CHAPTER ONE

1. INTRODUCTION

1.1 General overview

Many reports have demonstrated that cognitive abnormalities commonly occur in patients with the Human Immunodeficiency Virus (HIV) infection. Cognitive deficits among healthy HIV-positive patients are thought to be infrequent, but some investigators suggest that more sensitive measures may be needed to detect the mild cognitive decline during asymptomatic stage. Diagnosis of Acquired

Immune Deficiency Syndrome (AIDS) is primarily determined based on immunological and medical factors. Early diagnosis and treatment of HIV dementia are especially important because patients with early-stage dementia may show a reversal of their cognitive deficits and neurochemistry abnormalities after treatment. While individual scientific disciplines have documented the evidence of specific brain pathology in HIV, few studies have been able to directly examine abnormalities of brain function that underlie HIV- related cognitive and motor impairments. The underlying neuro-anatomic substrate for these neuropsychological deficits is unknown. Non-invasive neuro-imaging technique may play an important role in the study of the patient with HIV infection. Recently, a variety of functional neuro-imaging techniques, such as positron emission tomography (PET) , single photon emission computerized tomography (SPECT) , magnetic resonance spectroscopy (MRS), and functional magnetic resonance imaging (fMRI), have been applied to evaluate physiologic changes in the brains of patients with HIV. fMRI is an ideal technique to study cerebral activation because it is non-invasive and nonradioactive. Therefore, It could be performed repeatedly. [1]

With the advances of digital image processing, radiologists have a chance to improve their performance with computer-aided detection and diagnosis (CAD) system; this technology intends to provide assistance to the MRI abnormalities detection, reducing misdiagnosis, thus allowing better treatment and diagnosis.

1.2 The Problem Statement

Researchers have found significant damage in the brains of HIV-positive patients whose viral load is effectively suppressed by anti-retroviral therapy,[2](But It is unclear how HIV cause such brain injury. Understanding these mechanisms is important to develop appropriate neuro-protective interventions for those people in Sudan, Africa and all over the world.

1.3 Thesis Objectives

The objectives of this Thesis are:

1. The main objective at this work is to develop an algorithm which can be used to explore the effect of HIV/AIDS on human brain based on MRI images.

2. To Compare the variations of brain cells between normal and abnormal cases.

3- To select the suitable features those provide clear results.

1.4 Thesis Organization

This Thesis consist of six chapters, first chapter is an introduction, second chapter which introduce the previous studies and the literature reviews , third chapter will provide the theoretical background, forth chapter will describe the research methodology , the result obtained and discussion of these results given in the fifth chapter and in the last chapter will contain conclusion and recommendations future work should be considered.

CHAPTER TWO

2. THEORETICAL BACKGROUND

This section aims to demonstrate the importance of the HIV/AIDS study and to provide some fundamental knowledge about disease. The anatomic structures of the brain are shown, as well as a description of the different stages of HIV. There is also a description of magnetic resonance imaging equipment and computer aided diagnosis (CAD) idea.

2.1 Introduction to the Brain

The brain controls and co-ordinates everything we do. Its purpose is to receive messages, process those messages and respond to them. The responses generated by the brain allow us to think, move, breathe, speak, show emotion and regulate all of our other bodily functions. The brain forms a part of our central nervous system.

It is a soft jelly-like substance weighing about three pounds on average and sits inside the skull, cushioned by a liquid known as cerebrospinal fluid. Although the brain only accounts for two percent of body weight, it uses twenty percent of the body's oxygen supply and blood flow.

2.1.1 Brain cells

The brain is made of billions of brain cells. Some cells, known as neurons are responsible for carrying messages to and from the brain. Other cells, known as glia provide the support structure for the neurons.

Neurons require oxygen to function, and begin to die within 3 to 5 minutes without it. The neurons themselves are quite fragile and need extensive protection from being crushed, infected or other harm.

The long fibrous parts of the neurons, called axons are prone to tearing when the brain is injured by sudden movements such as those that occur during a car accident. This can result in a form of injury known as diffuse axonal injury.

2.1.2Protective Layers

There are several layers of tissue that protect the brain. Beneath the skin of your scalp is bone (your skull). Below the skull are three special coverings called the meninges. Meningitis is an infection of the meninges. The outer layer of the meninges is called the dura. This is a tough thick layer which restricts the movement of the brain within the skull and so protects it from damage. Bleeding below this layer can result in a subdural haematoma. Bleeding above the dura can result in an extradural haematoma. The middle layer of the meninges is called the arachnoid. A bleed that occurs in the space between this layer and the next is a subarachnoid hemorrhage. The inner layer, the one closest to the brain, is called the pia mater.

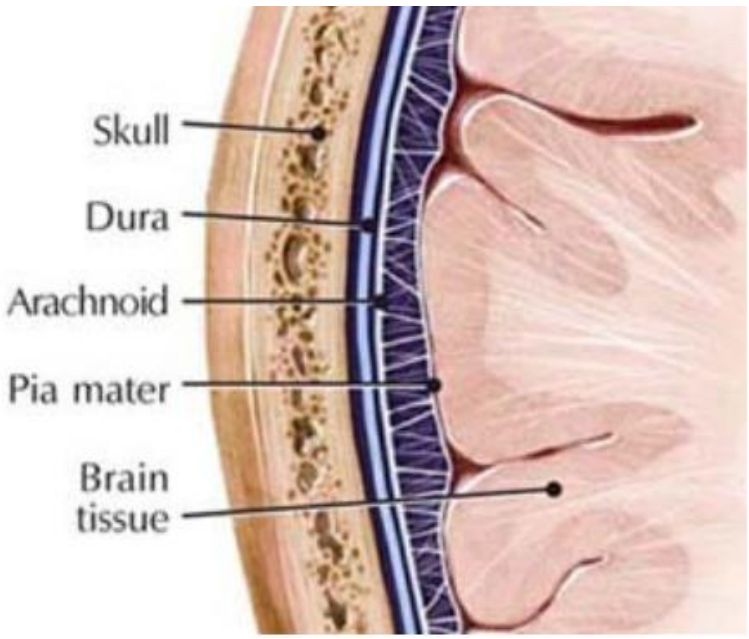

Figure2.1: the protective layers of human brain

2.1.3Internal Structure of the Brain

Over the course of its long evolution the brain has developed three major parts:

1) The cerebral cortex , or cerebrum is the large mass of tissue shaped like a wrinkled walnut.

2) The cerebellum is the fist-like structure located at the rear and base of the brain.

3) The brain stem is the lowest (and oldest in evolutionary terms) part of the brain connected to the spinal cord.

The cerebral cortex is divided into two halves or hemispheres, known as right or left cerebral hemispheres. The two hemispheres transfer information through a bridge of nerve fibers called the corpus callosum.

The left hemisphere controls the right side of the body. For most people the left hemisphere is involved in the understanding and expression of language. The right hemisphere controls the left side of the body, and is involved in spatial and artistic skills. Each half, or hemisphere of the cerebrum is divided into four areas known as lobes. The four lobes are: 1) Frontal lobe 2) Parietal lobe 3) Temporal lobe and 4) Occipital lobe

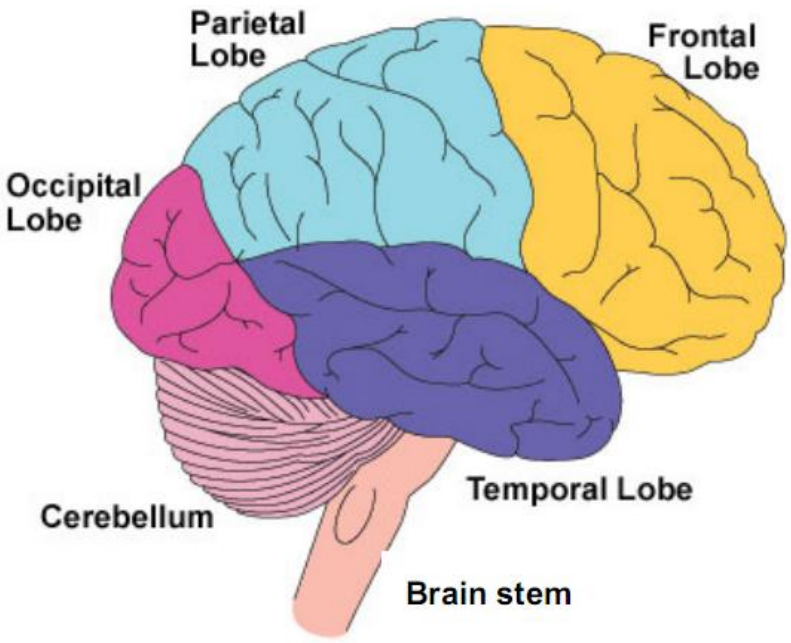

Figure 2.2: the human brain lobes

2.2 Functions of each part of the brain

Lobes of the cerebrum:

The frontal lobe is located behind the forehead and is involved in tasks such as reasoning, planning, problem-solving and organizing along with acting as a control for personality, behavior and emotions. Marked changes in a person's personality and social skills can occur from damage to this area. The motor cortex at the back of the frontal lobes controls movement. The parietal lobe controls the sense of touch including pressure, temperature and pain.

It is involved in fine motor movements, arithmetic and spelling .At the front of the parietal lobe is the sensory cortex which runs in line with the motor cortex in the frontal lobe. This controls our perception and how we interpret sensation and movement.

The temporal lobe is involved in receiving and processing auditory information e.g. music and speech and plays a major role in memory storage and learning. The occipital lobe is situated at the back of the head and is instrumental in controlling the sense of sight.

2.2.1The cerebellum

The cerebellum helps to regulate balance and co-ordination. It provides a "feedback mechanism" to adjust muscle activity so that balance is maintained. It also plays a role in regulating muscle tone.

2.2.2The brain stem

The brain stem comprising of the pons and medulla oblongata regulates essential life functions such as breathing, heart rate and blood pressure. It also serves as a "relay station" for messages regarding movement and sensation. Cranial nerves are located in the brain stem, which regulate a number of functions such as swallowing, speech and eye movement.

2.2.3 The limbic system

The limbic system which is sometimes known as the "emotional brain," is found buried within the cerebrum near the temporal lobe and is made up of the thalamus, hypothalamus, amygdala and hippocampus.

This system deals with sensory information such as vision, controls hunger and thirst. It also plays a role in emotions such as fear and is essential in memory and the process of memory retrieval and learning. [3].

2.3 Introduction of HIV:

HIV is the abbreviation used for the Human Immunodeficiency Virus. HIV attacks the body's immune system. Normally, the immune system produces white blood cells and antibodies that attack viruses and bacteria. The infection fighting cells are called T-cell lymphocytes. Months to years after a person is infected with HIV, the virus destroys all the T-cell lymphocytes. This disables the immune system to defend the body against diseases and tumors. Various infections will be able to develop; these opportunistic infections take advantage of the body's weakened immune system. These infection which normally won't cause severe or fatal health problems will eventually cause the death of the HIV patient.

With the rapidly increasing number of cases, it was soon recognized that other life threatening infections and neoplastic diseases were also observed and found to be associated with an unexplained defect in cell mediated immunity, common to each of these patients.

By early 1982 the group of disease entities was named the acquired immune deficiency syndrome (AIDS) by the Center for Disease Control (CDC).The term "syndrome" has been used because AIDS does not constitute a single illness, but rather encompasses a wide range of clinical diseases including specific life threatening infections and neoplasm's associated with a profound and irreversible unexplained acquired disorder of cell mediated immunity.

When the first cases of AIDS were reported, many hypotheses were proposed to explain the possible cause(s) of the newly recognized syndrome, but it is now widely accepted that AIDS is caused by a previously unknown human retrovirus, which was initially discovered and isolated in 1983 from patients with persistent generalized lymphadenopathy at the "Institute Pasteur" in Paris.

All the related viruses which were discovered were named the human immunodeficiency virus (HIV) by the International Committee on the Taxonomy of Viruses in 1986.

Untreated HIV disease is a chronic progressive process that begins with infection, is often followed by a "primary HIV syndrome," and progresses in adults over a median period of more than 10 years to the late stage: AIDS. From the time of infection, the virus continuously and rapidly replicates, mutates, and as a result diversifies and evolves in response to selective pressure. Immune system damage also begins upon infection. The burden of virus and the bulk of this process occurs in lymphoid tissue, and the immune system struggles to hold the process in check. Slowly, but relentlessly, the process destroys essential components of the host immune system. Progression is often accelerated in infants with prenatal HIV infection. Eventually the host becomes increasingly susceptible to and eventually dies as a result of complications of opportunistic infections and malignancies resulting from immune system dysfunction.

AIDS: The syndrome called AIDS (Acquired Immuno Deficiency Syndrome) is the late stage of HIV disease.

ARC: The term AIDS Related Complex has been abandoned, because the signs labeled with this term are manifestations of the middle stage of HIV disease.

PGL: The Progressive Generalized Lymphadenopathy syndrome is a common manifestation of early and middle stage HIV disease but it has no prognostic significance

HIV disease is a continuum of progressive damage to the immune system from the time of infection to the manifestation of severe immunologic damage by

opportunistic infections, neoplasm's, wasting, or low CD4 lymphocyte count that define AIDS.

The current worldwide expansion of the AIDS epidemic is primarily driven by the sexual transmission of human immunodeficiency virus type 1 (HIV-1), and its future will be determined largely by the degree to which sexual transmission can be reduced. HIV-2 is thought to be less infectious than HIV-1 although few data are available. HIV-2 infected individuals generally have a lower viral titer in peripheral blood samples than those infected with HIV-1, and incidence rates of infection appear lower in cohorts at risk for HIV-2 than among comparable populations at risk for HIV-1. Transmission of HIV among injection drug users occurs primarily through HIV infected blood contamination of injection paraphernalia, which is re-used by an uninfected injection drug user. Transmission of HIV by blood, blood products, tissue transplantation and artificial insemination, perinatal transmission of human immunodeficiency virus.

Testing serum for antibodies to HIV with a standard ELISA is currently the most common, cost effective, and accurate method of screening for infection.

2.3.1 Clinical course of untreated HIV disease

Primary infection, Early and Middle Stages of HIV Disease, Advanced HIV Disease & Late-Stage HIV Disease. Death eventually results from extensive disease of vital organs, most commonly the lungs, and presumably from effects of circulating toxins, electrolyte abnormalities, hematopoietic and circulatory failure, and autonomic nervous system damage.

2.3.2 Clinical manifestations of HIV Disease

Fever, wasting syndrome as a weight loss, Oral manifestations , Dermatologic manifestations , Neurological dysfunction's , Respiratory syndromes , cardiac abnormalities , Endocrine abnormalities, Hematologic abnormalities, Renal manifestations, Gastrointestinal manifestations, Ophthalmic manifestations, Otolaryngologic manifestations.

2.3.3 HIV and AIDS - An Important Distinction

Human Immunodeficiency Virus (HIV), HIV is a virus that aggressively attacks the immune system. Part of the reason HIV is such a serious disease is that it attacks and destroys cells of the immune system, called T-cells or CD4 cells that are designed to fight infections and diseases.

2.3.4 Function of CD4 Cells

CD4 Cells, also known as T-cells or "helper" cells, are white blood cells essential to a healthy immune system which protects the body against bacterial, fungal, and viral infections. With a depleted immune system, the body will experience "opportunistic infections" which take advantage of the body's inability to fight infection, this characterizes AIDS stage.

A normally functioning immune system has a "CD4 count" between 400-1600 per cubic millimeter of blood in men, and between 500-1600 in women. A normal CD4 count can fluctuate slightly due to factors such as a good night's sleep, nutrition, menstruation among women, and the use of other medications or treatments. However, with HIV a person's CD4 count will drop severely usually stabilizing around 500-600 parts per cubic millimeter. It is estimated that without treatment, CD4 cells will continue to deplete by approximately 45 cells every six

months, with greater declines among those with higher CD4 counts before HIV infection.

A CD4 count of 200-500 indicates that damage to the immune system has occurred.

CD4 counts are typically used to help determine when antiretroviral treatment is needed, and it is recommended that once CD4 counts drop below 200-250 treatment is needed to prevent opportunistic infections and progression to the AIDS stage.

Although a person infected with HIV can live a normal life for many years with no visible Evidence has also shown that if a person's CD4 count drops below 200, they are unlikely to respond well to treatment. This demonstrates the importance of well managed and accessible diagnostic treatment in the developing world, as people are being placed at higher rate of AIDS related illnesses without access and adherence to treatment in a timely fashion.[4]

2.4 MRI Equipment

MRI is a way of getting pictures of various parts of your body without the use of x-rays, unlike regular x-rays pictures and CAT scans. A MRI scanner consists of a large and very strong magnet in which the patient lies. A radio wave antenna is used to send signals* to the body and then receive signals back. These returning signals are converted into pictures by a computer attached to the scanner. Pictures of almost any part of your body can be obtained at almost any particular angle. [5]

* These "radio wave signals" are actually a varying or changing magnetic field that is much weaker than the steady, strong magnetic field of the main magnet. Figure2.1

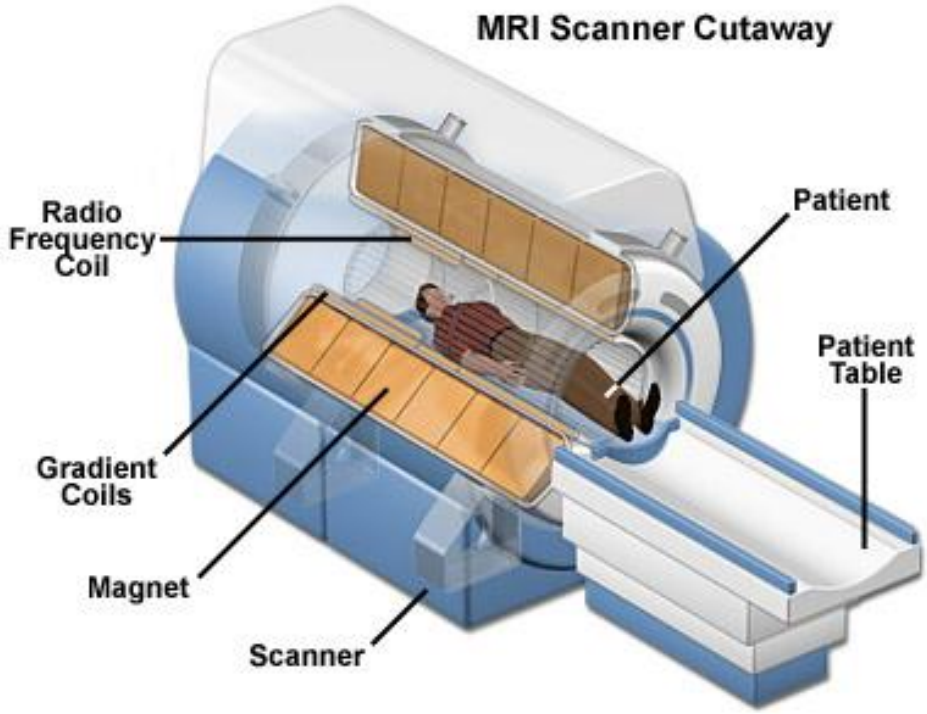

Figure 2.3 MRI equipment

2.4.1 Principle of working

2.4.2 Magnets with Muscle

The basis for this method is the behavior of atomic nuclei of certain elements when subjected to a strong constant magnetic field plus superimposed variable magnetic fields and then further modified by radio waves of frequencies that induce these nuclei into resonant states. Hydrogen is the usual element investigated by MRI but

Carbon, Phosphorus and some other elements are also capable of being responsive to the process. In such elements, the nucleus of each atom is spinning around an axis of rotation. Atoms of Hydrogen (which makes up about 60% of the body's soft materials) in their normal state have their individual axes (spin vector) spatially oriented at random. But, when subjected to an intense external magnetic field that is held constant (static), the hydrogen-bearing material (e.g., human tissue) is said to be itself magnetized to some degree. The hydrogen nucleus (single unpaired proton) behaves as a "tiny magnet" in which its axis tends to align parallel to the magnetic lines of force produced by the magnet that is a key part of an MRI instrument; its spin axis will also precess (wobble) around the direction of the external field. Like a compass needle, this hydrogen "magnet" can also be considered to be dipolar, with a "north" (parallel to the external field) and a "south" (anti parallel) end to the magnetic moment. Statistically, when hydrogen protons are thus aligned there are about as many oriented in one direction as the opposite one (in terms of polarity) and therefore the assemblage will almost cancel out in terms of net magnetization. There will not be an exact balance, so that a few atoms (of the billions of billions in, say, the human body's soft tissue) thus unmatched will remain in a free magnetic state that allows manipulation by small varying magnetic fields and by radio waves [6].

2.4.3 Slicing and Dicing

Responsible for that racket are the gradient magnets [7]. There are three of them in the scanner (called x, y and z), each oriented along a different plane of your body, all of them far less powerful than the main magnet. But what they lack in strength they make up for in precision. They modify the magnetic field at very particular

points and work in conjunction with the RF pulses to produce the scanner's picture by encoding the spatial distribution of the water protons in your body. When rapidly turned on and off (which causes that banging noise), the gradient magnets allow the scanner to image the body in slices – sort of like a loaf of bread. Using medical terminology, the transverse (or axial, or x-y) planes slice you from top to bottom; the coronal (x-z) plane slice you lengthwise from front to back; and the sagittal (y-z) planes slice you lengthwise from side to side. However, the x, y and z gradients can be used in combination to generate image slices that are in any direction, which is one of the great strengths of MRI as a diagnostic tool. Figure 2

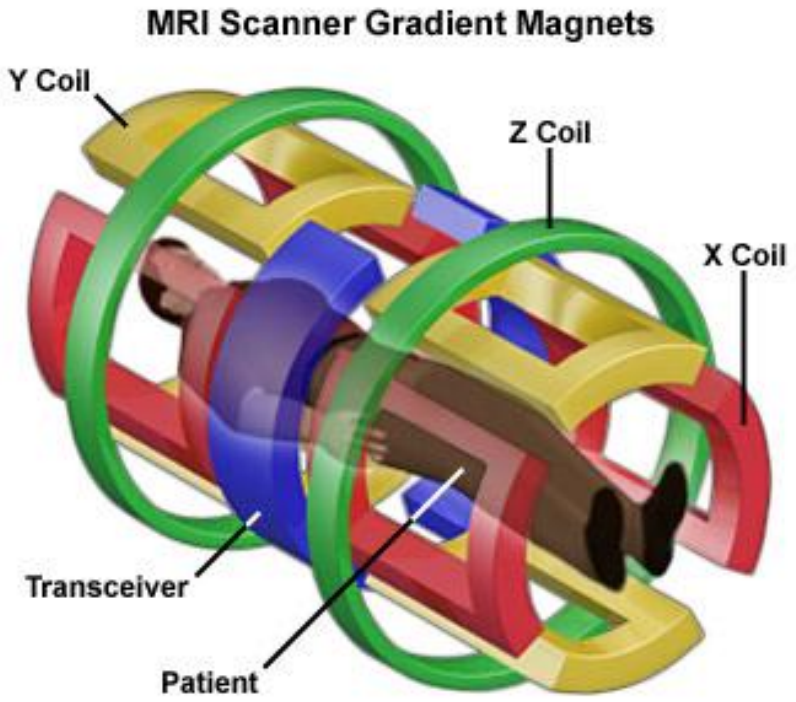

Figure 2.4: Slicing and Dicing

So, when alternating magnetic fields from auxiliary gradient magnets (of much weaker magnetic strength compared with the main magnet) [6] are superimposed on the hydrogen assemblage, those remaining (unbalanced) hydrogen protons will reach a new magnetic field state (B_1) and they experience new spin vector orientations, a change in precession angle (nutation), and oscillations that include a characteristic resonance frequency whose value lies in the Megahertz range (within the radio wave segment of the electromagnetic spectrum). A separate unit, coils that develop radio waves as pulses/second that can be tuned to the appropriate resonance frequency, produces a condition in which the protons absorb a specific amount of energy (resonance energy) and are therefore excited to a higher energy state as they acquire a new spin state and magnetic field strength B_1. When the alternating magnetic field is turned off, the protons revert to their lower energy state(s) (referred to as relaxation), giving off signals in the radio wave region of the EM spectrum that are detectable by radio receivers in the MRI unit. Since the B_1 field is repeatedly turned off and on, it produces a time varying magnetic field functioning as an electromagnetic wave. If the B_1 wave frequency is adjusted to match the proton precession frequency in the B_0 state (imposed by the master magnet), the hydrogen system as now influenced by the gradient magnet(s) is said to be in *resonance*. (Several factors govern the specific resonance frequency value, including the magnitude of the static field strength B_0.) Through electronic and computer processing (with sophisticated control programs, including construction of tomographic slices), these varying (in intensity) signals are used to construct images of the various spatially distinct organs and tissue that were subjected to magnetic resonance. Figure 2. 3

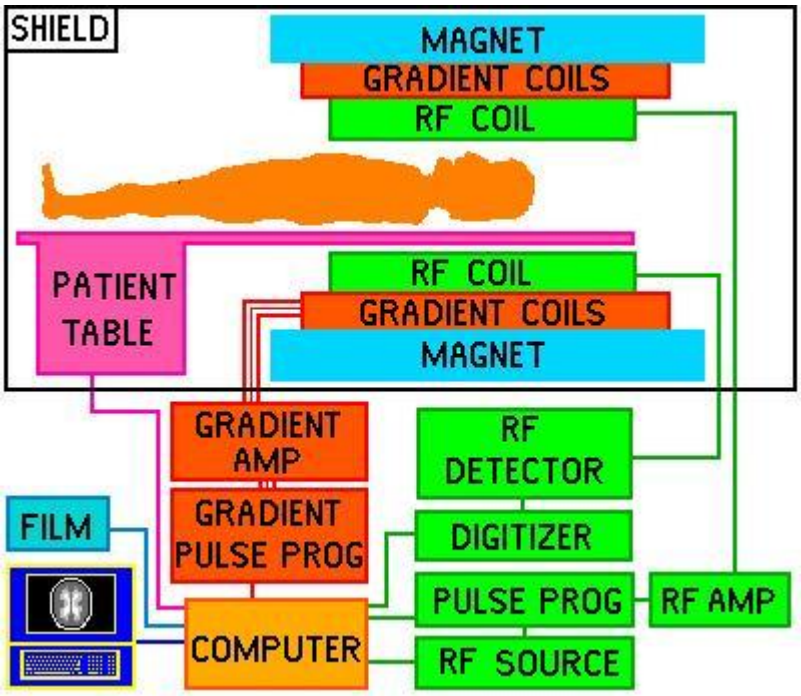

Figure 2.5 MRI Block diagram

2.5 Computer Aided Detection

Computer-aided diagnosis (CAD) has been developing fast in the last two decades. The main idea of CAD is to assist radiologists in interpreting medical images by using dedicated computer systems to provide 'second opinions'. The final medical decision is made by the radiologists. Studies on CAD systems and technology show that CAD can help to improve diagnostic accuracy of radiologists, lighten the burden of increasing workload, reduce cancer missed due to fatigue, overlooked or data overloaded and improve inter- and intra-reader variability. Two typical examples of application of CAD in clinical areas are the use of computerized systems in mammography and chest CT and radiography.[8]

Computed aided detection and computer aided diagnosis, both commonly abbreviated as CAD, can be defined as the detection and/or diagnosis made by the

radiologist considering the results of a computed algorithm which characterize lesions through automatic image analysis [9] [10].

