Brain Tumor Detection by Using Artificial Neural Networks
الكشف عن أورام الدماغ باستخدام الشبكات العصبية الاصطناعية

A Thesis submitted in partial fulfillment of the requirements for the M.Sc. Degree in Biomedical Engineering

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الآية

قال تعالى:

بسم الله الرحمن الرحيم

"فَقَالُوا سَبَّحَكَ لَا عِلْمٌ لَّنَا إِلَّا مَا تُهْدِيَنَا فَإِذَاذَا إِذْ أَنْتَ الْعَلِيمُ الْحَكِيمُ"

صدق الله العظيم

سورة البقرة الآية رقم 32
DEDICATION

I desire to dedicate this effort to everyone believe in me before I believe in myself,

A special feeling of gratitude to my loving parents Who encourage me to continue and go forward
To the man who is tired of us….. to the one who taught me the success getting by the effort and patience…. to my dear father Elnoor Mohamed
To who I am part of them in to taught me the meaning of life to my dear mother Aisha Mohamed.

I dedicate this thesis to my sisters and brothers and all my family, have never left my side, and support me to complete this thesis.

Also I can’t never forget my friends
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first and foremost I would like thanks to Allah for guiding my directions throughout to complete this thesis, and for granting me more knowledge, more insight and more enlightenment.

I would like to gratefully acknowledge the enthusiastic supervision to my supervisor Dr. Mohamed Yagoub Esmail for his wisdom to move me forward and help me to completed this thesis.

Special thanks to Dr. Majid Dirar Isaa, dean of engineering in future university for help me

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals, so I would like to extend my sincere thanks to all staff of Biomedical Engineering department special D. Zeinb Aadam, T. Kwther and T. Fatihya Grmma.

I am deeply indebted to my friends in Sudan University of sciences and technology and for their continued support assisted me with this thesis.
# ABBREVIATIONS

<table>
<thead>
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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
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<td>GUI</td>
<td>Graphic User Interface</td>
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<td>CAD</td>
<td>Computer Aided Detection</td>
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<td>ANNs</td>
<td>Artificial Neural Networks</td>
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<tr>
<td>SGLD</td>
<td>Spatial Gray Level Dependency</td>
</tr>
<tr>
<td>NBTF</td>
<td>The National Brain Tumor Foundation</td>
</tr>
<tr>
<td>PEs</td>
<td>Processing Elements</td>
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<tr>
<td>ADC</td>
<td>Analog-to-digital converter</td>
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<tr>
<td>DAC</td>
<td>digital-to-analog converter</td>
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<td>CNS</td>
<td>central nervous system</td>
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ABSTRACT

Brain tumor is one of the most dangerous diseases which require early and accurately detection methods, current used detection and diagnosis methods for image evaluation depend on decision of neuro-specialists, and radiologist which possible to human errors. Manual classification of brain tumor is time consuming. This study describes the processes and techniques used in detecting brain tumor from magnetic resonance imaging (MRI) and ANN techniques, which are of the most application of artificial intelligent that used in biomedical image classification and recognition.

In the proposed system, features are extracted from raw MRI images which are then fed to ANN through GUI to received suspected MRI for early tumor detection. This thesis implemented in the different stages for Computer Aided Detection System (CAD-system) after collected the image data (magnetic resonance images); first stage is pre-processing and post-processing of MRI images to enhancement it and then the processed image is being more suitable to analysis. The study was used threshold to segment the MRI images by applied mean gray level method. A comprehensive feature set, computed and ANN rules are selected to classify normal and abnormal image.

In the second stage statistical feature analysis was used to extract features from MRI images; the features were computed using Haralick’s equation for feature based on the spatial gray level dependency matrix (SGLD). The suitable and best features to detect the tumor in image were selected. In the third stage the artificial neural networks (ANN) were designed; the feed-forward back propagation neural network with supervised learning were apply as automatic method to classify the images under investigation into tumor or none tumor. The network performances were evaluated successfully tested and achieved best results with accuracy of 99%, specificity 100% and sensitivity 97.9%.
المستخلص

أورام الدماغ هي عبارة عن نمو غير طبيعي للخلايا داخل الجمجمة مما يؤدي إلى حدوث أضرار جسيمة وأمراض تهدد الحياة والأسباب التي تؤدي إلى نشوء هذه الأورام غير معروفة.

تعتبر أورام الدماغ من أكثر الأمراض الخطيرة التي تتطلب كشفاً مبكر أو تشخيص دقيقاً ومعظم الطرق المتبعة في تشخيص هذه الأورام عبارة عن قرار يتخذه أخصائي الأشعة والأورام لتقييم الصور المختصرة بالكشف عن الأورام ولكن هذا التشخيص الذي يعتمد على عين الإنسان ومهاراته المكتسبة قد يؤدي إلى حدوث أخطاء بشرية وكذلك يحتاج إلى وقت أطول.

الطريقة المستخدمة في هذا البحث للكشف عن ورم في الدماغ تقوم على تقنيات التصوير بالرنين المغناطيسي (MRI) وتقنيات الشبكات العصبية الاصطناعية (ANN)، والتي تمثل واحدة من التطبيقات الاصطناعية الذكية المستخدمة في الطب لتصنيف الصور واتخاذ القرار لها، وهذا المقتراح تم تنفيذه بعد تجميع عدد من صور الرنين المغناطيسي في مراحل مختلفة من نظام التشخيص بمساعدة CAD System.) الحاسوب (أول مرحلة تم فيها معالجة الصور لتحسينها وجعلها مناسبة لعملية التحليل وكذلك استخدمت التقسيم العصبي (threshold segmentation) في المرحلة التطبيقية التحليلية الاصطناعية الإحصائية (statistical texture analysis) وتم حساب خصائص الصور باستخدام معادلات هارليك (Haralick’s Features) فتم اختيار أفضل الخصائص والانسرب (Spatial Gray Level Dependant Matrix) لتشخيص الورم المتوقع.

وفي المرحلة الثالثة تم بناء الشبكة العصبية الاصطناعية من نوع propogation neural network كطريقة آلية للكشف عن الأورام المدخلة للمعالج بين مستويات غير طبيعية. وكان تقييم أداء الشبكة عالي النجاح حيث أعطت نتائج بحاسوب 97.7% ودقة قيمتها 99%. 

XI
CHAPTER ONE
INTRODUCTION
CHAPTER ONE
1. INTRODUCTION

1.1 Background

Brain tumor is any mass that results from an abnormal and an uncontrolled growth of cells in the brain. There are two main types of tumors: malignant or cancerous tumors and benign tumors. Cancerous tumors can be divided into primary tumors that started within the brain and those that spread from somewhere else known as brain metastasis tumors. Benign tumors generally have a slower growth rate than malignant tumors[1]. Its threat level depends on a combination of factors like the type of tumor, its location, its size and its state of development. Brain tumors either include tumors in the central spinal canal or inside the cranium[2]. The National Brain Tumor Foundation (NBTF) for research in United States estimates that 29,000 people in the U.S are diagnosed with primary brain tumors each year, and nearly 13,000 people die. In the UK, over 4,200 people are diagnosed with a brain tumor every year (2007 estimates). There are about 200 other types of tumors diagnosed in UK each year[3]. Magnetic Resonance Imaging (MRI) is one of the best technologies currently being used for diagnosing brain tumor and it create more detailed pictures. Automatic defects detection in MRI is quite useful in several diagnostic and therapeutic applications [4, 5]. MRI is one imaging modality that helps researchers and medical practitioners to study the brain by looking at it non-invasively.

