Chapter 1

INTRODUCTION
1.1 THE BRAIN

The brain is a delicate, flexible collection of tissue. It is sheltered by:

- The bones of the brainpan
- Three thin layers of flesh (meninges)
- Watery liquid (cerebrospinal liquid) that moves through spaces inside the brain.

According to the booklet published by ‘National Institute of Health, National Cancer Institute’, The brain gives us the instructions that we required to do (like wandering and speaking) and the things our body does without listening to brain (like breathing). The brain is also working as control unit of our intellects (vision, listening, touch, savor, and sniff), our remembering power, our feelings, and our personality. The complete network of nerves transfers the concern information about all the actions in the brain of human and the remaining body. Some nerves go inline from the brain to the tong, oculus, ears, and other parts of the human head. The remaining components of the human body will be interconnected with the spinal-cord using other nerves. Within the brain and spinal-cord, glial cells protect the nerve cells and keep them intact (1).

Three main components are there of the brain that manages different activities:

- **Cerebrum**: The cerebrum uses the real facts from our senses to gives us what is surrounding us and give suggestion to our body how to give reply to particular request. It controls all the activities like reading, thinking, learning, speech, and emotions. The cerebrum is bifurcated into the two parts such as right and list cerebral hemispheres. The right hemisphere manages the muscles on the left section of the body. The right section of the body is managed by left hemisphere.

- **Cerebellum**: The cerebellum manages the balance of our feet and hand that perform the regular activities such as rambling, lettering and standing, and other difficult actions.

- **Brain stem**: Spinal cord is connected with the brain using brain stem. It manages the different activities such as body heat, blood-pressure, and other simple body tasks (1).
1.2 TUMOR GRADES AND TYPES

When utmost of the working cells getting old or get injured, they expire, and the new cells are placed in their position. At times, this process goes incorrect. New cells might be formed while the body doesn’t require these cells, and older or injured cells don’t die as they must. The gathering of additional cells often produces a unwanted collection of tissue defined as a growth or tumor.

The primary brain tumors might be considered as malignant or benign (1):

- Benign brain tumors do not hold cancer cells:
  - Generally, benign tumors can be removed, and they occasionally propagate back.
  - Benign brain tumors usually have an noticeable border or edge. Cells from benign tumors irregularly conquer tissues surrounding them. They don’t pass to new components of the body. Conversely, delicate components of the brain can attacked by the primary brain tumors and may cause serious health complications.
  - Rarely Benign brain tumors can cause the human death.
  - There might be chance that benign might be converted to malignant.

• **Malignant** brain tumors (also termed brain cancer) hold cancer cells: Malignant brain tumors are usually more hazardous and often having a life risk.

- They are expected to grow speedily and crowd or invade the nearby normal brain tissue.
Cancer cells could break away from malignant brain tumors and expand to supplementary parts of the brain or to the spinal cord. They hardly carried to the different elements of the body.

**Types of Primary Brain Tumors**

According to the booklet published by ‘National Institute of Health, National Cancer Institute’, there are several kinds of initial brain tumors. These kinds of tumors are termed consequently to the kind of cells or the component that belongs to the brain in which they begin. For instance, glial cells are the main origin for the most of the brain tumors. This kind of tumor is referred as *glioma*.

Among grown person, the most ordinary types are:

- **Astrocytoma**: These tumors originate from stellar structured glial cell termed *astrocytes*. It might be of any grade. In grown person, astrocytoma is originated inside the cerebrum.

  Grade I or II Astrocytoma: It is labeled as Low-Grade-Glioma.

  Grade III Astrocytoma: It is sometimes labeled as Highest-Grade or an Anaplastic Astrocytoma.

  Grade IV Astrocytoma: It might be labeled as the *Glioblastoma* or may be referred as Malignant Astrocytic Glioma.

- **Meningioma**: This tumor originate in the meninges. It might be grade I, II, or III. It’s generally benign (grade I) and grows gradually.

- **Oligodendroglioma**: This tumor originates from cells that produce the greasy material that shelters and guards nerves. It generally arises in the cerebrum. It is mostly usual in adults of 30 to 50 year age. It might be grade II or III.

Among youngsters, the maximum general types are:

- **Medulloblastoma**: Cerebellum is the source for this tumor. It’s occasionally labeled as *primitive neuroectodermal tumor* (grade IV).

