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Segmentation of Brain MRI with Tumor by Image Overlapping using Cellular Automata

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***Abstract:** In order to improve the health care reach, we need efficient and fast computer aided simulation processes or algorithms. When some change is found in pathological reports and biomedical quantities, the person is susceptible to diseases. If the diseases are detected earlier then there can be increase in the rate of mortality. Tumor is one such disease which has been seen to be one of the most fatal for human beings. Detecting and removing tumor is big challenge for medical practitioners. Medical image processing can be used through cellular automata has proven to be one of the fast and reliable method for detection of tumor cells. To study the capabilities of medical science CA's are being used extensively, as they are useful in studying the self-reproducing biological systems.*

***Purpose:** This paper presents an algorithm for segmentation of MRI image through cellular automata, using Conway's Game of Life. A new approach is being used in this paper, first the image is converted into gray level image. Then edge detection is done for this image using Game of Life. This edge detected image is overlapped with the gray scale image to get the resulted segmented image as an output.*

***Materials and Methods:** In order to run the proposed algorithm MATLAB2019b is used and the images are obtained.*

***Results:** Algorithm was used on different MRI's and the results were taken.*

***Key Words:** Tumor, Segmentation, Cellular Automata, MRI, Edge, Grid.*

I. INTRODUCTION

A.1: Brain tumor

Unnatural growth of cells in brain gives rise to brain tumor. Tumors are classified in two types (malignant and benign). Benign tumors do not spread to other tissues while as malignant tumor spread to other part of brain and body. Benign tumors either grow slowly or they don't grow at all, they do not spread to other parts of body. This tumor is life threatening, as it can cause brain inflammation or it can effect some nerves in brain and hence brain functioning can be hindered. Malignant tumor either spreads from brain to other parts of body or from other parts of body to brain. This is the most fatal type of tumor.

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Tumors grow abnormally, hence making the categorization of tumors more difficult. Thus we should find an image processing tools which can understand these complex behaviours. Cellular automata are efficient where we start from very simple structure and move on to a complex structure of cells.

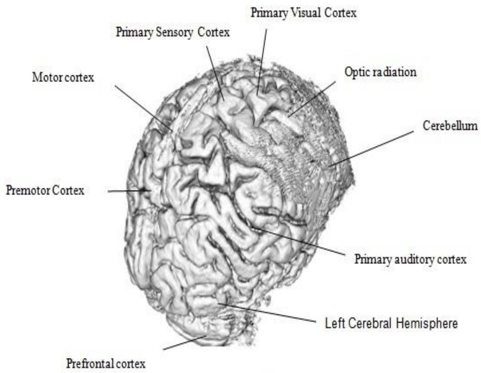


Figure I: Regions of brain

A.2: Brain tumor imaging

Magnetic Resonance imaging (MRI) is the technique, which is used by medical practitioners, for diagnosis of brain tumor. MRI is available in most clinics. In this paper focus will be on MRI based methods of tumor detection. Tissue contrast produced by MRI is of different types and thus making MRI a versatile tool for tumor classification. Appearance of tumor can vary; therefore to segment a tumor one MRI is insufficient for all sub regions of brain. Many MRI sequences are used for this purpose:

a) T1 weighted MRI: Most commonly used MRI sequence. Healthy tissues can be distinguished can be distinguished in T1 weighted MRI due to its structural analysis.

b) Contrast enhancement with T1 weighted MRI: Borders of the tumor appear brighter. The blood flow is disrupted by tumor (known as bloodbrain barrier). Contrast agent used gets accumulated in these regions.

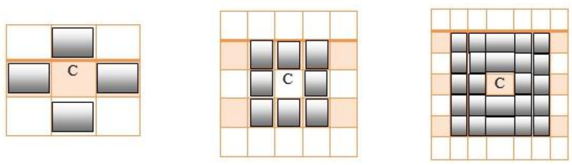
c) T2 weighted MRI: Tumor is surrounded by edema region. In this sequence of MRI this region is bright.

d) T2 weighted MRI through inversion recovery by acquisition parameters: This sequence is taken by free water signal, when this signal is suppressed the regions between (CSF) cerebrospinal uid and edema region is separated.

T1 weighted MRI image, contrast enhancement with T1 weighted MRI image, T2 weighted MRI image, T2 weighted MRI through inversion recovery by acquisition parameters image are all obtained from Stefan Bauer et.al.[1].