With the advances of digital image processing, radiologists have a chance to improve their performance with automatic methods like computer-aided detection (CAD) system and Artificial Neural Networks. Computer-aided diagnosis (CAD) aims to increase the predictive value of the technique by pre-reading medical images to show the locations of suspicious abnormalities, and analyze their characteristics, as an aid to the radiologist[6].
Artificial neural networks are one application of artificial intelligent and it’s a model that emulates a biological neural network. An ANNs is composed of a collection of interconnected neurons that are often grouped in layers. Neurons is the processing elements (PEs) in a network. Each neuron receives input data, processing it, and delivers a single output. A neural network is a powerful computational data model that is able to capture and represent complex input/output relationships [7].

And also it is provides a powerful tool to help doctors to analyze, model and make sense of complex clinical data across a broad range of medical applications. Most applications of artificial neural networks to medicine are classification problems such as pattern recognition; that is, the task is on the basis of the measured features to assign the patient to one of a small set of classes [8, 9].

1.2 Significance of the study

Brain tumor is one of the most dangerous diseases which require early and precision detection and most of its detection methods depend on decision of neuro-specialists , and radiologist for image evaluation which possible to make misdiagnosis due to human errors and also requires more effort and a long time to detect it.

1.3 Aim of the Study:

1.3.1 General Objectives:

The main purpose of this thesis is to design automatic algorithm system to detect brain tumor abnormality using artificial neural networks.

1.3.2 Specific Objectives are:

1. The main purpose is detection brain tumors from magnetic resonance image.

2. Using automatic method to detect the brain tumor by artificial neural network’s to increase the accuracy and yield.

3. Decrease the diagnosis time and support the decision of doctors and radiologist.
4. Find out the extent of artificial neural network’s merit in brain tumor detection.

5. Design graphic user interface window(GUI) for detection method.

1.4 Subject and Method:

In this study artificial neural networks (ANNs) were used as diagnosis method for brain tumor detection from magnetic resonance image (MRI). The detection of the tumor is performed in two stages: Preprocessing and enhancement in the first stage and segmentation and classification in the second stage which using different stages of Computer Aided Detection System (CAD) then use statistical method; Haralick’s feature extraction which one of texture analysis and the last used this feature as input parameters to the feed-forward back propagation Artificial neural networks which designed by the neural networks toolbox in MATLAB and implemented all the result in graphic user interface window.

1.6 Thesis layout:

In this thesis; Chapter one discusses the briefly background, problem statements and thesis objectives, thesis methodology briefly introduced and literature reviews, Chapter two will discuss the related studies; computer aided diagnosis system, digital image processing, feature analysis and literature review, Chapter three discusses the theoretical fundamental include; brain tumor, MRI brain images and artificial neural network, Chapter four discusses and describe the methodology that apply to detect brain tumor from MRI images, Chapter five introduces the obtained results from the proposed system designed and discussions of the analysis results and the last chapter; Chapter six provide the conclusions and recommendations of the thesis.
CHAPTER TWO
RELATED STUDIES
CHAPTER TWO
2. RELATED STUDIES

This chapter discusses an introduction about computer aided diagnosis, digital image processing, texture analysis and literature review by different methods to detect brain tumor.

2.1 Computer-Aided Diagnosis (CAD) System

Computer-aided diagnosis (CAD) is a procedure in medicine that assist doctors in the interpretation of medical images. Imaging techniques in X-ray, MRI, and Ultrasound diagnostics yield a great deal of information, which the radiologist has to analyze and evaluate comprehensively in a short time. CAD systems help scan digital images. It is a relatively young interdisciplinary technology combining elements of artificial intelligence and digital image processing with radiological image processing. A typical application is the detection of a tumor.

2.2 Digital Imaging Processing

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. A complete digital image processing system is a collection of hardware (equipment) and software (computer programs) that can: acquire an image, using appropriate sensors to detect the object, Analog-to-digital converter (ADC) to digitize image, store the image, manipulate, process the image; and display the image, ideally on a television or computer monitor, which requires the production of an analog video display signal by a digital-to-analog converter (DAC). Imaging processing consists of several processes; some of them are segmentation and feature extraction, which describe below:
2.2.1 Image Segmentation:
Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images. There are many different ways to perform images segmentation[10].there are some categories of image segmentation:

- **Threshold based segmentation.** Its the simplest method of image segmentation. This method is based on a threshold value to turn a gray-scale image into a binary image. Histogram thresholding and slicing techniques are used to segment the image. They may be applied directly to an image, but can also be combined with pre- and post-processing techniques.

- **Edge based segmentation.** With this technique, detected edges in an image are assumed to represent object boundaries, and used to identify these objects.

- **Region based segmentation.** Where an edge based technique may attempt to find the object boundaries and then locate the object itself by fling them in, a region based technique takes the opposite approach, by (e.g.) starting in the middle of an object and then “growing” outward until it meets the object boundaries.

- **Clustering techniques.** Although clustering is sometimes used as a synonym for (agglomerative) segmentation techniques, it used to denote techniques that are primarily used in exploratory data analysis of high-dimensional measurement patterns. Clustering methods attempt to group together patterns that are similar in some sense. This goal is very similar to what we are attempting to do when we segment an image, and indeed some clustering techniques can readily be applied for image segmentation.
• **Matching.** When we know what an object we wish to identify in an image (approximately) looks like, we can use this knowledge to locate the object in an image. This approach to segmentation is called matching.

2.2.2 Feature Extraction

Feature extraction is an essential pre-processing step to pattern recognition and machine learning problems. The problem of feature extraction can be decomposing in two steps: feature construction, and feature selection. Although feature selection is primarily performed to select relevant and informative features, it can have other motivations, including:

- General data reduction, to limit storage requirements and increase algorithm speed.
- Feature set reduction, to save resources in the next round of data collection or during utilization.
- Performance improvement, to gain in predictive accuracy.
- Data understanding, to gain knowledge about the process that generated the data or simply visualize the data [11].

2.3 Texture Analysis

Texture analysis are usually categorized into four Approaches: first is **Structural** approaches represent texture by well-defined primitives (*microtexture*) and a hierarchy of spatial arrangements (*macrotexture*) of those primitives. To describe the texture, one must define the primitives and the placement rules. The choice of a primitive (from a set of primitives) and the probability of the chosen primitive to be placed at a particular location can be a function of location or the primitives near the location. The advantage of the structural approach is that it provides a good symbolic description of the image; however, this feature is more useful for synthesis than analysis tasks.
Second is **statistical** approaches represent the texture indirectly by the non-
deterministic properties that govern the distributions and relationships between
the grey levels of an image. Methods based on first (statistics given by
individual pixel) and second-order statistics (statistics given by pairs of pixels)
have been shown to achieve higher discrimination rates than the power
spectrum (transform-based) and structural methods. The most popular second-
order statistical features for texture analysis are derived from the so-called co-
ocurrence matrix. They were demonstrated to feature a potential for effective
texture discrimination in biomedical-images.

Third is **Model based** texture analysis is using fractal and stochastic models,
attempt to interpret an image texture by use of, respectively, generative image
model and stochastic model. The parameters of the model are estimated and
then used for image analysis. In practice, the computational complexity arising
in the estimation of stochastic model parameters is the primary problem. The
fractal model has been shown to be useful for modeling some natural textures.

The last one is **Transform methods** of texture analysis, such as Fourier, Gabor
and wavelet transforms represent an image in a space whose co-ordinate system
has an interpretation that is closely related to the characteristics of a texture
(such as frequency or size)[12].

**2.4 Literature Review**
In the last decade, many research activities were conducted to different methods
to detect and classify the brain tumor (different type of tumor) in digital image,
some papers are summarized below:

Shweta Jain, Shubha Mishra; they proposed a presents the artificial neural
network approach namely Back propagation network (BPNs) and probabilistic
neural network (PNN) to classify brain cancer. It is used to classify the type of
tumor in MRI images of different patients with Astrocytoma type of brain
tumor. The image processing techniques are used in this system is to isolate the
tumor region from the rest of the image or separate the tumor region from the MRI images composed from (Histogram Equalization, Segmentation by Threshold method). Gray Level Co-occurrence Matrix (GLCM) is used to achieve the feature extraction. Then used Back propagation method which is a supervised learning method. Probabilistic neural networks (PNN) are a kind of radial basis network suitable for classification. The whole system worked in two modes firstly Training/Learning mode and secondly Testing/Recognition mode [2].

