Brain Tumors: An Engineering Perspective

Jobin Christ M.C. [1], Dr. Parvathi R.M.S. [2]

[1] Department of Biomedical Engineering, Adhiyamaan College of Engineering
MGR Nagar, Hosur, Tamilnadu – 635109, India

[2] Principal, Sengunthar College of Engineering
Tiruchengode, Tamilnadu, India

Abstract

With the rapid growth in technical evolution, medical field is growing like anything. For making good sound we need cooperation from both hands. In this manner, now a day's medical and engineering technology, both are joined together and developing new innovations in medical field. These innovations are enlightening the life of human by providing proper treatment. Medical field reached a tremendous place in diagnosing tumors after the discovery of CT and MRI. And still researchers are finding new things in the area of medical imaging. Recent bioengineering researchers involved in medical image segmentation algorithms to speed up the physician's diagnostic process. In this paper we are describing the various types of brain tumor and their diagnostic methods in an engineering perspective.

Keywords: Brain tumor, Medical Imaging, MRI, Segmentation.

1. Introduction

Brain tumor, a notorious disease, has affected and distraught many lives. These brain tumors have been the centre of attention of thousands of researchers for many decades, in and around the world. Technologists and physicians have combined their knowledge and efforts from many areas ranging from medical to mathematical sciences, to better understanding of the brain tumors and to find more effective diagnosing methods as well as treatments. Yet, there is far more to be done before brain tumor can become a curable disease. Life-threatening brain tumors begin from a single cell that has undergone a chromosomal or genetic mutation that affected its protein balance, increasing its capacity for mitotic division or decreasing the suppression mechanism for cell division. As the malignant cell loses its normal function, it starts to abnormally divide much faster than the surrounding normal tissues. A small mass of malignant cells results from that single dividing cell, and starts to attack adjacent normal tissue, and to threaten the affected brain. In this paper we describe the various types of brain tumor, their diagnostic methods, symptoms and their treatments in an engineering perspective.

2.Symptoms of Brain Tumor

The symptoms of brain tumors depend on various factors like size of the tumor, type of the tumor, and location of the tumor. Symptoms may be originated when a tumor pushes on a nerve or damages a certain area of the brain. They also may be caused when the brain bulges or fluid builds up within the skull. Symptoms caused by a brain tumor often mimic the symptoms of other diseases also [1]. The most common symptoms include:

- Headaches are a common initial symptom. Typical "brain tumor headaches" are often described as worse in the morning, with improvement gradually during the day.
- Seizures are a common symptom of a brain tumor. Seizures are caused by a distraction in the normal flow of electricity in the brain.
- Nausea is an uneasiness of the stomach that often precedes vomiting. Nausea and vomiting are not diseases, but they are one of the symptoms of brain tumor.
- Mental and/or Personality Changes can range from problems with memory, especially short-term memory, speech, communication and/or concentration changes to severe intellectual problems and confusion.
- Focal symptoms like hearing problems such as ringing or buzzing sounds or hearing loss, decreased muscle control, lack of coordination, decreased sensation, weakness or paralysis, difficulty with walking or speech, balance problems, or double vision.

3.Diagnosing Brain Tumors by Imaging Techniques

A scan is a photograph of the internal structures in the brain. A specific machine takes a scan in much the same way a digital camera takes a snap. Using computer technology, a scan compiles an image of the brain by photographing it from various angles. Some types of scans use a contrast agent or contrast dye (or a ferromagnetic substance such as gadolinium). This is injected into a vein and flows into brain tissue. Abnormal or diseased brain tissue absorbs more dye than normal, healthy tissue. The contrast agent allows the doctor to see the difference between normal and abnormal brain tissue [2].