A.3: Cellular Automata

Cellular automat was developed by Von Neumann. Celular automata is a mathematical model, which is being extensively used to study natural systems.Space and time are discrete in a CA. Cellular automata is fast and reliable due its property of localization. Each cell has its own value but in next iteration the cell value depends on its previous value and the value of its neighbors, based on rules of CA as disscussed by *Wolfram* in 1986. One dimensional CA's are the simplest, in terms of localization , rule application and decentralization.Rules applied can determine whether the cell remains black(0) or white(1).The value of a cell (other than the first and last cell) in the next time span is dependent on its previous value and the value of its two neigbors. Majorly used CA's are the two dimensional. Two dimensional CA is represented by a grid(array) of cells , where each of its cells can have one state among different number of states.The next value (state) of a cell at a discrete time step is determined by the current value of the cell, current value of its neighboring cells and the rule for the next state. Neighborhood of a cell can mainly be differentiated as Von-Neumann, Moore and Extended Moore Neighborhood. In this paper, the algorithm is written for Moore neighborhood, however it can be easily applied to extended Moore neighborhood. Figure II shows the types of neighborhood mainly used in square tesselation.



(a) (b) (c)

Figure II: (a) Von Neumann Neighborhood (b) Moore Neighborhood (c) Extended Moore Neighborhood

A.4: Image segmenation

In image segmentation, a given image is partitioned into several smaller segments(Pham et al -2000). These segments are then chosen according to their shape and place where they are presented. In a brain tumor MRI segmentation will show the segments which contain tumor cells as different fragments(segments). The medical practioner can diagnose tumor through MRI . But image, segmentation provides a detailed segments in an MRI, which can help to find the accurate places of tumor. Segmentation can be used in detecting the growth of tumor cells as well as reduction in tumor cells(during therapy). It plays a vital role in planning of surgery and radiotherapy. Segmentation done maually is time consuming and is prone to error, where as the segmenation done through compute aided processes can help a great deal. The algorithm proposed is beneficial in segmentation of images, will take less time and has greater efficiency.

II. PROPOSED WORK

In this paper Edge detection and segmentation is done on MRI brain through Cellular automata using Conway's Game of Life. A cell can be either *Alive* or *Dead* based on its previous state and the state of its neighbors. A cell can die if it is *overcrowded* (all cells in the neighborhood are alive) or, it is *alone* (no cell in the neighborhood is alive). This MRI brain with tumor is converted into gray level image.

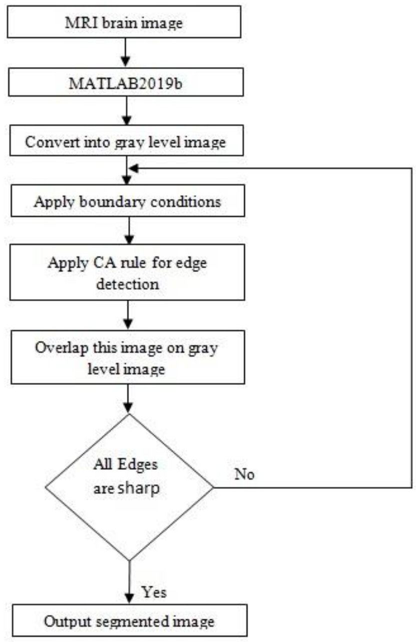


Figure III: Flowchart of the proposed algorithm.

The boundary conditions are included so there is no error at the edges of the image. The image where the edges are detected is overlapped on the original image. Thus giving rise to a very definite segmented image. If the edge detection algorithm has left any edge in the original image we can easily detect it. Or getting the next MRI of same patient and overlapping the edge detected image will help us detect how much has the tumor expanded.

In the proposed algorithm, each cell in a CA has definite state at initial time stamp which changes with time. Change in a state of a cell is governed by:

Previous state of a cell

Previous state of its neighboring cells (in this case 8 surrounding cells)

CA Transition rules

Here, 'S' denotes state of a cell,'t' represents current time stamp, 'i' row and 'j' column of the cell. The Cellular Automata transition rules applied here are according to the Game of Life rules. These rules are:

$$\text{Sum} = \sum((S_{i-1,j-1})^{t-1},(S_{i,j-1})^{t-1},(S_{i+1,j-1})^{t-1},(S_{i-1,j})^{t-1},(S_{i+1,j})^{t-1},(S_{i-1,j+1})^{t-1},(S_{i,j+1})^{t-1},(S_{i+1,j+1})^{t-1})$$

$$(S_{i,j})^t=1 \text{ if } \begin{cases} 1)\ (S_{i,j})^{t-1}=1 \ \&\&\ 4>\text{Sum}\geq 1 \\ 2)\ (S_{i,j})^{t-1}=0 \ \&\&\ \text{Sum}=3 \end{cases}$$

$$(S_{i,j})^t=0 \text{ if } \begin{cases} 1)\ (S_{i,j})^{t-1}=1 \ \&\&\ 4<\text{Sum}<1 \\ 2)\ (S_{i,j})^{t-1}=0 \ \&\&\ \text{Sum}\neq 3 \end{cases}$$

The problem arises for the cells which are at the boundary of the grids, as they lack all the neighbors necessary for transition rules.

