ANALYSIS OF BRAIN TUMOR THROUGH CELLULAR AUTOMATON BASED SIMULATION

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ABSTRACT- Advancement of technologies is proving to be boon for researchers. Researchers can perform the experiments with the help of simulation by using the simulation techniques. This is based on the cellular automaton. Cellular automaton is grid of cells acquiring the discrete values. For analyzing the internal mechanism of brain tumor growth and describing the brain structure phenomenon, simulation models are very helpful. By simulating the tumor growth, we can help in the diagnosis of brain tumor diseases and therefore in the precautions and cures. After this phase of experiments, we can validate our results with the actual brain tumor images results. Here we have formulated new approach to characterize brain tumor using fractal dimensions.

Keywords: Brain tumor, Cellular automation, brain structure.

1. INTRODUCTION

In the recent past an important area is the Brain Mapping Research (1), (2), (3), (4), (5) - that seem to have attracted some best scientists of different areas in Neurobiology, Psychology, Radiology, Physics, Computer Science and Mathematics. The idea is to have brain scans that will reveal our thoughts, moods, behaviors and memories including abnormalities if any as clearly as an X-Ray reveals our bones, Multimodal Neuro-imaging such as CT, MRI, IMRI, PET, SPECT etc. plays an important role in that process (6), (7), (8), (9), (10), (11). Lahiri et al (12), (13), (14) have shown the need of extensive data mining to extract efficient feature for diagnosing various patho-structural condition of heart and brain. Also, effective use of multiple features through the design of multiple classifiers has been shown by Lahiri et al (15) to enhance the pattern-recognition efficiency against a biometrics problem.

Bio medical imaging is broad and important area of research. After lot of research in the medical field, there is always a scope of advancement. Day by day new diseases are generating. New drugs are being designed for the treatment of diseases. This process is continuously happening. Even though the we are not in state to say that this disease can be cured or controlled. This area of biomedical imaging is really a focused and very important area for the researchers. Performing experiments directly on human body or brain is not possible because the law and regulations do not allow performing experiments on human body or brain directly. To perform the experiments, we have to select some living animals, which are having similar body phenomenon like humans. The use of modelling and simulation has been expanding for last few years. Simulation techniques reduce the time and cost for conducting the real time applications. It is the manipulation of a model in time and space so that it becomes possible to study those interactions which were separated in time and space. A model is a simplified representation of a system in a particular time and space which gives information about the real system. The more detailed the model, the more detailed the output. The type of model which one should employ is determined by the type of output required. As tumors grow at different rate and follow different pattern of growth so because of this biological diversity it becomes difficult to characterize them. If a tumor is benign then it can be removed surgically however a malignant tumor spreads through-out the body. Tumor growth is a very complex process and it becomes difficult to characterize them by using classical Euclidian geometry. However recent studies have shown that pathological architecture of tumors can be described by using fractals.

A cellular automaton is data storage model in which there are number of cells acquiring discrete values in each cell. Each cell has a set of cells called neighborhood cells which lie at a particular grid distance from the cell. First of all a seed cell is selected for each simulation. Then next generation is created by following certain rules and selecting cells from neighbourhood of seed cell. Sometimes a particular state is assigned to each cell for example whether a particular cell is on or off. With cellular automaton it is possible to analyze the spatio-temporal dynamics at cellular level.

A model is a simplified representation of a system in a particular time and space which gives information about real system and thus promotes understanding. Simulation is the manipulation of a model in time and space so that it
becomes possible to study interactions which were separated in time and space.

Observing the formation, growth and regression of tumors under various Patho physiological conditions has great clinicopathological importance due to its predictability for gradation, drug choice and as a whole - diagnostics. A successful diagnostic methodology combining these aspects could be made using brain image as the starting sample material. In the area of brain imaging technologies, due to complexity of brain structure, it is difficult to perform each type of analysis deterministically. We expect to deliver a brain image processing based diagnostic which will be useful for better therapeutics. The Objective of research will explore the following:

a) Analyze growth and regression analysis of tumor and other abnormalities from their 3 dimensional segmented images to extract growth and decay rule,
b) Develop simulation model to cross verification of the growth or decay mechanism,
c) Correlate these models with various pathophysiological conditions of disease formation.