CAD systems are used to assist radiologists to locate the abnormalities, being a second reader, rather than substitute the human diagnosis. This allows the reduction of variability in the radiologists.

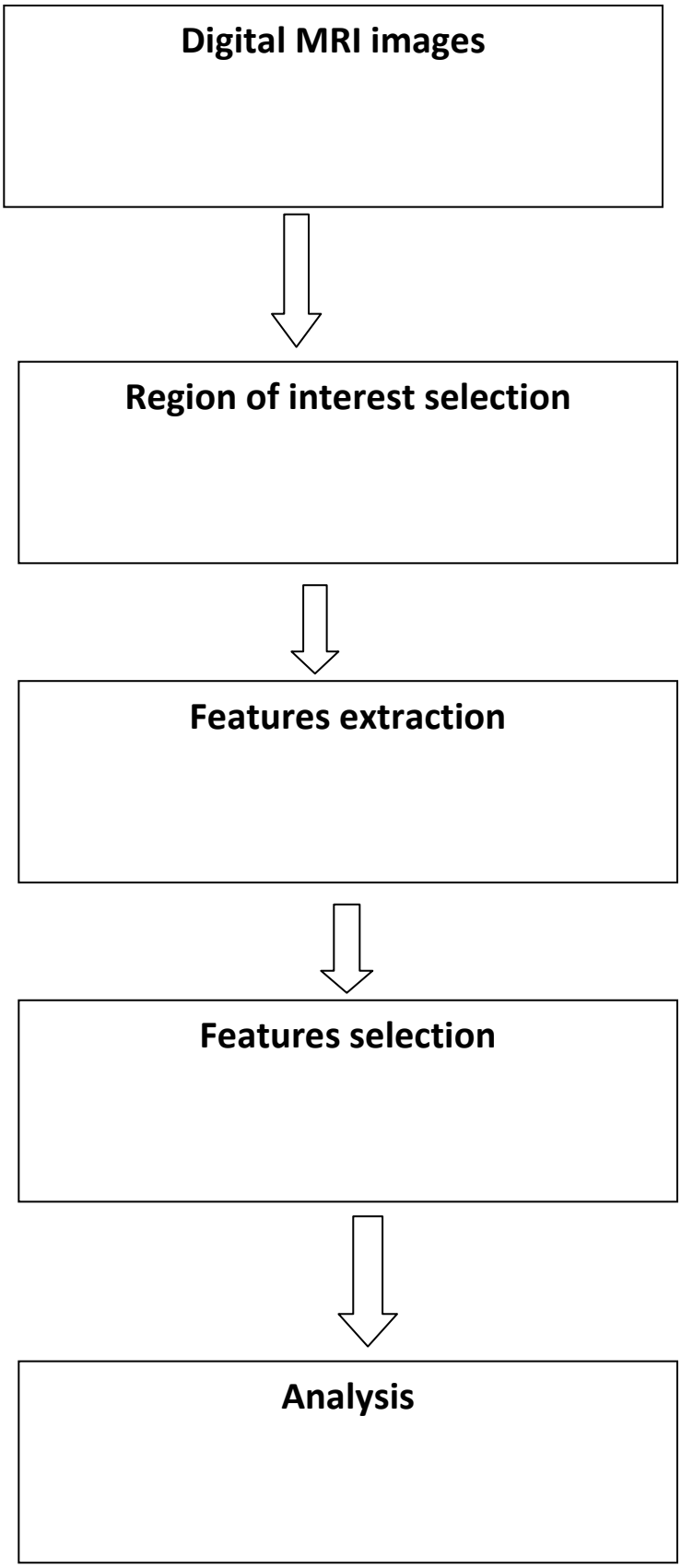

Figure 2.6 A schematic diagram for CAD system.

2.5.1 Texture analysis

Texture, the pattern of information or arrangement of the structure found in an image, is an important feature of many image types. In a general sense, texture refers to surface characteristics and appearance of an object given by the size, shape, density, arrange- ment, proportion of its elementary parts.[11]

Texture is observed in structural patterns of surfaces of objects .the visual texture is something that everyone understands it, but it is difficult to define. The term Texture generally refers to repetition of primitive texture elements called texels, the texels describe the spatial relations between them. Texture may be lightness, uniformity, density, roughness, regularity, linearity, frequency, phase, directionality, coarseness, randomness, fineness, smoothness, granulation, etc., of the texture as a whole. Approaches to texture analysis are usually categorized into

1. Structural,
2. Statistical,
3. Model-Based
4. Transform

2.5.1.1 Structural approaches

Structural approaches represent texture by well-defined primitives

(micro texture) and a hierarchy of spatial arrangements (macro texture) 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. The abstract descriptions can be ill defined for natural textures because of the variability of both micro- and macrostructure and no clear distinction between them.

2.5.1.2 Statistical approaches

Statistical approaches do not attempt to understand clearly the hierarchical structure of the texture. Instead, they represent the texture indirectly by the non-deterministic properties that govern the distributions and relationships between the grey levels of an image.

2.5.1.3 First-order statistics

First-order statistics measure the likelihood of observing a gray value at a randomly- chosen location in the image. First-order statistics can be computed from the histogram of pixel intensities in the image. These depend only on individual pixel values and not on the interaction or co-occurrence of neighboring pixel values. The average intensity in an image is an example of the first-order statistic.

2.5.1.4 Second-order statistics

Second-order statistics are defined as the likelihood of observing a pair of gray values occurring at the endpoints of a dipole (or needle) of random length placed in the image at a random location and orientation. These are properties of pairs of pixel values.

Methods based on second-order statistics (i.e. 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 common second-order

statistical features for texture analysis are derived from the so-called co-occurrence matrix [11]. They were demonstrated to feature a potential for effective texture discrimination in biomedical-images. The approach based on multidimensional co-occurrence matrices was recently shown to outperform wavelet packets (a transform-based technique) when applied to texture classification.

2.5.5 Model based method

Model based texture analysis 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. It can be used also for texture analysis and discrimination however; it lacks orientation selectivity and is not suitable for describing local image structures.

CHAPTER THREE

3. LITERATURE REVIEW

As **HIV/AIDS** (Acquired immunodeficiency syndrome AIDS is the final stage of HIV infection has shifted to a chronic, largely manageable condition, thanks to the advent of antiretroviral in the mid-1990s, Researchers have found significant damage in the brains of HIV-positive patients AIDS-related disorders of the nervous system may be caused directly by the HIV virus by certain cancers and opportunistic infections (illnesses caused by bacteria, fungi, and other viruses) that would not otherwise affect people with healthy immune systems or by toxic effects of the drugs used to treat symptoms.

AIDS dementia complex (ADC) or HIV Associated Dementia (HAD) occurs primarily in persons with more advanced HIV infection. Symptoms include encephalitis (inflammation of the brain), behavioral changes and a gradual decline in cognitive function including trouble with concentration, memory and attention. Persons with ADC also show progressive slowing of motor function and loss of dexterity and nation.

San Francisco Veterans Affairs Medical Center (SFVAMC) [12] mentioned ADC in a study; HIV can produce neurological abnormalities in any part of the nervous system, including the brain. HIV dementia is an advanced stage of neurological damage that before the advent of antiretroviral drug therapy afflicted some 20 percent of HIV patients.

Sean Cahill, PhD, Robert Valadéz [13]**,** MSW Study focuses on patients whose viral load is effectively suppressed by anti-retroviral therapy. Although it is not known whether any or all of the damage occurred before patients started drug therapy, even minor damage that is present now should serve as a warning, before

the advent of antiretroviral drug therapy, ADC afflicted some 20 percent of HIV patients.

Also suggested that the older the HIV positive patient gets "thanks to the antiretroviral" their brain function deteriorates naturally due to age or as side effects of the ARVs themselves.

Beau M. Ances et al [14].study stated that Biological similarities exist between aging and (HIV) infection found that statistically significant differences in functional brain activity occur in younger (<40years old). The results suggested that HIV infection and aging independently affect brain functional demands that are measurable by fMRI. The study showed that age and HIV erostatus were independent risk factors for the development of HIV-associated neurocognitive disorders.

The National Institute of Mental Health (NIMH) [15] satated that HIV Associated Neurocognitive Disorders (HAND) can occur when HIV enters the nervous system and impacts the health of nerve cells. There are several different types of HAND:

- Asymptomatic Neurocognitive Impairment (ANI) is diagnosed if testing shows HIV-associated impairment in cognitive function, but everyday functioning is not affected.
- Mild Neurocognitive Disorder (MND) is diagnosed if testing shows HIV-associated impairment in cognitive function, and mild interference in everyday functioning.
- HIV-associated Dementia (HAD) is diagnosed if testing shows marked impairment in cognitive function, especially in learning of new

information, information processing, and attention or concentration. This impairment significantly limits the ability to day-to-day function.

MND appears to be the most common type of HAND. Despite its name, even mild cognitive problems can interfere with everyday functioning and reduce quality of life. Neuropsychologic testing can reveal subtle deficits even in the absence of symptoms.

National Institute of Neurological Disorders and Stroke[16] presented that Based on the results of the individual's medical history and a general physical exam, the physician will conduct a thorough neurological exam to assess various functions: motor and sensory skills, nerve function, hearing and speech, vision, coordination and balance, mental status, and changes in mood or behavior. The physician may order laboratory tests and one or more of the following procedures to help diagnose neurological complications of AIDS. Brain imaging can reveal signs of brain inflammation, tumors and CNS lymphomas, nerve damage, internal bleeding or hemorrhage, white matter irregularities, and other brain abnormalities. Several painless imaging procedures are used to help diagnose neurological complications of AIDS .Computed tomography (also called a CT scan) uses x-rays and a computer to produce two-dimensional images of bone and tissue, including inflammation, certain brain tumors and cysts, brain damage from head injury, and other disorders. It provides more details than an x-ray alone.

- Magnetic resonance imaging (MRI) uses a computer, radio waves, and a powerful magnetic field to produce either a detailed three-dimensional picture or a two-dimensional “slice” of body structures, including tissues, organs, bones, and nerves. It does not use ionizing radiation (as does an x-ray) and gives physicians a better look at tissue located near bone.

- Functional MRI (fMRI) uses the blood's magnetic properties to pinpoint areas of the brain that are active and to note how long they stay active. It can assess brain damage from head injury or degenerative disorders such as Alzheimer's disease and can identify and monitor other neurological disorders, including AIDS dementia complex.
- Magnetic resonance spectroscopy (MRS) uses a strong magnetic field to study the biochemical composition and concentration of hydrogen-based molecules, some of which are very specific to nerve cells, in various brain regions. MRS is being used experimentally to identify brain lesions in people with AIDS.

Electromyography, or EMG, is used to diagnose nerve and muscle dysfunction (such as neuropathy and nerve fiber damage caused by the HIV virus) and spinal cord disease. It records spontaneous muscle activity and muscle activity driven by the peripheral nerves.

Biopsy is the removal and examination of tissue from the body. A brain biopsy, which involves the surgical removal of a small piece of the brain or tumor, is used to determine intracranial disorders and tumor type. Unlike most other biopsies, it requires hospitalization. Muscle or nerve biopsies can help diagnose neuromuscular problems, while a brain biopsy can help diagnose a tumor, inflammation, or other irregularity.

Cerebrospinal fluid analysis can detect any bleeding or brain hemorrhage, infections of the brain or spinal cord (such as neurosyphilis), and any harmful buildup of fluid. It can also be used to sample viruses that may be affecting the brain. A sample of the fluid is removed by needle, under local anesthesia, and studied to detect any irregularities. Mainly magnetic resonance imaging (MRI),

play an important role in the diagnosis and follow up of AIDS patients with neurological disorders.

Efsun Şenocak, et al [17] The brain may be affected by a variety of abnormalities in association with HIV infection. The spectrum of central nervous system (CNS) abnormalities can be divided into three main categories; HIV-associated lesions, opportunistic infections, and neoplasm. Although there is a considerable overlap in the imaging characteristics of different entities, some findings are found to be very suggestive of a particular disease and imaging modalities, mainly magnetic resonance imaging (MRI), play an important role in the diagnosis and follow up of AIDS patients with neurological disorders. In addition to infections and neoplasm,Catabolic trend of the metabolism of these immunodeficient patients with consecutive thiamine deficiency may result in Wernicke encephalopathy. **Ogawa, et al** [18] stated in the study that When neurons in the brain become active, the amount of blood transported to these neurons is increased. As a consequence, both regional cerebral blood flows (rCBF) as well as regional blood volume (rRBV) is increased in the region surrounding these neurons. The increase in blood flow supplies an increase of oxygenated hemoglobin that largely exceeds the regional oxygen consumption. Because oxygenated hemoglobin is diamagnetic (i.e. it exerts a very little effect on the regional magnetic field) and deoxygenated hemoglobin is paramagnetic (i.e. it disturbs the regional magnetic field), a relative increase of oxygenated hemoglobin will reduce local instabilities in the magnetic field at the site of the neuronal activation. As a result, the BOLD signal is slightly stronger at sites of activation, which leads to an increase in image intensity. CT and MRI were both found to be excellent means of detection of cerebral lesions in AIDS patients, useful in initial diagnosis and in therapeutic follow-up evaluation.

MRI has a higher sensitivity. Imaging findings of the lesions in HIV-infected patients may overlap, and differential diagnosis may be difficult; however, certain imaging characteristics and localizations of lesions may favor the diagnosis. Adjunctive imaging tools such as proton MRS, perfusion-weighted. MRI, CT, or MR angiography may help to identify certain pathologic abnormalities to highlight the diagnosis.

Wenjuan Qiu, et al [19] applied in their study another fMRI method called ReHo to process the data in resting-state fMRI to investigate abnormalities of brain function that underlie HIV-related cognitive. The results indicated that there were abnormalities in regional homogeneity in patients with HIV infected compared with the control group. There was weakening of synchronization in most brain regions. The results revealed the functional changes of brain in patients with HIV infection. In addition, this study provided a new approach to study the etiology of HIV and confirmed the possibility to apply ReHo to preclinical and clinical HIV studies at the same time.

Y. Zhang, et al [20] they have developed a novel hybrid classifier to distinguish between normal and abnormal MRIs of the brain. The method obtained 98.75% classification accuracy on both training and test images of the selected dataset.

The most important contribution of this paper is that the integration of principle component analysis PCA, forward neural network FNN, and adaptive chaotic particle swarm optimization ACPSO method presented as a powerful tool for identifying normal MR images from abnormal MR images. This technique of brain MRI classification based on FNN is a potentially valuable tool to be used in computer assisted clinical diagnosis. It would be useful in finding a correlation between such measurements from MR images and behavioral or physiological parameters of research populations.

Irwin Walot, et al [21] stated that approximately 40%-90% of patients with AIDS will develop CNS manifestations during the courses of their illnesses. As a consequence, neuroimaging has come to play an important role in the treatment of AIDS. Patients with AIDS develop a variety of CNS lesions, and the diagnosis of these lesions may require the application of several imaging techniques including CT, MRI, and single-photon emission computed tomography (SPECT), or magnetic resonance spectroscopy (MRS). Because the sensitivity of MRI is superior to that of CT and because MRI allows acquisition of images in multiple planes, it has become the "gold standard" in neuroimaging.

Imaging characteristics of focal CNS mass lesions in patients with AIDS summarize the CT and MRl findings with respect to brain abnormalities in patients with AIDS.

Diagnostic imaging studies serve as an adjunct to clinical acumen and laboratory studies in the management of AIDS.

Namita Aggarwal, R. K. Agrawal, investigated performance of texture-based features in comparison to wavelet-based features with commonly used classifiers for the classification of Alzheimer’s disease based on T2-weighted MRI brain image. The performance is evaluated in terms of sensitivity, specificity, accuracy, training and testing time. Experiments are performed on publicly available medical brain images.

Experimental results show that the performance with First and Second Order Statistics based features is significantly better in comparison to existing methods based on wavelet transformation in terms of all performance measures for all classifiers.[24]

CHAPTER FOUR

4. METHODOLOGY

This chapter introduces the research methods that were used for this thesis. The methodology proceeds as follows.

Automated and accurate analysis of magnetic resonance (MR) brain images is an integral component of the analysis and interpretation of neuro imaging. Many different and innovative methods have been proposed to improve upon this technology. In this study, we presented a statistical based method to analyze given MR brain image -for positive HIV patients- as abnormal and negative HIV cases as normal.

This method first employs first and second order statistical features to extract features from images, and then sent to SPSS for analysis.

SPSS, standing for Statistical Package for the Social Sciences, is a powerful, user-friendly software package for the manipulation and statistical analysis of data. The package is particularly useful for students and researchers in psychology, sociology, psychiatry, and other behavioral sciences, contain- ing as it does an extensive range of both univariate and multivariate procedures much used in these disciplines.[23]

4.1 Pre-processing stage:

Real MRI brain images was captured for ten HIV/AIDS positive patients (45+/-15 years old), signed written informed consents, at Royal Care International Hospital, Khartoum, Sudan. Also ten healthy volunteers were participated this study as control cases. The baseline data were collected using matrix=64*64, field of view

(FOV)=20cm*20cm, slice thickness=5mm, T1 Sequence(TE/TR=15/537), T2 Sequence(TE/TR=105/5000). On Toshiba clinical scanner 1.5 T.

4.1.1 MRI Data:

The MRI machine which used has the Standard composition of:

• 1.5-tesla actively shielded magnet with an active shield gradient coil

• Patient couch

• Wall cabinet

• Controller

– Large LCD color monitor

– Keyboard and mouse

– Control pad

– Control box

• RF cabinet with integrated 4-channel array platform

• Transformer cabinet

• Refrigerator

• Gradient power supply and control cabinet

• RF coils

– QD whole-body coil

• Emergency run-down unit

• Heat exchanger

• Oxygen monitor

• Step-down transformer

• Line filter box for RF shield room

• Software

– Basic Soft 2002

– Pianissimo Plus 2002

– Auto-Voice

– DICOM Basic License

– Storage SCU kit

– Print SCU kit

4.2 Selection of ROI

The MRI studies was diagnosed and reported by the radiologist consultant at Royal Care International Hospital, then sequences of T1 and T2 was selected for processing and analysis. The region of interest was the area which had abnormalities in the images, windows of 128*128 used.

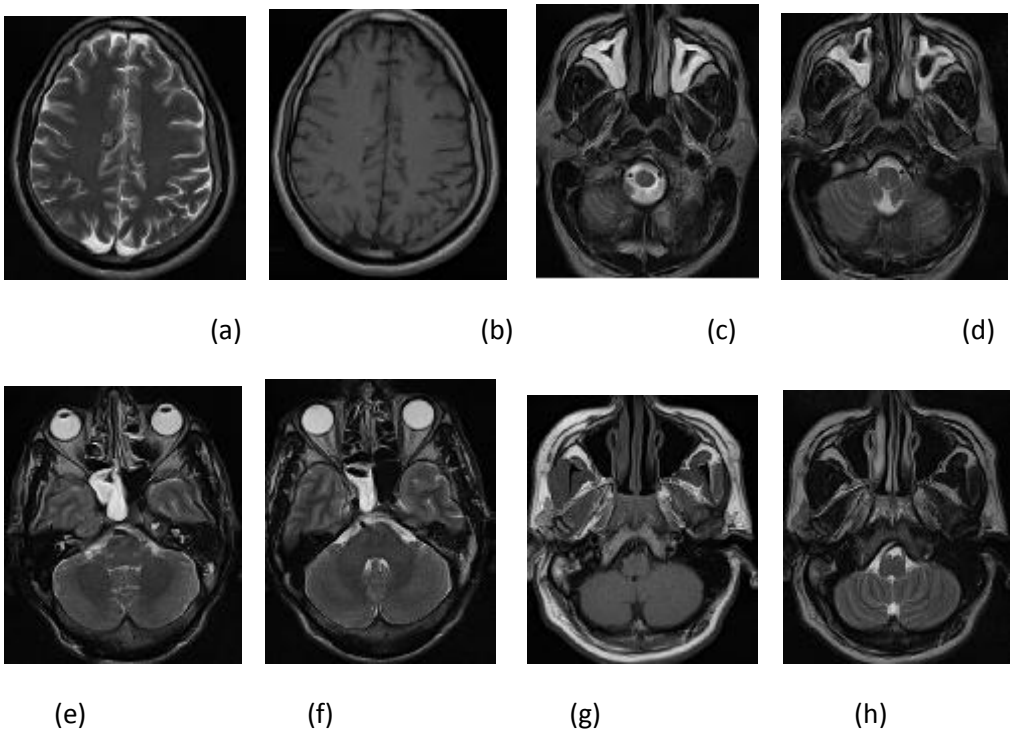

Figure 4.1 before selecting the ROI show different abnormalities brain images at T1 and T2.

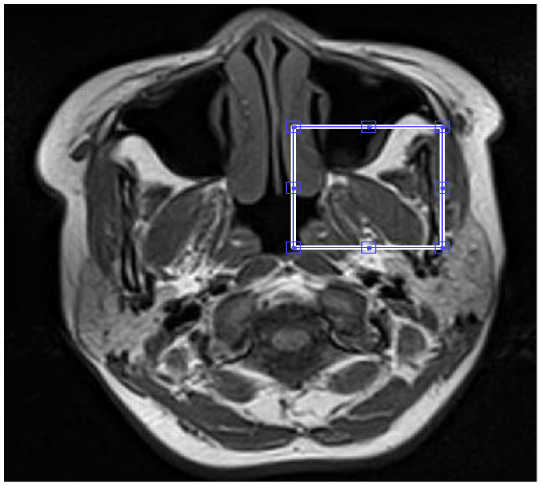

Figure 4.2: Selecting the ROI using 128*128 window

4.3 Feature Extractor

Feature extraction is the techniques to measure of difference characteristics of image segments. Each segmented region in a scene may be described by a set of such features. In this step the features extractor consists of the SGLD matrix generator.

Texture features (statistical features) calculated from each ROIs.

4.4 Texture Analysis

Texture can be defined as the set of local statistical properties of the coefficients (pixel gray level) which constitute the image multi scale orientation. Texture analysis is defined as the classification or segmentation of textural features with respect to the shape of a small element, density, and direction of regularity.

The advantage of using texture features is that they provide Additional information about a region of an image. They can be used to characterize a whole image, not just a small region within an image.

Because of these advantages statistical texture features were used for this project.

In this study, following statistical texture features including the Mean, Variance, Standard Deviation, Smoothness, Moment, Percentile, Entropy (EN), Energy (EG), Inertia (IN), inverse different moment (IDM), Correlation (CO), Variance (VA), Sum Average (SA), Sum Entropy (SE), Sum Variance (SV), Difference Average (DA), Difference Entropy (DE) and Difference Variance (DV)were calculated from the (SGLD) matrix.

