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Edge Detection in Grayscale Image of Brain MRI with Tumor Cells using Game of Life

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Abstract: ***This paper proposes new algorithm for edge detection in a grayscale image of brain MRI with tumor cells through cellular automata. Edge detection makes detection of tumor cells easier. Applying cellular automata for edge detection makes it very efficient because of its local nature. In Cellular automata filters are used locally to each cell and then it evolves into a more complex form. Due to this property of Cellular Automata it is being widely used in medical image processing. Algorithm presented in this paper is completed with the help of MATLAB2019b. Results from the proposed algorithm are compared with Sobel edge detector (to detect edges it uses simple calculations, but is sensitive to noise).***

Keyword: Cellular Automata, Brain tumor, MRI, image processing, edge detection, MATLAB, Game of Life.

I. INTRODUCTION

Computers have played a very big role in detection of tumor cells, as it is very fast and highly efficient and accurate. Our study is concerned about the edge detection in brain MRI (Magnetic Resonance Imaging) containing tumor cells. MRI is used because results are better than X-Ray images. For benign tumor (where tumor cells remain static) the detection is easy as compared to malignant tumor (where tumor cells keeps on increasing). Edge detection is very efficient in case of malignant tumor where we can find strong changes in the pixels of an image. For identifying the mode and analyzing an image edge detection has proved to be a major method. Many edge detection techniques have been proposed till now. In this paper edge detection is done using the Game of Life rule through cellular automata. The images which are generated by MRI are further enhanced with the help of image processing using Cellular automata. In the field of cryptography, medical imaging, simulation, language recognition, computer architecture etc cellular automata is being efficiently used. Algorithm proposed in this paper is more efficient, as we do not need to convert the grayscale image into binary image. This algorithm directly works on grayscale image.

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I. EDGE DETECTION

It is a basic process in image processing and is most commonly used, as it helps in finding and identifying sharp discontinuities in an image. The abrupt changes are usually seen in the pixels which are at the boundary of an image. Edge detection identifies these pixels in an image.

In medical imaging edge detection is commonly used to locate cell walls. It can also be used in detecting edges of an aircraft and can be used in character recognition.

II. CELLULAR AUTOMATA

For the dynamic complex systems(physical systems) having discreet time and space, Cellular Automata was introduced. Cellular Automata consists of a wide area(grid) which is usually divided into cells. Each cell is locally connected with other cells in the grid and can have any finite value. A cell value can change its value in discreet time steps, based on its previous value and the value of its neighboring cells, according to certain
transition rules. A Cellular Automata is a 4-tuple(d,V,N,f), where:
'd' is dimension of Cellular space(it can take values from 1 to 3)
'V' is set of states of CA
'N' is set of neighborhood type
'f'is the transition function(f: Qv↔Q)
Two-dimensional CA can have neighbors based on various models like Von Neuman neighborhood, Moore neighborhood, extended Moore neighborhood. They are all shown in figure I below:

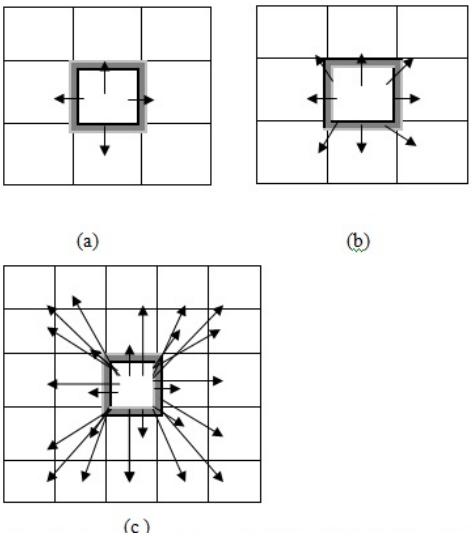


Figure I: a) Von Neuman Neighborhood b)Moore Neighborhood c)Extended Moore Neighborhood

III. PROPOSED METHOD

The proposed algorithm will use edge detection method through Conway's Game of Life rule of CA. The gray scale image is not further converted into binary image, it is as such used for image segmentation.