2. TUMOR DIAGNOSIS

Different types of imaging techniques are used to scan whole body or a particular tissue. Most commonly used techniques to diagnose brain tumors are CT scan, MRI technique, PET scan or PET/CT scan. Different Scans are preferred as compared with x-rays. Tumors behind the bone can not be interpreted by normal x-rays. CT or CAT and the Magnetic Resonance Imager (MRI) are the different imaging technologies used for brain imaging. Positron Emission Tomography (PET) is also available, but it tends to be used more for research than for routine diagnosis.

2.1 Computer Tomography (CT)

The word tomography has been derived from greek words tomo which means slices and graphein means to write. It is a medical imaging method which combines X-ray equipment with computer to produce 2-D images. These 2-D images taken along single axis of rotation are then used to generate 3-D image of body. Before scan patient is given a contrast dye intravenously to increase the visibility. These are generally gadolinium or iodine dyes. X-ray tube and detector which are located opposite to each other rotate around the patient. Detectors detect the amount of radiation being absorbed by different parts of the body. Amount of X-ray absorbed depends on type of tissue through which they pass. A computer programme produces 2-D image from this data. These 2-D images are then reassembled by computer to produce 3-D image.

2.2 Magnetic Resonance imaging (MRI)

Magnetic resonance imaging (MRI) uses magnetic resonance properties of nuclear particles (hydrogen) and depending on interaction of hydrogen particles. It generates images of body with the help of magnetic field and radio waves. As water constitutes around 70% body weight so hydrogen is present in large amount in human body. When a patient is placed under magnetic field different tissues magnetizes to lesser extent as compared to water as tissues contain less hydrogen concentration. Due to magnetization protons align themselves in the direction of magnetic field. After the protons have been aligned a radiofrequency electromagnetic field is the applied [16]. RF alters the direction of aligned proton. When RF is applied protons absorb some energy and when RF is turned off protons release some energy at radio frequency and returns to their ground state. This released energy constitutes signals which are detected by scanner. Thus in MRI the spatial distribution of protons is mapped in the 2 or 3 dimensional image. MRI can detect oedema and is specially used in case of neurological tissue examination and soft tissue diagnosis. MRI imaging does not involve any ionising radiation and so it is safe but it is very noisy. Due to magnetic field patients with implanted pacemaker and surgical clips are prevented from having MRI. Mining brain tumors and tracking their growth pattern in the course MRI imaging is a very crucial task that assists a surgeon to describe the appropriate treatment. [17]

2.3 PET scan

Positron emission tomography (PET) is a type of imaging technique [18]. In PET scan, it uses small amount of radioactive material to trace or diagnose cancerous growth and abnormal cellular activity. In case of PET scan the radiotracer is generally fluorodeoxyglucose (FDG) which is a sugar. As Cancerous cells are more active so they metabolize sugar at higher rate as compared to normal cells. As a result the radiotracer accumulates in cancer cells at higher concentration as compared to normal cells. Radiotracer releases gamma rays which can be detected by positron
emission tomography (PET). PET/CT combines two different techniques in a single procedure. While PET shows abnormal cell activity, CT scan shows the location of cells imagined in PET scan [19].

3. ALGORITHMIC BACKGROUND

Brain tumors can be analyzed with the help of cellular automaton based simulation: In this method, the growth of brain tumors are analyzed in the sense that how its growth is taking place. Growth pattern of tumors are very important for its treatment and analysis. Depending on the growth pattern of tumors, further operations can be performed. Therefore the growth pattern process is very important part of our algorithm. It is well known tales that “Prevention is better than cure”. Our method will prove to be an achievement to meet out the above mentioned goal. As mentioned above in part I, there are different diagnostic techniques available for tumor growth diagnosis. But all the techniques give result of diagnosis, after clear growth of tumor in the body. At that stage of growth of tumors, cure of the disease becomes tougher than the growth in earlier stage of growth. Our technique offers the diagnosis method to trace the growth pattern of tumors in the starting stages. Thereby the treatment of the tumors may be insured 100 percent in the most of the cases of brain tumors. Growth of tumors starts from a single infected cell. Then next neighboring cell is infected and in the same way others. Growth processes (model of tumor growth) comprise a class of mathematical models that allow computer simulation of a variety of dynamic processes [20, 21] that govern the shape and growth of natural objects. As the tumors grow in the body. We will try to simulate the same way. Therefore the growth of tumors can be described and analyzed in the same way. Analyzing the brain tumors through cellular automaton based simulation will be performed with the following algorithm.