The most commonly used scan for detecting brain tumors is magnetic resonance imaging (MRI). Magnetic resonance imaging (MRI) is the gold standard for diagnosing a brain tumor. It does not use radiation and provides pictures from various angles that can enable doctors to construct a three dimensional image of the tumor. It gives a clear picture of tumors near bones, smaller tumors, brainstem tumors, and low-grade tumors. MRI is also useful during surgery to show tumor bulk, for accurately mapping the brain and for detecting response to therapy. There are several types of MRI scans. These techniques assist doctors before and during surgery in various ways. 1) Magnetic Resonance Angiography (MRA) generates an image of blood vessels and blood flow without the use of a contrast agent. It is less invasive than an arteriogram, a traditional blood-vessel exam that requires injecting a contrast agent. MRA is used to find the presence and position of the blood vessels leading to the tumor and determine whether or not these vessels have been displaced due to the tumor mass. 2) Contrast-Enhanced MRA (CE-MRA) is a form of MRA that uses contrast agents to look at the movement of blood through the region of interest. 3) Flow Sensitive MRI (FS MRI) shows the flow of CSF through the ventricles and spinal cord. It is used when examining tumors in the spinal cord and at the base of the skull. 4) Functional MRI (fMRI) provides instant images of brain activity by tracking the use of oxygen in the brain as it occurs. 5) Magnetic Resonance Spectroscopy (MRS) is a type of MRI that measures the levels of metabolites in the body. An MRS can detect patterns of activity that may help diagnose the type of tumor and evaluate tumor response to therapies. 6) Perfusion MRI uses contrast agents to examine the flow of blood into the tissues. In some institutions, perfusion MRI is used to grade certain types of tumors. 7) Diffusion MRI measures the diffusion (random motion) of water in the tissues. Since the diffusion of water along the nerve can be measured with this technique, it can be used in surgical planning to avoid injuring nerve bundles (ganglia) that have been shifted or displaced.

Computed tomography (CT) uses a sophisticated x-ray machine and a computer to create a detailed picture of the body's tissues and structures. It is not as sensitive as an MRI in detecting small tumors, brain stem tumors, and low-grade tumors. It is useful in certain situations, however. Often, doctors will inject the patient with a contrast material to make it easier to see abnormal tissues. A CT scan helps locate the tumor and can sometimes help determine its type. It can also help detect swelling, bleeding, and associated conditions. In addition, computed tomography is used to check the effectiveness of treatments and watch for tumor recurrence.

Numerous other advanced imaging techniques may be used for specific purposes. Single photon emission tomography (SPECT) is similar to PET but is not as effective in distinguishing tumor cells from destroyed tissue after treatments. It is also used after CT or MRI to help distinguish between low-grade and high-grade tumors. Magneto encephalography (MEG) scans measure the magnetic fields created by nerve cells as they produce electrical currents. It is used to evaluate functioning in various parts of the brain. However, this procedure is not widely available [3].

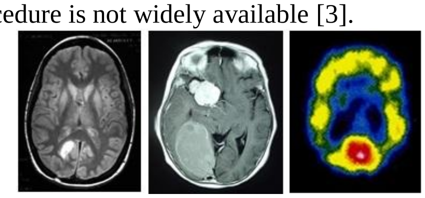

Figure 1. Sample Brain Tumor Images taken using MRI, CT, SPECT

4.Causes of Brain Tumor

There are many possible risk factors that could play a role.

- Exposure to radiation at work or to power lines, as well as head injuries, smoking.
- Some inherited conditions increase the risk of brain tumors, including neurofibromatosis, Von Hippel-Lindau syndrome, Li-Fraumeni syndrome, and Turcot syndrome.
- Lymphomas that begin in the brain in people with a weakened immune system are sometimes linked to the Epstein-Barr virus.
- The risk of using cell phones is hotly debated. However, most recent studies have found that cell phones, cordless phones, and wireless devices are safe and do not increase the risk [4].