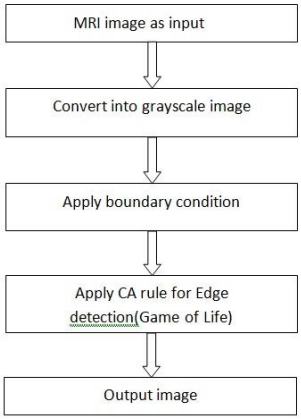


Figure II: Block diagram of the proposed method

In Conway's Game of Life, a cell can be either *Alive* or *Dead* based on the state of its neighbors. A cell can die if it is *alone* (no neighboring cell is alive) or it is *overcrowded* (all neighboring cells are alive). This rule will be used while detecting the edge of the MRI image. This MRI image is first converted into gray scale image and then the boundary conditions are included, so that the output edges are sharp. The block diagram of this method is shown in Figure II.

The CA rules are applied to Moore neighborhood grid and can easily be used for extended Moore neighborhood too. 'S' is the state of the cell, 't' represents the current time stamp, 'i' represents row and 'j' column of the cell in a grid. The Cellular Automata transition rules applied in the proposed algorithm are:

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

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

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

a)Algorithm

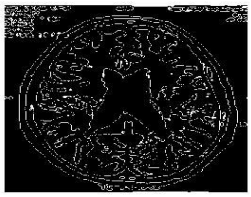
The algorithm is written for any number of neighborhoods. The CA rules discussed above can be changed accordingly.

1. Input an MRI image with tumor cells.
2. Convert it into gray scale image.
3. Add Boundary conditions (we add 2 rows and 2 columns at the boundary of the image and initialize them with value 0)
4. Each cell has its initial state(for initial values grayscale image is used).
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. End

b) Experimental Results

This algorithm was run in MATLAB R2019b over MRI brain.

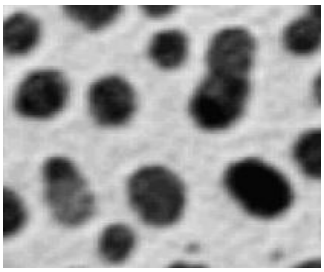
(a)



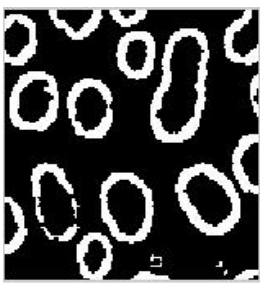
(b)

Figure III: (a) Original image (b) Output of proposed image

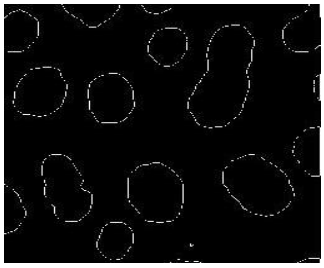
We also checked this algorithm for other image in order to see the difference between sharpness of edges in the given algorithm and Sobel edge detector. The sharpness of the edges in the proposed algorithm is better than Sobel edge detector.



(a)



(b)



(c)

Figure IV: (a) Original image (b) Sobel edge detector image (c) Output of proposed algorithm

IV. RELATED WORK

In Cellular Automat several algorithms have been developed over past two decades. Image processing through cellular automat has been very efficiently used. Edge detection being the basic and important part in most algorithms has got a lot of attention. Some papers, where image processing through cellular automata is discussed are Chen et al.,2008, Viher et al.,1998.Davis, L. S. [5] has used Gaussian preconvolution for edge detection and noise education.
Canny. Sharifi, M. et al. [6] has introduced another algorithm for edge detection. ZHANG Ke et al.[4] have Combined cellular automata and cloud model, and gave new algorithm for edge detection based on CCA.

V. CONCLUSION

In the field of computer science, cellular automata in combination with artificial intelligence and image processing are becoming very readily used. Cellular automat is very easy to use, even for the most complex problem due to its own localization and then carrying out the process based on transition rules. In this paper Cellular automaton is used for edge detection in an image. It can be used further for image segmentation.

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