CHAPTER 1

INTRODUCTION

1.1 PROLOGUE

Tumor is the foremost reason of death in economically developed countries and the second most important reason of death in developing countries. Tumor recognized medically as a malignant neoplasm, is an extensive group of a mixture of diseases, all concerning unregulated cell growth. In cancer, cells break up and breed widely, forming malignant tumors, and raid nearby parts of the body. The cancer may also expand to more distant parts of the body through the lymphatic system or bloodstream. Not all tumors are cancerous. Benign tumors do not produce uncontrollably, do not attack neighboring tissues, and do not spread throughout the body.

Tumor can be detected in a number of ways, including the presence of certain signs and symptoms, screening tests, or medical imaging. Once a possible Tumor is detected, then it is diagnosed by microscopic examination of a tissue sample. Tumor is usually treated with chemotherapy, radiation therapy and surgery. The chances of surviving the disease vary greatly by the type and location of the Tumor and the extent of disease at the start of treatment.

While Tumor can affect people of all ages, and a few types of Tumor are more common in children, the risk of developing Tumor generally increases with age. In 2008, Tumor caused about 13% of all human deaths worldwide (7.9 million). Rates are rising as more people live to an old
age and as mass lifestyle changes occur in the developing world (Jemal et al 2011). More than 70% of all cancer deaths occurred in low- and middle-income countries. Deaths from cancer worldwide are projected to continue rising, with an estimated 11.5 million deaths in 2030.

Brain tumor is one of the foremost reasons for the rise in mortality among children and adults. A tumor is a mass of tissue that propagates out of control of the normal forces that regulate growth. Brain tumors occur when one type of cell changes from its normal characteristics and grows and multiplies in an abnormal way.

MRI is used to detect the presence and absence of tumors. MRI produce much greater variation between the various soft tissues of the body than computed tomography (CT) does, making it peculiarly useful in neurological (brain), oncological, musculoskeletal, cardiovascular and (cancer) imaging. It’s not like a CT scan. It benefits no ionizing radiation, but uses a powerful magnetic field to adjust the nuclear magnetization of (usually) hydrogen atoms in water in the body.

1.1.1 Human Brain

The brain is a permanent place for patterns to enter and maintain among each other. It is the origin of all human behavior, thoughts, feelings and understanding. It also integrates and controls relating to balance and autonomic functions in the body. The brain produces many hormones and regulates its processing, awareness, attention and integration related to emotion. It is supported and protected by the surrounding skin, bones of the skull and the meanings. It also holds watery fluid called cerebrospinal fluid. This fluid flows through spaces between the meanings and within the brain spaces called ventricles. The skull is another special protector of brain. It is a
highly complicated structure and has compact and elastic types of bones. It provides the structure of the face and protects the brain. The brain is shaped of three major parts: the forebrain, midbrain and Hindbrain. The forebrain is shape up of cerebrum, thalamus and hypothalamus. The biggest part of the brain is the cerebrum. The cerebrum makes up 85% of the brain’s weight. The cerebrum is the thinking part of the brain and it controls and maintain human voluntary muscles. The midbrain has tectum and tegmentum.

The hindbrain is forming of cerebellum, pons and medulla. Brain is the supervisor for the displacement, dream, hunger, thirst and essentially every other vital activity necessary to survive. It controls main five functions are receiving or taking the information by the senses, storing and recalling the information, Analyzing and thinking about the information, Force the Controlling, Process the functions simultaneously or one by one and assigning all internal and external functions of the body. This brain encloses amazing number of neurons for computational process in particular unit. These neurons are attached within the brain and those makes direct connections to other neurons.