- **Ependymoma**: Inner canal of the spinal cord hold some cells that might produces this tumor. This tumor most frequently initiate in children and young adults. It might be grade I, II, or III.
• **Brain stem glioma**: This tumor might be observed in the bottom portion of the brain. It might be a low-grade or high-grade tumor. *Diffuse intrinsic pontine glioma* is the most usual type (1).

### 1.3 MEDICAL IMAGE PROCESSING

Medical image analysis, it is the methodology and procedure used to generate the images (pictures) of the human being (or portions and part there of) for clinical drives (medical procedures looking for to reveal, diagnose, or examine disease). Though imaging of detached body part and tissues can be gain for medical causes, such connections are never frequently mentioned to as medical imaging, but rather that can be considered as portion of pathology.

The medical scans (Images) of the human brain can be acquired from various kinds of modalities that give us the corresponding information: anatomical modalities and functional modalities. Between these two categories there are various kinds of different modalities. Computed tomography (CT) and standard magnetic resonance imaging (MRI) provide different characteristics of internal structure of the human body, but there is very small information about function. Images from positron emission tomography (PET), single photon emission tomography (SPECT), and functional magnetic resonance imaging (FMRI) provide functional information. These associate diagnostic instruments are most supportive for the doctor through disease diagnosis and treatment, as well as decreasing the intrusive pain of the patient. The sufficiently acquired medical images show the inside to doctor, however, the physician or doctors want to know more than absolute images, such as highlighting the abnormal tissue, determining its size, interpreting its shape, and so on. If these jobs are concealed by the doctors themselves, it may be incorrect or difficult, and loads them seriously.

Thus, medical image processing is the important phase in radiology. Among all medical image processing, image segmentation and classification are important phases, which are helpful for diagnosing as well as for the further treatment in the hospitals.
1.4 MEDICAL IMAGE MODALITIES

1.4.1 Computed Tomography

Cunningham et.al., (2000) written about computed tomography in the “biomedical engineering handbook”; The development of computed tomography (CT) in the initial 1970s restructured medical radiology. For the first time, doctors were able to get high-quality tomographic (cross-sectional) images of human beings anatomy (Internal Structure). Over the next decade, number of manufacturers has entered in to the world of CT market. Technical complexity increased intensely, and even today, CT continues to be advanced, with new proficiencies being investigated and established. Computed tomographic pictures are reassembled from a big quantity of dimensions of x-ray transmission through the patient (called projection data). The resulting images are tomographic “maps” of the x-ray linear lessening coefficient.

The first real-world CT device was industrialized in 1971 by DR. G. N. Hounsfield in England and was utilized to capture the image from the brain. The projected data were received in nearly 5 minutes, and the tomographic image was reassembled in nearly 20 minutes. Subsequently then, CT expertise has industrialized intensely, and CT has become a standard imaging modality for generally all components or parts of the body in number of amenities throughout the world. Projected data are naturally acquired in nearly 1 second, and the image is reassembled in 3 to 5 seconds. The essential job of CT systems is to make an enormously large number (nearly 500,000) of highly precise measurements of x-ray transmission through the patient in a exactly controlled geometry. A simple model usually holds of a scaffold, a patient stand, a control console, and a computer. The gantry contains the source-x-ray, detectors- x-ray, and the Data-Acquisition System (DAS) (2).
The authors Raj Acharya et al. (1995) have mentioned about Computed Axial Tomography (CAT) also reoffered as X-ray CT. It is also a basic and prominent medicinal imaging modality, which can be used to gather the 3D representation of a patient’s internal structure. This kind of three dimensional structures may be imagined from a subjective viewpoint, giving the important information for anatomical mapping, to find the exact position of the tumor, to plan the surgery, and many other medical applications.

Physicians are generally using the imaging instruments that based on long utilized x-ray for non-primary medical diagnostics. In the case of the traditional radiograph, a patient is required to stand in front of an x-ray source which travers the radiation through the patients body. Every x-ray incident on the patient is weakened by the tissues it transfers through along its direct flight route. Diverse tissue types in the body show differing densities with comparing to x-ray radiation. Every tissue-type may consequently be allocated a value, $\mu(x, y, z)$ that means the tissue density at Cartesian coordinate $(x, y, z)$. The mathematical equation of these tissue densities,

$$ s = \int \mu(x, y, z) dl $$  \hspace{1cm} (1.1) 

It is relational to the attenuation observed with an x-ray traversing along the given path. A Two Dimensional projected image or “shadow” of these x-rays is scanned by calculating the x-ray energy putting the patient’s body in some Two Dimensional region of interest. Traditional radiography is a inadequate diagnostic modality, in the
sense that it produces a Two Dimensional projection of a Three Dimensional object. Subsequently, a huge amount of data concerning anatomical internal structure is not available to the radiologist.