5.Classification Of Tumors

There are over 120 different types of brain tumors. In most cases, a brain tumor is named for the cell type of origin. Brain tumors are generally classified depending on the following factors like, the location of the tumor, the type of tissue involved, Whether they are noncancerous (benign) or cancerous (malignant) and some other factors. All brain tumors are under any one of the category of primary or secondary brain tumors. A primary tumor means that the tumor is made up of cells that are found in the brain. If the tumor is secondary, that means that it has metastasized or spread from some other organ of the body. Metastasized cancer is difficult to treat. Primary brain tumors are classified into two groups: glial tumors, which are called gliomas, and non-glial tumors. A brain tumor that develops from glial cells is called a glioma. About one third of all primary brain and other nervous system tumors form from glial cells. Gliomas tend to grow in the cerebral hemispheres, but may also occur in the brain stem, optic nerves, spinal cord, and cerebellum. Non-glial tumors are like Acoustic Neuroma, Chordoma, CNS Lymphoma, Craniopharyngioma, Hemangioblastoma, Medulloblastoma, Meningioma, etc. These types of tumors develop on or in structures within the brain, such as nerves, blood vessels, and glands. Metastatic brain tumors are often referred to as lesions. Metastatic brain tumors are the most common brain tumors. The primary cancer is usually in the lung, breast, colon, kidney, or skin (melanoma), but can originate in any part of the body. Most are located in the cerebrum, but can also develop in the cerebellum or brain stem [5].

6.Treatment of Brain Tumor

Treatment of brain cancer is usually complex. Most treatment plans involve several consulting doctors.

- The team of doctors includes neurosurgeons (specialists in the brain and nervous system), oncologists, radiation oncologists (doctors who practice radiation therapy), and, of course, your primary health care provider. Your team may also include a dietitian, a social worker, a physical therapist, and, possibly, other specialists.
- The treatment protocols vary widely according to the location of the tumor, its size and type, your age, and any additional medical problems that you may have.
- The most widely used treatments are surgery, radiation therapy, and chemotherapy. In most cases, more than one of these is used [6].

7.Role of Engineers in Brain Tumor Diagnosis

Years ago, most people assumed that a diagnosis of a “brain tumor” was the worst possible news that one could hear. The field of neuroimaging brought us new and improved methods for visualizing the anatomy and physical characteristics of brain tumors. CT and MRI imaging of the brain revolutionized the diagnosis and treatment of brain tumors in the 1970’s and 1980’s. Engineering research in medical imaging speed up the physician’s work in diagnosing brain tumor. Image processing allows the physician to see what they wish to see, allow the physician to measure things they want to measure and allow the physician to see beyond the limitations of the human vision system. A lot of clinical processes involve the quantification of observations made in images. For example, the physician wants to know the volume of a tumor they see. In MRI data in the regions around malignant tumors the distribution of recorded values are clearly skewed. Is it possible then, that the invisible diffuse boundary of the tumor may be detected by looking for changes in the skewness of the distribution of the data along rays as we move away from the visible tumor? The answer is "maybe". Such boundaries have been detected, but detailed clinical studies are required to establish whether they correspond to boundaries that are physically related to the actual tumor [7]. Image segmentation is one of the most widely used applications of Image Processing which helps the physician to diagnose boundary of the tumor. Lot of engineers are effectively involved in writing segmentation algorithms for MRI brain images. Image segmentation is an essential but critical component in low level vision image analysis, pattern recognition, and in robotic systems. It is one of the most difficult and challenging tasks in image processing which determines the quality of the final result of the image analysis. Three main regions of brain, white matter (WM), gray matter (GM) and cerebrospinal fluid (CSF) are the important subject of study in brain diagnostic system Image segmentation algorithms are classified into two types, supervised and unsupervised. Unsupervised algorithms are fully automatic and partition the regions in feature space with high density. The different unsupervised algorithms are Feature-Space Based Techniques, Clustering (K-means algorithm, C-means algorithm, E-means algorithm), Histogram thresholding, Image-Domain or Region Based Techniques (Split-and-merge techniques, Region growing techniques, Neural-network based techniques, Edge Detection Technique), Fuzzy Techniques, etc. It is essential to know which method is to be applicable for the segmentation of medical images [8]. In this paper we present few brain tumor segmentation algorithms.

7.1 Brain tumor detection using segmentation based on Hierarchical Self Organizing Map (HSOM)

In this method, a clustering based approach using a Self Organizing Map (SOM) algorithm is developed. This method consists of two phases. In the first phase, the MRI brain image is acquired from patient database. In that film artifact and noise are removed. In the second phase (MR) image segmentation is to accurately identify the principal tissue structures in these image volumes. A new unsupervised MR image segmentation method based on fuzzy C-Means clustering algorithm also applied [9]. The following figure shows the output of this algorithm.