V.P. Gladis Pushpa Rathi and Dr. S. Palani proposed a novel method to classification brain tumor using Linear Discriminant Analysis which includes this steps, Image collection, Normalization, Intensity, shape and Texture feature extraction, feature selection and classification. In this method the shape, Intensity and Texture features are extracted and used for classification. Vital features are selected using Linear Discriminant Analysis (LDA). The results are compared with Principal Component Analysis (PCA) dimension reduction techniques. The number of features selected or features extracted by PCA and the classification accuracy by The Support Vector Machine (SVM) is 98.87%. Then train the system by both continuous and without continuous data to minimize the error rate as well as increase the classification accuracy[13].

R. J. Deshmukh and R. S. Khule; they proposed Neuro-fuzzy systems use the combined power of two methods: fuzzy logic and artificial neural network (ANN) using to detect the brain tumor. The work carried out involves processing of MRI images of brain cancer affected patients for detection and Classification on different types of brain tumors. A suitable Neuro Fuzzy classifier is developed to recognize the different types of brain tumors. Steps which are carried out for detection of tumor are enlisted below:

Step1: Consider MRI scan image of brain of patients.
Step2: Train the neural network with database images.
Step3: Test MRI scan with the knowledge base. Step4: Two cases will come forward (Tumor detected and Tumor not detected). The features extracted from image are further given to Neurofuzzy classifier which is used to detect candidate circumscribed tumor. Generally, the input layer consists of seven neurons corresponding to the seven features. The output layer consists of one neuron indicating whether the MRI is a candidate circumscribed tumor or not, and the hidden layer changes according to the number of fuzzy rules that give best recognition rate for each group of features. [14].

P.B.Nikam and V.D.Shinde proposed brain image classification and detection using distance classifier method, this theses presents a system for automatic classification of healthy or affected person using Region growing segmentation by watershed algorithm, Euclidean distance classifier for fast computation, accompanied with preprocessing and post processing method apply on database consisting both normal and timorous samples of MR brain images. This system had two main stages, first is pre-processing of MRI images and then other post processing operations, which includes operations like noise removal, convert input image into gray scale image, High pass filter. Segmentation process using Threshold segmentation; it is the most common approach for detecting meaningful discontinuities in gray level, second applied Morphological operations and feature extracting process. Their work used Watershed for segmentation and considers the gradient magnitude of an image as a topographic surface and Euclidean distance classifier; this classifier based on the distance measure is direct and simple. The mean class values are used as class centers to calculate pixel-center distances for use by the Euclidean distance rule. For major level classification of a homogeneous area this scheme is better. Its advantageous nature comes from the minimum time it takes to classify Distance Measures are used to group or cluster brightness values
together. The results ensures that the method is efficient, and satisfying for quick detection whether person is healthy or unhealthy [15].
CHAPTER THREE
THEORETICAL
FUNDAMENTAL
CHAPTER THREE
3. THEORETICAL FUNDAMENTAL

Medical images can obtain by different modalities but all imaging modalities can be divided into those that show body anatomy and those that show metabolic activity or function. One of the Anatomical Imaging is Magnetic Resonance Image (MRI) one of its objectives used to detect the brain tumors.

3.1 Brain Tumor

Brain has a very complex structure and is considered as a kernel part from the body and it is a soft, spongy mass of tissue. It is protected by: The bones of the skull, Three thin layers of tissue (meninges) and Watery fluid (cerebrospinal fluid) that flows through spaces between the meninges and through spaces (ventricles) within the brain [16].

A brain tumor or intracranial neoplasm occurs when abnormal cells form within the brain[17]. Intracranial tumours are a diverse group of tumours that differ in localization, symptoms, histological composition and the occurrence of some species depend on age. The most common symptoms are limb movement
disorder, numbness, vision, speech or mental changes. Another group of symptoms are resulted from local brain tissue irritation manifested as different types of seizures. Syndrome of increased intracranial pressure is referred to a set of symptoms, which include mainly headache, vomiting and visual disturbances[18].

3.1.1 Type of Brain Tumors:
There are more than 100 types of brain and spinal cord tumors (also called central nervous system or CNS tumors). They are usually named after the cell type they started in [19] but there are two basic kinds of brain tumors; primary brain tumors and metastatic brain tumors

3.1.1.1 Primary Brain Tumors:
Primary brain tumors start, and tend to stay, in the brain; there are several types of primary tumor described below:

A. Malignant Tumor
Malignant tumours usually grow rapidly and spread within the brain and spinal cord. Malignant brain tumours can also be life-threatening. About 40% of brain and spinal cord tumours are malignant [19]. These include:

*High-grade astrocytomas:* Astrocytomas are tumors that are thought to arise from astrocytes—cells that make up the “glue-like” or supportive tissue of the brain, Grade II to IV tumors have increasing degrees of malignancy. Grade II astrocytomas have slightly unusual looking cells. The cells of a grade III and IV astrocytoma are very abnormal in appearance.

*Oligodendroglialomas:* These tumors arise from oligodendrocytes, one of the types of cells that make up the supportive, or glial, tissue of the brain. Oligodendroglialomas can be low-grade (grade II) or high-grade (grade III also called anaplastic).
**Ependymomas:** These tumors are usually located along, within, or adjacent to the ventricular system, often in the posterior fossa or in the spinal cord. Based on the appearance of the cell patterns when viewed under a microscope, this group of tumors can be sub-divided into smaller groups based on the appearance of their cell patterns.

**Glioblastoma:** Also called “astrocytoma, grade IV” and “GBM” “Grade IV astrocytoma,” “glioblastoma,” and “GBM” are all names for the same tumor. This tumor represents about 17% of all primary brain tumors and about 60-75% of all astrocytomas. They increase in frequency with age, and affect more men than women. Only three percent of childhood brain tumors are glioblastomas. Glioblastoma is generally found in the cerebral hemispheres of the brain, but can be found anywhere in the brain or spinal cord.

**Mixed gliomas:** Mixed gliomas commonly contain a high proportion of more than one type of cell. Most often these tumors contain both astrocytes and oligodendrocytes (oligoastrocytoma).

In some malignant tumors, the cells are confined to one area. In other tumours, malignant cells are also found in surrounding tissue [20].

**B. Benign Tumor**

Benign tumors are typically surrounded by an outer surface (fibrous sheath of connective tissue) or remain with the epithelium [21]. Benign tumours usually have slow-growing cells and clear borders (margins), and they rarely spread. However, they may be found in essential areas of the brain that control vital life functions, which can make them life-threatening. Some benign brain tumours can develop into a rapidly growing malignant tumour [19]. This process is called malignant transformation. The most common types are:

**Meningiomas:** These tumors arise from the “arachnoid mater” — one of the layers of the meninges (the lining of the brain). Meningiomas represent about 34% of all primary brain tumors and occur most frequently in middleaged
women. The majority of meningiomas are benign, grade I, slow-growing tumors which are localized and non-infiltrating. Meningiomas are most often located between the cerebral hemispheres (“parasaggitalmeningiomas”) or over (“convexity meningiomas”) at the base of the skull, and in the back, lower part of the brain called the posterior fossa.

Acoustic Neuroma: Also called Neurilemmoma, Vestibular Schwannoma or Neurinoma. The acoustic neuroma is a benign tumor of the nerve of hearing (the 8th cranial nerve). It is located in the angle between the cerebellum and the pons, in the posterior fossa (the back of the skull).

A chondroma: This rare, benign tumor tends to arise at the base of the skull, especially in the area near the pituitary gland. It is generally might be present for a long time before causing any symptoms. A chondroma can grow to a large size, and may occur as a single or as multiple tumors.