The brain is a soft, delicate, non-replaceable and spongy mass of tissue. It is a stable place for patterns to enter and stabilize among each other. It is the source of all human behavior, thoughts, feelings and experience. The brain produces many hormones and regulates its processing, recognition, cognition and integration related to emotion. It is supported and protected by the surrounding skin, bones of the skull and the meninges. It also contains watery fluid called cerebro-spinal fluid. This fluid flows through spaces between the meninges and within the brain (Charles et al 2005).
1.1.2 Brain Tumor

The abnormal growth of cells within the brain or inside the skull, which can be cancerous or non-cancerous. The tumor is a type of cancer. Cancer begins in cells, the building blocks that make up tissues. Tissues make up the organs of the body. Normally, cells grow and divide to form new cells as the body needs them. When cells grow old, they die, and new cells take their place. Sometimes this orderly process goes wrong. New cells form when the body does not need them, and old cells do not die when they should (Louis et al 2007).
These extra cells can form a mass of tissue called a growth or tumor. Many tumor or cancer types can spread to the brain, the most common being lung cancer, breast cancer, melanoma, kidney cancer, bladder cancer, certain sarcomas, testicular and germ cell tumors, and a number of others. Some types of cancers only spread to the brain infrequently, such as colon cancer, or very rarely, such as prostate cancer. Brain tumors can directly destroy brain cells, or they may indirectly damage cells by producing inflammation, compressing other parts of the brain as the tumor grows, inducing brain swelling, and causing increased pressure within the skull.

Brain tumors are a dissimilar group of central nervous system neoplasm’s that arise within or adjacent to the brain. Some are curable by surgical resection, but many cannot be wipe out by current treatments, and, when they are, disabling neurological injury often occur. Brain tumor is one of the major elements for the increase in Mortality among children and adults. A tumor is a mass of tissue that grows out of control of the normal forces that regulate growth. (Selvanayaki et al 2010). The terrible brain tumors can be distributed into two generic categories depending on the tumors root, their growth pattern and malignancy. Primary brain tumors are tumors that begin from cells in the brain or from the covering of the brain. A secondary or metastatic brain tumor arises when cancer cells spreading to the brain from a primary cancer in parts inside of the body. The speculative brain tumors may be of any size, may have a array of shapes, may appear at any location and may appear in different image intensities (Marcel et al 2004).
1.1.3 Categories of Brain Tumor

1.1.3.1 Primary brain tumor

A Primary malignant brain tumor is one that originates in the brain itself. Although primary brain tumors often shed cancerous cells to other sites in the central nervous system (the brain or spine), they rarely spread to other parts of the body. Primary brain tumors are named due to the cell types, from which they are originated.

1.1.3.2 Secondary brain tumor

A secondary (metastatic) brain tumor occurs when cancer cells spread to the brain from a primary cancer in another part of the body. Secondary tumors are about three times more common than primary tumors of the brain. Secondary or metastatic brain tumors take their origin from tumor cells which spread to the brain from another location in the body.

1.1.3.3 Benign tumor

A tumor (solid neoplasm) that has self-limiting growth does not conquer other tissues or metastasis. A benign tumor does not contain cancer cells and usually, once removed, does not recur. Most benign brain tumors have clear borders, meaning they do not invade surrounding tissues. These tumors can, however, cause symptoms similar to cancerous tumors because of their size and location in the brain (Francis Ali-Osman 2005).

1.1.3.4 Malignant tumor

Malignant brain tumors contain cancer cells. Malignant brain tumors are usually fast growing and conquer surrounding tissues. It very hardly spread to other areas of the body, but may recur after treatment.
Sometimes, brain tumors that are not cancer are called malignant because of their size and location, and the damage they can do with the vital functions of the brain.

### 1.1.4 Types of Brain Tumor

The distribution of brain tumor histology is shown in the Table 1.1. The most frequently reported histology is the predominately non–malignant meningioma, which accounts for 35% of all tumors, followed by glioblastoma (16%). The predominately non-malignant pituitary and nerve sheath tumors account for 13% and 8% of all tumors, respectively. The least affected brain tumor categories are medulloblastoma, craniopharyngioma and germ cell tumor each with 1%. This data is based on the Central Brain Tumor Registry (CBTR) of the United States during the year 2012.