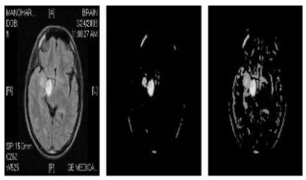

Figure 2. Results of HSOM based segmentation of brain tumor

7.2 Segmentation Brain Tumors using Alignment-Based Features

This paper presented a fully automatic method to segment brain tumors and edema. This method quantitatively evaluates the performance of 4 different types of Alignment-Based (AB) features encoding spatial anatomic information for use in supervised pixel classification. This method used a soft-margin Support Vector Machine (SVM) trained using the SVM light optimization strategy [10].

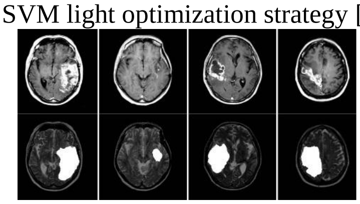

Figure 3. Results of segmentation using alignment based features

7.3 Segmentation Brain Tumors using Modified gradient magnitude region growing technique (MGMRGT)

In this method proper threshold is chosen in order to distinguish the interior area from other organs in the MR image dataset. Then modified gradient magnitude region growing algorithm is applied, in which gradient magnitude is computed by Sobel operator and employed as the definition of homogeneity criterion. This implementation allowed stable boundary detection when the gradient suffers from intersection variations and gaps. By analyzing the gradient magnitude, the sufficient contrast present on the boundary region that increases the accuracy of segmentation. To calculate the size of segmented tumor the relabeled method based on remaps the labels associated with object in a segmented image such that the label numbers are consecutive with no gaps between the label numbers used. Any object can be extracted from the relabeled output using a binary threshold. Here, the algorithm is adjusted to extract and relabeled the tumor and then find its size in pixels. The algorithm works well in two stages. The first stage is to determine the input image labels and the number of pixels in each label. The second stage is to determine the output requested region to get total number of pixels accessed. Segmented areas are automatically calculated to get desired tumor area per slice [11].

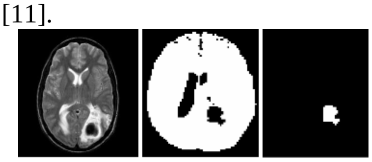

Figure 4. (a) Original image, (b) segmented mage, (c) extracted tumor after MGMRGT and ROI

8.Conclusion

In this paper we presented various types of brain tumor and their diagnostic methods in an engineering perspective. From this paper we concluded that medical field and engineering field both are like rail tracks. If both tracks are in parallel, then only the human train will travel a smooth journey. So physicians can give their expectations to the engineers and engineers can give the solution to the physician's problems. This may lead the development of new diagnosing and treatment procedures and will nullify the death rate due to brain tumor.

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M.C.Jobin Christ received Bachelor degree from Manonmaniam Sundaranar University, Tirunelveli and Master Degree from Anna University, Chennai. Currently he is pursuing PhD in Anna University, Coimbatore in the area of Image Processing. His research interest includes Digital Image Processing, Digital Signal Processing and Artificial Neural Networks. Currently he is working as an Assistant Professor in the department of Biomedical Engineering at Adhiyamaan College of Engineering, Hosur. He is having total teaching experience of 7 years. He is a life member of BMESI.

Dr. R.M.S Parvathi has studied B.E. (ECE) and M.E.(CSE) from Govt. College of Technology, Coimbatore, and obtained Ph.D. in Computer Science & Engineering from Bharathiar University Coimbatore.Dr. R.M.S. Parvathi is having total teaching experience of 22 years both in UG & PG Engineering. Also having 11 year Industrial, R & D Experience. Dr. R.M.S. Parvathi has published nearly 56 technical papers in both national and International conference. Dr.R.M.S. Parvathi has also published 64 technical papers in National & International journals.