These features were calculated from the SGLD matrix the following equations are defined these features:

1. 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:

$$EN = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} p(i,j) \log_2 p(i,j) \quad (4.1)$$

2. Energy (EG)

The Energy feature (EG) returns the sum of squared elements in the

SGLD matrix as expressed by the following equation:

$$EG = \sum_{i=0}^{n=1} \sum_{j=0}^{n=1} p^2(i,j) \qquad (4.2)$$

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:

$$IN = -\sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (i-j)^2 \, p(i.j) \qquad (4.3)$$

4. Inverse Difference Moment (IDM)

Inverse Difference Moment is also called the "Homogeneity". Mathematically, it can be written as:

$$IDM = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \frac{1}{1+(i-j)^2} p(i,j) \qquad (4.4)$$

5. 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

:

$$CO = \frac{\sum_{i=0}^{n-I} \cdot \sum_{j=0}^{n-I} (i-\mu_x)(j-\mu_y) p(i,j)}{\sigma_x \sigma_y} \qquad (4.5)$$

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.

$$VA = \sum_{i=0}^{n-1} (i - \mu)^2 P_x(i) \qquad (4.6)$$

7. Sum Average (SA)

$$\boldsymbol{SA = \sum_{k=0}^{2n-2} kP_{x+y}(k)} \qquad \boldsymbol{(4.7)}$$

8. Sum Entropy (SE)

$$\boldsymbol{SE = -\sum_{k=0}^{2n-2} p_{x+y}(k) \log_2 p_{x+y}(k)} \qquad \boldsymbol{(4.8)}$$

9. Sum Variance (SV)

$$\boldsymbol{SA = \sum_{k=0}^{2n-2} (k - SA)^2 p_{x+y(k)}} \qquad \boldsymbol{(4.9)}$$

10. Difference Entropy (DE)

$$\boldsymbol{DE = -\sum_{k=0}^{n-1} p_{x-y(k) \log_2 p_{x-y(k)}}} \qquad \boldsymbol{(4,10)}$$

11. Difference Average (DA)

$$\boldsymbol{DA = \sum_{k=0}^{n-1} kp_{x-y}(k)} \qquad \boldsymbol{(4.11)}$$

12. Difference Variance (DV)

$$\boldsymbol{DV = \sum_{k=0}^{n-1} (k - DA)^2 \, p_{x-y}(k)} \qquad (\mathbf{4.12})$$

Where: n is the number of grey level in the image. μx ,μy are the mean and σx, σy are variance of the marginal distribution Px(i) and Py(j).

$$p_x(i) = \sum_{i=0}^{n-1} p(i.j)$$

$$p_y(j) = \sum_{j=0}^{n-1} p(i.j)$$

$$p_{x+y}(k) = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} p(i,j)$$

$$k = i + j, k = 0, \ldots 2n - 2$$

$$p_{x-y}(k) = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} p(i,j)$$

$$k = |i - j|, k = 0, \ldots n - 1$$

13. Information measures of correlation feature 1

$$f_{12=} \frac{HXY - HXY1}{\max(HX, HY)} \qquad (4.13)$$

14. Information measures of correlation feature 2

$$f_{13=} (1 - exp[-2(HXY2 - HXY)])^{\frac{1}{2}} \qquad (4.14)$$

15. Mean

Average or mean value of array

16. Standard deviation

The Standard Deviation block computes the standard deviation of each row or column of the input, along vectors of a specified dimension of the input, or of the entire input. The Standard Deviation block can also track the standard deviation of a sequence of inputs over a period of time. The Running standard deviation parameter selects between basic operation and running operation.

17. Smoothness

The desired accuracy and smoothness of the data returned by a lookup table determine which of the blocks you should use. Most blocks provide options to perform interpolation and extrapolation, improving the accuracy of values that fall between or outside of the table data, respectively.

18. Variance

The Variance block computes the unbiased variance of each row or column of the input, along vectors of a specified dimension of the input, or of the entire input. The Variance block can also track the variance of a sequence of inputs over a period of time.

19. Moment:

m = moment(X,order) returns the central sample moment of X specified by the positive integer order. For vectors, moment(x,order) returns the central moment of

the specified order for the elements of x. For matrices, moment(X,order) returns central moment of the specified order for each column. For N-dimensional arrays, moment operates along the first nonsingleton dimension of X.

moment(X,order,dim) takes the moment along dimension dim of X.

20. Percentile

Y = quantile(X,p) returns quantiles of the values in X. p is a scalar or a vector of cumulative probability values. When X is a vector, Y is the same size as p, and Y(i) contains the p(i)th quantile. When X is a matrix, the ith row of Y contains the p(i)th quantiles of each column of X. For n-dimensional arrays, quantile operates along the first nonsingleton dimension of X.

CHAPTER FIVE

5. RESULTS AND DISCUSSION

In this section, will show different features extraction methods and statistical analysis for two different types of MRI brain images , normal image and HIV cases image. The feature extraction methods were: Features based on First and second order statistics.

For the forty statistical features used in this study, numbers of them illustrate considerable changes between the two groups. The Frequency histogram for had the following figures:

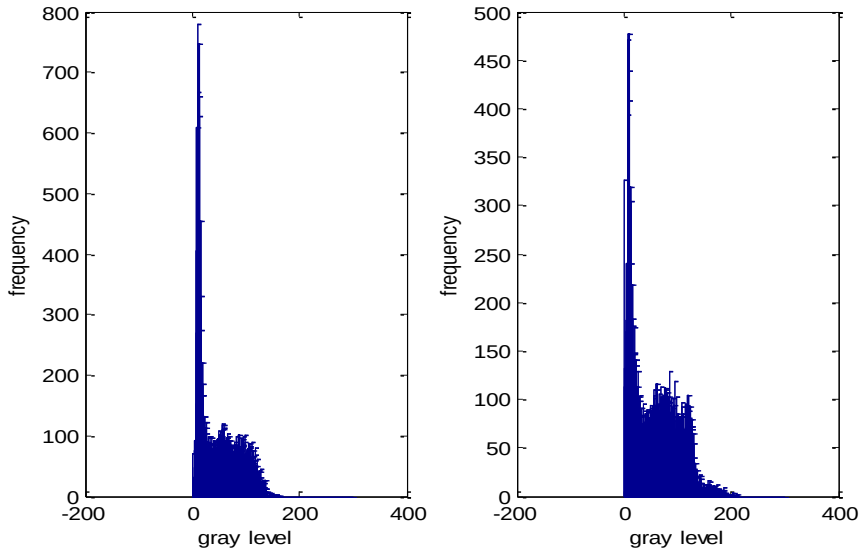

Figure 5.1 Comparison between histogram of ROI 1 of normal group against histogram of ROI 1 of abnormal group.

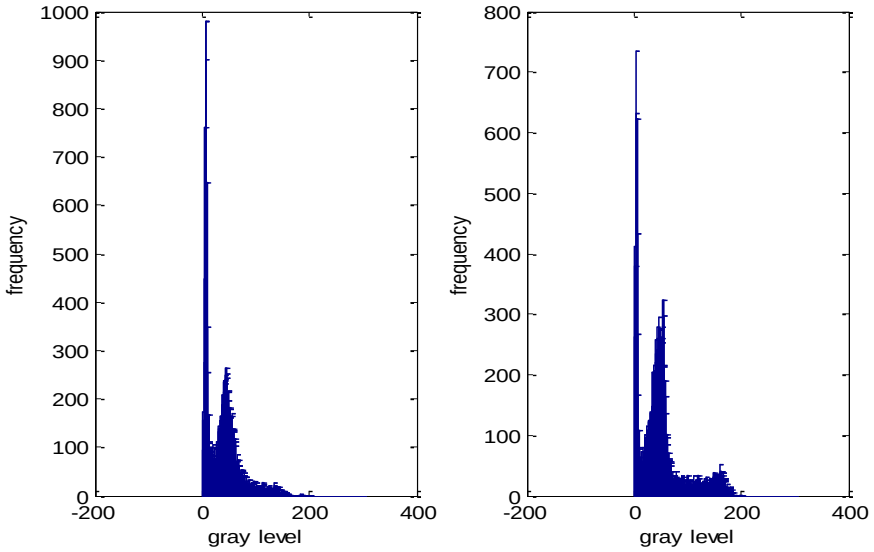

Figure 5.2 Comparison between histogram of ROI 2 of normal group against histogram of ROI 2 of abnormal group.

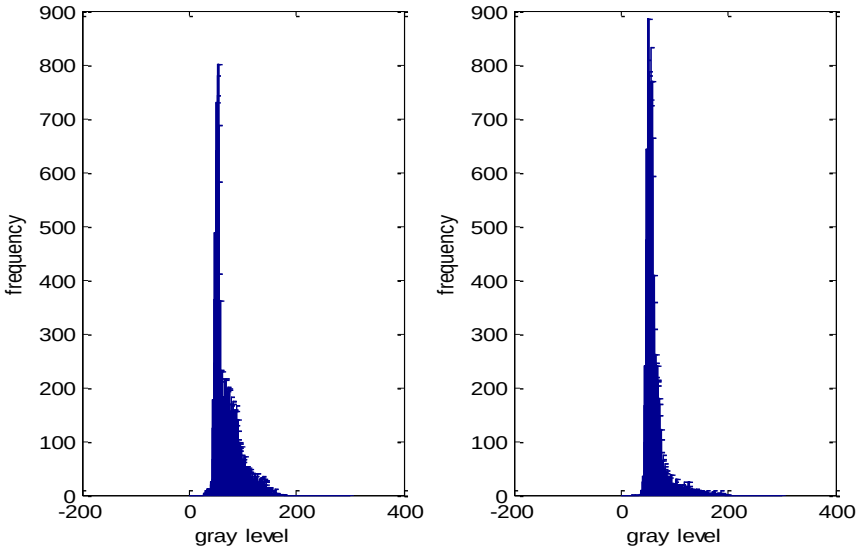

Figure 5.3 Comparison between histogram of ROI 3 of normal group against histogram of ROI 3 of abnormal group.

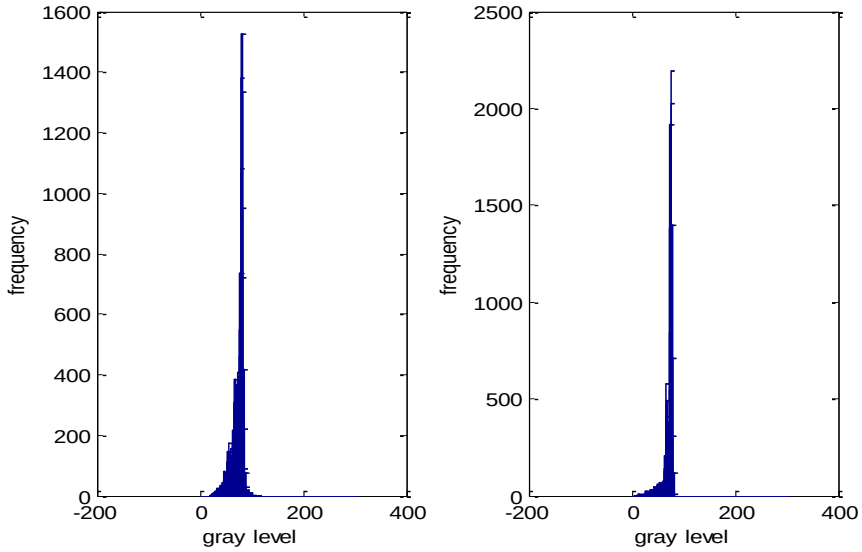

Figure 5.4 Comparison between histogram of ROI 4 of normal group against histogram of ROI4 of abnormal group.

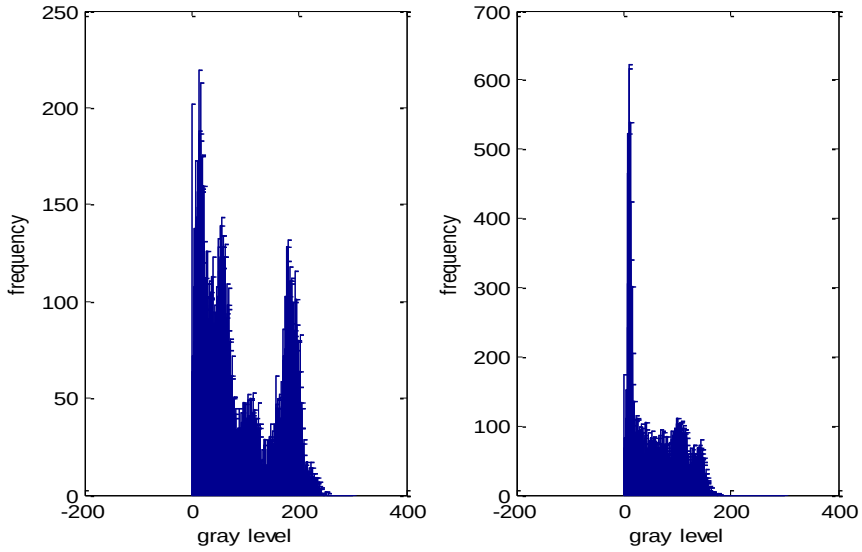

Figure 5.5 Comparison between histogram of ROI 5 of normal group against histogram of ROI5 of abnormal group.

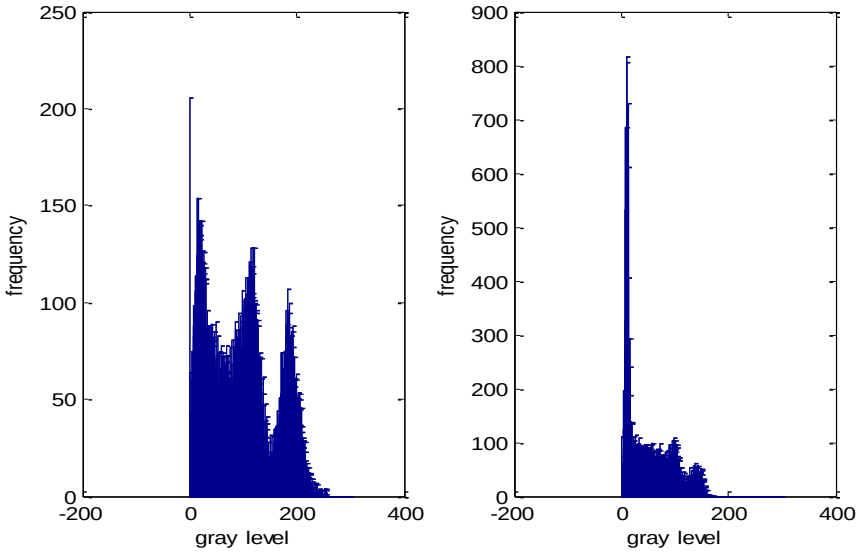

Figure 5.6 Comparison between histogram of ROI 6 of normal group against histogram of ROI 6 of abnormal group.

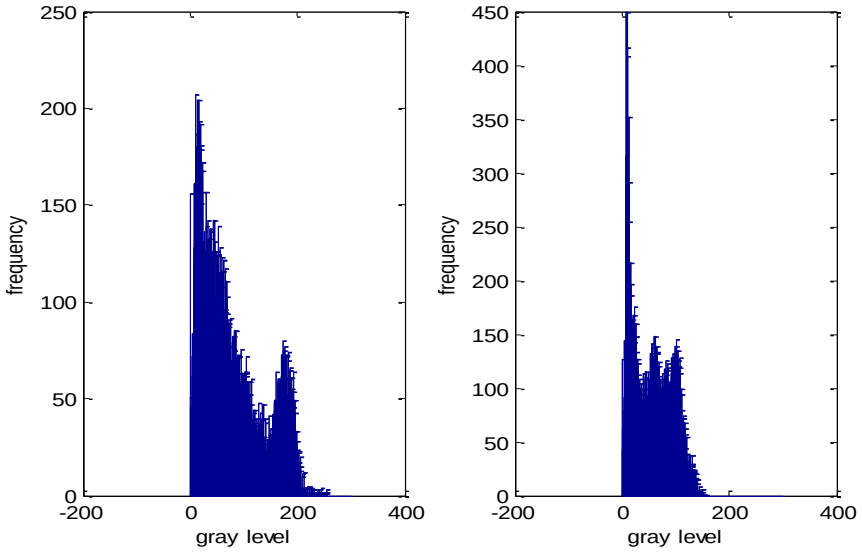

Figure 5.7 Comparison between histogram of ROI 7 of normal group against histogram of ROI 7 of abnormal group.

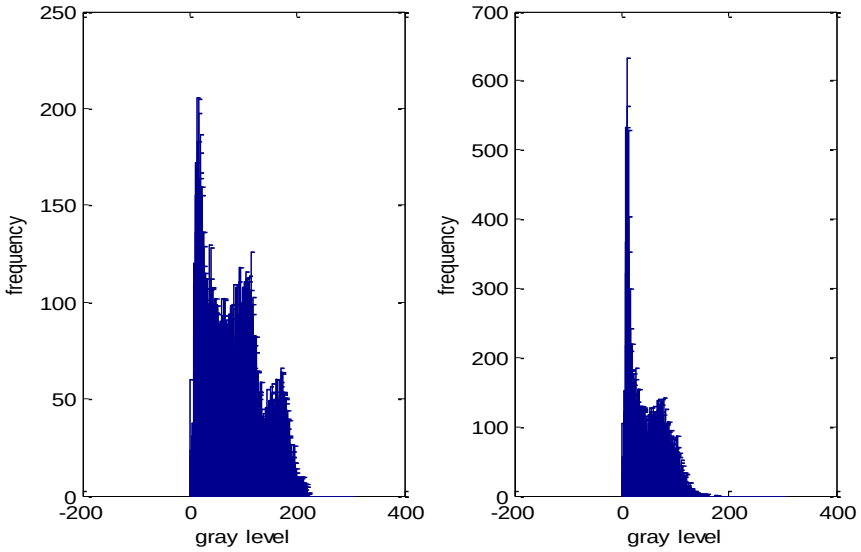

Figure 5.8 Comparison between histogram of ROI 8 of normal group against histogram of ROI 8 of abnormal group.

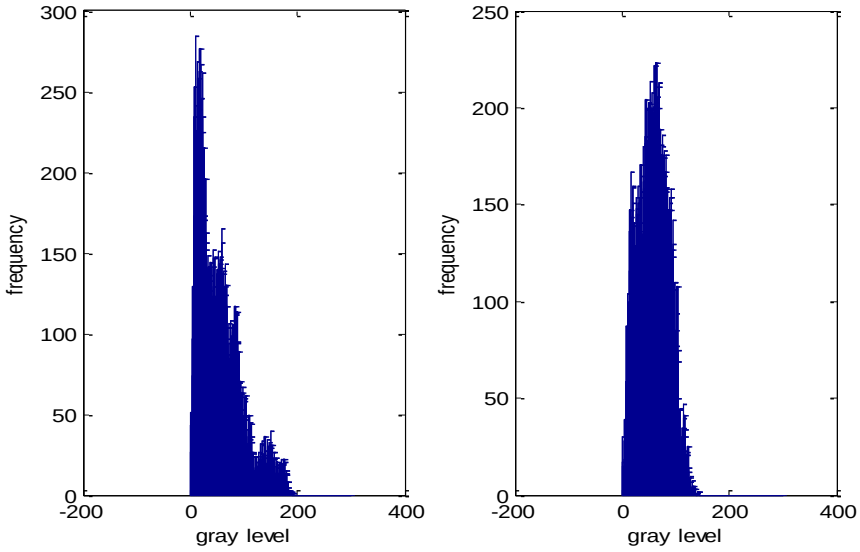

Figure 5.9 Comparison between histogram of ROI 9 of normal group against histogram of ROI 9 of abnormal group.

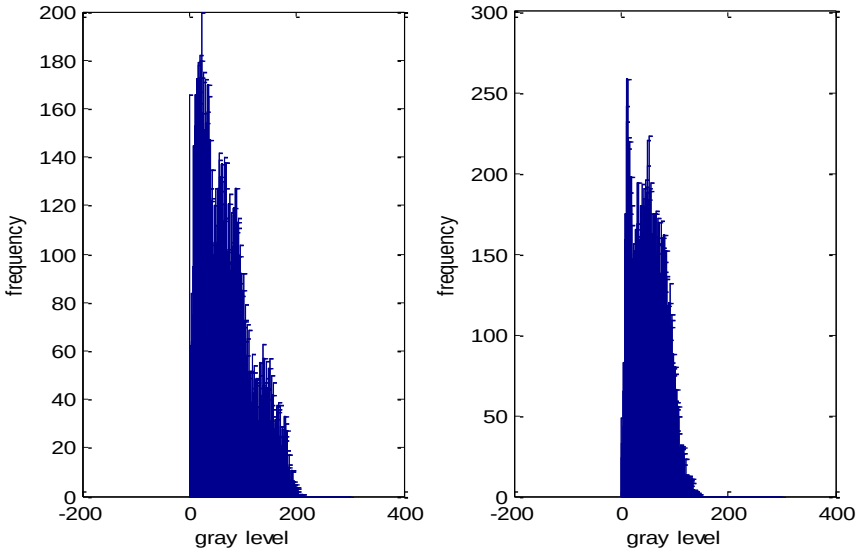

Figure 5.10 Comparison between histogram of ROI 10 of normal group against histogram of ROI 10 of abnormal group.

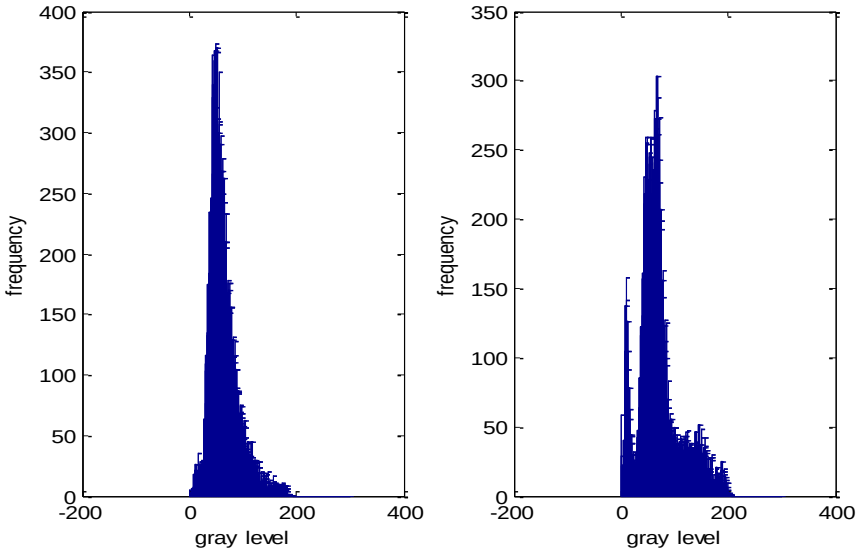

Figure 5.11 Comparison between histogram of ROI 11 of normal group against histogram of ROI 11 of abnormal group.

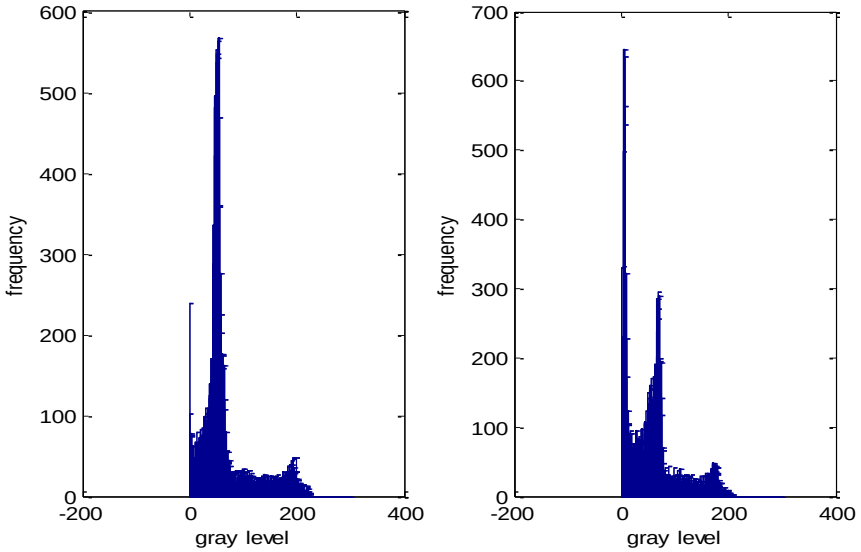

Figure 5.12 Comparison between histogram of ROI 12 of normal group against histogram of ROI 12 of abnormal group.

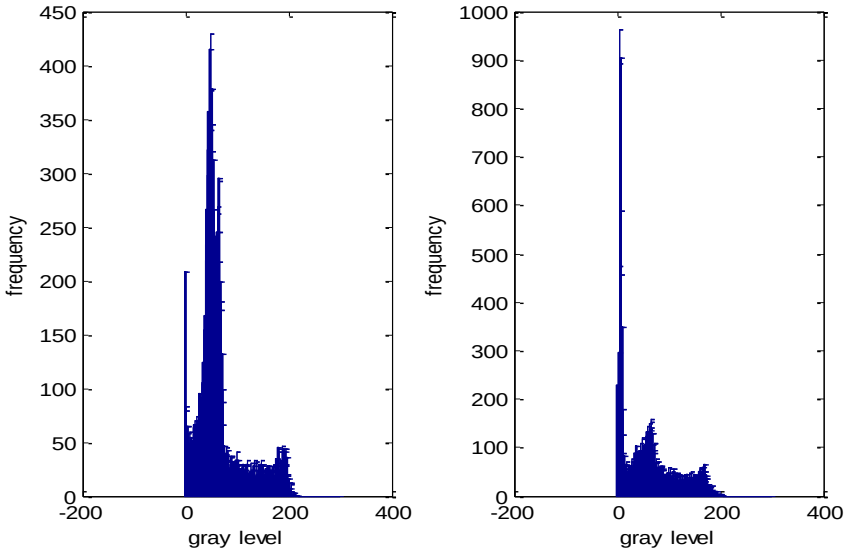

Figure 5.13 Comparison between histogram of ROI 13 of normal group against histogram of ROI 13 of abnormal group.