Craniopharyngioma (Grade I): A craniopharyngioma is a rare tumor that usually forms just above the pituitary gland. It can form from different types of brain or spinal cord cells[17].

cysticastrocytomas: It is Grade I tumors include pilocyticastrocytomas, which are usually localized tumors and are often cured with surgical removal[20].

3.1.1.2 Metastatic Brain Tumors:
Cancer cells that begin growing elsewhere in the body and then travel to the brain form metastatic brain tumors. For example, cancers of the lung, breast, colon and skin (melanoma) frequently spread to the brain via the bloodstream or a magnetic-like attraction to other organs of the body. All metastatic brain tumors are, by definition, malignant, and can truly be called “brain cancer” [20].

3.1.2 Tumor Grade:
The grade of a tumor refers to the way the cells look under a microscope [16]:

• Grade I: The tissue is benign. The cells look nearly like normal brain cells, and they grow slowly.
• Grade II: The tissue is malignant. The cells look less like normal cells than do the cells in a Grade I tumor.
• Grade III: The malignant tissue has cells that look very different from normal cells. The abnormal cells are actively growing (anaplastic).
• Grade IV: The malignant tissue has cells that look most abnormal and tend to grow quickly.

### 3.2 Magnetic Resonance Image (MRI)

Magnetic resonance imaging (MRI) is a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the inside of the body. The results of an MRI scan can be used to help diagnose conditions, plan treatments and assess how effective previous treatment has been[22].

![Figure 3](image)  

**Figure 3.** Show standard slice directions in MRI[23]

### 3.2.1 Optimal Processing of Brain MRI [24]:

The ultimate goal of medical image analysis in general and brain magnetic resonance imaging (MRI) analysis in particular, is to extract important clinical
information that would improve diagnosis and treatment of disease. In the past few years, MRI has drawn considerable attention for its possible role in tissue characterization. The image gray levels in MRI depend on several tissue parameters, including proton density (PD); spin-lattice (T1) and spin-spin (T2) relaxation times; flow velocity (v); and chemical shift. A sequence of MRI images of the same anatomical site (an MRI scene sequence) contains information pertaining to the tissue parameters. This implicit information is used for image analysis. In brain tumor studies, existence of abnormal tissues is easily detectable most of the time. However, accurate and reproducible segmentation and characterization of abnormalities are not straightforward. For instance, a major problem in tumor treatment planning and evaluation is determination of the tumor extent[24]. In an image analysis system designed for brain studies summarized in several steps These image analysis steps are shown in fig(3.3).

3.2.1.1 Preprocessing
the consists of Preprocessing of brain in MRI these tasks are explained in the following sections.

A. **Registration**
To follow sequential changes that may occur over time, it is necessary to register the image sets obtained at different times. Also, if the patient moves between different scans, images should be registered before multispectral image processing and analysis are applied fig(3.4). Several methods have been proposed for medical image registration. These techniques can be partitioned into three categories: (a) landmark based (point matching); (b) surface based (surface matching); and (c) intensity based (volume matching).
figure3. A flowchart of image-processing steps for analysis of brain MRI studies[24]
B. **Intracranial Segmentation:**
The image background does not usually contain any useful information but complicates the image restoration and tissue segmentation/classification and increases the processing time. It is therefore beneficial to remove the image background before image restoration and analysis begins. In addition, in brain studies, tissues such as scalp, eyes, and others that are outside of the intracranial cavity are not of interest. Hence, it is preferred to segment the intracranial cavity volume from scalp and background. This segmentation is usually straightforward for brain MRI studies. Thresholding and morphological operators have been used to do this segmentation.

![figure3. 4 An illustration of image registration.](image)

A, An axial T1-weighted MRI of a tumor patient, with skin edges (contour) overlaid. B, Corresponding axial T2-weighted MRI, with contour of the T1-weighted image overlaid to show the need for registration. C, The T2-weighted image after being registered to the T1-weighted image, with the contour of the T1-weighted image overlaid to illustrate the match generated by the image registration method[24]

C. **Nonuniformity Correction:**
MRI brain images acquired using standard head coils suffer from several possible sources of nonuniformity, including (a) main field ($B_0$) nonuniformity;
(b) the time domain filter applied before Fourier transformation in the frequency encoding direction; (c) nonuniformity caused by uncompensated gradient eddy currents; (d) transmitted and received radiofrequency (RF) field nonuniformity; (e) RF penetration depth effects; and (f) RF standing wave effects. The first effect is usually corrected by using a multiple spin-echo sequence. However, because most of the current scanners use digital filters whose effect on the image is limited to two or three pixels at the edge of the image, this correction is usually unnecessary. The third effect on modern MRI systems, such as GE signa, that are equipped with shielded gradients is small for spin-echo sequences at long repetition times used in tumor studies. The fourth effect needs to be estimated and used to correct MRI scans. The fifth and sixth effects are normally negligible in tumor patient studies; thus, no correction is necessary for them.

**D. Tissue In Homogeneities:**

A tissue type may have biological variations throughout the imaged volume. For example, biological properties of white matter in the anterior and posterior of the brain are slightly different. A tissue type may also have biological heterogeneity in it; many brain lesions are heterogeneous in nature. These cause variations of signal intensity for a single tissue in the imaged volume. The feature space representation of the entire volume may therefore be spread out (i.e., clusters for different tissues may overlap). Sources of this variation include the difference in the proton density and T1 and T2 relaxation times from voxel to voxel. These differences generate a different multiplicative factor in image gray levels from voxel to voxel, and application of a ratio filter seems appropriate. However, in general, because of these effects, feature space analysis is not recommended for the entire 3-D volume in one stage; superior results may be obtained using a slice-by-slice analysis approach.
E. Noise Suppression

Noise limits the performance of both human observers and computer vision systems. As such, noise should be suppressed before inputting data to image segmentation and classification algorithms. To reduce the computation time, noise suppression is performed after intracranial volume segmentation. General purpose filters such as low-pass, Weiner, median, or anisotropic diffusion filters may be used.

![Image of T2-weighted and T1-weighted images](image)

**Figure 3.5** Noise-suppression and filter. O1–O4, Four T2-weighted multiple spin echo images and a T1-weighted image of a tumor patient, respectively, after registration and intracranial segmentation. R1–R4, Noise-suppressed images generated using the filter[24]

3.2.1.2 Contrast Enhancement

Contrast/noise ratio is one of the standard measures of MR image quality. There are at least three approaches for improving the image CNR: (a) by injecting contrast agents to the patient; (b) by optimizing MRI protocols and pulse sequence parameters; and (c) by combining multiple MR images obtained in clinical studies.

3.2.1.3 Feature Extraction

Brain tumors are normally large, and detection of their presence is simple. They may be found by a symmetry analysis of the image gray levels in the axial images, because they generate significant gray level asymmetry in these images. Detection of multiple zones in the tumor and accurate estimation of the tumor
extent are, however, difficult, and different image analysis approaches may be used for this purpose.

3.2.1.4 Image Segmentation:
Tumor segmentation methods are mainly region based. They use MRI pixel intensities or features extracted from them as representatives of biological properties of tissue. Image pixels are classified into different regions on the basis of these features. Classification is done using a decision method such as those explained in the next section.

3.3 Artificial Neural Networks:
Artificial neural networks is one of applications of artificial intelligent and it has a wide used in medical diagnosis system.