<table>
<thead>
<tr>
<th>Types of Tumor</th>
<th>Affected Rate (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meningioma</td>
<td>35</td>
</tr>
<tr>
<td>Glioblastoma</td>
<td>16</td>
</tr>
<tr>
<td>Pituitary Tumor</td>
<td>13</td>
</tr>
<tr>
<td>Nerve Sheath</td>
<td>8</td>
</tr>
<tr>
<td>Astrocytomas</td>
<td>7</td>
</tr>
<tr>
<td>Others</td>
<td>7</td>
</tr>
<tr>
<td>Neuroepithelial tumor</td>
<td>5</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>2</td>
</tr>
<tr>
<td>Oligodendroglioma</td>
<td>2</td>
</tr>
<tr>
<td>Ependymomas</td>
<td>2</td>
</tr>
<tr>
<td>Medulloblastoma</td>
<td>1</td>
</tr>
<tr>
<td>Craniopharyngioma</td>
<td>1</td>
</tr>
<tr>
<td>Germ Cell Tumor</td>
<td>1</td>
</tr>
</tbody>
</table>
The above table is graphically represented in Figure 1.2 that clearly shows the various types of primary brain tumor and their affected rate in the humans.

![Primary Brain Tumor Types and the Affected Rates (in %)](image)

**Figure 1.2 Types of primary brain tumor and the affected rates**

### 1.1.5 Brain Tumor Statistics

According to American Brain Tumor Association (ABTA), brain tumors are the:

- Second leading cause of cancer-related deaths in children under age 20.
- Fifth leading cause of cancer-related deaths in females ages 20-39.

An estimated 69,720 new cases of primary brain tumors are expected to be diagnosed in 2013 which includes 4,300 children younger than age 20 will be diagnosed with primary brain tumors, of which 3,050 will be under age 15. For every 100,000 people in the United States, approximately 221 are living following the diagnosis of a brain tumor. This represents a prevalence rate of 221.8 per 100,000 persons.

In 2010, 9,156 new brain, other Central Nervous System (CNS) and intracranial tumor cases were registered in UK 4,541 (50%) in men and 4,615 (50%) in women. The crude incidence rate shows that there are 14.8 new brain, other CNS and intracranial tumor cases for every 100,000 males in the UK and 14.6 for every 100,000 females.

According to GLOBOCAN, during the year 2015 the estimated number of new Brain cancer cases will be 25,313 (15,116 males and 10,197 females) out of which 21,071 (12,843 males and 8228 females) brain cancer deaths are expected.

1.1.6 **Brain Tumor Symptoms**

According to the research conducted by the Musella foundation for brain tumor research and information on various patients and identified the following major symptoms of brain tumor.
Table 1.2 Brain tumor symptoms and the percentage of patients

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Percentage of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headaches</td>
<td>46%</td>
</tr>
<tr>
<td>Seizures</td>
<td>33%</td>
</tr>
<tr>
<td>Nausea and Vomiting</td>
<td>22%</td>
</tr>
<tr>
<td>Vision or hearing problems</td>
<td>25%</td>
</tr>
<tr>
<td>Problems with weakness of the arms, legs or face muscles</td>
<td>25%</td>
</tr>
<tr>
<td>Strange sensations in head</td>
<td>16%</td>
</tr>
<tr>
<td>Strange sensations in hands</td>
<td>9%</td>
</tr>
</tbody>
</table>

In addition to the symptoms mentioned in the Table 1.2, many of the people participated in the survey reported behavioral and cognitive changes, such as: problems with recent memory, inability to concentrate or finding the right words, acting out - no patience or tolerance, and loss of inhibitions - saying or doing things that are not appropriate for the situation. Brain tumor symptoms vary from patient to patient, and most of these symptoms can also be found in people who do not have brain tumors.

