignant [4]. Thresholding operation can also be performed for brain tumor detection [5] which consists of preprocessing, image enhancement followed by segmentation process that is thresholding. Use of symmetry analysis as a fully automatic detection technique involves detection of tumor followed by segmentation and finally area calculation of tumor [6]. A method of edge detection based on Cellular Automata gives better results as compared to other edge detection techniques for cancerous cells in brain by giving exact location and size of tumor [7]. Another edge detection method makes use of canny algorithm that detects the weak edges then labeling these weak edges by different numbers. The histogram segmentation process detects the only weak edge thus detecting the abnormal edge of tumor [8]. Region growing is an efficient image segmentation technique. Region growing requires the determination of threshold for region growing and initial seed collection which can also be considered a drawback [9]. Brain tumors being blunt, faint and non-homogenous structures differ in intensity from the neighbor pixels which can be detected through modified Texture based region growing. This technique can considerably increase the performance as it takes both intensity and texture constraint into account [10]. Attempts were made to detect the tumor by neural network approach which makes use of back propagation for classification [11] and histogram equalization, image adjustment and thresholding operations for detection. Probabilistic Neural Network (PNN) with the use of learning vector quantization (LVQ) along with analysis of image and data accompanied by manipulation techniques has been proposed to classify the tumor from MRI images [12]. Deshmukh et.al. reviewed another method that inputs the features extracted from MRI image to the Artificial Neural Fuzzy Interface system (ANFIS). The overall set of features and fuzzy rules help to segregate irregular images to the respective tumor type [13]. In order to improve the accuracy of detection process, combination processes have been broached. In one such technique, two segmentation processes have been associated that is modified texture based region growing and cellular automata edge detection resulting in the increase in tumor detection probability [14].

The paper is organized in following format such that section 2 shows the proposed technique. Methodology and results are shown in section 3 and 4 respectively. Last section displays the conclusion.

II. METHODOLOGY

The technique proposed in this paper for brain tumor detection is the combination of two segmentation techniques that are modified texture based region growing and cellular automata edge detection followed by Hybrid Roundness Metric.

The process is divided into a series of steps that are briefly defined as follows:

A. Image Acquisition: MRI images of brain are taken in .jpg format.

B. Pre-processing: The input MRI image cannot be taken as such for processing as it contains noise incident form external source, noise due to patients movement during scan, machine generated noise etc. Hence, the MRI image requires enhancement before it can be further processed for segmentation. The pre-processing involves RGB to grey conversion, resizing ending with filtering

C. Segmentation: In the proposed technique two segmentation methods have been applied, first being "modified texture based region growing" and second being "cellular automata edge detection".

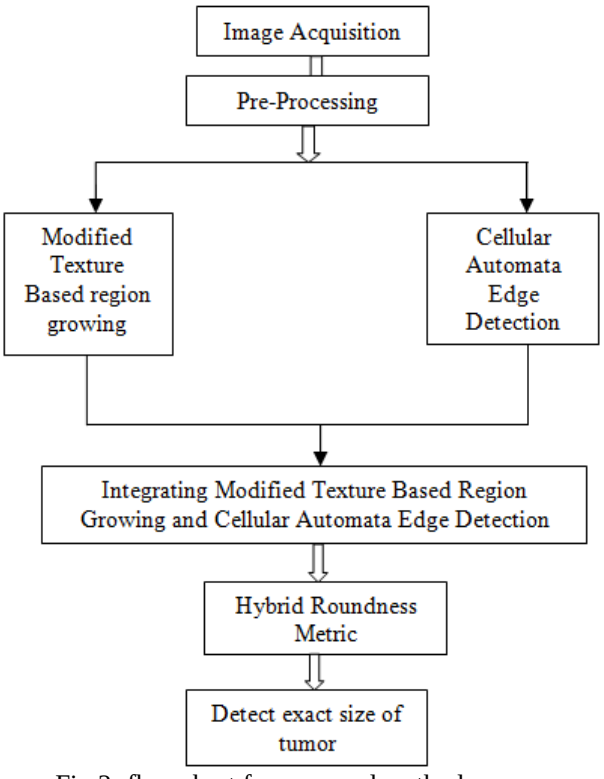

Fig.2**:** flow chart for proposed method

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Modified texture based region growing [10] - Texture based region growing takes texture as well as intensity properties into account in contrast to ordinary region growing methods. Here, threshold value for both texture and intensity are defined. A pixel is grown only if it satisfies two constrains underlain by the method. Two constrains are-

- Textures constrain- The texture threshold should be greater than the difference between texture value of seed pixel and neighboring pixel.
- Intensity constrain- The difference between seed pixel's intensity value and that of neighboring pixel should be less than or equal to intensity threshold value.