3.3.1 Architecture of ANNs:
An artificial neural network (ANN) is a computational model that attempts to account for the parallel nature of the human brain. An (ANN) is a network of highly interconnecting processing elements (neurons) operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. A subgroup of processing element is called a layer in the network. The first layer is the input layer and the last layer is the output layer. Between the input and output layer, there may be additional layer(s) of units, called hidden layer(s) [25] show in figure(3.6) .the mathematic operation for each perceptron or processing element(neuron) describe in figure(3.7).The weights in an ANN express the relative strengths (or mathematical values) of the various connections that transfer data from layer to layer. In other words, the weights express the relative importance of each input to a Processing element.
From figure (3.7) Where: \( x \) is input, \( w \) is weight and \( y \) is output, the activation of perceptron by flowing equation (1) & (2) and learning rule by Eq.3.

\[
y = f\left(\sum_{j=1}^{n+1} w_j x_j - \theta\right) \tag{1}
\]

\[
y = f\left(\sum_{j=1}^{n} w_j x_j\right), \quad x_{n+1} = -1 \tag{2}
\]
\[ f = \text{threshold function: unipolar \cite{27} or bipolar \{-1,+1\}} \]

\[
x_{k+1} = x_k - \alpha_k g_k \tag{3}
\]

Where: \( x_k \) is a vector of current weights and biases, \( g_k \) is the current gradient and \( \alpha_k \) is learning rate.

### 3.3.2 Artificial Neural Networks Learning:

After designed the ANNs it must be learned on information understanding, learn simply mean adjusting ANN weight until the network understand the input information. There are two ways for artificial neural network learning which are supervised learning and unsupervised learning.

**A. Supervised Learning**

In the supervised learning approach, we use a set of inputs for which the appropriate outputs are known. In one type, the difference between the desired and actual outputs is used to calculate corrections to the weights of the neural network (learning with a teacher). This process, known as the backpropagation of error, is repeated until the network produces the entire training and testing database results in an answer that is most accurate. After the learning phase, the network is given the input data and it gives its best answer based on prior learning\cite{28}.

**B. UnSupervised Learning**

In unsupervised learning, the desired response is not known a priority. Thus, explicit error information in unavailable to improve network behavior. Since no information is available as to the correctness or incorrectness of the response, learning must somehow be accomplished based on observation of responses to inputs that yield marginal or no knowledge about them. The network is therefore training towards some optimum output where optimum is usually some clustering of the data\cite{28}.
In almost all applications of artificial neural networks in the field of cancer research, the target or desired output is explicitly provided. Almost invariably medical experts assist with the most likely diagnosis given a certain set of pathological information. Similarly, prognostic information is based on survival analysis procedures, and patient management is optimized through retrospective assessment of previous and long-term responses to treatment. Thus, in the vast majority of neural structures described in this book, supervised learning constitutes the basic mode of learning.
CHAPTER FOUR

METHODOLOGY
CHAPTER FOUR
4. METHODOLOGY

4.1 Overview of Methodology
This chapter describes and discusses the research methods that were used for this study brain tumor detection. It can be summaries in three stages. In first stage it start with pre-processing of MRI images to enhancement it and make it more suitable to analyze such as reduce and remove noise, contrast enhancement, and image sharpening[29]. Second stage is processing of images like edge detection, segmentation, morphological operations feature selection and extraction, classification etc. Final stage is implement the feature of images for pattern recognition to detect the tumor. The propose method described in flowchart fig.4.1.

4.2 Database
In this thesis used digital magnetic resonance image database which were obtained from Whole Brain Atlas website that collected from the Harvard University, medical educational school and various sources[30]. The MRI brain images are taken of person above 20 years age group as there are no significant changes observed in image pattern after 18 years of age. Database consists of images of both male and female. In this database, every image is 256×256 pixels and 8-bit gray level scale. It consists of 239 images which belong to normal and abnormal(with and without tumor) brain image. This data downloaded in gif format but were changed to png format before used it through Matlab environment.
4.3 Preprocessing Stage

The pre-processing stage that applied in this study is used to enhancement the images and make it more suitable for analysis. Some process like reduce and remove noise, and image sharpening are obtained in the flowing paragraphs.
4.3.1 Sharpening Filter
In this research used Laplacian filter which one of Spatial Sharpening Filters. Also Laplacian filter is a second-order derivative. It is better to enhance fine detail (including noise) much more than a first-order derivative[29]. The principal objective of sharpening is to highlight fine detail in an image or to enhance detail that has been blurred, either in error or as a natural effect of a particular method of image acquisition. The digital implementation of the two-dimensional Laplacian in Eq. (4) is obtained by summing these two components:
\[
\nabla^2 f(x,y) = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1)] - 4f(x,y) \quad \text{............(4)}
\]

4.3.2 Smoothing Filter
The laplacian filter sharped all final details of imaging including the noise; that requires smoothing filter to remove or reduce this noise. So in this research used Averaging filter which one of Spatial Smoothing Filters. The response of a smoothing, linear spatial filter is simply the average of the pixels contained in the neighborhood of the filter mask. In general, average filtering of an image \(f(x,y)\) of the size \(M\times N\) with a weighted averaging filter of size \(m\times n\) (\(m\) and \(n\) odd) is given by the expression (5)
\[
g(x,y) = \frac{\sum_{s=-a}^{b} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t)}{\sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t)} \quad \text{............................(5)}
\]
where, \(a=(m-1)/2\) and \(b=(n-1)/2\). To generate a complete filtered image \(g(x,y)\) this equation must be applied for \(x=0, 1, 2, \ldots, M-1\) and \(y=0, 1, 2, \ldots, N-1\). After applied the preprocessing filters calculated the error by measure Mean square error (MSE) between the original MRI image and preprocessing image to measure the degradation that happen in original image or loss it is information.
\[ NMSE = \frac{\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} [f(m,n) - g(m,n)]^2}{\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} [f(m,n)]^2} \]  

(6)

Where: \( f(m,n) \) is original image, \( g(m,n) \) preprocessing image and \( M, N \) images size.

### 4.4 Post-Processing Stage

The post-processing stage that applied in this study is used to extract the region of tumor from images. Some process like image segmentation, morphological operation and feature extraction are obtained in the following paragraphs:

#### 4.4.1 Image Segmentation

Brain Magnetic Resonance Imaging (MRI) segmentation is a complex problem in the field of medical imaging despite various presented methods. In this work used threshold method. Thresholding has been used for segmentation as it is most appropriate for the present system in order to achieve a binarized image with gray level (1) representing the tumor and gray level (0) representing the background [27]. The value of threshold calculated by mean gray level(T) in Eq.(7). The main purpose of the segmentation in this project to segment the MRI image just to tumor and background.

\[ T = \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} f(x,y)}{M \times N} \]  

(7)

Where \( f(x,y) \) is gray level of the pixel in coordinated (x,y) of MRI image and \( M \times N \) is the size of MRI image.

\[ f_s(x, y) = \begin{cases} 255, & f(x,y) \geq T \\ 0, & f(x,y) < T \end{cases} \]  

(8)

Where \( f_s(x, y) \) is thresholding image or binarization image.
4.4.2 Morphological Operations

After segmentation the image to binary image, the binarized image needs some operations to enhance the region of tumor, because the segmentation of brain tumors in magnetic resonance images (MRI) is the very difficult because the variety of their possible shapes, locations and image intensities[31]. however in this work the morphological operations is applied. The main process of the morphological operators is opening, closing, erosion, and dilation that remove the hurdle and small holes from the image. The morphological operations used in this research are erosion and dilation these operations are fundamental of morphological processing[29]. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image, applied by matlab functions `imerode` and `imdilate` for erosion and dilation respectively show by this expressions:

\[
f_e(x, y) = \text{imerode}(f(x, y), E) \\
f_e(x, y) = \text{imdilate}(f(x, y), E)
\]

Where: \(f(x, y)\), binary image, \(f_e(x, y)\), returning the eroded or dilated image. The argument \(E\) is a structuring element.