In order to avoid this problem, the boundaries are added on each side of the group, called as *periodic boundary conditions*. The cells which are added are given zero values at the beginning.

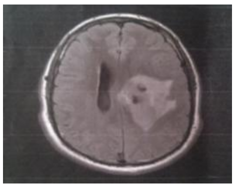
Algorithm

The proposed algorithm deals with the MRI image and uses CA rules discussed to get the desired results.

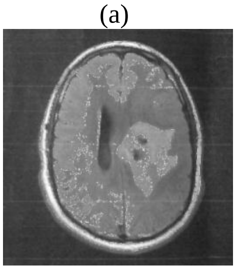
1. Input an MRI image with tumor cells. It will be taken as an *input image*.
2. Convert *input image* into *grayscale* image (thus we will get only two colors).
3. Add Boundary conditions (2rows and 2columns at the boundary of the grid, each with initial value 0)
4. Initialize the state of each cell of a grid.
5. Based on the initial value of each cell, detect the edge of the image using already discussed CA rule.
6. Repeat step 5 for each cell in the grid
7. Overlap the edge detected image on the gray scale image.
8. Get segmented image as an end result.

III. EXPERIMENTAL RESULTS

This algorithm was run in MATLAB R2019b over MRI brain.

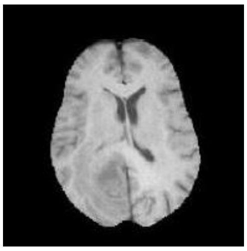



(a) (b)

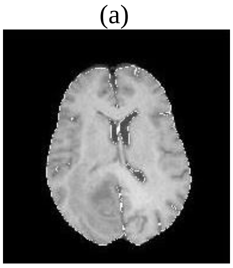


(c)

Figure IV: (a) Original image (b) Edge detected image (c) Image after segmentation

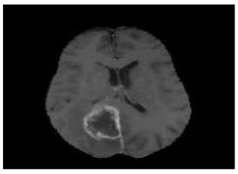



(a) (b)

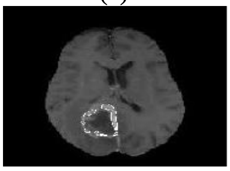


(c)

Figure V: Experimental results on T1 weighted MRI.

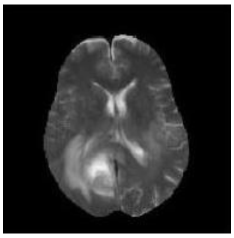
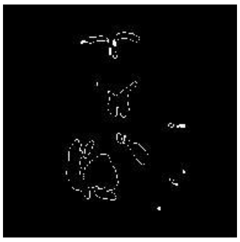



(a) (b)

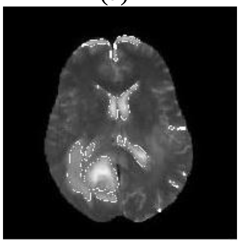


(c)

Figure VI: Experimental results on T1 weighted image with contrast enhancement

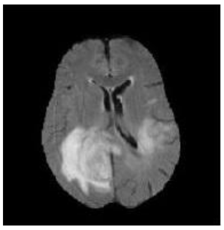



(a) (b)

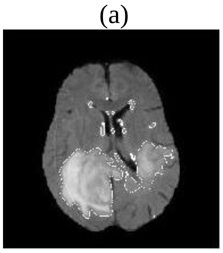


(c)

Figure VII: Experimental results on T2 weighted images




(a) (b)



(c)

Figure VIII: Experimental results on T2 weighted images through inversion recovery by acquisition parameters

IV. RELATED WORK

Maintz and Viergever-1998, has given image registration technique, where two different images are aligned in one space. Klein et al.-2005, has compared many non-linear algorithms for image registration (brain). Over past two decades many algorithms were presented in image processing through Cellular automata. Cellular automat has proven to be very efficient tool in image processing and Artificial intelligence. In Cellular automata, the major work has been done in edge detection and segmentation of images. Some of the related works were done by Chen et al.-2008, Davis L.S.[5], Vihet et al.-1998., Canny, Zhang Ke et al.[4], Sharifi M.et al.[6].

V. CONCLUSION

In the field of computer science, cellular automata in combination with artificial intelligence and image processing are becoming very readily used. Cellular automata is very easy to use, even for the most complex problem due to its localization property and then carrying out the process based on transition rules. In this paper Cellular automaton is used for edge detection in an image and then the image is overlapped to obtain the segmented image. A new method is presented for image segmentation. The proposed algorithm works on a gray sale image. The algorithm is used on various levels of MRI's, and the output images are obtained fast and quality of edges is good.

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