Pixels are grown only if both the constrains are satisfied.
Cellular Automata Edge Detection [7]-The basic component of this technique is cell which exists either in 0 or 1 state. All cells are initially in state 0, they change their state to 1 after meeting certain conditions based upon the surrounding cells. Cellular automata detection is based on Moore's law, which states that next stage of a cell relies upon its eight neighbors and the cell itself. It ends up forming 2^{512} rules out of which rule 124 is followed according to which a cell encounters any one of these four conditions that are loneliness, over-population, happiness and reproduction.

- Loneliness- When an alive cell dies ("0") due to shortage of neighbors (<2).
- Overpopulation- When an alive cell dies ("0") due to excess of neighbors (>8).
- Happiness condition- an alive cell continues to live ("1") when number of alive neighbors is 3, 4, 6 or 7.
- Reproduction- renewal of dead cell ('0') into an alive cell ("1") when number of neighbors is exactly 5.

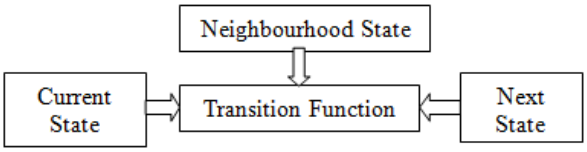

Fig.3: Generalized model of Cellular Automata Edge Detection [7]

The input image if firstly converted into binary format with black cells signifying dead cells and white depicting alive ones. Then, for each pixel, surrounding pixel count is determined leading to application of rule 124. Only the cells having 3, 4, 6 or 7 alive neighbour pixels will survive rest die out. The method results in exact detection of edges.

Hybrid roundness metric- it is a technique used to determine the roundness of an object and detect them accurately, such as in the case of tumors. The process involves taking an input image and thresholding it. The noise in the image needs to be removed before further processing; following which boundaries of various segments of image is found out such as that of tumor in this case.

The process concentrates on only calculating the outer boundaries and not inner contours. The final step of determining as to which objects are round is done by calculating the area and perimeter of each object leading to formation of a metric that indicates roundness of an object.

Metric= $4*pi*area/ perimeter^2$
Metric value is approximately 1 for circular objects and falls drastically for other shapes.

Modified Texture Based Region Growing + Cellular Automata Edge Detection + Hybrid Roundness Metric:

Region growing is a similarity criterion based segmentation technique while edge detection utilizes discontinuity. Texture based region growing takes both texture and intensity limitation into consideration thus exhibiting the greatest advantage of not being affected by the in-homogeneity of the tumor. The efficiency remains the same, except being affected by threshold values. On the other hand, cellular automata edge detection accurately detects the boundaries. The only limitation of this technique is that if the intensity difference between the tumor and normal cells is less, the tumor might not be detected. If detected, the exact size of the tumor shall be demonstrated by this technique. Lastly, hybrid roundness metric locates the tumor among other brain matter and precisely gives the size and location of the tumor in brain. The addition of roundness metric to the above combination not only increases the overall efficiency and precision of detection but also helps doctors in proper diagnosis and treatment. The detected tumor is finally added to the input MRI image for further analysis.

III. EXPERIMENTAL RESULTS

Proposed method is simulated in MATLAB. The results achieved from proposed method consist of pre-processing outputs, output on application of modified texture based region growing and cellular automata edge detection and finally results obtained from application of Hybrid roundness metric. This section also constitutes comparisons made of proposed technique with that of artificial neural networks. Figures 4-7 show the simulation outputs of the proposed method.

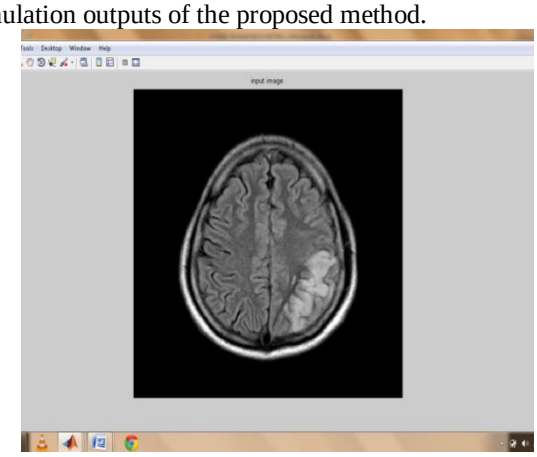
Fig. 4: Input MRI Image with Tumor

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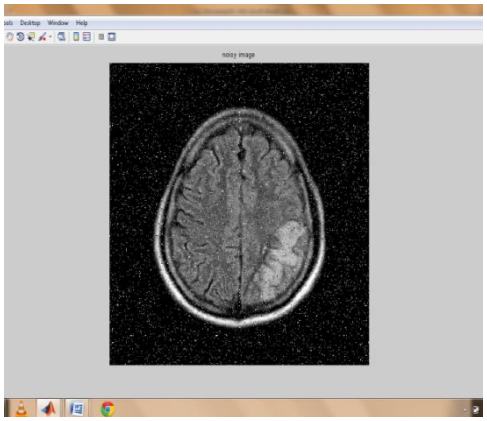