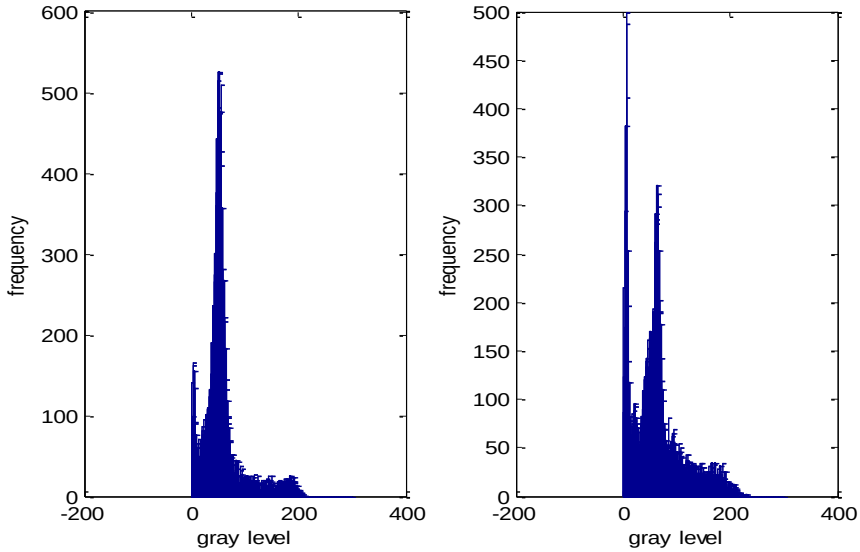

Figure 5.14 Comparison between histogram of ROI 14 of normal group against histogram of ROI 14 of abnormal group.

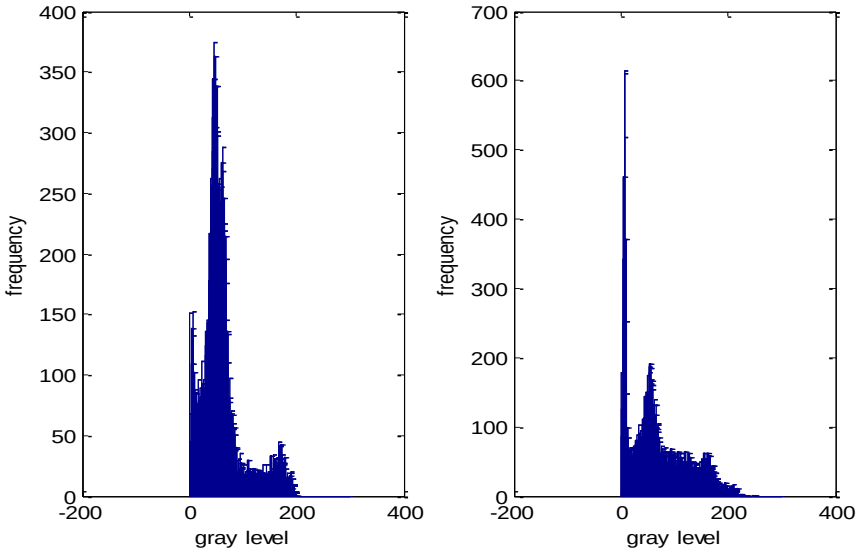

Figure 5.15 Comparison between histogram of ROI 15 of normal group against histogram of ROI 15 of abnormal group

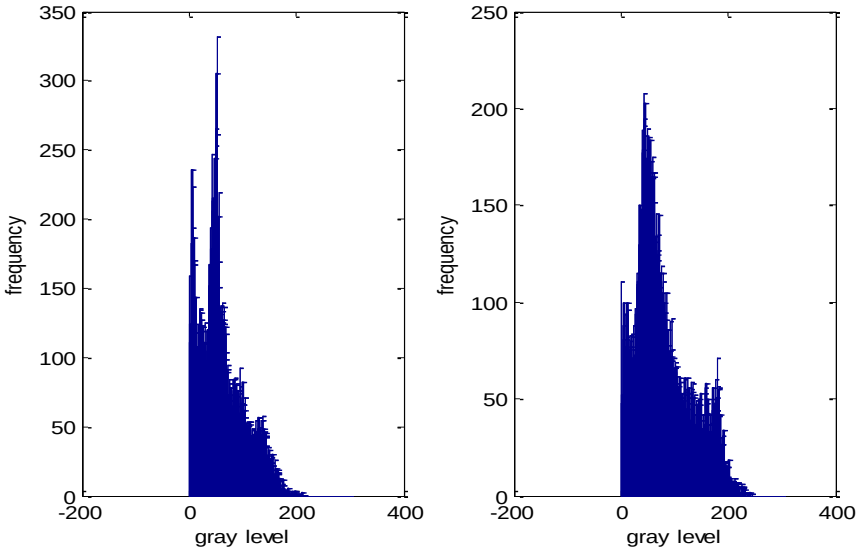

Figure 5.16 Comparison between histogram of ROI 16 of normal group against histogram of ROI 16 of abnormal group.

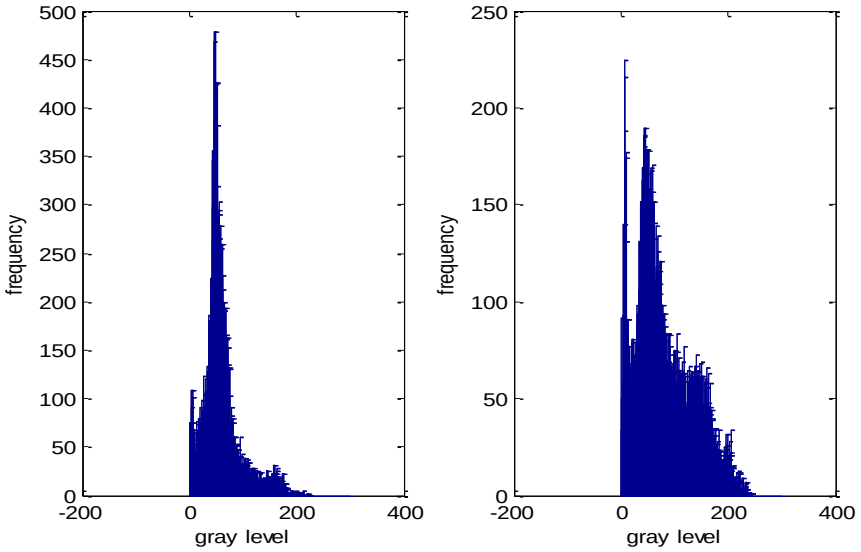

Figure 5.17 Comparison between histogram of ROI 17 of normal group against histogram of ROI 17 of abnormal group.

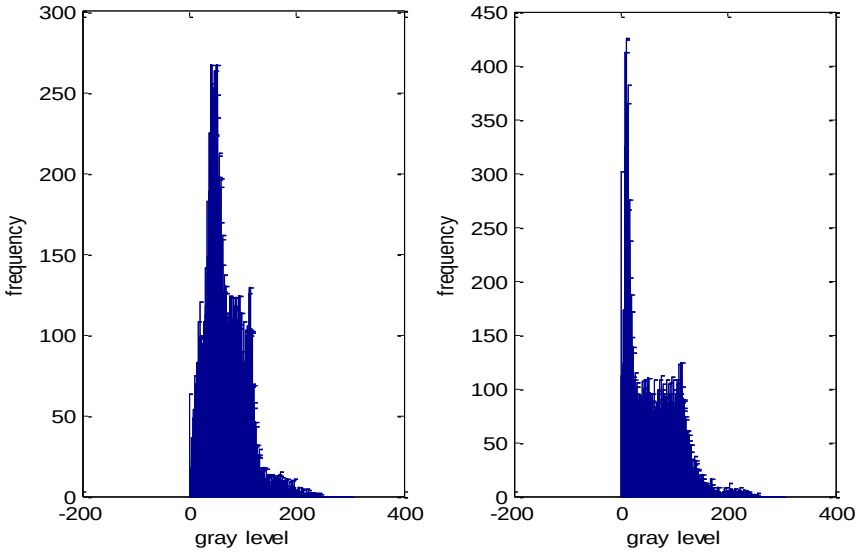

Figure 5.18 Comparison between histogram of ROI 18 of normal group against histogram of ROI 18 of abnormal group.

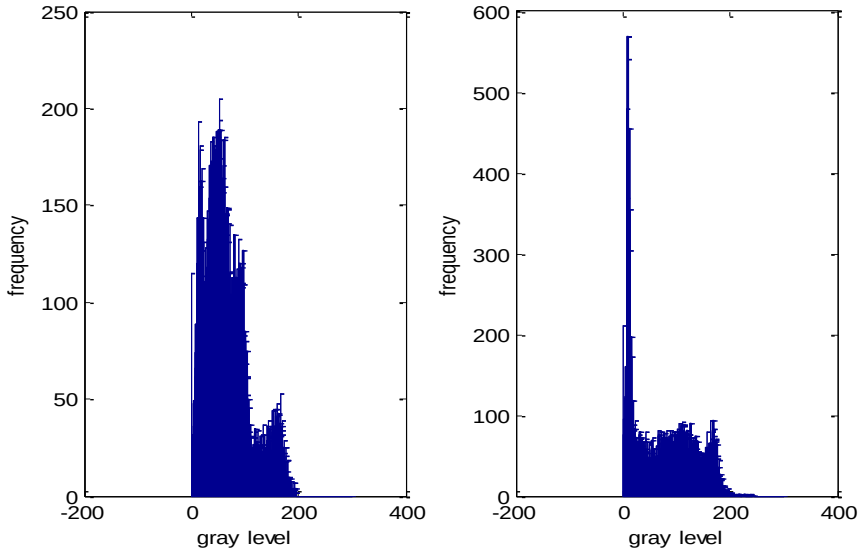

Figure 5.19 Comparison between histogram of ROI 19 of normal group against histogram of ROI 19 of abnormal group.

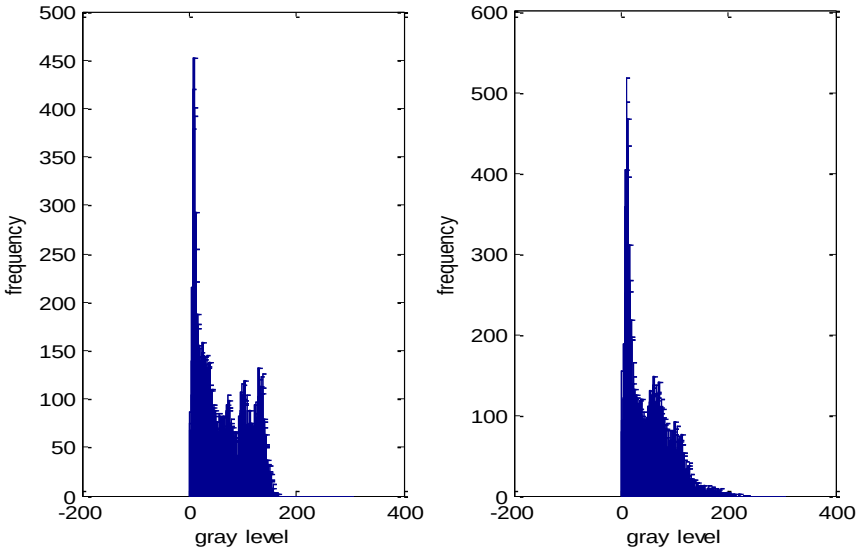

Figure 5.20 Comparison between histogram of ROI 20 of normal group against histogram of ROI 20 of abnormal group.

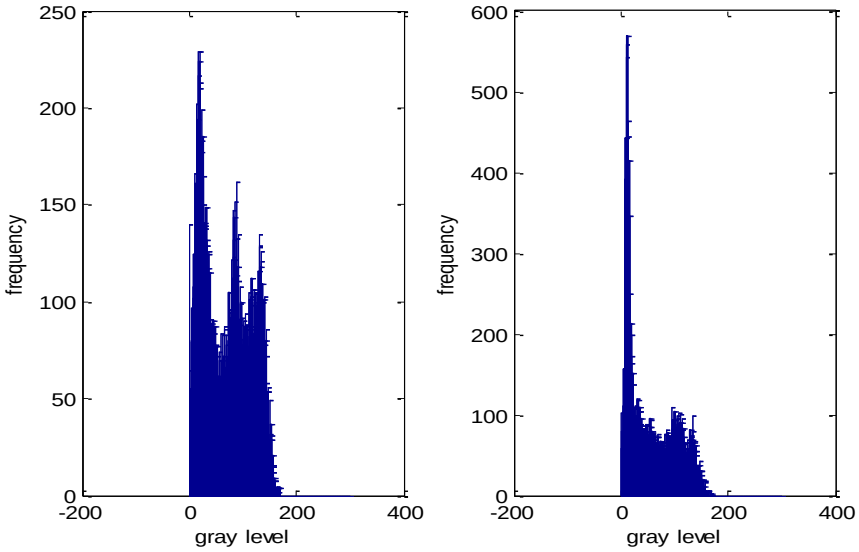

Figure 5.21 Comparison between histogram of ROI 21 of normal group against histogram of ROI 21 of abnormal group.

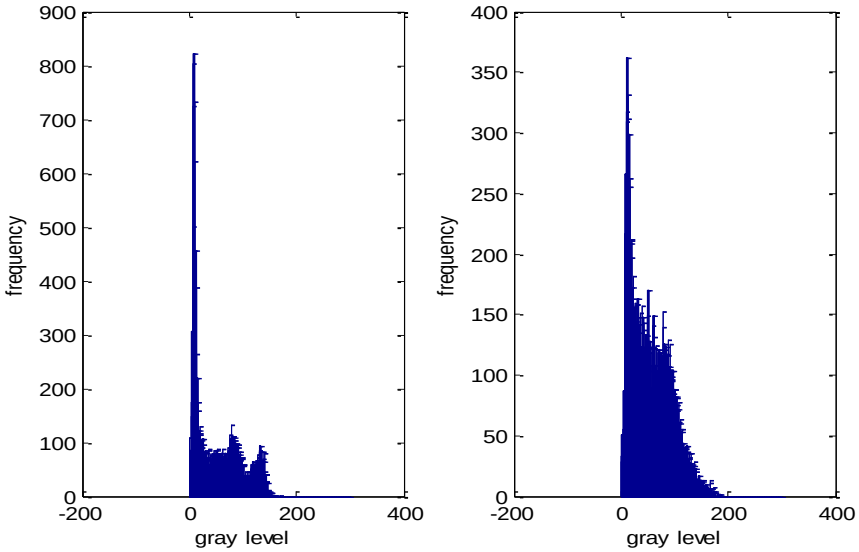

Figure 5.22 Comparison between histogram of ROI 22 of normal group against histogram of ROI 22 of abnormal group.

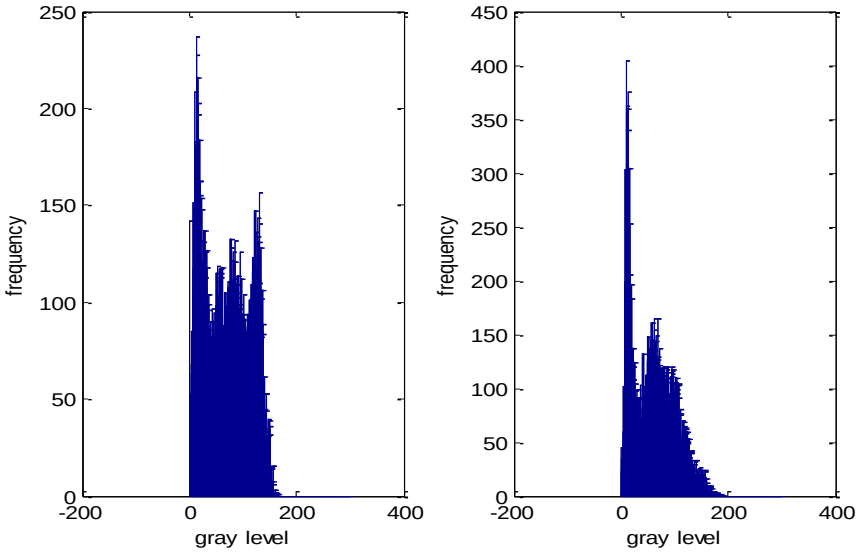

Figure 5.23 Comparison between histogram of ROI 23 of normal group against histogram of ROI 23 of abnormal group

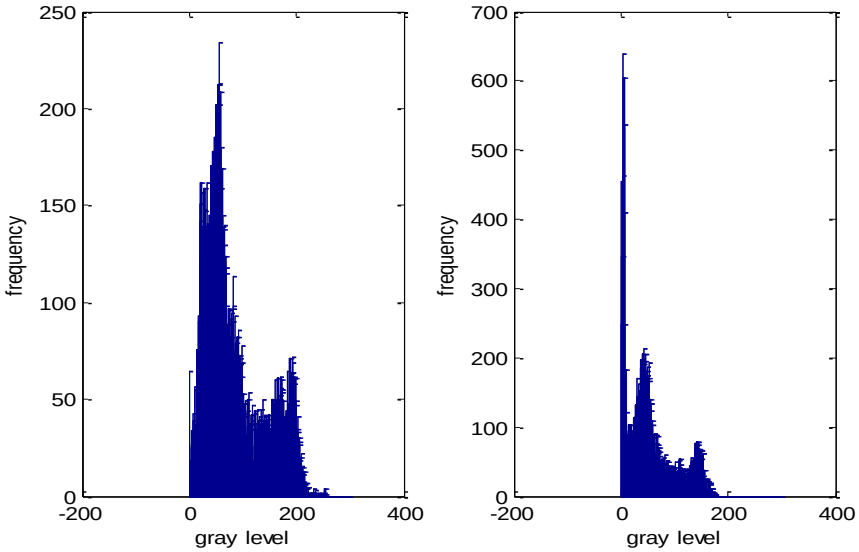

Figure 5.24 Comparison between histogram of ROI 24 of normal group against histogram of ROI 24 of abnormal group.

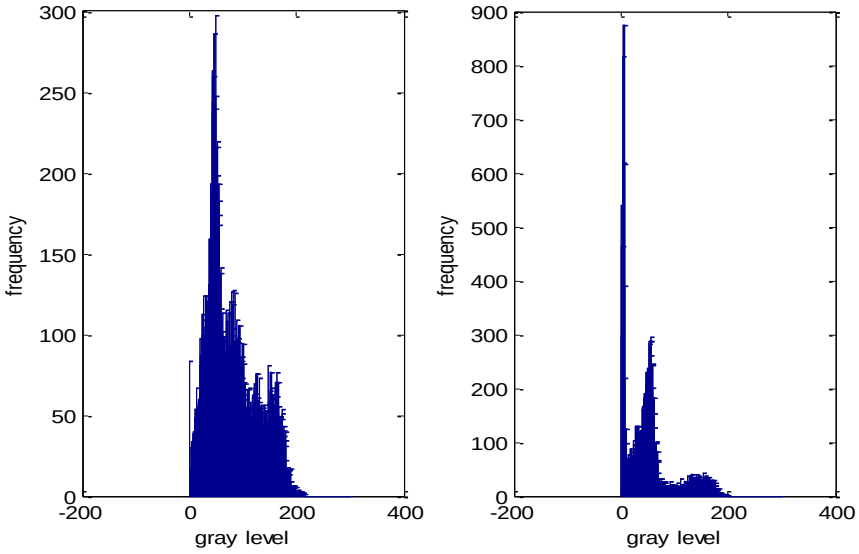

Figure 5.25 Comparison between histogram of ROI 25 of normal group against histogram of ROI 25 of abnormal group.

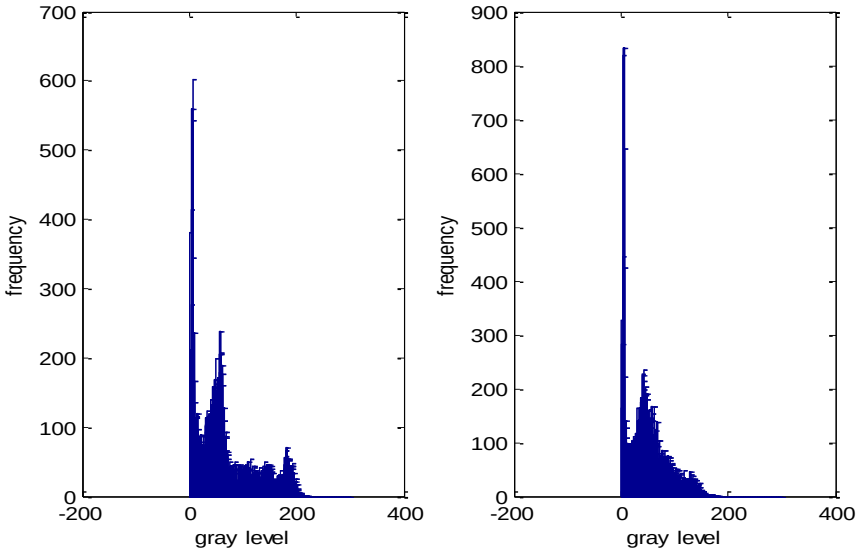

Figure 5.26 Comparison between histogram of ROI 26 of normal group against histogram of ROI 26 of abnormal group.

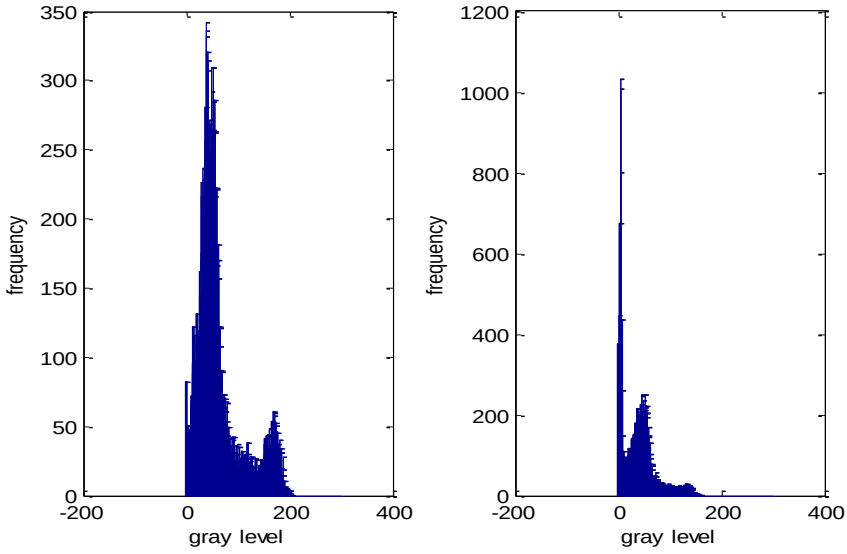

Figure 5.27 Comparison between histogram of ROI 27 of normal group against histogram of ROI 27 of abnormal group.

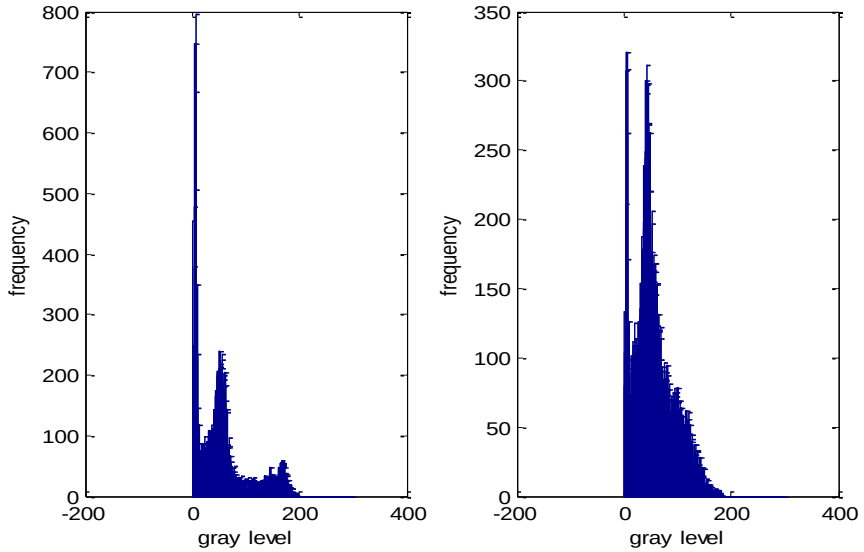

Figure 5.28 Comparison between histogram of ROI 28 of normal group against histogram of ROI 28 of abnormal group.