4.4.3 Feature Extraction

Feature extraction is the techniques or method that used to measure of difference characteristics of image segments also its process to represent raw image in its reduced form to facilitate decision making such as pattern classification. Each segmented region in a scene may be described by a set of such features In this work used texture analysis method; The Spatial Gray Level Dependency matrix(SGLD) matrix generator, which decomposes the input image into texture features(Haralick’s features)[32].
The Spatial Gray Level Dependency matrix (SGLD)

The SGLD matrix also known as the gray-level co-occurrence matrix (GLCM) is a statistical approach of examining texture that has been proven to be a very powerful tool for texture image segmentation and considers the special relationship between pixels of different gray levels. The SGLD is one of second-order statistics methods of a texture image.

The SGLD matrix calculated between two pixels one of a certain intensity i occurs in relation with another pixel j. The SGLD matrix is described by the relative frequencies

\[ p(i, j, d, \emptyset) = \#( (k, l), (m, n) \in (L_x \times L_y) \times (L_x \times L_y) | k - m = d, |l - n| = d, \emptyset) \] (11)

\[ p(i, j, d, 45^\circ) = \#( (k, l), (m, n) \in (L_x \times L_y) \times (L_x \times L_y) | k - m = d, |l - n| = d, \emptyset, \emptyset) \] (12)

\[ p(i, j, d, 90^\circ) = \#( (k, l), (m, n) \in (L_x \times L_y) \times (L_x \times L_y) | k - m = d, l - n = 0, \emptyset, \emptyset) \] (13)

\[ p(i, j, d, 135^\circ) = \#( (k, l), (m, n) \in (L_x \times L_y) \times (L_x \times L_y) | k - m = d, |l - n| = d, \emptyset, \emptyset) \] (14)
Where: # denotes the number of elements. It is observed that SGLD matrix is symmetrical because \( p(i, j, d, \theta) = p(j, i, d, \theta) \).

In this work the SGLD matrix calculated from MRI images, firstly setting the size of the spatial gray level dependency matrix depend on the grey level of MRI image then used equations(11,12,13,14) , in angles of 0°, 45°, 90°, and 135° and d=1. Then used matrix to calculate texture feature of specific MRI image.

### 4.6 Texture Feature Extracted from SGLD matrix

Texture in one of the important characteristics used in identifying objects or regions of interest in an image[33], whoever in this project applied Haralick’s feature from SGLD matrix.

#### 4.6.1 Haralick’s Features:

The Haralick's texture features are: Energy(EG), Correlation(CO), Inertia(IN), Entropy(EN), Inverse Difference Moment(IDM), Sum Average(SA), Sum Variance(SV), Sum Entropy(SE), Difference Average(DA), Difference Variance(DV), Difference Entropy(DE), Information measure of correlation-1(ICO-1) and Information measure of correlation-2(ICO-2).These features can be calculated by using the following equations:

Denote \( p(i,j):(i,j) \) then try in a normalized SGLD matrix \( N_g \) is Number of distinct gray levels in quantized image.

\[
p_x(i) = \sum_{i=1}^{N_g} p(i,j) \tag{15}
\]

\[
p_y(j) = \sum_{j=1}^{N_g} p(i,j) \tag{16}
\]

\[
p_{x+y}(k) = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} p(i,j) \tag{17}
\]

\[
i + j = k, \quad k = 2,3,\ldots,2N_g
\]

\[
p_{x-y}(k) = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} p(i,j) \tag{18}
\]

\[
|i - j| = k, \quad k = 0,1,\ldots,N_g - 1
\]
1. **Energy(EG):**

The Energy feature (EG) returns the sum of squared elements in the SGLD matrix as expressed by the following equation:

\[ EG = \sum_i^{N_g} \sum_j^{N_g} \{p(i,j)\}^2 \]  

(19)

2. **Entropy(EN):**

The Entropy coefficient (EN) is a descriptor of randomness produces a low value for an irregular SGLD matrix. It achieves its highest value when all elements of the SGLD matrix are equal for an irregular image. This coefficient is defined by the following expression:

\[ EN = -\sum_i^{N_g} \sum_j^{N_g} p(i,j) \log(p(i,j)) \]  

(20)

3. **Inertia(IN):**

The Inertia (IN) also called Contrast feature is a measure of image intensity contrast or the local variations present in an image to show the texture fineness. This parameter is specified by the following equation:

\[ IN = -\sum_i^{N_g} \sum_j^{N_g} (i - j)^2 p(i,j) \]  

(21)

4. **Correlation(CO):**

The descriptor Correlation (CO) measures the linear dependence of gray level values in the co-occurrence matrix or describes the correlations between the rows and columns of the co-occurrence matrix. This parameter is specified by the following equation:

\[ CO = \frac{\sum_i^{N_g} \sum_j^{N_g} (i-\mu_x)(j-\mu_y)p(i,j)}{\sigma_x \sigma_y} \]  

(22)

Where \( \mu_x, \mu_y, \sigma_x \) and \( \sigma_y \) are the means and standers deviations of \( p_x \) and \( p_y \).
5. **Inverse Difference Moment (IDM):**
Inverse Difference Moment is also called the "Homogeneity" Mathematically, it can be written as:

\[ IDM = \sum_i^{Ng} \frac{1}{1+(i-j)^2} p(i,j) \] ..................(23)

6. **Variance (VA):**
The Variance (VA) is a measure of variation. A variance of zero indicates that all the values are identical. A non-zero variance is always positive: A small variance indicates that the data points tend to be very close to the mean and hence to each other, while a high variance indicates that the data points are very spread out from the mean and from each other.

\[ VA = \sum_i^{Ng} (i - \mu_x)^2 p_x(i) \] .............................(24)

7. **Sum Average (SA)**

\[ SA = \sum_k^{2Ng-2} kp_{x+y}(k) \] .............................(25)

8. **Sum Entropy (SE):**

\[ SE = -\sum_k^{2Ng-2} p_{x+y}(k) \log_2 p_{x+y}(k) \] .............................(26)

9. **Sum Variance (SV)**

\[ SV = \sum_k^{2Ng-2} (k - SA)^2 p_{x+y}(k) \] .............................(27)

10. **Difference Entropy (DE)**

\[ DE = -\sum_k^{Ng-1} p_{x-y}(k) \log_2 p_{x-y}(k) \] .............................(28)

11. **Difference Average (DA)**

\[ DA = \sum_k^{Ng-1} kp_{x-y}(k) \] .............................(29)

12. **Difference Variance (DV)**

\[ DV = \sum_k^{Ng-1} (k - DA)^2 p_{x-y}(k) \] .............................(30)
13. information measures of correlation 1:

\[ inf1 = \frac{H_{XY} - H_{XY1}}{\max \{H_{XHY}\}} \] .................................(31)

14. information measures of correlation 2:

\[ inf2 = \left(1 - \exp[-2.0(H_{XY2} - H_{XY})]\right)^{1/2} \] .................................(32)

\[ H_{XY} = -\sum_{i}^{N_g} \sum_{j}^{N_g} p(i,j) \log(p(i,j)) \] .................................(33)

\[ H_{XY1} = -\sum_{i}^{N_g} \sum_{j}^{N_g} p(i,j) \log\{p_x(i)p_y(j)\} \] .................................(34)

\[ H_{XY2} = -\sum_{i}^{N_g} \sum_{j}^{N_g} p_x(i)p_y(j) \log\{p_x(i)p_y(j)\} \] .................................(35)

After calculated all thirteen parameter by haralick equations, calculated correlation coefficient between them and plot the characteristics curve; to choose the best parameter which have good performance and gives the true result to detect the tumor. That to facility the study parameters in the following terms:

- Homogeneous: the specific parameter must be homogeneity in one case (normal or abnormal in this project) and has a significant difference between the cases.

- Uncorrelated: also the parameters will choose as input to ANNs it must be uncorrelated between them every one it has different effect in image from another and Covering all properties of feature.

- Coherent: the parameter must be coherent and it does not has interface between them.