Fig.5: Noisy MRI Image

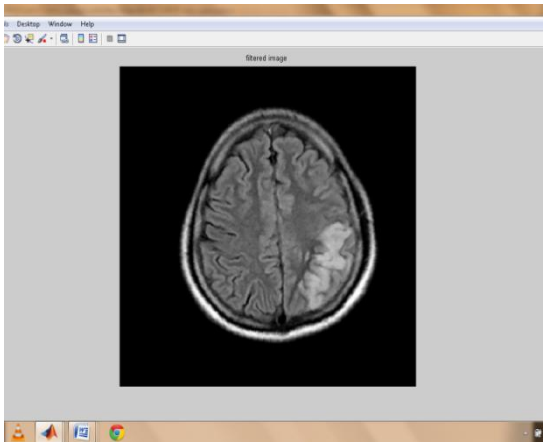

Fig. 6: Filtered Image

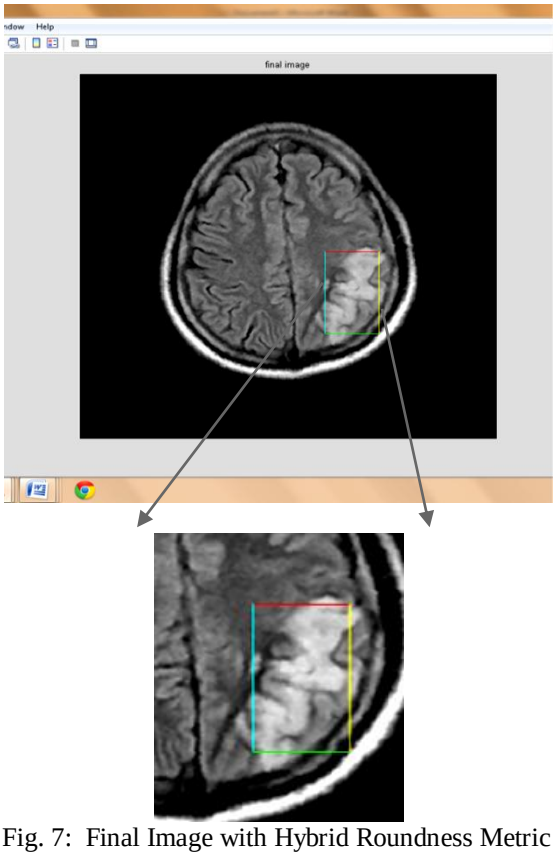

Fig. 7: Final Image with Hybrid Roundness Metric Implemented

Comparison of proposed technique with that of Artificial Neural Network:

Both the methods, that are the proposed method and one using Neural Network, were performed in MATLAB to obtain following results. In figures 8 and 9, results obtained from artificial neural network technique are shown, following which the tables and graphs illustrate the difference between two techniques. The graphs also demonstrate the efficiency and success of proposed technique in comparison to the neural network technique.

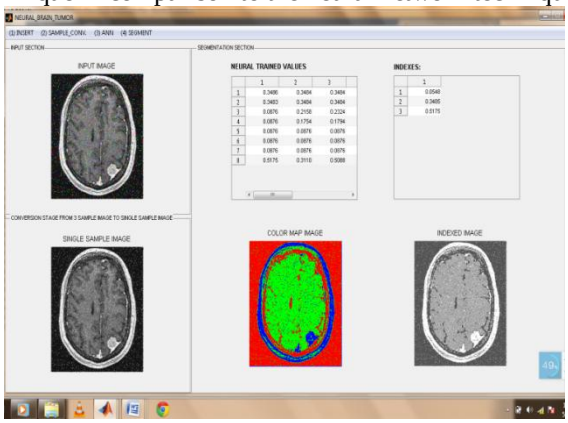

Fig. 8: Pre-Segmentation Operations in Artificial Neural Network Technique

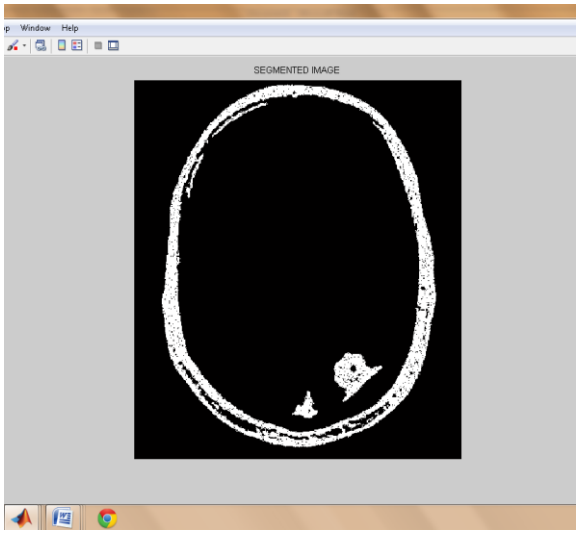

Fig.9: Segmented image

Tables of comparison of various parameters for neural network technique and proposed technique:

TABLE I: RECALL PARAMETER FOR ARTIFICIAL NEURAL NETWORK

Image	Neural	Proposed
1	0.5418	0.9867
2	0.5552	0.9856
3	0.5674	0.9873
4	0.5720	0.9895
5	0.5765	0.9918
6	0.6268	0.9948
7	0.6527	0.9963

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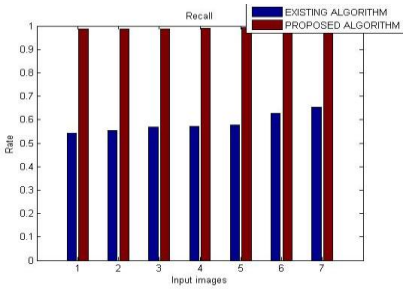

Fig.10: bar graph plotting recall parameter for old technique (ANN) and proposed technique

TABLE III: PSNR PARAMETER FOR ARTIFICIAL NEURAL NETWORK

Image	Neural	Proposed
1	6.8969	33.9759
2	7.1631	33.5273
3	7.4022	34.3360
4	7.5016	36.0686
5	7.5863	38.9069
6	8.7334	43.2798
7	9.3019	47.0368

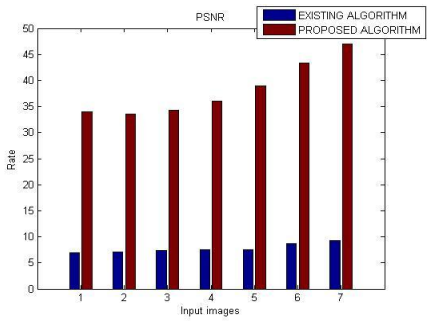

Fig.11: Bar graph plotting PSNR parameter for old techniqu (ANN) and proposed technique

TABLE IIIII: ACCURACY PARAMETER FOR ARTIFICIAL NEURAL NETWORK

Image	Neural	Proposed
1	0.5480	0.9800
2	0.5616	0.9789
3	0.5735	0.9808
4	0.5784	0.9843
5	0.5825	0.9887
6	0.6341	0.9931
7	0.6573	0.9956

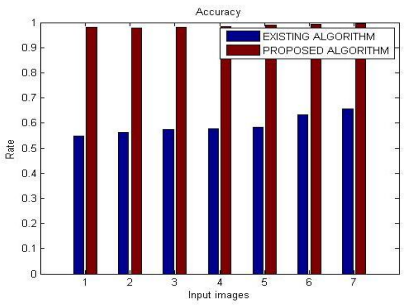

Fig.12: bar graph plotting accuracy parameter for old technique (ANN) and proposed technique

TABLE IVV: BER PARAMETER FOR ARTIFICIAL NEURAL NETWORK

Image	Neural	Proposed
1	22.9111	2.0411
2	22.2524	2.1680
3	21.6575	1.9989
4	21.4142	1.6430
5	21.1881	1.1818
6	18.6613	0.7343
7	17.3657	0.4735

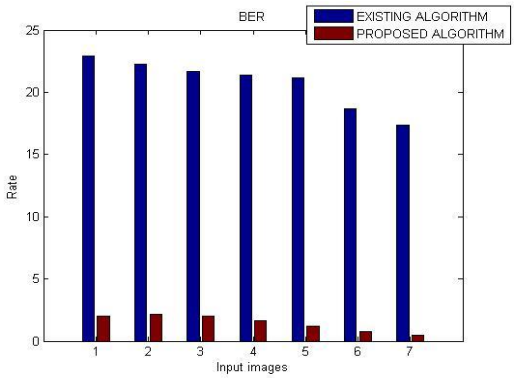

Fig.13: bar graph plotting BER parameter for old technique (ANN) and proposed technique

The tables' I-IV and accompanying graphs clearly show the improved parameter efficiency for the proposed technique in comparison to the old detection method such as artificial neural network based approach.

IV. CONCLUSION

The Brain tumor detection using Hybrid roundness metric in combination with modified texture based region growing and cellular automata edge detection is proposed. The simulated results demonstrate the proposed technique to be an efficient brain tumor detection technique as it provides clear boundary of the tumor present in brain as compared to other segmentation techniques applied alone. The proposed approach shows significant improvement of parameters linked to brain tumor detection process. The proposed technique can be viewed to be applied for tumor detection in other body parts as well.

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BIOGRAPHY

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