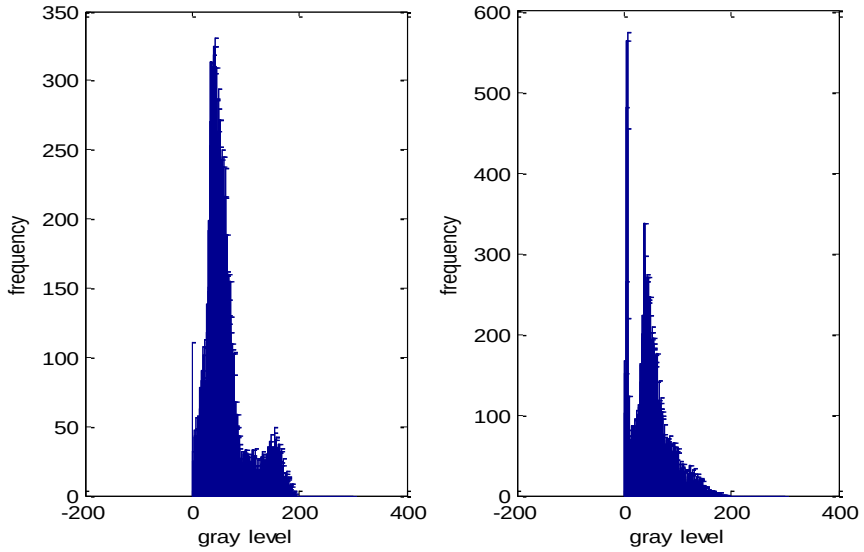

Figure 5.29 Comparison between histogram of ROI 29 of normal group against histogram of ROI 29 of abnormal group.

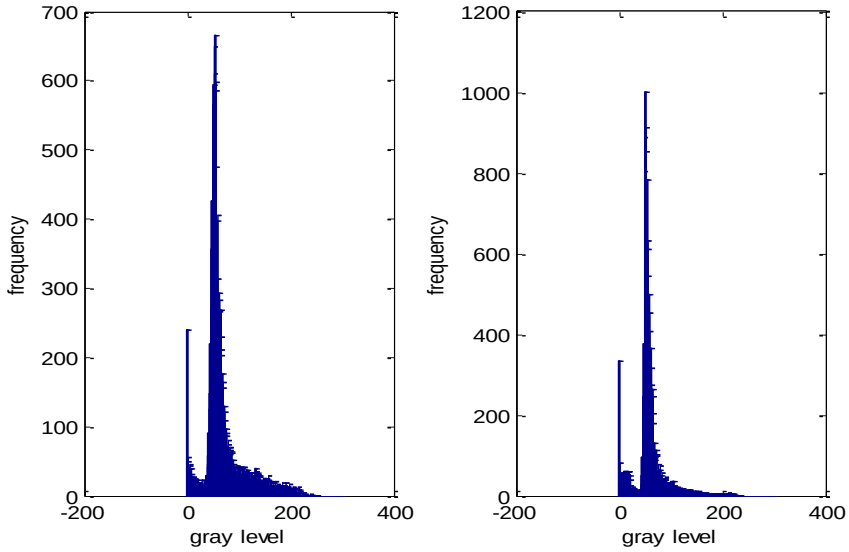

Figure 5.30 Comparison between histogram of ROI 30 of normal group against histogram of ROI 30 of abnormal group.

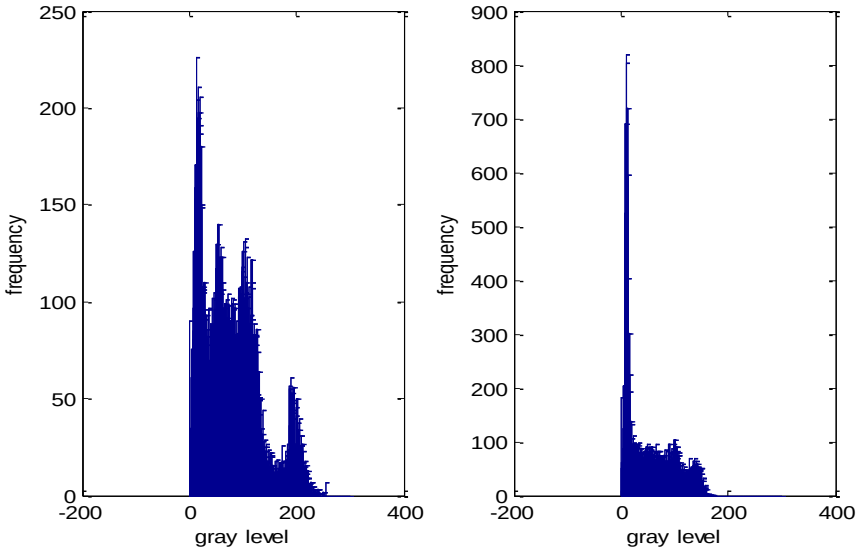

Figure 5.31 Comparison between histogram of ROI 31 of normal group against histogram of ROI 31 of abnormal group

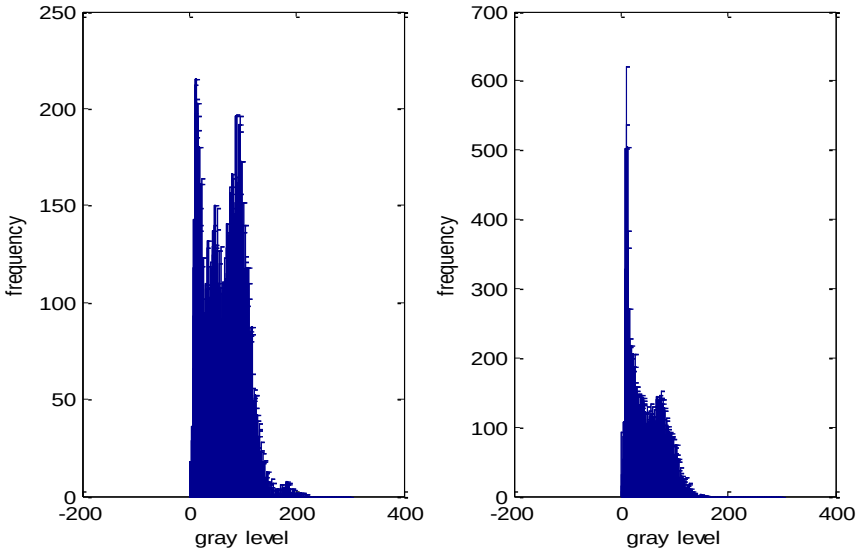

Figure 5.32 Comparison between histogram of ROI 32 of normal group against histogram of ROI 32 of abnormal group.

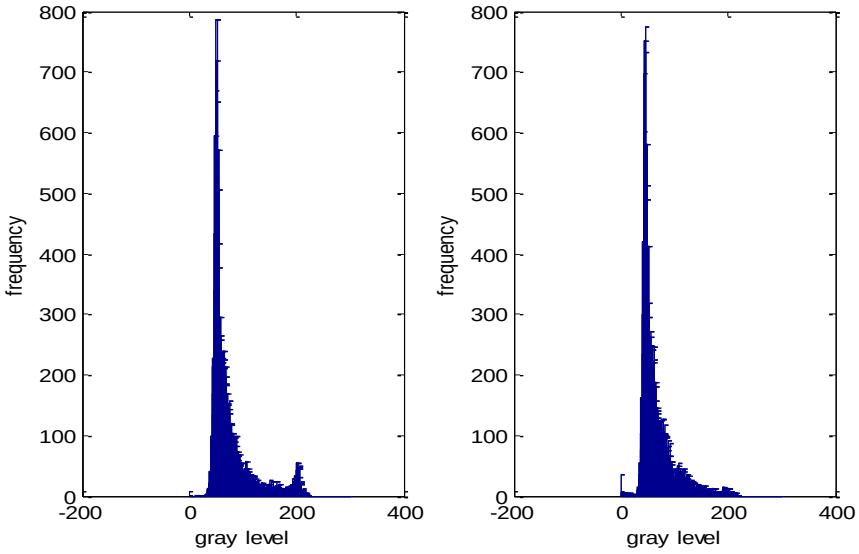

Figure 5.33 Comparison between histogram of ROI 33 of normal group against histogram of ROI 33 of abnormal group.

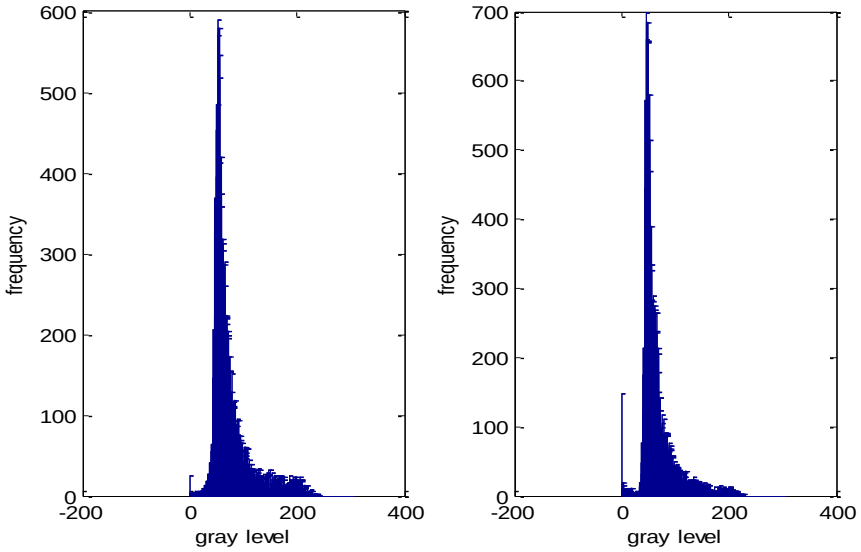

Figure 5.34 Comparison between histogram of ROI 34 of normal group against histogram of ROI 34 of abnormal group.

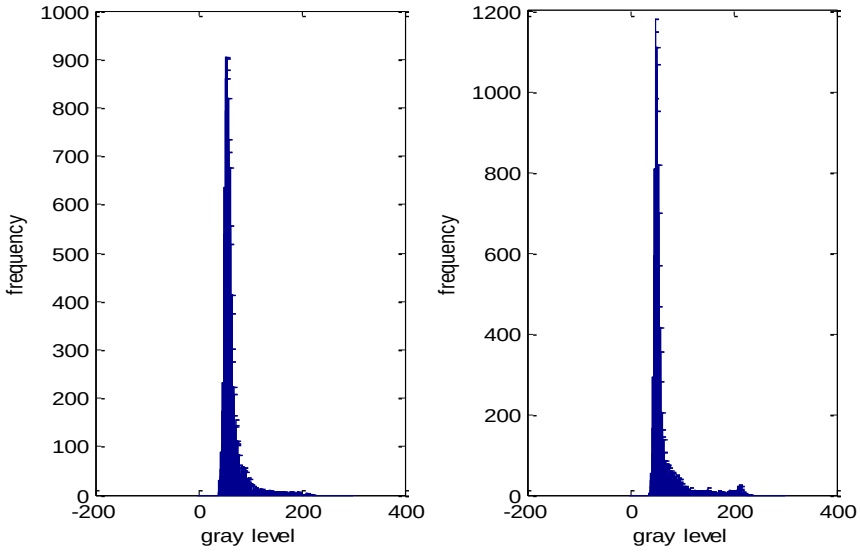

Figure 5.35 Comparison between histogram of ROI 35 of normal group against histogram of ROI 35 of abnormal group.

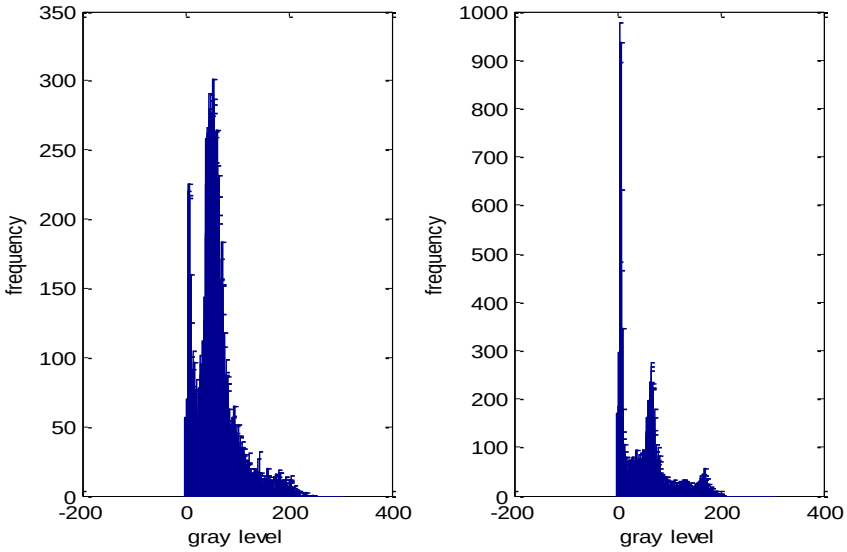

Figure 5.36 Comparison between histogram of ROI 36 of normal group against histogram of ROI 36 of abnormal group.

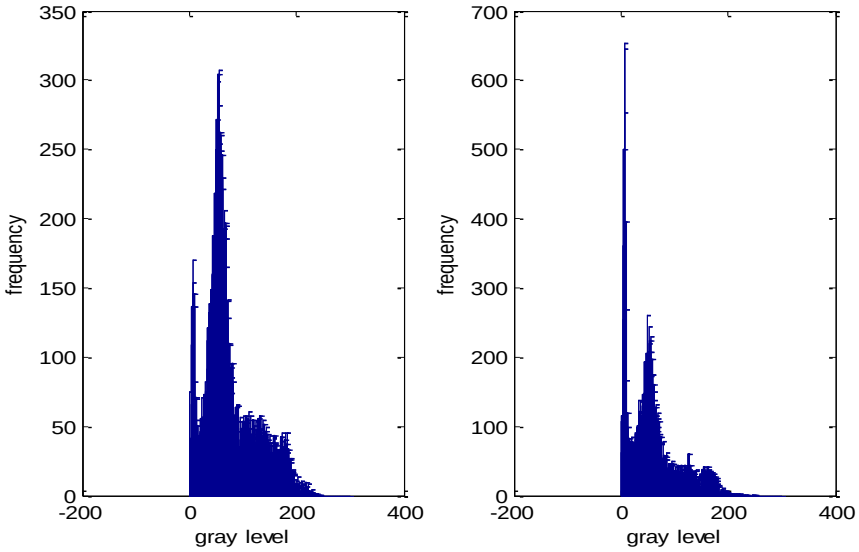

Figure 5.37 Comparison between histogram of ROI 37 of normal group against histogram of ROI 37 of abnormal group.

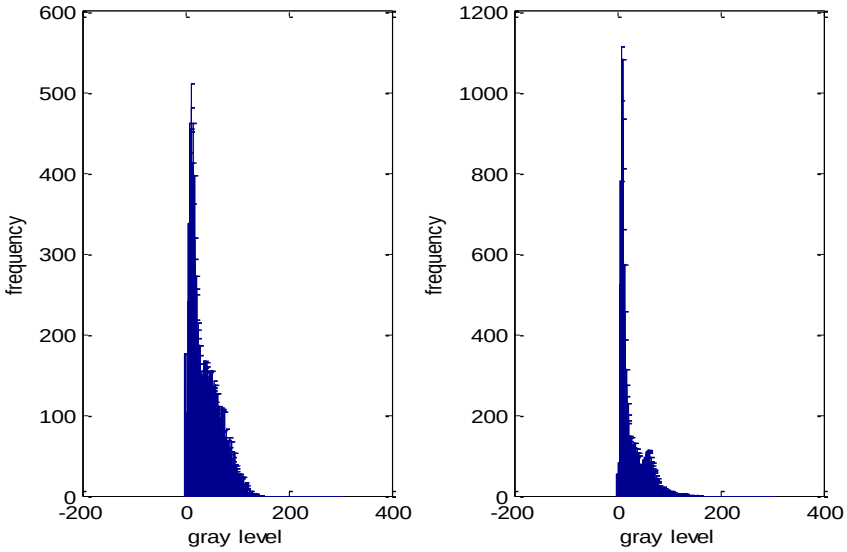

Figure 5.38 Comparison between histogram of ROI 38 of normal group against histogram of ROI 38 of abnormal group.

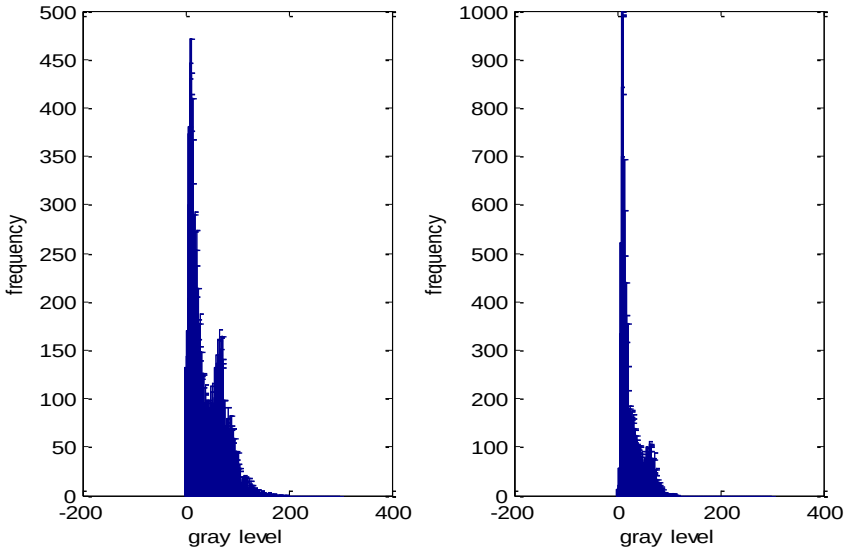

Figure 5.39 Comparison between histogram of ROI 39 of normal group against histogram of ROI 39 of abnormal group

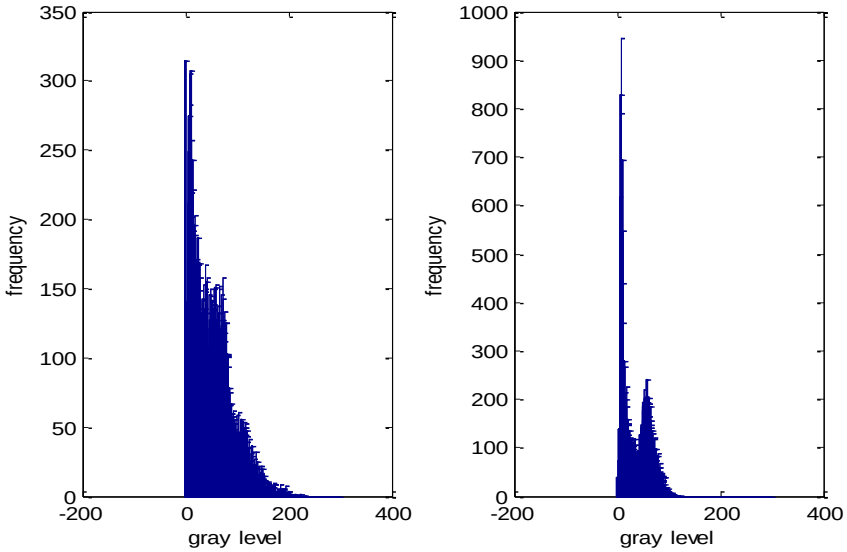

Figure 5.40 Comparison between histogram of ROI 40 of normal group against histogram of ROI 40 of abnormal group.

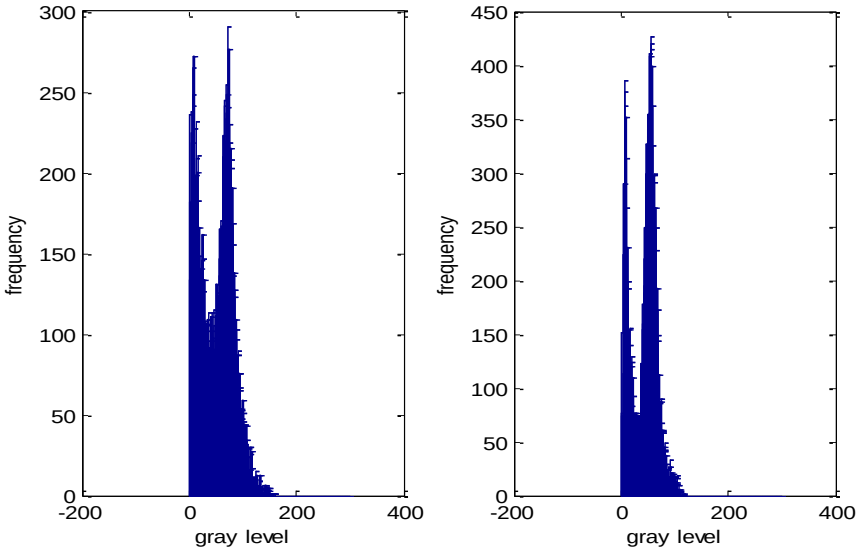

Figure 5.41 Comparison between histogram of ROI 41 of normal group against histogram of ROI 41 of abnormal group.

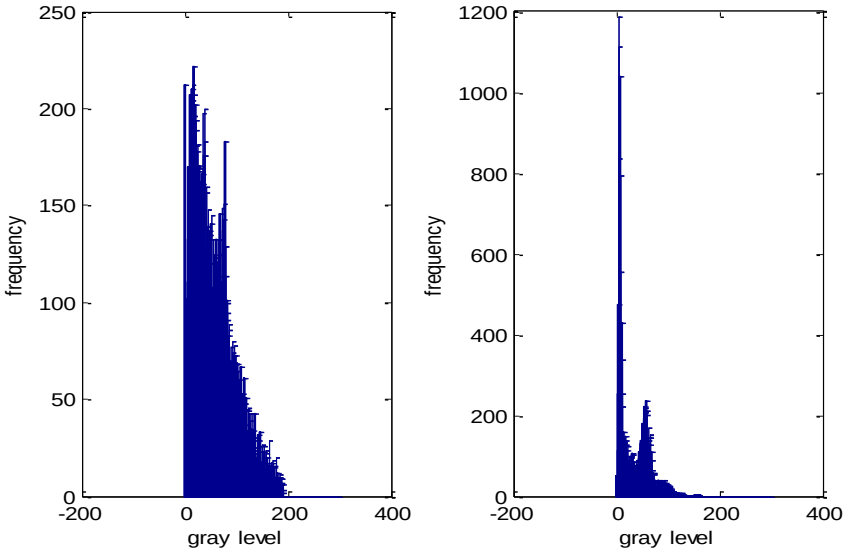

Figure 5.42 Comparison between histogram of ROI 42 of normal group against histogram of ROI 42 of abnormal group.

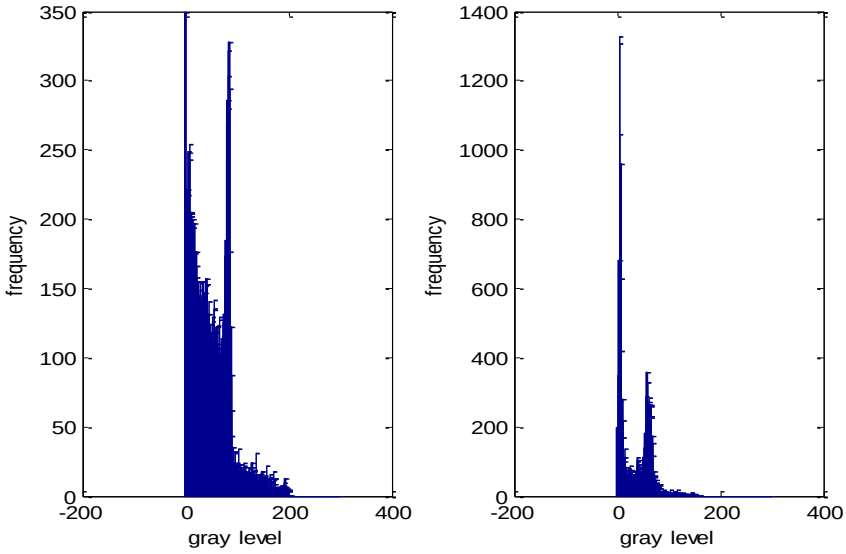

Figure 5.43 Comparison between histogram of ROI 43 of normal group against histogram of ROI 43 of abnormal group.

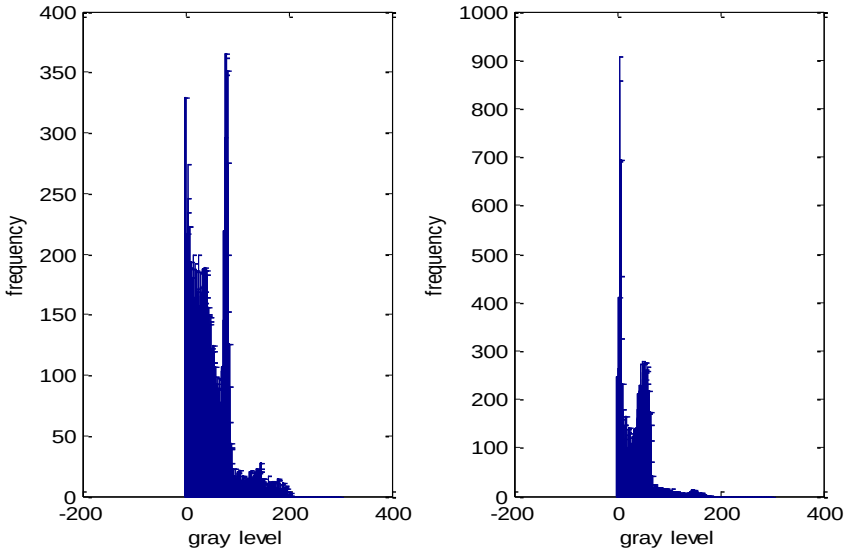

Figure 5.44 Comparison between histogram of ROI 44 of normal group against histogram of ROI 44 of abnormal group.