1.1.7 Stages of Brain Tumor

Tumor names depend on where the tumor originated, its pattern of growth, and whether it is cancerous or not. Grading is a way of predicting how bad a tumor is. Generally, higher grade tumors look less like the specialized cells. Such cells are described as anaplastic, so tumors that are described as anaplastic are often higher grade than those that are not.
1.1.8 Magnetic Resonance Image

Currently most of the medical imaging studies and detection are conducted by means of MRI, Positron Emission Tomography (PET) and Computed Tomography (CT) scan. An MRI scan is a radiology method that uses magnetism, radio waves, and a computer to produce images of human body structures. The MRI scanner is a tube surrounded by a massive circular magnet. The patient who needs the scanning is placed on a moveable bed which can pass through the magnet. The magnet creates a strong magnetic field that aligns the protons of hydrogen atoms, which are then exposed to a beam of radio waves. This spins the various protons of the body, and they produce a faint signal that is detected by the receiver portion of the MRI scanner. The receiver information is processed by a computer, and an image is
produced. The image and resolution produced by MRI is quite detailed and can detect tiny changes of structures within the body. A contrast agent like gadolinium can be used to increase the accuracy of the images (Joseph 2013).

An MRI scan can be used as an extremely accurate method of disease detection throughout the body. In the head, trauma to the brain can be seen as bleeding or swelling. Other abnormalities often found include brain aneurysms, stroke, tumors of the brain, as well as tumors or inflammation of the spine. MRI scanners can produce 1500 images per second. Intraoperative MR imaging can acquire high contrast images of soft tissue anatomy. It can also be acquired individually in as little as half a second per image.

1.1.8.1 Advantages of MRI

The advantages of MRI are; MRI does not use ionizing radiation, and is thus preferred over CT in children and patients requiring multiple imaging examinations. MRI is the modality of choice for evaluating brain morphology because it provides a superior soft-tissue contrast with flexible data acquisition protocols that highlight several different properties of the tissue. MR image illustrates anatomy in greater detail, and is more sensitive and specific is abnormalities within the brain itself. MRI scanning can be performed in any imaging plane without having to physically move the patient. Often, surgery can be deferred or more accurately directed after knowing the results of an MRI scan.

MRI contrast agents have a considerably smaller risk of causing a deadly allergic reaction. MRI allows the evaluation of structures that may be covered with artifacts from bone in CT images. It provides greater detail when looking at soft tissue, show the differences between various types of tissue, show swelling and inflammation, show the condition of blood vessels and blood flow, and show both three-dimensional and cross-section images of
the body. MRI is completely painless, but rather noisy. An MRI scan can be used to find the stage of tumors and also produce images of almost any part of the body from all angles (Christopher 2013).

1.1.8.2 Drawbacks of MRI

The drawbacks are that they are very noisy and they can be affected by movement. So, they are not used so often for some mouth tumors. High static magnetic fields may induce nausea, vomiting, dizziness and headaches in humans.

1.1.9 Computer-aided Diagnosis System

A Computer Aided Diagnosis (CAD) system is developed for automatic detection of brain tumor through MRI. The CAD system can provide a better mechanism to identify the brain tumors than the conventional methods. The system consists of two stages. The first stage has brain image acquisition, preprocessing and enhancement. Second, stage consists of segmentation, feature extraction, classification, and performance analysis. Preprocessing and enhancement techniques are used to improve the detection of the suspicious regions in MRI. The preprocessing and enhancement methods remove film artifacts and high frequency components from the MR image. Segmentation describes the separation of the suspicious region from the background MR image using various optimization techniques. Textural features are extracted and selected from the suspicious region and then classified as normal or malignant. Finally a performance analysis is done for the proposed technique with the existing techniques.
1.1.10 Database (Image Acquisition)

In the medical world, to ingress the real medical images like MRI, PET or CT scan and to resume a research are a very complicated because of privacy problem and heavy technical deadlocks. The objective of this study is
to compare enhancement filters for detection of brain tumor through Brain MRI. Generally the proposed work can be implemented in a hospital by maintaining patients MRI in a database which can be available in Linux Network through LAN (Local Area Network) for easy access. for example, Kovai Medical Center Hospital (KMCH), India. They acquire all patients MRI acquired from 0.5T intra operative Magnetic Resonance scanner and distributed it immediately in their own LAN. The proposed work only focus on T2 weighted images and its size like 256×256×58 (0.86mm, 0.86mm, 2.5 mm). (Selvanayaki et al 2010). The following table shows the properties of MRI brain image. Figure 1.4 shows some sample images acquired from the databases.