X-ray CT is the modality that is developed based on the similar physical philosophies that practice the basis of traditional radiography. Attenuation coefficients changes based on different tissue types. This reality is used in combination with x-ray shadows from multiple view-points in order to renovate a demonstration of internal anatomical structure (3).

The data which originates from a typical Computed Tomography scan consists of a series of Two Dimensional Tran-axial slices of a patient, which could be stored to build a 3D demonstration. Each 2D scan is a matrix of voxel parameters which contains the considered tissue density at each point within the imaged region. Though CT scans naturally get slice data laterally the axial plane, it is likely to get planar views from other alignments.

1.4.2 Magnetic Resonance Imaging

Raj Acharya et.al, (1995) have stated that Magnetic Resonance imaging can generates the comprehensive images of the human being with not parallel soft tissue contrast in a non-invasive manner. The occurrence of nuclear magnetic resonance (NMR) is comparatively new to the field of diagnostic medicine. Bloch and Purcell discovered NMR in the year of 1946, two investigators working individualistically at Stanford and Harvard, respectively. They have been felicitated as Nobel award winner in the year of 1952 for their research work.

Magnetic Resonance

In the physical sense resonance is described as the absorption of energy from an origin at a explicit frequency, often termed the natural or resonant frequency. Radio-Frequency (RF) energy is the main source for the magnetic resonance imaging and nuclear magnetic resonance, and nuclei of atoms can be treated as object resonating. Whereas in an external magnetic field, Nuclei are stimulated to a greatest energy state via the absorption of the RF energy. The higher energy or excited state cannot be indeterminately maintained. Subsequently the nuclei relief energy in accordance to
reappeared to their lower energy or ground state. RF energy is released by the nuclei when the ground state is returned. This produced RF energy can be mentioned to as the MR signal. The characteristics of the MR signal are depending on the definite molecular situation of the emitting nucleus. Varied types of information can be composed regarding a molecular environment from the MR signal. The following Figure 1.3 is a basic version of NMR. The bar which is shown below represents the energy in the system (3).

**Figure 1.3: Basic view of nuclear magnetic resonance**

**Nuclei properties in external magnetic field**

All the nuclei would not be applied by MR imaging. Nuclei should be either revolving, or therefore owning angular momentum (spin), or should own an anomalous numeral of protons or neutrons. Only nuclei with this types of features will be ready to resonate. In the meantime electric charge is possessed by nuclei; their spinning generates a magnetic momentum \( \vec{\mu} \), related with the axis of a spin. \( \vec{\mu} \), It is an vector component representing the power and track of the magnetic field neighboring the nucleus. Therefore, a revolving nuclei is a dipole, and might be supposed as a microscopic bar magnet that is given in the following figure: Fig. 1.4 (3).

**Figure 1.4: Magnetic nuclei act like microscopic bar magnets.**
MRI Architecture

A. K. Andriola Silva et al., (2006) given the basic MRI scanners are cylindrically symmetric; however there can be other types and geometries such as open systems. The main magnet generates a solid and identical stationary magnetic field $B_0$ that polarizes the imaged anatomy. Within this magnet are the gradient coils that generates linear and uniform gradients of $B_0$ in the x, y and z-direction for spatial encoding. Situated inside the gradient set is the RF coil system that produces $B_1$ magnetic field pulses of $90^\circ$, $180^\circ$, or any other value said by a particular pulse sequence. The Radio Frequency coil system also identifies indicators from the body.

**Figure 1.5: Basic schematic representation of the MRI System**

During an imaging experimentation, the patient is placed on an MRI table, which takes the patient into the solid static magnetic field $B_0$ in such a way that the anatomy to be imaged is in the region where the field is uniform. The $B_0$ field lines are aligned along the longest body axis, the z-axis. The supplementary two short body axes are the x and y axis, which is shown in the figure 1.5. The MRI table has a locating accuracy of around 1 mm. The main magnet is located in a room that is electromagnetically protected with tones of ferromagnetic iron or a similar composite. The MRI room avoids undesired signals produced by foreign transmitters of the surroundings to extent and disrupt the MRI system and at the same time it minimizes stray fields from the system to the surroundings according to apt compliance regulations. A host computer system generally utilized to control the hardware
constituents of the scanner. The prerequisite scan, comprising the geometrical factors and the imaging method are carefully chosen on the host computer. The computer transferred the selected information to the gradient pulse programmer that corrects the amplitude and waveform of the three gradients. The gradient amplifier then upsurges the power required to initiate the gradient coils in generation of the desired gradient field strength. The RF transmission also starts with the host computer, which sets the required B1 field frequency on the frequency synthesizer. Using an amplitude modulator, the carrier frequency is modulated into apodized sinc-pulses (i.e. f(x) = sin(x) / x ). The RF amplifier upturns the influence of the pulse is used to convert milli Watts to kilo Watts, which is then used to drive the RF transmit coil. The body signals are attained with a RF receive coil, followed by pre-amplification, demodulation and digitalization, before the signals are being transfer on to the computer. The computer then produces the image, which can be kept as an electronic hard copy (4).