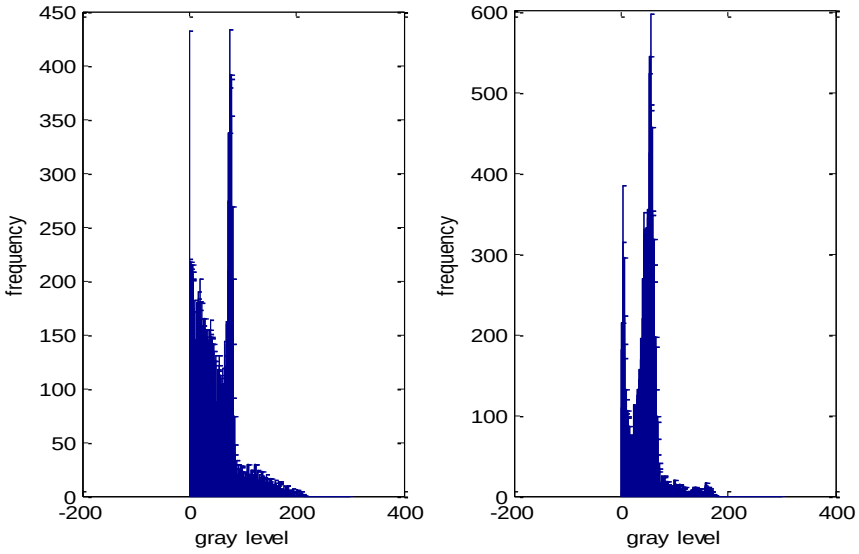

Figure 5.45 Comparison between histogram of ROI 45 of normal group against histogram of ROI 45 of abnormal group

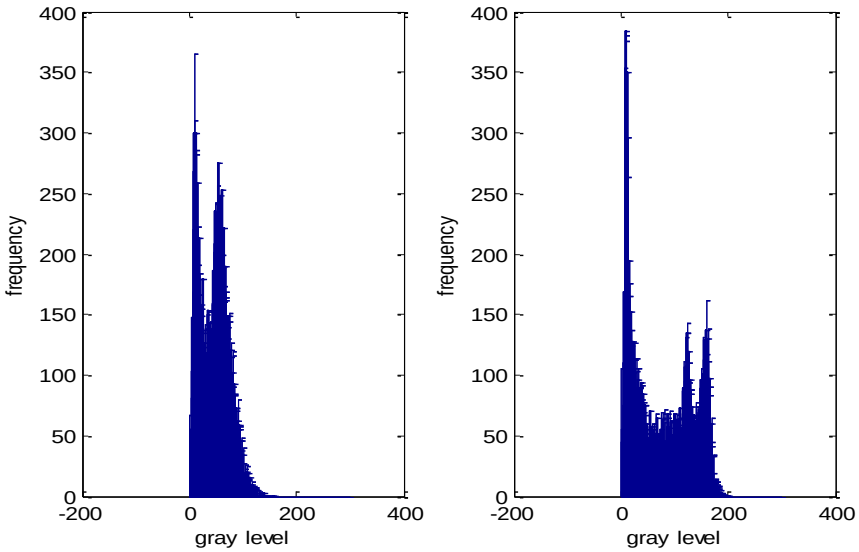

Figure 5.46 Comparison between histogram of ROI 46 of normal group against histogram of ROI 46 of abnormal group.

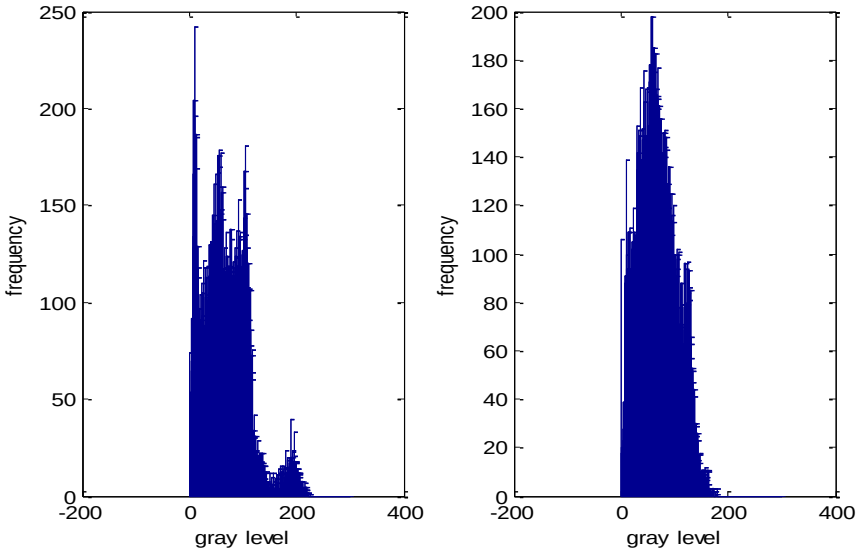

Figure 5.47 Comparison between histogram of ROI 47 of normal group against histogram of ROI 47 of abnormal group

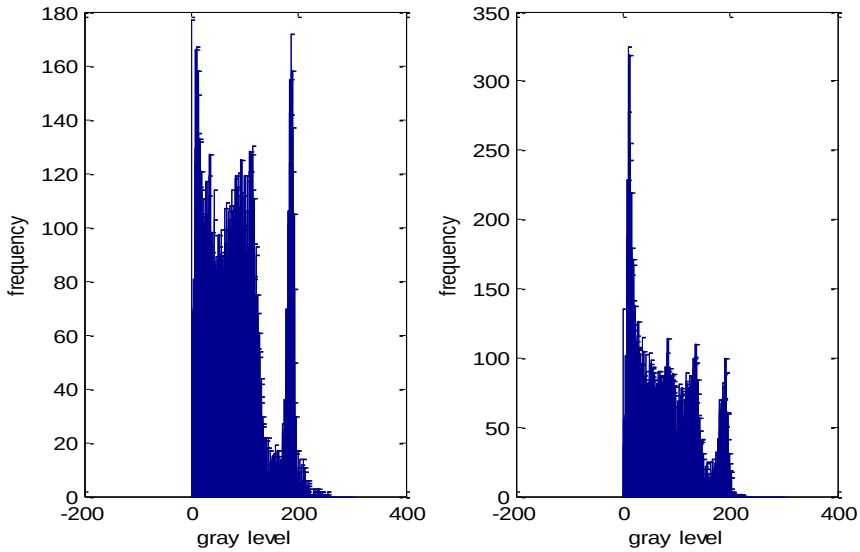

Figure 5.48 Comparison between histogram of ROI 48 of normal group against histogram of ROI 48 of abnormal group.

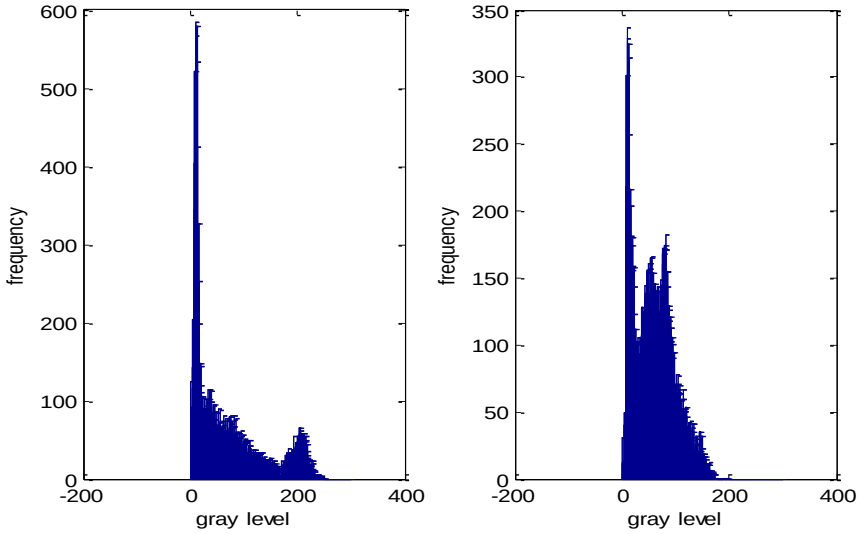

Figure 5.49 Comparison between histogram of ROI 49 of normal group against histogram of ROI 49 of abnormal group

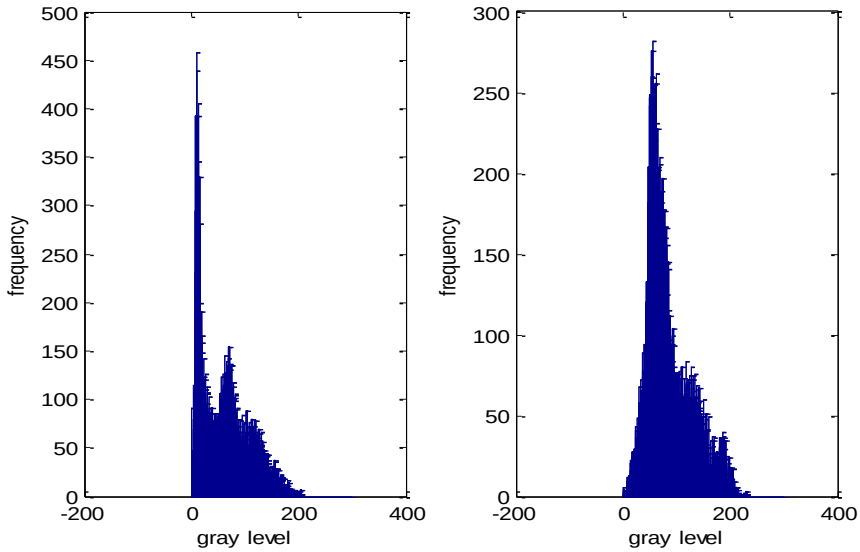

Figure 5.50 Comparison between histogram of ROI 50 of normal group against histogram of ROI 50 of abnormal group.

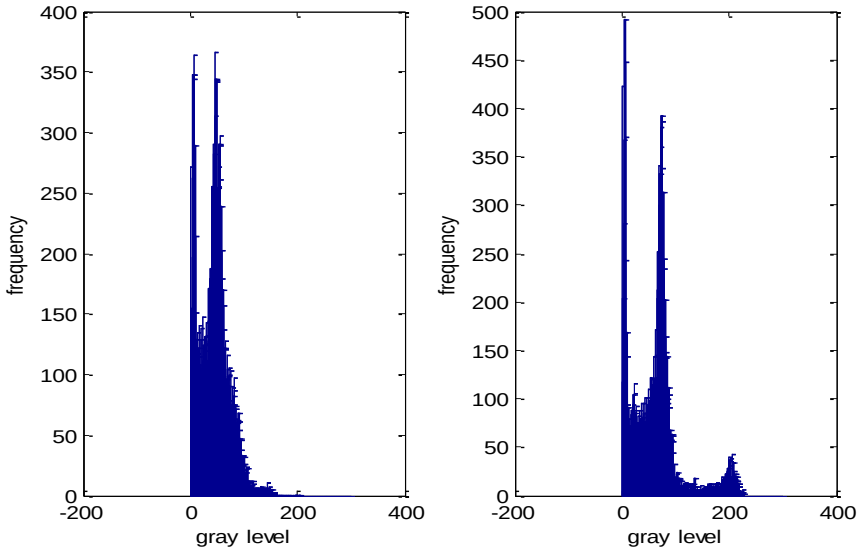

Figure 5.51 Comparison between histogram of ROI 51 of normal group against histogram of ROI 51 of abnormal group.

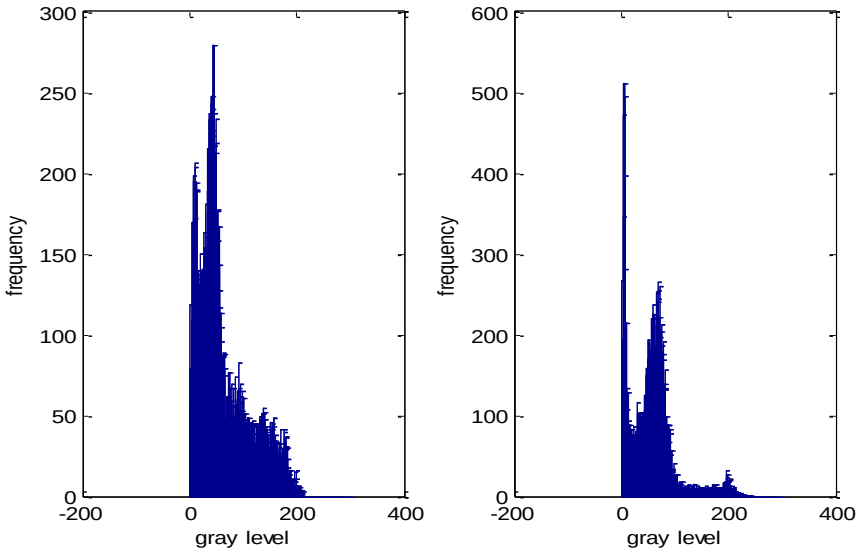

Figure 5.52 Comparison between histogram of ROI 52 of normal group against histogram of ROI 52 of abnormal group.

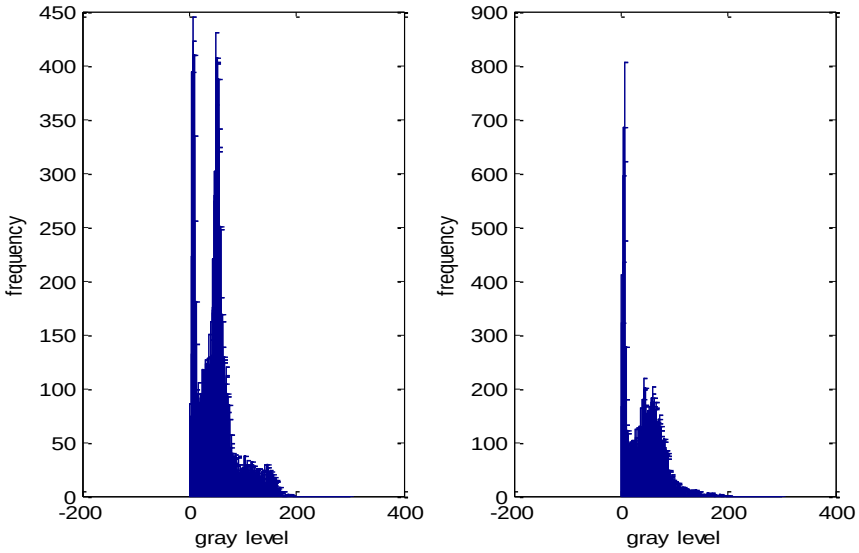

Figure 5.53 Comparison between histogram of ROI 53 of normal group against histogram of ROI 53 of abnormal group.

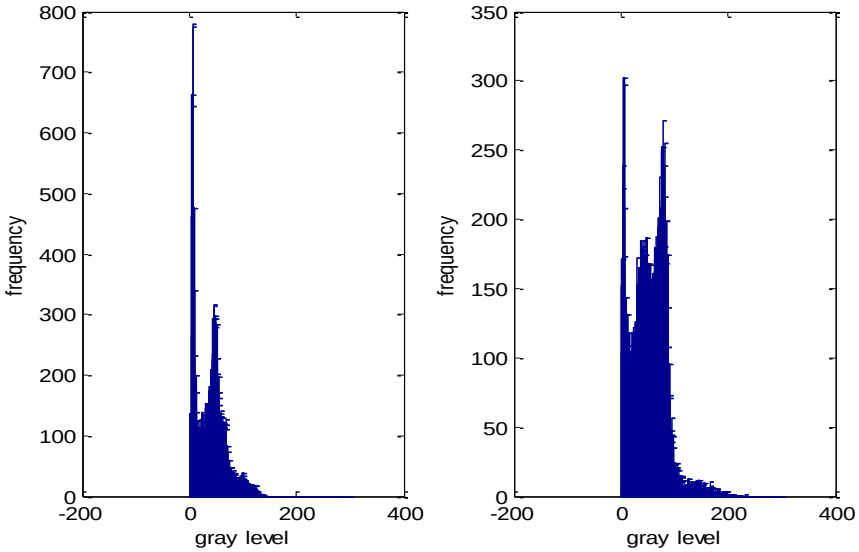

Figure 5.54 Comparison between histogram of ROI 54 of normal group against histogram of ROI 54 of abnormal group.

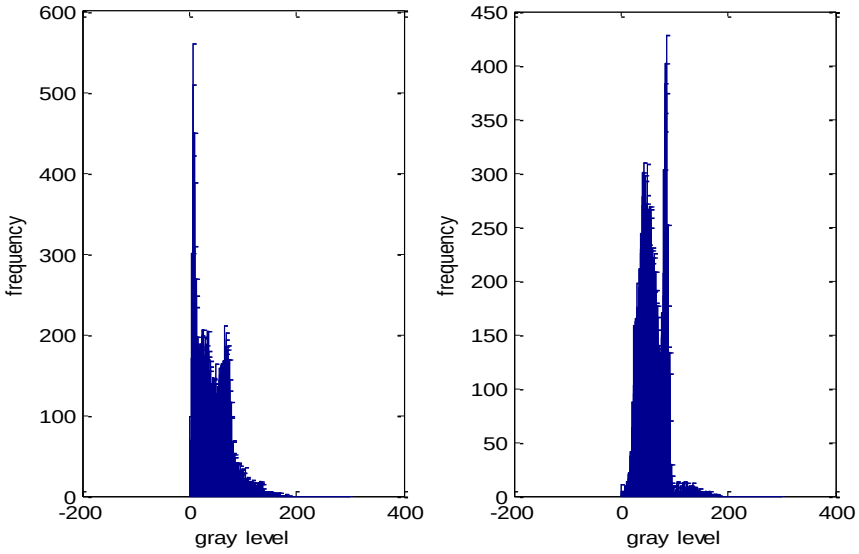

Figure 5.55 Comparison between histogram of ROI 55 of normal group against histogram of ROI 55 of abnormal group.

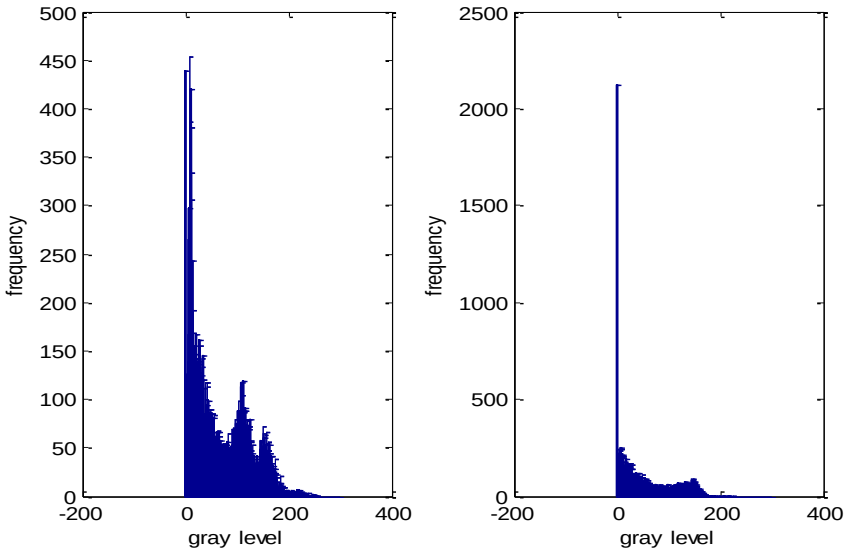

Figure 5.56 Comparison between histogram of ROI 56 of normal group against histogram of ROI 56 of abnormal group.

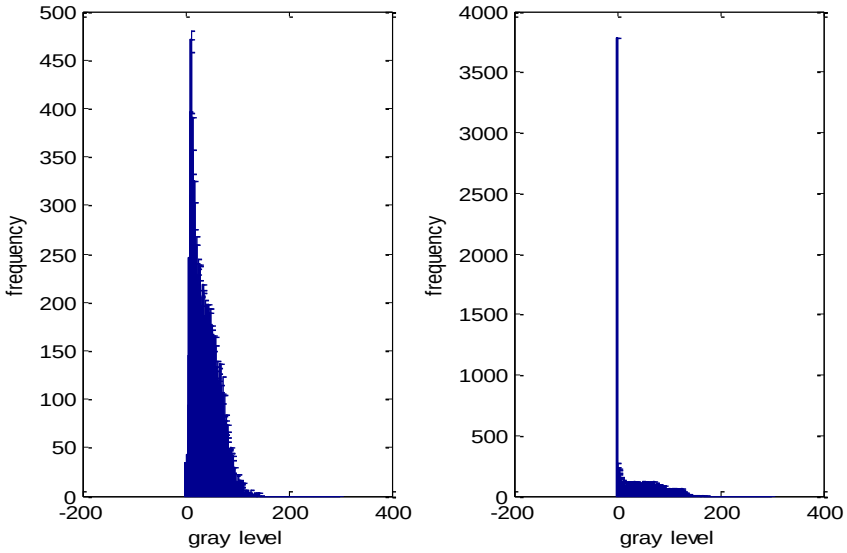

Figure 5.57 Comparison between histogram of ROI 57 of normal group against histogram of ROI 57 of abnormal group.

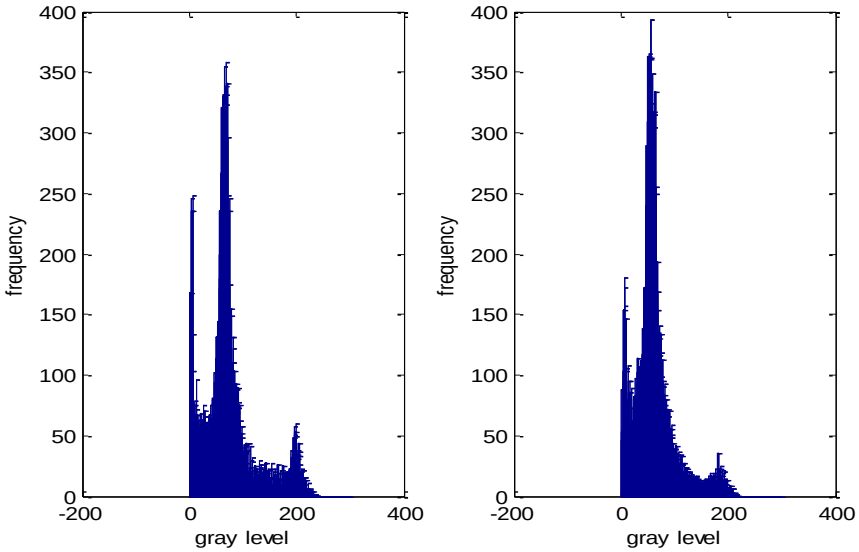

Figure 5.58 Comparison between histogram of ROI 58 of normal group against histogram of ROI 58 of abnormal group.

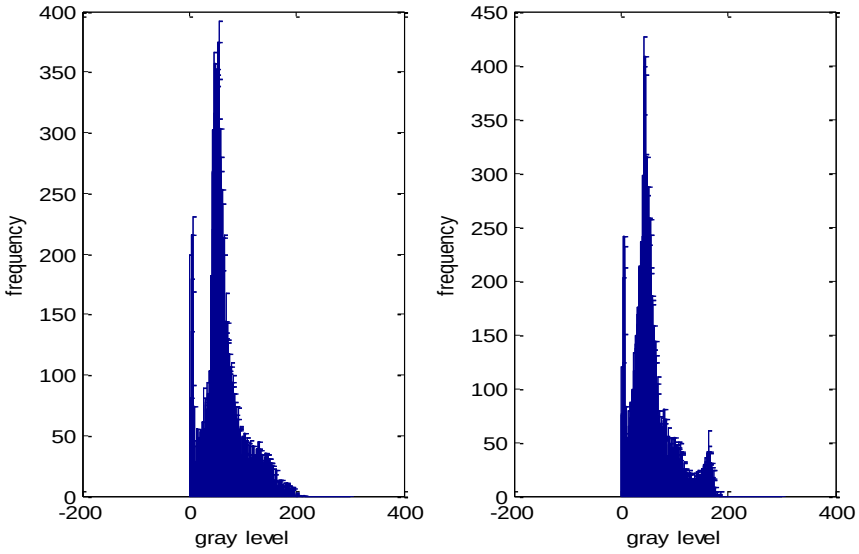

Figure 5.59 Comparison between histogram of ROI 59 of normal group against histogram of ROI 59 of abnormal group.

The previous figures from 5.1 to 5.59 illustrate 59 ROIs for both groups, negative and positive cases.