![Figure 1.4 sample MRI Brain Tumor images.](image)

### 1.2 MOTIVATION

The human brain is the most complex structure where identifying the tumor like diseases are highly challenging. In general the brain tumor is detected by radiologist through a comprehensive analysis of MR images, which takes substantially a longer time. The main idea is to develop a computer aided diagnostic system that would assist the radiologist to have a second opinion regarding the presence or absence of tumor.
The principal aim of this research work is to provide more accuracy (both sensitivity and specificity) to the result and to decrease the time complexity by finding the best optimization technique.

1.3 PROBLEM DEFINITION

Manual segmentation and analysis of MR brain images by radiologists is tedious, time-consuming and unrealistic in medical imaging. Current brain tumor diagnosis systems use a large number of images taken for a single patient and most of them provide compound information about the brain and they lack in providing an accurate result on existence of tumor. As a result, a formal consultation with a radiologist is mandatory. Therefore the problem here is to develop a system that provides an automatic result of the presence or absence of tumor from a brain MR images. The system should devise new and accurate intelligent algorithm to enhance, segment and classify the brain MR images with less time.

1.4 RESEARCH APPROACH

The research approach mainly focuses on devising intelligent algorithms to identify the tumor from the brain MR images. Population-based optimization algorithms find near-optimal solutions to the difficult optimization problems with motivation from nature. Two important classes of population-based optimization algorithms are evolutionary algorithms and swarm intelligence-based algorithms. Swarm intelligence-based algorithms like Particle Swarm Optimization, and Ant Colony Optimization (ACO) outperforms the evolutionary algorithms. Swarm intelligence-based systems are typically made up of a population of simple agents interacting locally with one another and with their environment (Yuhui Shi 2012). The best optimization for complex problems can be achieved by the PSO algorithm.
1.5 METHODOLOGY

The methodology used for this research work begins from the intensive literature survey; methods of automatic detection of tumor in digitized brain MRI used in various stages of intelligent systems are summarized and compared. In particular, the pre-processing and enhancement, segmentation algorithms, feature extraction, feature selection, classification, receiver operating characteristics curve analysis and their performance measures are studied and compared.

The MRI scan of brain image data was collected from different sources that include simulated and real, normal and tumorous datasets designing a framework for preprocessing, enhancement, segmentation and classification of brain tumor from the MR images. Then the designed framework is implemented and simulated on MATLAB 7.0 environment. Finally, the proposed system performance is validated against ground truth using commonly used quantitative metrics and the ROC analysis.

1.5.1 Preprocessing and Enhancement

Initially the proposed modified tracking algorithm is used to remove film artifacts from the MRI. The newly proposed Weighted Median Filtering is applied to enhance the brain MRI by removing the high frequency components. The advantage of using this filter is that it removes the noise without disturbing the edges.

1.5.2 Image Segmentation

The suspicious region or tumors is segmented using Markov Random Field (MRF) hybrid with PSO algorithm for MRI. Initially, a unique label is assigned to similar patterns in the MRI. A kernel of 3×3 matrix is selected randomly from the enhanced image.
The MRF is used to compute the MAP values of each kernel. The metaheuristic algorithm called PSO is implemented to obtain the optimum labels by minimizing the MAP values. The intensity value corresponding to the central pixel of the kernel that holds the optimum label is used as the threshold value for segmentation.

The whole process of preprocessing and segmentation is shown in Figure 1.5

![Figure 1.5 Preprocessing and segmentation steps](image-url)
1.5.3 Feature Extraction and Selection

The textural features are extracted from the segmented MRI to classify the tumors into malignant or normal. Textural analysis methods such as Spatial Gray Level Dependency Matrix (SGLDM) and Surrounding Region Dependency Matrix (SRDM) are used to extract the core features from the segmented image. The reduced features are selected from the extracted set of features using the metaheuristic algorithm such as PSO algorithm. The feature selection technique is applied to obtain the reduced feature set in order to reduce the space and running time of the system.

1.5.4 Classification

Initially the values of the features available in the reduced feature set are constructed from the feature selection algorithms and then normalized between zero and one. These normalized feature values are given as input to a three-layer Back Propagation Neural network (BPN) to classify the tumors into malignant or normal. For each testing image, the output is calculated using sigmoid function. The error is calculated between the actual output and the target output. Based on this error value the weights are propagated to reduce the error value.