Finally, choose eight parameter that has best performance in neural networks training process: Energy, Inertia, Entropy, Inverse Difference Moment, Sum Variance, Sum Entropy, Difference Variance and Difference Entropy, This texture feature used as input parameters of image for back propagation neural networks to detect the tumor from MRI image (normal or abnormal) Appendix (A).
4.7 Artificial Neural Networks

In this project was used back propagation network which one of Artificial neural networks types.

4.7.1 Back propagation Network

*Creating a Network:* was Create feed-forward back propagation network by `newff` function in toolbox of matlab with three layers input layer with eight(8) preceptron or processing elements, hidden layer with twenty(20) preceptron or processing elements and output layer with two(2) processing elements. Also it requires three arguments and returns the network object. The first argument is a matrix of sample R-element input vectors. The second argument is a matrix of sample S-element target vectors. The sample inputs and outputs are used to set up network input and output dimensions and parameters. The third argument is an array containing the sizes of each hidden layer. (The output layer size is determined from the targets). It has 8-element input vectors that mean the best eight feature or parameter of images, 2-element target and output vectors for classifier the input to normal and abnormal(with or without tumor).

*Training the Network:* after create the network the training processing come. For this proposed used `train` function in toolbox of matlab. first identified the transfer function of the training to be used in each layer. was used tangent sigmoid transfer function fig4.3. Transfer functions calculate a layer's output from its net input by using training Algorithm[34]. The type of back propagation network training is supervised learning which it best method for simples that has nonlinear transformation like sigmoid transfer function. The weights in an ANN express the relative strengths(or mathematical values) of the various connections that transfer data from layer to layer. in supervised learning initializes the weights and biases of the network it can be automatically.
Back propagation Algorithm: There are many variations of the back propagation algorithm, the BPN for one iteration is obtained by Eq.36 to adjust the weights values.

\[ x_{k+1} = x_k - \alpha_k g_k \]  

(36)

Where: \( x_k \) is a vector of current weights and biases, \( g_k \) is the current gradient and \( \alpha_k \) is learning rate.

4.8 Graphic User Interface(GUI):

In this section was built window of Graphic User Interface(GUI) to describe all the proposed algorithm for brain tumor detection from load image to detect the tumor. The GUI window contains six panel:

- Panel of input data: is the start of proposed a logarithm which contains the MRI images that wanted to classify it.
- Panel of image processing: its composed from load original image, pre-processing, segmentation, morphological operation feature extraction and the tumor in original image.
- Panel of axis: this contains eight axis to display the each step result of imaging processing.
- Panel of result of detection: display the result of detection; normal or abnormal.
Panel consist from reset to restart the window of GUI and exit to close and exit from GUI window.

The algorithm described in this project is developed and successfully trained in Matlab version R2008 a using a combination of image processing and neural network toolbox.
CHAPTER FIVE

RESULTS AND DISCUSSION
CHAPTER FIVE
5. RESULTS AND DISCUSSION

5.1 Results Overview

This section presents and analyzes the results of all a logarithm method that described in chapter three. The algorithm method successfully applied in Matlab version R2008 using a combination of image processing and neural network toolbox.

5.1.1 Results of Haralick’s Features

This shows all the statistical characteristics of Haralick’s features for normal and abnormal MRI images data processed from fig.5.1 to fig.5.13 to know the correct selection from the parameters and gives the true result of tumor detection. So it plotted in the curve and calculated the correlation between them to facilitate the study parameters in the following terms: Homogeneous, uncorrelated, and coherent.

![plot Energy parameter vs all Normal and Abnormal](image)

Figure 5. 1Energy’s feature for 101 abnormal and 102 normal
Figure 5. 2 correlation’s feature for 101 abnormal and 102 normal.

Figure 5. 3 Inertia’s feature for 101 abnormal and 102 normal.

Figure 5. 4 Entropy’s feature for 101 abnormal and 102 normal.
Figure 5. 5 Inverse Difference Moment’s feature for 101 abnormal and 102 normal.

Figure 5. 6 Sum Average’s feature for 101 abnormal and 102 normal.

Figure 5. 7 Sum Variance’s feature for 101 abnormal and 102 normal.
Figure 5. 8 Sum Entropy’s feature for 101 abnormal and 102 normal.

Figure 5. 9Diff-Average’s feature for 101 abnormal and 102 normal.

Figure 5. 10 Diff-Variance’s feature for 101 abnormal and 102 normal.
Figure 5. 11Diff- Entropy’s feature for 101 abnormal and 102 normal.

Figure 5. 12Info-correlation-1 feature for 101 abnormal and 102 normal.

Figure 5. 13 Info-correlation-2 feature for 101 abnormal and 102 normal.
From above figures was selected the best eight feature and used as input to Artificial neural network.

5.1.2 Result of the Image Processing:
This show and summarized the results of all image processing steps for two images; original image, preprocessing, threshold segmentation, morphological operations and the tumor in image see fig.5.14.

5.1.3 Results of Artificial Neural Networks Training:
This is result of Back propagation Artificial neural networks training and performance of training for best eight parameter and random choose different parameter.

A. Result of random parameter:
First, choose eight random parameter from thirteen Haralick’s features to test the performance of Artificial Neural Networks, the parameter are: Energy(EG), Correlation(CO), Inertia(IN), Entropy(EN), Sum Average(SA), Difference Average(DA), Information measure of correlation-1(IC-1) and Information measure of correlation-2(IC-2) and their performance to detect the tumor is show in fig(4-15) in confusion matrix of networks. And then choose another eight features; Sum Average(SA), Sum Variance(SV), Sum Entropy(SE), Difference Average(DA), Difference Variance(DV), Difference Entropy(DE), Information measure of correlation-1(IC-1) and Information measure of correlation-2(IC-2) and their performance to detect the tumor is show in fig(5-14) in confusion matrix of networks. Finally, choose another eight parameter Energy(EG), Correlation(CO), Inertia(IN), Entropy(EN), Sum Variance(SV), Sum Entropy(SE), Information measure of correlation-1(IC-1) and Information measure of correlation-2(IC-2) and their performance to detect the tumor is show in fig(5-16) in confusion matrix of networks.
figure 5. 14 steps of region segmentation
B. Result of best parameters:
This is the results of the best eight parameter (features) which used to detect the
tumor in this project, the parameter are: Energy(EG), Inertia(IN), Entropy(EN),
Inverse Difference Moment(IDM), Sum Variance(SV), Sum Entropy(SE),
Difference Variance(DV) and Difference Entropy(DE). The effect of these
feature for training process of networks show from fig.5.17 to fig.5.24.

figure 5. 15 confusion matrix of (Energy, Correlation, Inertia, Entropy, Sum Average, Difference
Average, Information measure of correlation 1 and Information measure of correlation 2)
figure 5. 16 confusion matrix of (Sum Average, Sum Variance, Sum Entropy, Difference Average, Difference Variance, Difference Entropy, Information measure of correlation 1, Information measure of correlation 2)

figure 5. 17 confusion matrix of (Energy, Correlation, Inertia, Entropy, Sum Variance, Sum Entropy, Information measure of correlation-1 and Information measure of correlation-2)
figure 5. 18 Architecture of Backpropagation Neural Network Training for best eight feature

figure 5. 19 confusion matrix of best eight feature
figure 5. Plot performance of best eight feature.

figure 5. Plot Training State of best eight feature.
figure 5. 22 Architecture of Backpropagation Neural Network Training for best eight feature for 300 data.

figure 5. 23 Confusion matrix of best eight feature for 300 data
Figure 5.24 plot performance of best eight feature for 300 data.

Figure 5.25 plot Training State of best eight feature for 300 data.
5.1.3 Results of Graphic User Interface (GUI):
this section presented result of Graphic User Interface (GUI) widow to describe all the proposed algorithm for brain tumor detection from load image to detect the tumor step-by-step.