1.4.3 Positron Emission Tomography

The research authors John M. Ollinger (1997) and M. M. Ter-Pogossian (1980) both of them have given the description about PET (5) (6). It has integral benefits that prohibit these inadequacies. Attenuation enhancement is easily consummate; positron-emitting isotopes of carbon, nitrogen, oxygen, and fluorine follow obviously in many composites of biological importance, and can therefore be willingly incorporated in the wide variety of convenient radio-medicines; and integration is done electronically, so no integration is mandatory, leading to comparatively great sensitivity. The major problem with PET is its price. The less life span of the most positron emitting isotopes needs an on-site cyclotron, and the capturing devices are expressively more expensive than single-photon cameras. Nevertheless, PET is extensively used in many innovative research experiments and their findings growing clinical acceptance, predominantly for the diagnosis and staging of cancer. The study of the PET starts with the inoculation or inhalation of radio-medicines. The scan is started after a interval ranging from seconds to minutes to allow for transport to and uptake by the part of interest. The positron is released when the radio-isotope is decomposed, which covers a optimal distance before annihilating with an electron. The annihilation process produces two photons with high-energy of 511 KV which are spreading in the revers direction.
The procedure of timing window in which these first and second photons are observed inside a short (~10 ns) timing window called as a true coincidence. If neither photon is scattered nor it is observed along the line which connects two detectors, generally referred as a line-of-response (LOR). Adding many such procedures result in measures that estimates line integrals with the help of radio-isotope distribution. The number of integrals collected validates the approximation. For two 2D images, line integrals produce a distinct approximation of the Cross-Section of the Radio-Isotope concentration, and can be reversed to form the specific scan. If they are suitably calibrated, PET images yield quantifiable assessments of the concentration of the radio-pharmaceutical at specific locations inside the body.

The energetic movement of the pharmaceutical can be demonstrated as a linear dynamic system with the main concentration of radio-isotope inside the blood treated as the input and the measurement of the PET as the output. The state parameters are the concentrations in the different parts of the tissue, where examples of sections would be blood, the interstitial space between cells, and the interiors of cells. The different Sections not required to relate with the physical spaces, and can be represented, for instance, bound and unbound states of the radiopharmaceutical. The exchange rates between the compartments are parameters of the models. Acquiring a chain of pictures successively afterward injection yields a time-course of the sum of the quantity of tracer in each partition, i.e., of the output of the model, which can be utilized to predict the model’s parameters. These factors can then be used to calculate physiological factors of interest, such as blood flow, glucose metabolism, receptor binding features, etc. Thus, quantifiable amounts of specific physiological quantities can be done by PET.

1.4.4 Ultrasound Imaging

The research author Raj Acharya et.al, (1995) also given the emphasis on ultrasound imaging, this technique involves a set of methods capable of obtaining both quantitative and qualitative investigative information. Several ultrasound based methods are prominent based on their competence to obtain factual imagery holding compact and mobile equipment at an effectively lower price than other medical imaging techniques. The factual nature of ultrasound does it possible for physicians to notice the motion of structures inside a patient’s body. This capability has given the
output in the extensive use of ultrasound technology in the medical areas of pediatrics and cardiology. The instruments which implements doppler echo techniques could retrieves quantitative velocity information such as the rate of blood movement in a VOI (vessel of interest). Moreover, the taster of ultrasound signals into a patient at the levels currently implemented has been determined to be very safe (3).

Ultrasound is categorized as sound waves owning a high temporal frequency. General medical equipment’s for diagnostic ultrasound implements waveforms that oscillate in the scope of 1-10 MHz. Such waves could be generated using a single or an group of transducers. Ultrasound transducers having capacity to produce ultrasound signals when they are excited electrically. Contrariwise, electrical signals are generated by these transducers when excited by incident ultrasound rays. Consequently, the same set of ultrasound transducers are generally utilized for both ultrasound transmission and detection in various medical applications.