These ROIs was represented using the frequency histogram, which is computes the frequency distribution of elements in the inputs.

As it shown in figures, the left figure represent positive cases while the right one represent the negative cases.

Noticed from the histogram that, the infected cases had

a considerable high frequency in the gray level in comparison to normal cases.

Simply that’s due to the abnormalities found in the brain cells of positive HIV/AIDS patients.

Then , subtraction for normal and abnormal features was done for clarifying the variation of images, also a second group of healthy volunteers was participate the study and their images subtraction doesn't show a significant variation in comparison with the main group of normal vs. abnormal cases.

The subtraction of ROIs had the following figures:

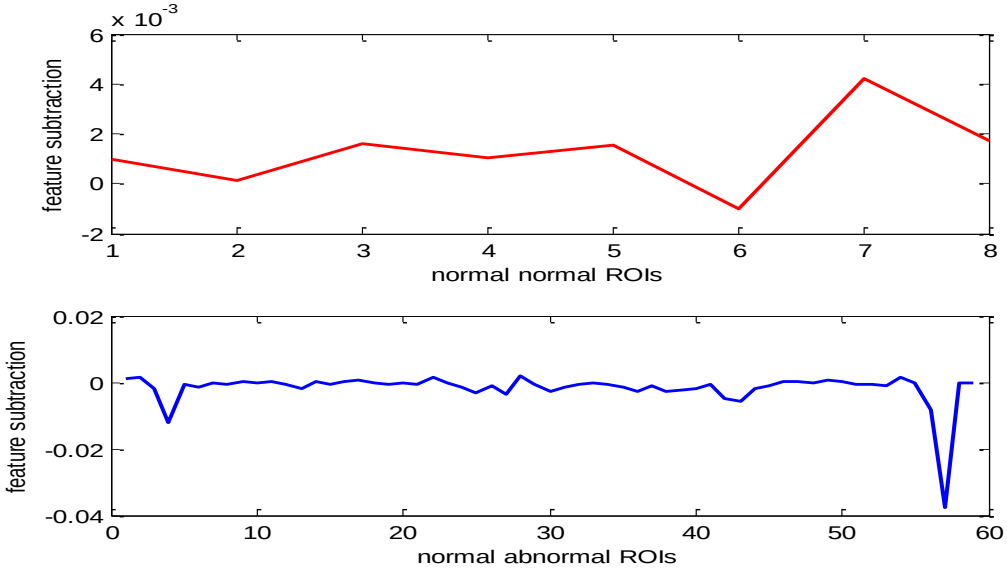

Figure 5.60 Comparison between Energy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

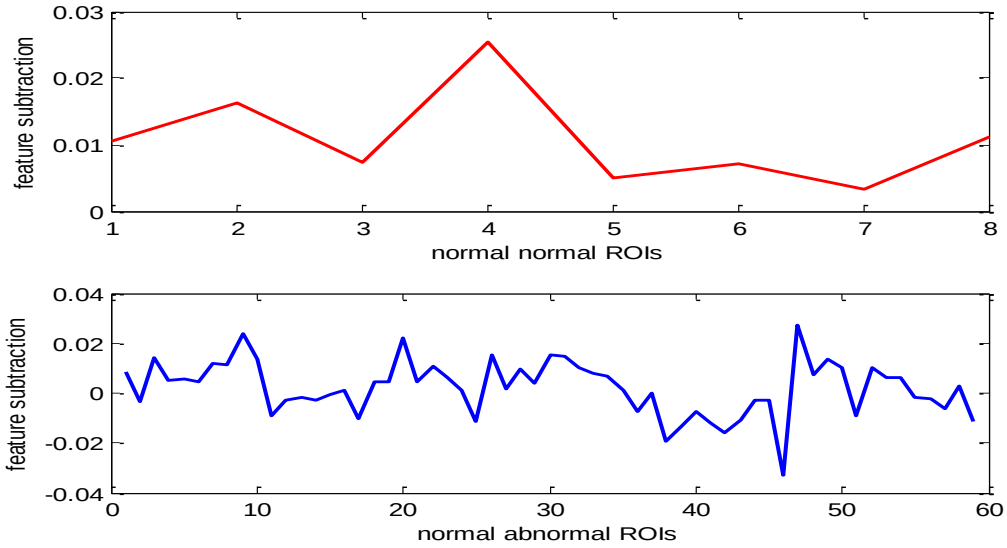

Fig 5.61 Comparison between Correlation (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

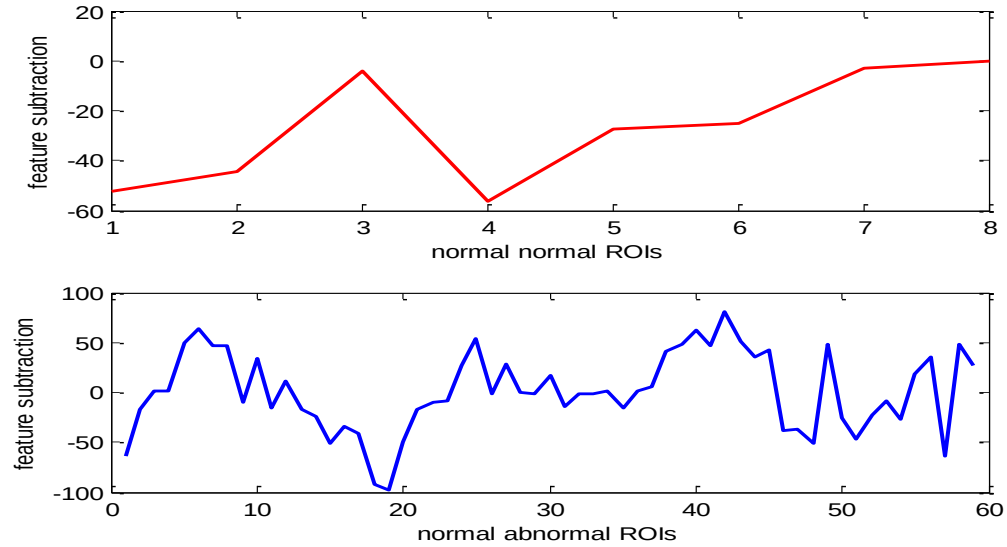

Figure 5.62 Comparison between Inertia (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

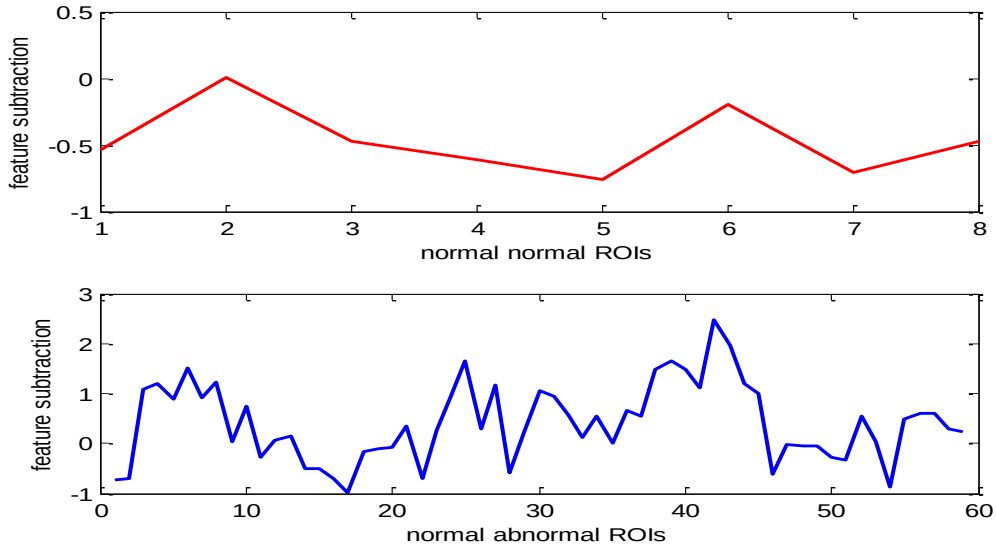

Figure 5.63 Comparison between Entropy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

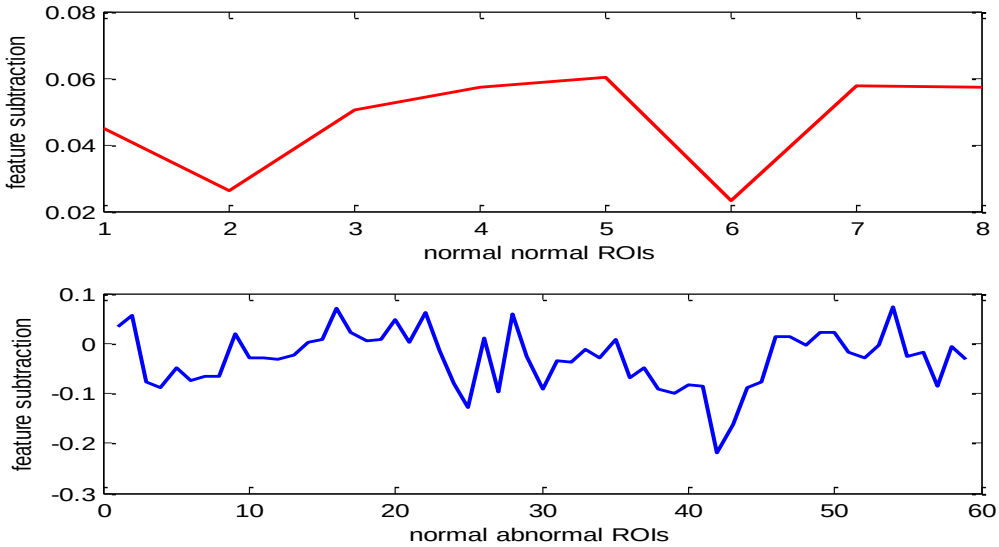

Figure 5.64 Comparison between Inverse Difference Moment (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

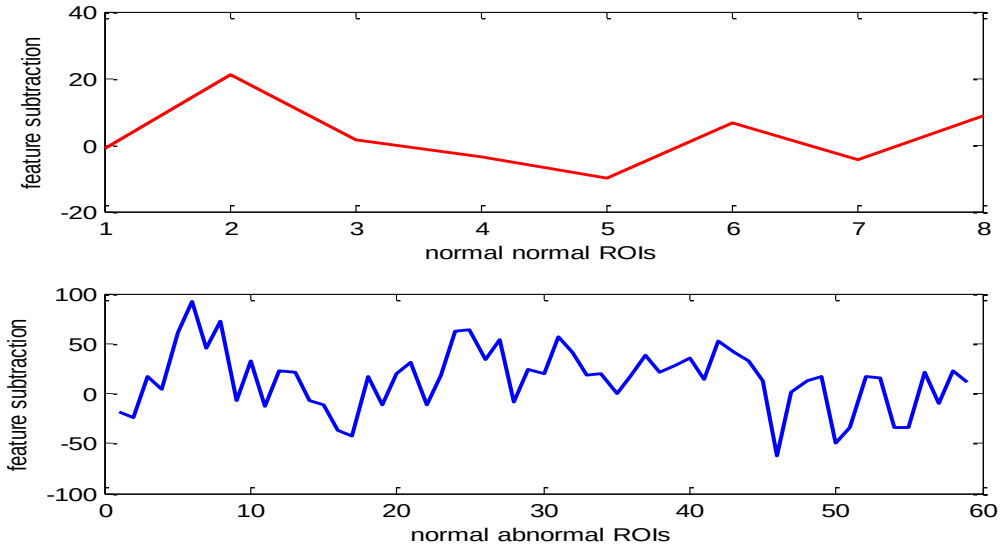

Figure 5.65 Comparison between Sum Average (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

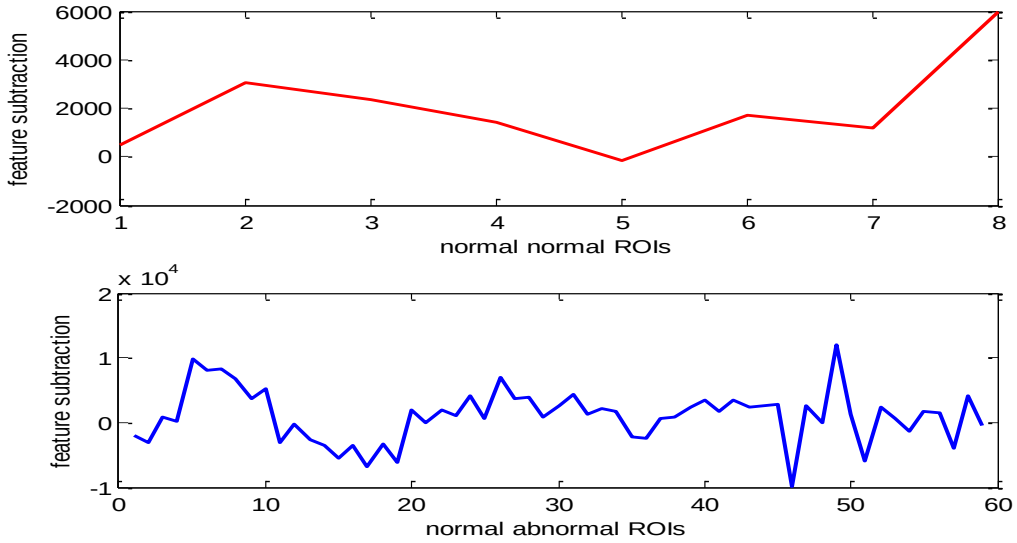

Figure 5.66 Comparison between Sum Variance (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

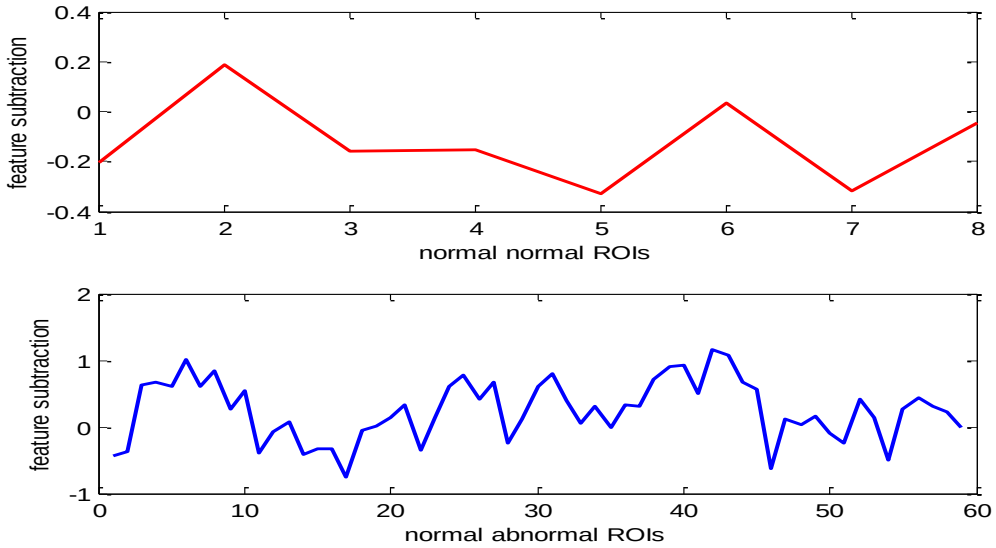

Figure 5.67 Comparison between Sum Entropy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

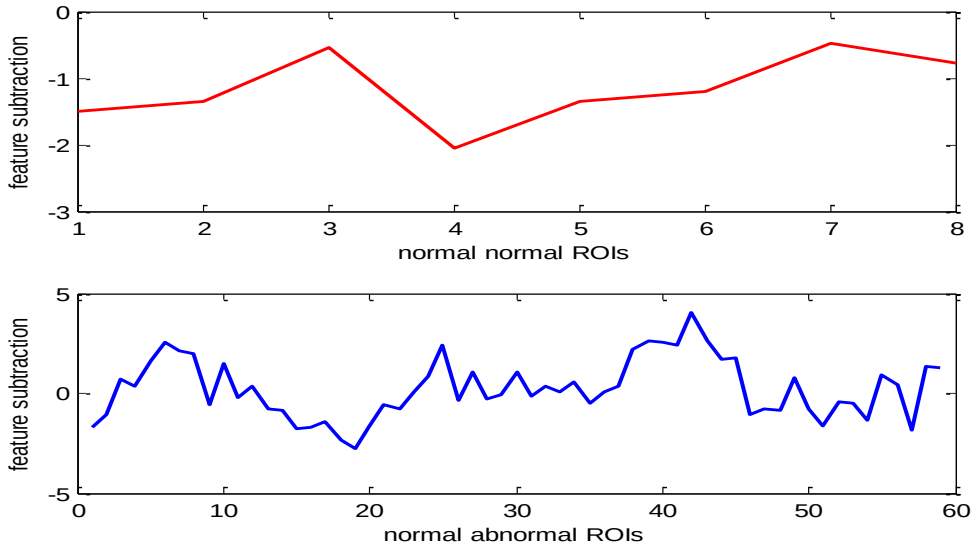

Figure 5.68 Comparison between Difference Average (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

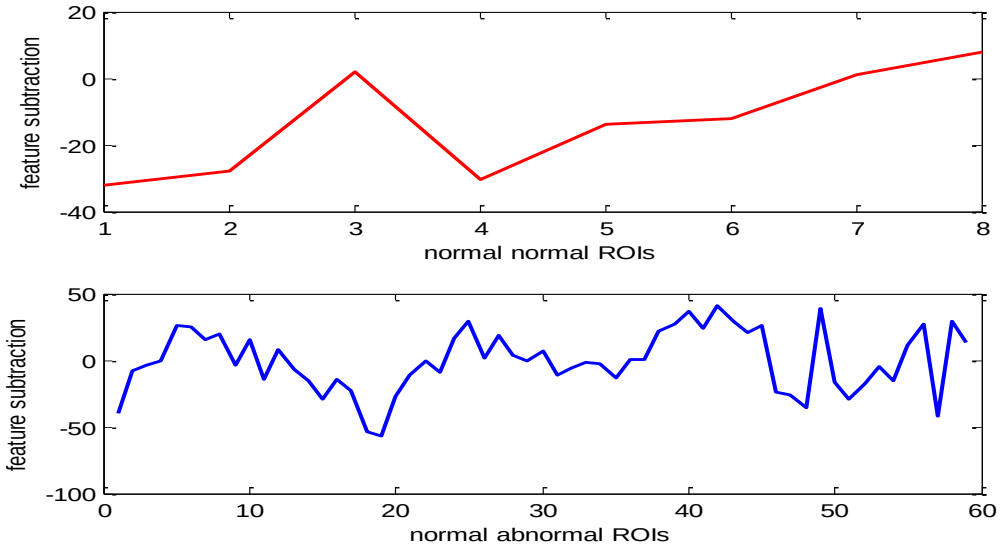

Figure 5.69 Comparison between Difference Variance (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

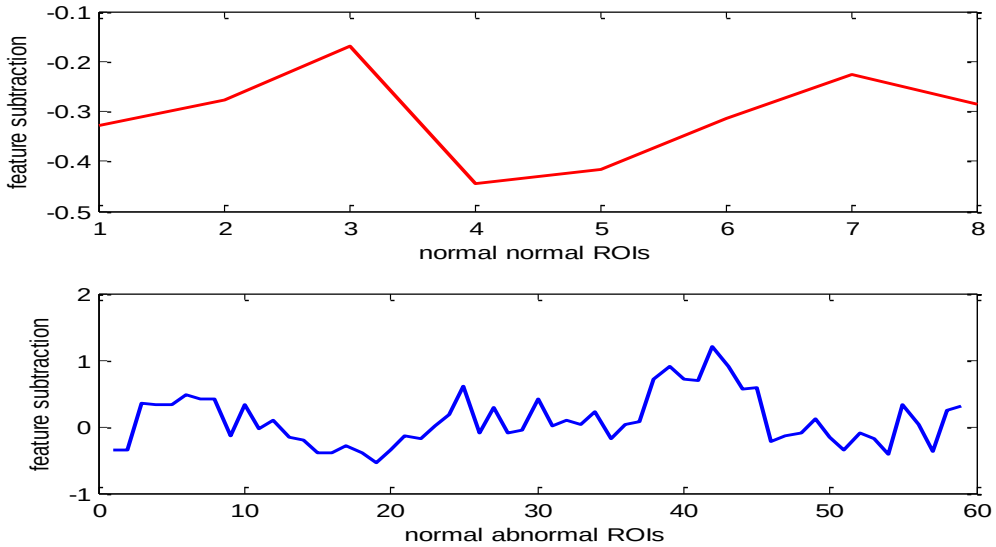

Figure 5.70 Comparison between Difference Entropy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

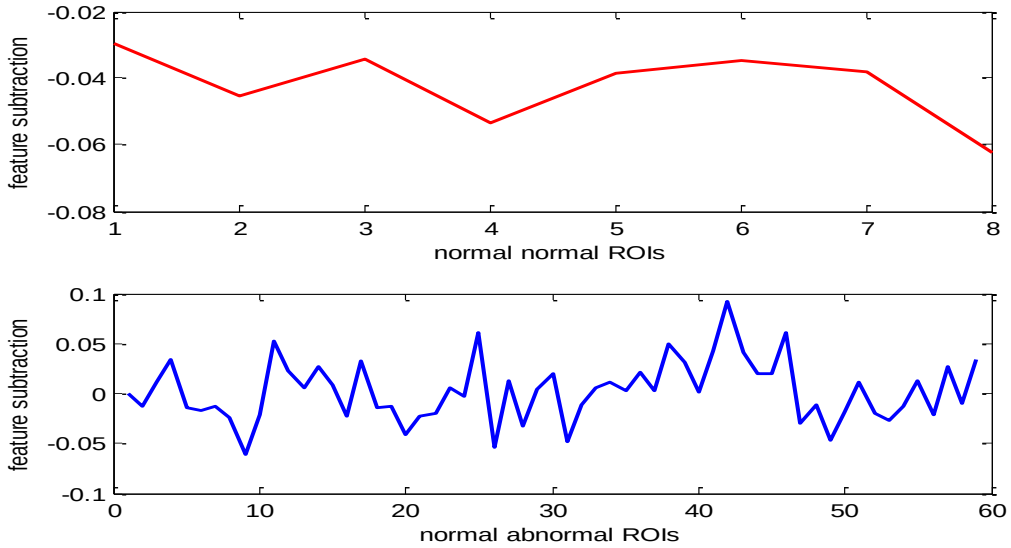

Figure 5.71 Comparison between Infomation measure of correlation 1 (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

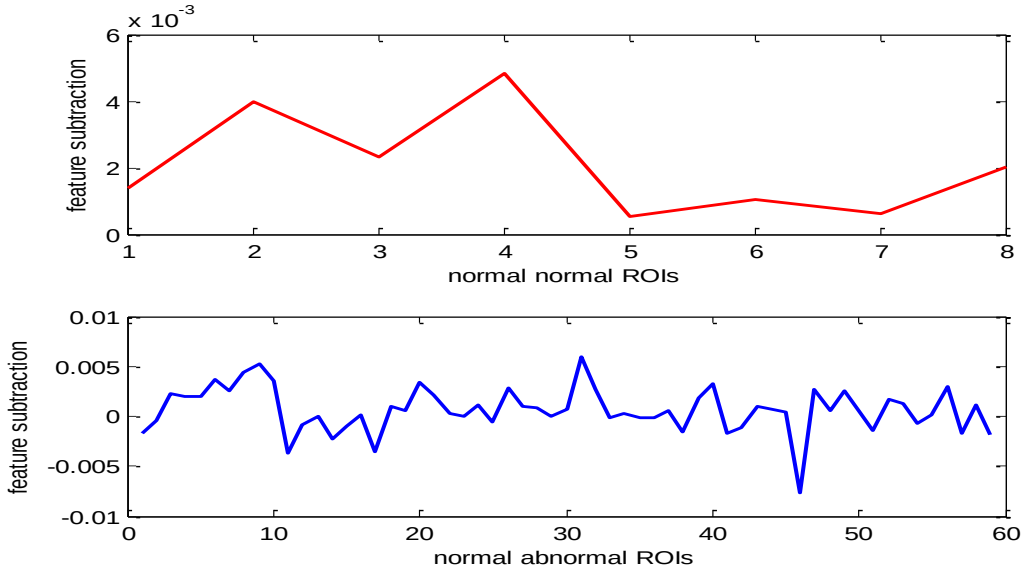

Figure 5.72 Comparison between Information measure of correlation 2 (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