![GUI window for Automatic Brain tumor detection](image1)

*figure 5. 26GUI window for Automatic Brain tumor detection*

![Image selector and load Original Image](image2)

*figure 5. 27 Image selector and load Original Image*
figure 5. 28 Pre-processing of Image

figure 5. 29 Image segmentation
figure 5. 30 Enhance Image segmentation

figure 5. 31 Apply Morphological Operation
figure 5. 32 Feature Extraction

figure 5. 33 The Tumor in Original Image
figure 5. 34 The Recognition of ANNs and the Result of Detection

figure 5. 35 The Result of Detection
5.1.4 Efficiency of the Results:
The efficient of proposed algorithm can be calculate by predictive values. There are four predictive values: true positive value (TP), true negative value (TN), false positive value (FN) and false positive value (FP). This used to calculate the performance of proposed algorithm results which applied in MRI images by sensitivity, specificity and accuracy of the system[35].

The calculation for test images (images used for test after training process) show in table (5.1).

Table 5.1: Predictive values (TP, TN, FP and FN) of the system

<table>
<thead>
<tr>
<th>Statement</th>
<th>Abnormal</th>
<th>Normal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>47(TP)</td>
<td>0(TN)</td>
<td>47</td>
</tr>
<tr>
<td>Negative</td>
<td>1(FP)</td>
<td>52(FN)</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>52</td>
<td>100</td>
</tr>
</tbody>
</table>
The sensitivity: This is the probability of positive result given that the subject has the disease.

\[
\text{Sensitivity} = \frac{TP}{TP+FP} \times 100 \quad \text{..................(37)}
\]

\[
\text{Sensitivity} = \frac{47}{47+1} \times 100 = 97.92\%
\]

The specificity: This is the probability of negative result given that the subject does not have the disease.

\[
\text{Specificity} = \frac{TN}{FN+TN} \times 100 \quad \text{..................(38)}
\]

\[
\text{Specificity} = \frac{52}{52+0} \times 100 = 100\%
\]

Accuracy: Accuracy is how close a measured value is to the actual (true) value.

\[
\text{Accuracy} = \frac{\text{Number of correct data}}{\text{Number of all data}} \quad \text{..................(39)}
\]

\[
\text{Accuracy} = \frac{99}{100} = 0.99
\]

5.2 Discussions:

After collected the database from Whole Brain Atlas, then applied the preprocessing steps, this process effect for in image and change the some in formations of images for this reasons was calculated the mean square error. The values of mean square error (MSE) between original images and after applied preprocessing steps for all MRI images database that used in this project are less than 0.3 that mean preprocessing does not reduce the information of images.

In section (5.1.1) the results of Haralick’s features in plot figures can be observed some figures like fig(5.1), fig(5.5) fig(5.7) fig(5.8) and fig(5.11), their values versus the abnormal cases (form begging to 101) they have very variation because the tumor has different type of cell which has various intensity in their images; but in the normal cases (from 102 to 203 in x axis) the values are
homogeneity and have a little variation, that can very easily distinguish between normal and abnormal cases, also in figures: fig (5.3) and fig(5.10) Can be observed the values of abnormal have very variation and some homogeneity in abnormal images, that can easily distinguish between normal and abnormal cases, and in the figures: fig(5.2), fig(5.6), fig(5.9), fig(5.12) and fig(5.15) it difficult distinguish between the normal and abnormal. So the Energy(EG), Inertia(IN), Entropy(EN), Inverse Difference Moment(IDM), Sum Variance(SV), Sum Entropy(SE), Difference Variance(DV) and Difference Entropy(DE) were selected as the best and suitable features to detect the tumor in MRI images.

In section (5.1.3) when the select eight feature randomly contains (just three from suitable features and five from unsuitable features ) the performance of network in training state is equal 86.6% in confusion matrix see fig(5.14) and when choose another eight contains(four from suitable and four from unsuitable ) the performance of network in training state is equal 96.2% see fig(5.15), and it equal 96.7% for (five from suitable and three from unsuitable) see fig(5.16); but when choose all the suitable eight feature the performance equal 100% see fig(5.18).

Finally from section (5.1.4) evaluate the result by applied 100 cases(52 normal and 48 abnormal) in network after the training process. The proposed algorithm reaches accuracy about 99%, and sensitivity about 97.9%. Notice that the proposed method and their algorithm gave acceptable results according for it is sensitivity and accuracy percentage and anther methods.
CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS
CHAPTER SIX
6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This thesis aimed to design automatic algorithm to detect the brain tumor from MRI images by Artificial neural networks. This algorithm has been successfully designed. The data collected from Whole Brain Atlas website and its prepared by pre-processing and post-processing operation to make it suitable to detect.

The statistical feature analysis was used to extract features from images; the features computed from equations of Haralick’s features based on the spatial gray level dependency matrix (SGLD) of images. Then selected the suitable and best eight features to detect the tumor from thirteen Haralick’s features.

For artificial neural networks the feed-forward back propagation neural network with supervised learning was used to classify the images to with or without tumor. And all the best eight features were used as input parameters for back propagation network, then the network was trained and its performance was evaluated.

Finally; the proposed algorithm, which based on the back propagation network has been successfully tested and achieved the best results with accuracy 99%, and sensitivity 97.9%.

And all the results of this study step by step were presented in window of Graphic User Interface (GUI).

The system is designed to be user friendly by creating Graphical User Interface (GUI). The proposed system efficiently classifies the MRI brain tumor images. The tumor is isolated from the MRI brain images by using integrated image processing algorithm based on a modified method texture detection algorithm spatial gray level dependency matrix (SGLD) of images using MATLAB.
The brain tumor detection and classification is successfully implemented by using the image processing tool box, neural network tool box and graphical user interface.

6.2 Recommendations:

Diagnosis of brain tumors is dependent on the detection of abnormal brain structure, but the successful treatment of brain tumors depends on a number of factors such as the type, location and size of the tumor. As diagnosis tumor is a complicated and sensitive task; therefore, accuracy and reliability are always assigned much importance. The algorithm designed in this study is proposed for brain tumor classification from MRI data by means of texture analysis based on GLCM to train the ANNs. In this work study a suitable artificial neural network classifier is designed used back propagation algorithm to identify the brain tumors with good accuracy.

The following recommendations are suggested:

- There is need for automated classification of brain tumor built in modern imaging technology, and it is vital to develop a system with novel algorithms to detect brain tumor efficiently at early stages.
- More features that could be added in addition to the Haralick’s feature to the system include metabolic and genetic data as well as anatomical attributes of the brain.
- Develop the proposed algorithm to classify abnormal feature into benign and malignant tumor or according to type of brain tumors.
- Design auto dynamic brain tumor detection system, detect the tumor according to its size, direction and shape in image.
- The system can further be further used for classification of images with different pathological condition, types and disease status by using
other types of image modalities (e.g. CTS canner, PET, MRS, and mammogram) for cancers classification.
REFERENCES


Available: http://www.nhs.uk/conditions/MRIscan/Pages/Introduction.aspx


http://www.med.harvard.edu/aanlib/home.html


APPENDIX
APPENDIX

Features of The Data:

This section presents the thirteen features of MRI images; normal and abnormal which used in this project. These features calculated by using the haralick’s equations.

The Haralick's texture features are: Energy(EG), Correlation(CO), Inertia(IN), Entropy(EN), Inverse Difference Moment>IDM), Sum Average(SA), Sum Variance(SV), Sum Entropy(SE), Difference Average(DA), Difference Variance(DV), Difference Entropy(DE), Information measure of correlation-1(ICO-1) and Information measure of correlation-2(ICO-2) in the table below:

Table(A1) show features of the data:

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Correlation Coeffeciant between the features of images:

Correlation quantifies the extent to which two quantitative variables, X and Y, “go together.” When high values of X are associated with high values of Y, a positive correlation exists. When high values of X are associated with low values of Y, a negative correlation exists. If the correlation is 0 that mean no correlation between them. The correlation coefficients of Haralick’s Features show in the table bellow.

Table(A2) show correlation coeffeciant between the features:

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