<table>
<thead>
<tr>
<th>Brain tumor Analysis Algorithm:</th>
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<tbody>
<tr>
<td>1: Extract the features of simulated images.</td>
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<tr>
<td>2: Extract the features of real experimental images downloaded or taken from medical centre.</td>
</tr>
<tr>
<td>3: Features of both the images are matched.</td>
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<tr>
<td>4: Find out the most matching features giving the efficient results.</td>
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<tr>
<td>5: Results of the previous steps can be analyzed for diagnosis of the tumor.</td>
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Now we discuss the above steps in details step wise. Our main objective is to diagnose the brain tumor images. This diagnosis is performed by utilizing the different medical imaging techniques such as MRI, CT, PET etc. but the above diagnosis techniques produce the better results only when the tumors in the desired objects are clearly grown or visible. Diagnosis of brain tumor at this level of visibility or grown status is not going to help patient or clinician for the treatment of the disease because the treatment of the tumors require early diagnosis. For this above mentioned purpose, we require the growth pattern of the brain tumors. This can be done with the help of cellular automaton based simulation. In this model, we apply the eden growth model for simulation purpose. In this growth model, we start from the seed point and find out the neighbors of the seed point. The neighbors can be taken in many ways, it can be 4 connected neighbors or 8 connected neighbors. Simply we use four connected neighbors for the tracing the neighbors of seed point. This neighbors can be selected by generating the random numbers and selecting the one of them, whose probability is maximum. Then by adding the element with seed point. Now this is the grown cluster. After the grown clusters, the features are extracted. Since the grown cluster is irregular in shape, therefore the fractal dimension is the best feature for describing the properties of clusters. Therefore the fractal dimension values are calculated from the simulated images and the fractal dimension values are also calculated from the real experimental data. Those two fractal dimension values are matched with each other. Depending on the matched values of fractal dimension, we can interpret about the brain tumors and its diagnosis.

4. IMPLEMENTATION

In this work we have applied the proposed simulation techniques to grow brain tumor. As we know not much reference is available directly on the topic. We can divide our work in the following phases. First we will simulate the image and then calculate the fractal dimension values. In the same way we have to calculate the fractal dimension values of real
images on the basis of fractal values we can say that either the both results are matching or not. Following graph is showing the fractal dimension values for the first data.

![Fractal image of data 1](image)

**Figure 1: Fractal image of data 1**

The following graph is showing the fractal dimension values for the second simulated data i.e. data2

![Fractal image of data 2](image)

**Figure 2: Fractal image of data 2**

The purpose of this work to provide the help in the diagnosis of brain tumors. This work gives us an initial guess of what actually is the growth mechanism of the brain tumors inside the human body.

**Acquisition**: The Brain tumor image databases were acquired from a website named cancerimagingarchive.net. We collected images of different brain tumors and studied their different structures.

**Segmentation**: Because the whole brain tumor is not our region of interest, so we perform segmentation for further processing.

After the above processing the growth of tumor images are taken and their features are calculated and matched with features calculated from the simulated images. And final results interpretations are done.

5. **RESULT AND DISCUSSION**

Our proposed methods are applied for the growth of brain tumor simulation. The growth of simulated images is performed and then the important features of the grown images are calculated. We have performed the simulation for many clusters and two of them are shown in figure1 and figure2.

Fractal dimension values of the two simulated images are shown. In the next step, we applied feature extraction techniques on real segmented images. The fractal dimension values are calculated. These two values are matched with
each other and brain tumor analysis and diagnosis are validated.

Figure 3: Matching of feature values

This technique has been adopted from the work of Lahiri et. al. (1998) with proper modification of simulation attributes of row (i.e. Eden iteration) and column (i.e. DLA iteration) of the tables.

6. CONCLUSION

Our proposed technique for analysis and diagnosis of brain tumor is implemented and giving the desired result. The multi-feature brain image analysis of brain tumors is performed. It can be helpful to the clinicians and individuals for the diagnosis of brain tumors. The simulated images are grown for the description of growth of brain tumors and the features are extracted from the simulated images. In the next step, the real brain tumor images downloaded or taken from medical centres are selected for segmentation. Now the features are calculated from the segmented real images. Now after matching the features of the both the images i.e. Simulated images and real images. We can say that which image belongs to brain tumors. In this way, it can be very helpful to clinicians and individuals in the analysis and diagnosis of brain tumors. Further improvements in classification accuracy can be expected with more careful experimentation. Proposed idea can be further extended to other tumor like disease.

7. REFERENCES


[19] “PET/CT scan”, Information for Patients, University of Pittsburgh Medical Center.


[21] James W. Baish and Rakesh K. Jain, 2000 Fractals and Cancer,