Thus the classifier was trained to produce the output value 0.9 for tumor images and 0.1 for normal images. The performances of all possible combinations between segmentation and feature extraction methods were evaluated using this analysis. The whole process of Feature extraction, selection and classification are shown in Figure 1.6
Figure 1.6 Feature extraction, selection and classification
1.5.5 Performance Analysis

The BPN classifier is validated using Jack Knife Method (JKM). For the Jack Knife method, one half of the segmented images are selected randomly from the database for training of the neural network; subsequently, the other halves of the segmented images are used for testing the trained neural network. The training set is used to train the BPN algorithm. Each training in this experiment is completed once the value of the error is less than 0.1. In this thesis, ten combinations of training and testing pairs are used to generate the curves.

A Receiver Operating Characteristics (ROC) analysis is performed to evaluate the classification performances of the proposed approaches. The area under the curve is used as a measure of the classification performance and it is denoted by Az. A larger value of Az indicates better classification performance. The proposed system is tested on 200 digitized brain MRI from the database to establish its competence.

To make the graph, the X-axis is 1 minus the specificity and the Y-axis is the sensitivity. Draw a diagonal line on the graph from (0, 0) in the lower left hand corner to (1, 1) in the upper right hand corner. This is best suited to analyze the performances of segmentation, feature extraction, selection and classification (Passino 2002).
Figure 1.7 A typical curve

A typical curve is shown in Figure 1.7. The area under the curve is an accepted way of comparing classifier performance. A perfect classifier would have a True Positive (TP) rate of 1.0 (or 100%) and a False Positive (FP) rate of 0.0 and therefore would have an area under the curve of 1.0.

1.6 ORGANIZATION OF THE THESIS

In this study, a novel method is proposed for image segmentation using meta heuristic algorithms. The thesis is organized into seven chapters.
Chapter 1: The first chapter is introductory in nature and the subsequent chapters discuss the proposed technique in detail. The gist of each chapter is provided below.

Chapter 2: Systematic overviews of the existing techniques for automatic detection of Segmentation of brain tumor are summarized in this chapter. In particular, the Preprocessing and Enhancement methods and Segmentation algorithms are studied and compared.

Chapter 3: This chapter explains methods of preprocessing and enhancement. The tracking algorithm is proposed to remove film artifacts such as labels and X-ray marks from the MRI Image. The three filtering technique such as Median filter, Weighted Median Filter and Adaptive Filter is applied to remove the high frequency components in the MRI image.

Chapter 4: In this chapter presents the Segmentation of brain tumor region from background MRI using two approaches like Clustering approach and meta heuristic approach. In first clustering approach, Fuzzy C Means algorithm (FCM) is applied for MRI image Segmentation. In second meta heuristic approaches are applied for brain tumor segmentation. It describes Modified Particle Swarm Optimization (MPSO) and Hybrid MPSO-FCM.

Chapter 5: In this chapter textural analysis method such as Spatial Gray Level Dependency Matrix (SGLDM) and Surrounding Region Dependency Matrix (SRDM) is used to extract the Haralick features from the segmented images. The features are selected using PSO algorithms from the features extracted using textural analysis methods. The Selected features are given as input to the three-layer BPN to classify the abnormal and normal ones.
Chapter 6: In this chapter, ROC analysis is presented to evaluate the classification performance of the textural features extracted by texture analysis method. The area under the ROC curve $A_z$ is used as a measure of the classification performance.

Chapter 7: In this concluding chapter, result obtained through this research work and contributions made are presented and scope for future research is also discussed.

1.7 SUMMARY AND CONCLUSION

The overview of the research work automatic detection of brain tumor segmentation from Meta heuristic algorithms is discussed. The study of the detection and segmentation methodologies for this problem is reported. The motivation and the main objectives of this thesis are given. In this section, the essence of the present research work is briefed. Organization of the thesis shows the arrangements of the outcome of the present research work.