It has been already mentioned that the configuration of ultrasound source/detector can involve of a only one transducer or an collection of transducers. Array transducers organizations are often implemented in modem medical ultrasound units. These array configurations give a big receptor aperture and afterwards improved image rebuilding. In order to identify the procedure in which ultrasound machines gets images it is best to first innovate a simple, perfect scenario. There might be situation like, the task that entails imaging a single dimensional scene containing of a only one, perfect reflector using a only one transmitter placed at the origin. If an ultrasound pulse is send at time $t_1$, and a return pulse is identified at time $t_2$ then the distance to the specific destination from the transmitter might be considered as

$$x = \frac{t_2 - t_1}{c}$$  \hspace{1cm} (1.2)

Where $c$ is a variable used for the speed of sound. Ranging this method to medical applications, particularly the body can be witnessed as a series of point sources situated at the intersections of tissues with divergent properties acoustic impedances. Ultrasound measuring units can be treated as to image internal structures for applications such as echography. This can be anticipated to calculate the time of arrival of ultrasound signals with respect to their time of transmission in actual time. The resultant output is the exact dimension between the internal structured surface and the transducer which is nothing but the real time image.
1.5 PROBLEM STATEMENT

In the medical sciences the involuntary recognition system for the diagnosis purpose and designing such system using medical image processing is challenging task. In the medicinal area, brain tumor separation means segmentation and classification are very important stages for the better treatment of the patient. The human can not interpret the large number of MRI slices (Normal or Abnormal), still if he/she tends to do so, it may leads to misclassification hence there is a requirement of such an automated recognition system, which can discriminate the kind of the brain tumor. Many researchers have contributed their work for Medical image processing and image discrimination as discussed in literature review.

The study discusses the textural feature extraction of MR images. MR image scans from the Whole Brain Atlas (WBA) database are used for experimental work. The main task and concentration of our problem is to study existing segmentation techniques, feature extraction methods and Neural Network classification techniques for the medical image analysis and discrimination and to propose new system.

1.6 OBJECTIVE OF STUDY

There can be a various methodologies and techniques for the recognition of the medical images. The main task and objective of the research work is to study of the present procedures and to suggest a new one, which helps to detect and discriminate the different types of tumor in the human brain MR images.

- To discriminate the normal and abnormal MR images.
- To discriminate the different types of tumor.
- To compute the recognition rate using ANN approaches.
- To discover the region of interest.
1.7 ORGANIZATION OF THESIS

In the medical field, brain tumor identification means segmentation and classification plays an important role for the physician for diagnosing and further treatment. This study focuses on brain tumor identification means segmentation and discriminating the different types of tumor in the given MR image.

Thesis consists of seven chapters and describes statistical approaches for the segmentation and textural features for the tumor classification. In the first chapter the study represents the introduction of medical image modalities. The second chapter gives the literature review of existing brain tumor segmentation techniques as well as classification techniques. This chapter also focuses on Neural Network approach for brain tumor Classification. The objective of ANN learning rule based on the applications. For example, the objective in pattern recognition is to discriminate the sample data and estimate effectively on new data. In pattern analysis, each cycle of presentation of all sample patterns is usually referred as learning epoch. In chapter three we have introduced some brain tumor identification means segmentation and quantification techniques based on statistical parameters like semiautomatic segmentation, Watershed transformation, and segmentation using Level-Set.

Chapter four emphases on projected technique in which we used four different classes of brain tumors and extracted the GLCM based textural features of each class, and trained the Feed forward NN, which gives 97.5% recognition rate.

Chapter five gives a proposed method in which we have used 5 different classes of brain tumors and extracted the LBP textural features of each class, and trained the NN using 4 different training algorithms, out of which LM back-propagation gives the better recognition rate of 96.00%

In chapter six we projected the effective technique for brain tumor discrimination which contains 4 important steps. The first step belongs to collection and normalization of 5 different classes of tumor. In the second step we have extracted the LBP and GLCM textural features. Third step belongs to feature reduction using PCA. Final step belongs to combining both features and see the result. In the experimental work, it is observed that when only LBP textural features are utilized we acquired the recognition rate of 96.00% and when GLCM textural features are utilized we acquired
97.00% but by combining \textit{LBP} and \textit{GLCM} we acquired the better recognition rate of 99.00%. And last chapter seven discusses about conclusions, research outcomes and Future scope.