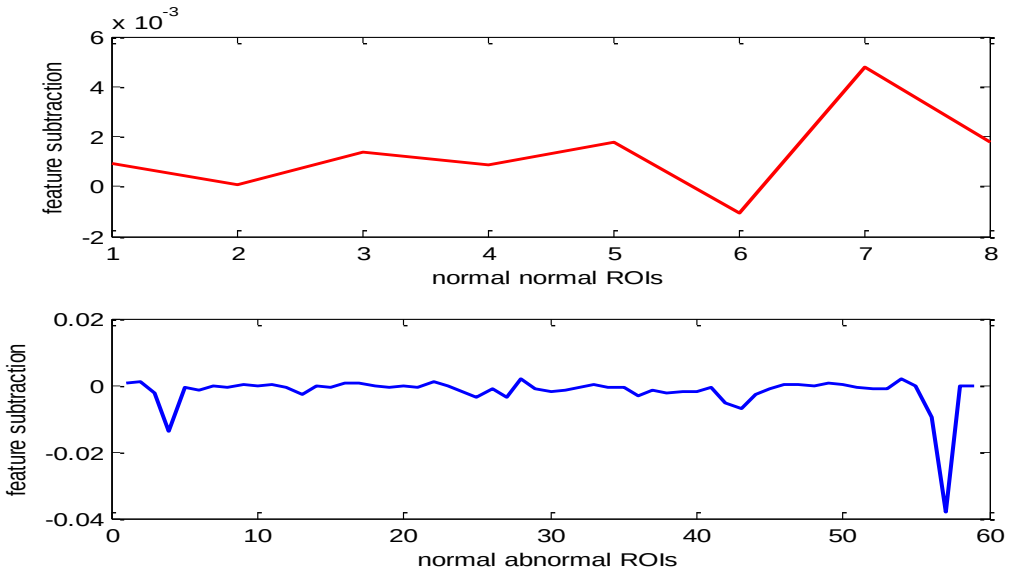

Figure 5.73 Comparison between Energy (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

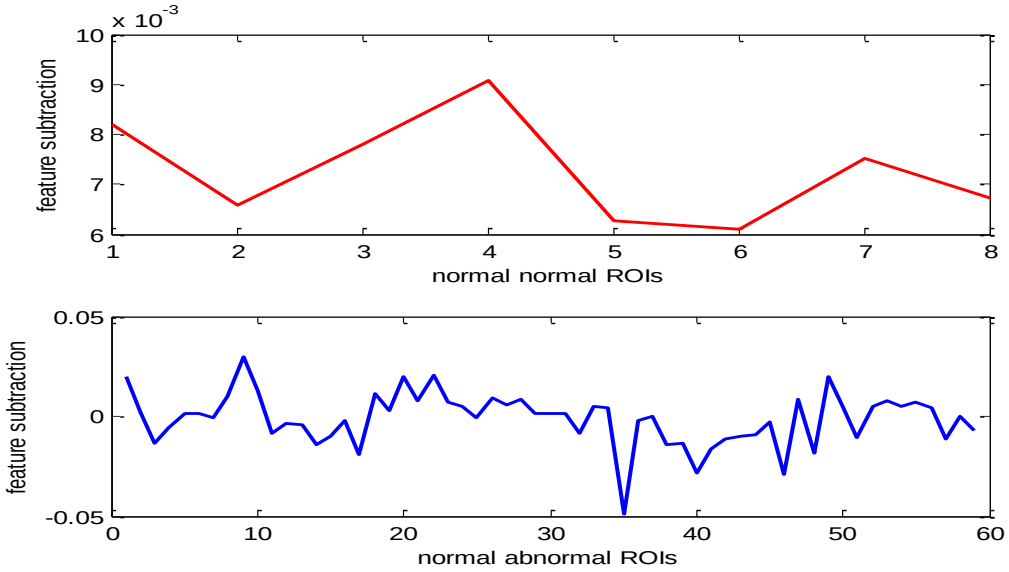

Figure 5.74 Comparison between Correlation (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

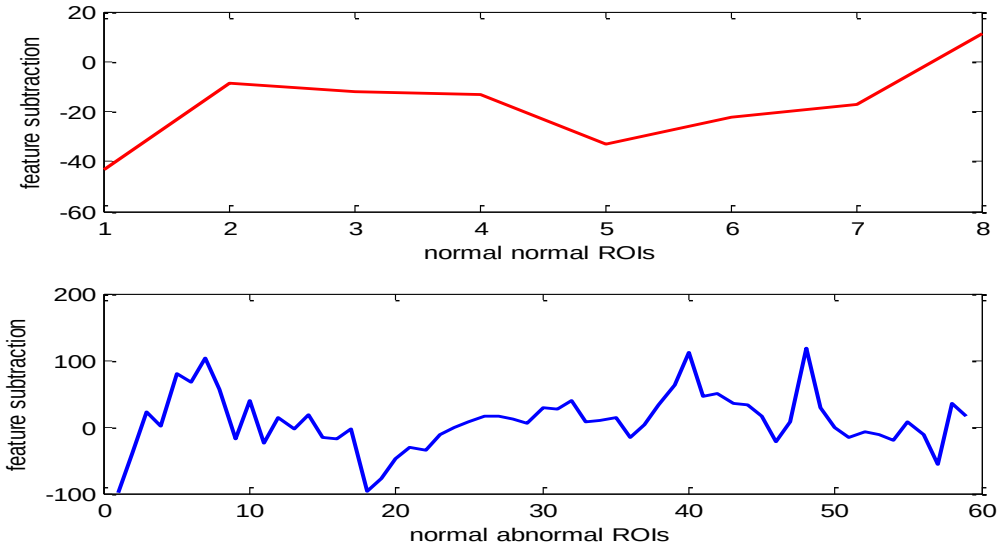

Figure 5.75 Comparison between Inertia (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

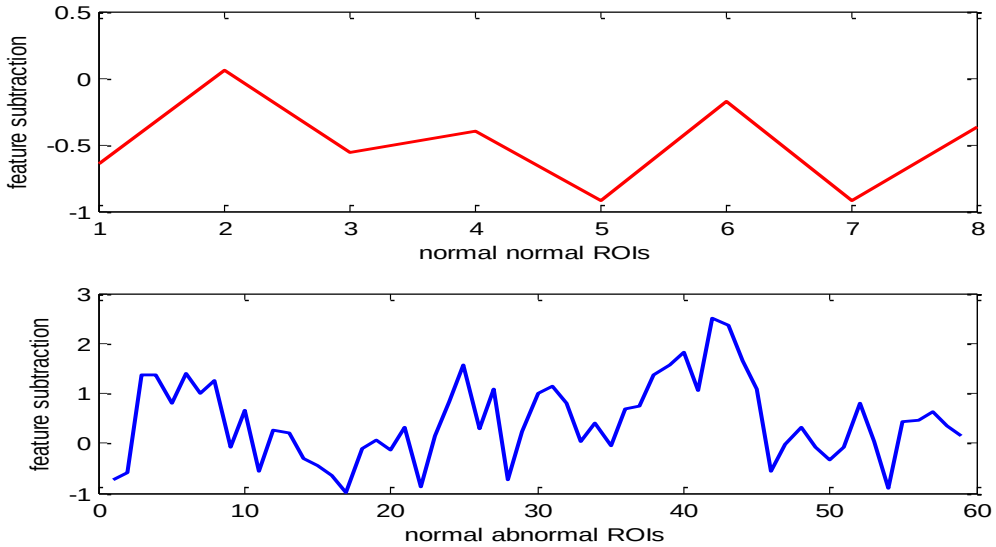

Figure 5.76 Comparison between Entropy (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

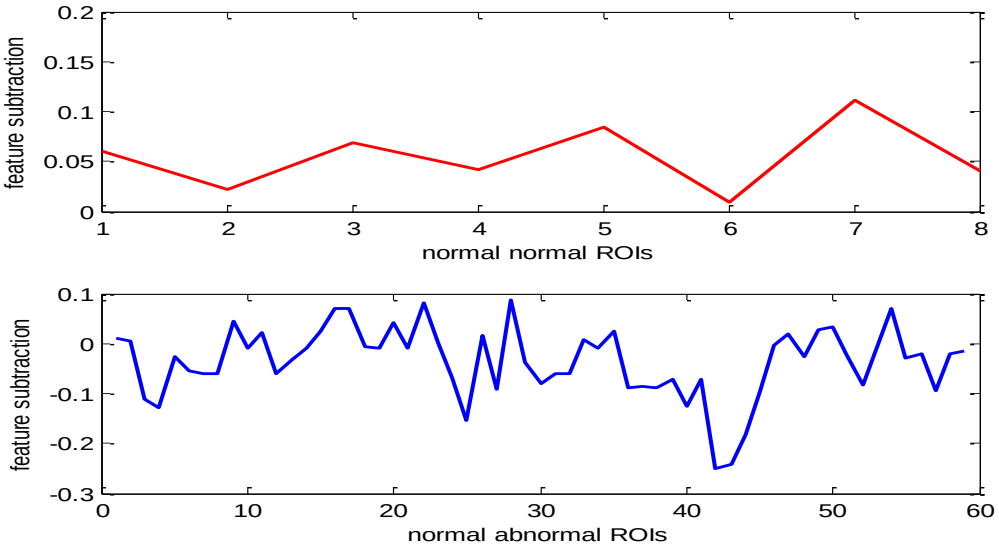

Figure 5.77 Comparison between Inverse Difference Moment

(Theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

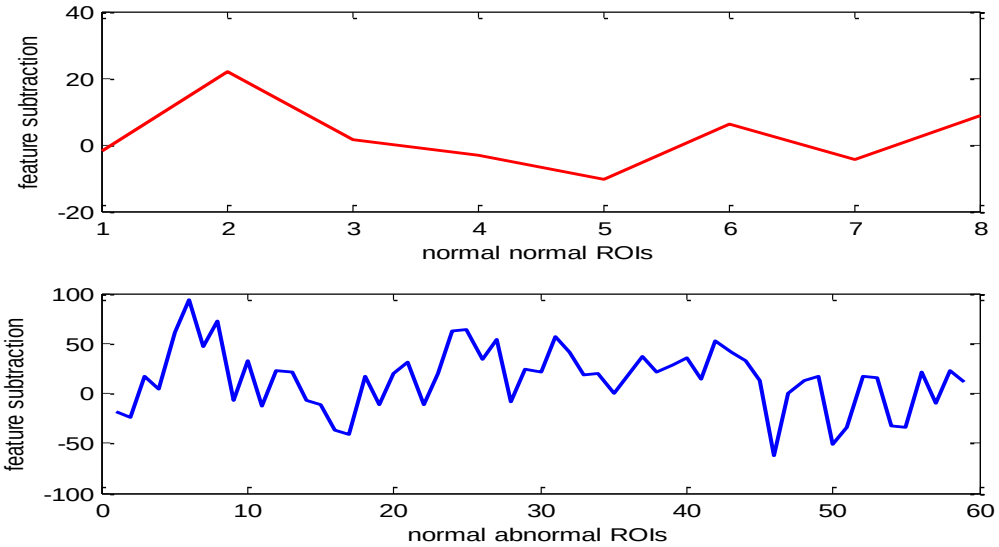

Figure 5.78 Comparison between Sum Average

(Theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

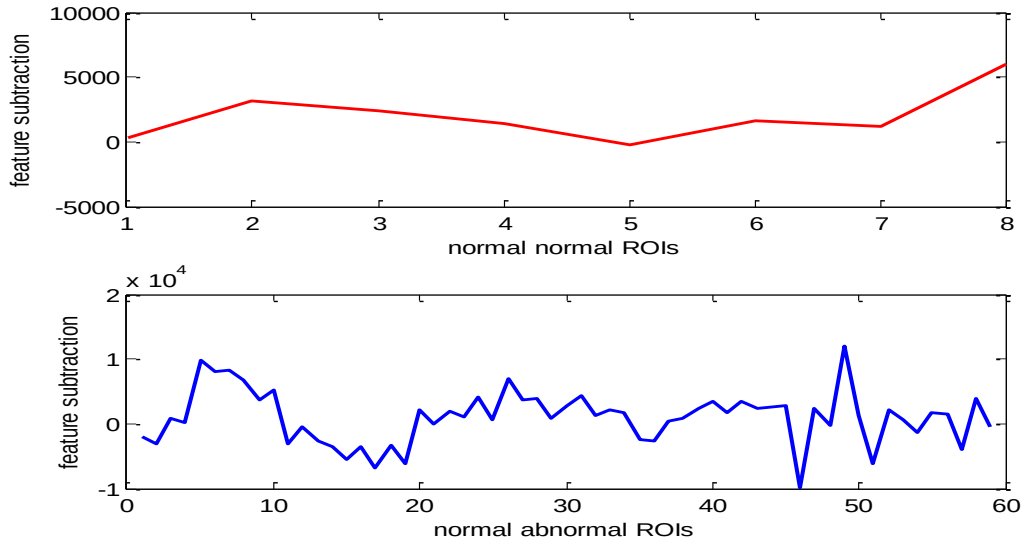

Figure 5.79 Comparison between Sum Variance (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

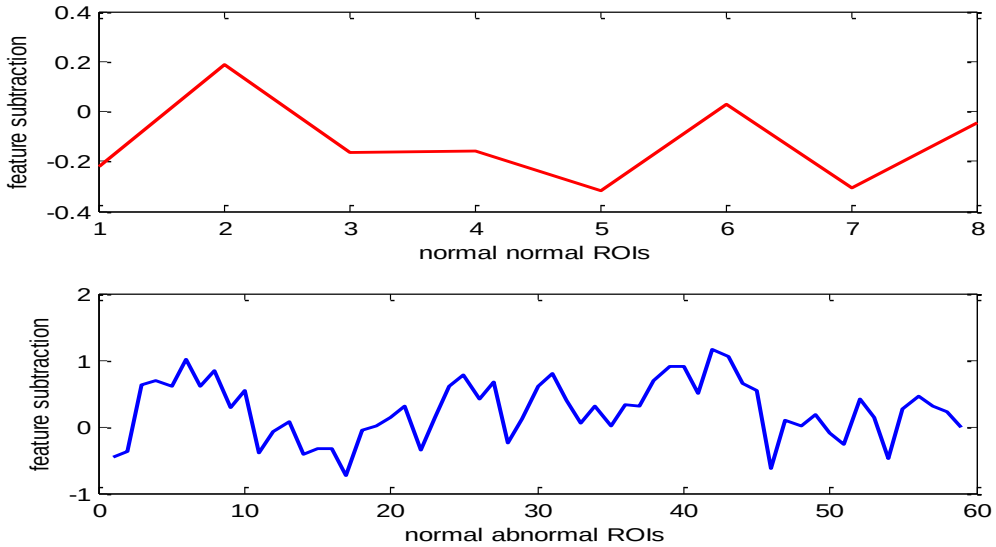

Figure 5.80 Comparison between Sum Entropy (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

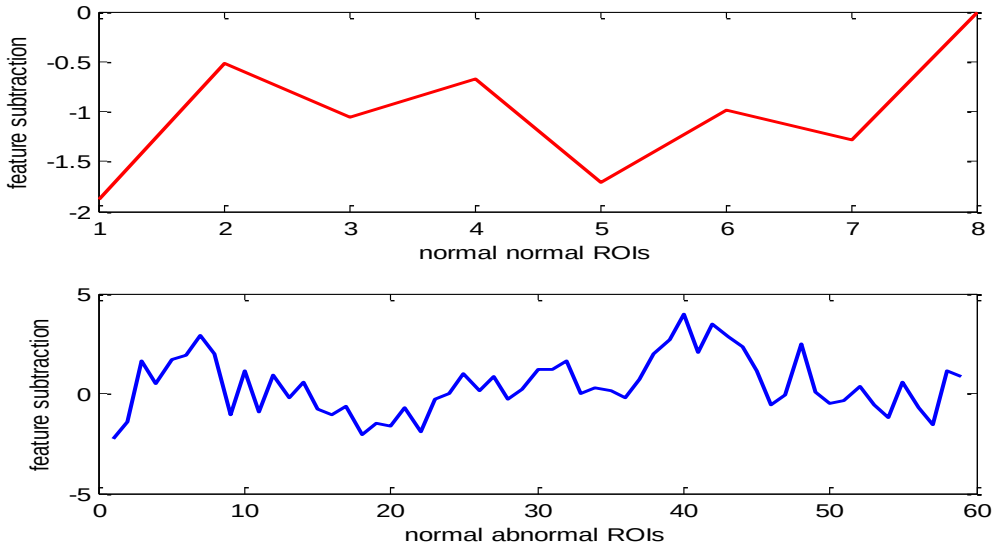

Figure 5.81 Comparison between Difference Average (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

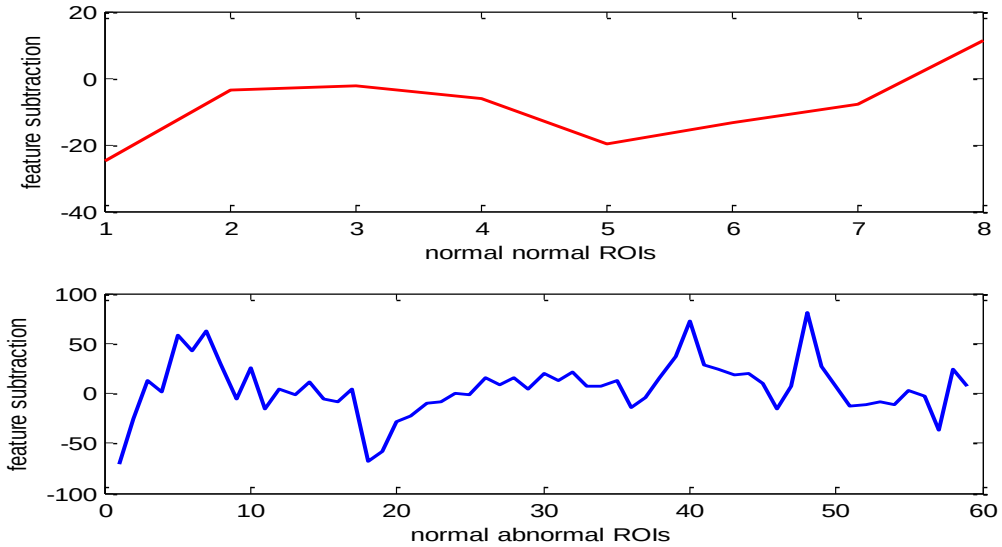

Figure 5.82 Comparison between Difference Variance (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

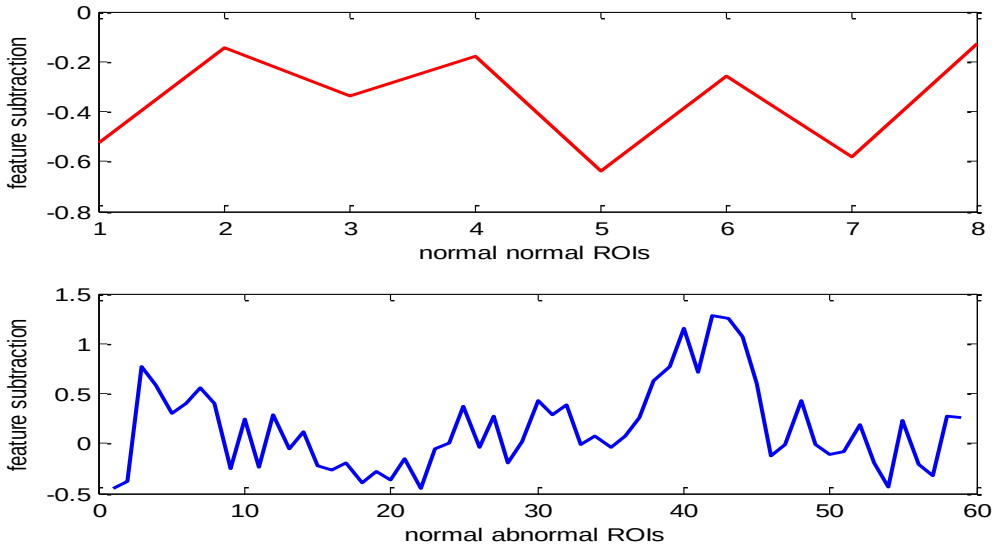

Figure 5.83 Comparison between Difference Entropy (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

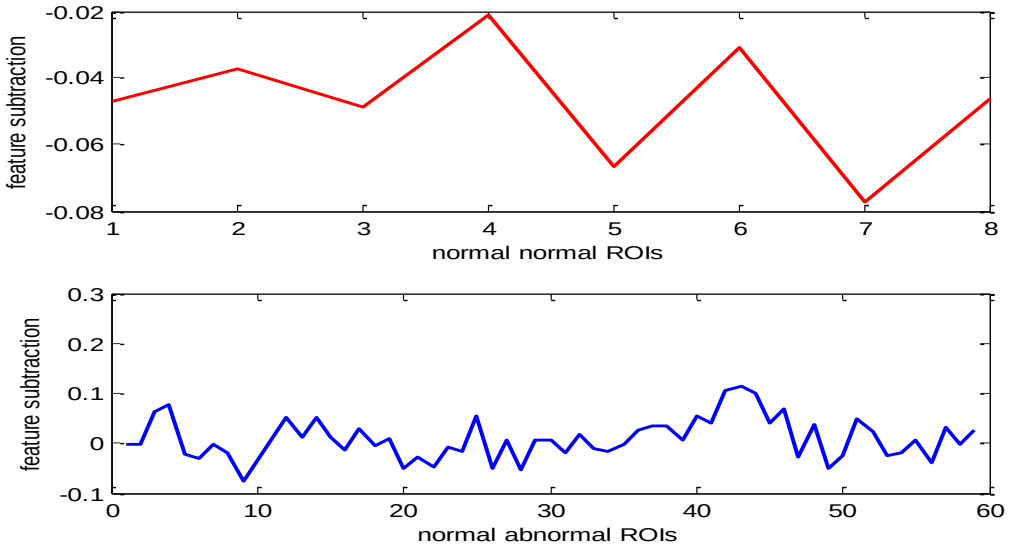

Figure 5.84 Comparison between Infomation measure of correlation 1 (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

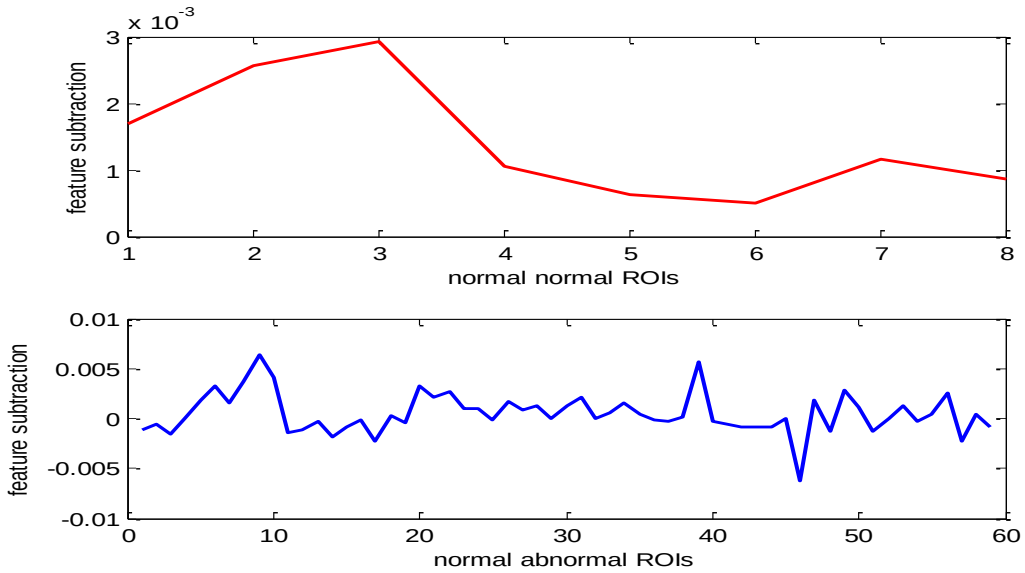

Figure 5.85 Comparison between Information measure of correlation 2 (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

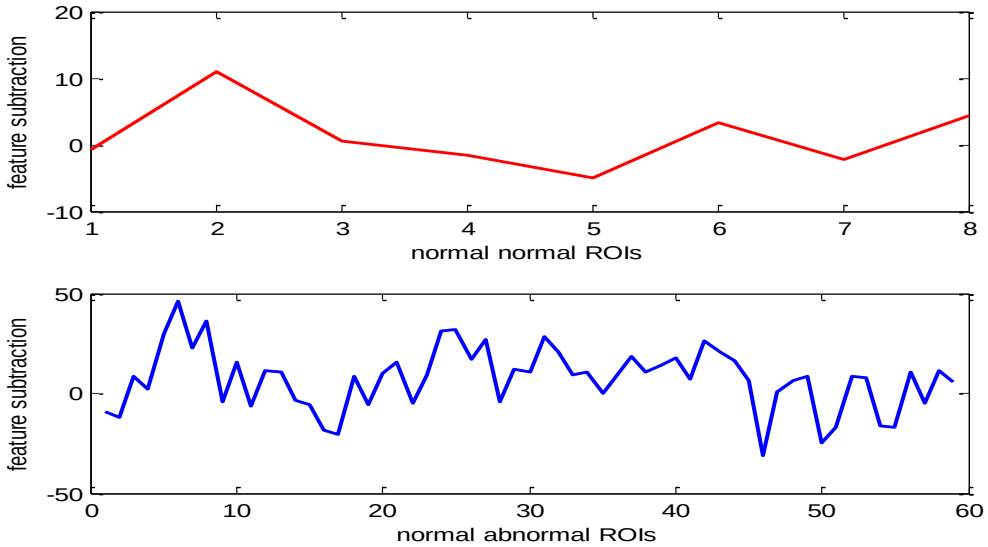

Figure 5.86 Comparison between mean subtraction for normal-normal ROIs and normal-abnormal ROIs.

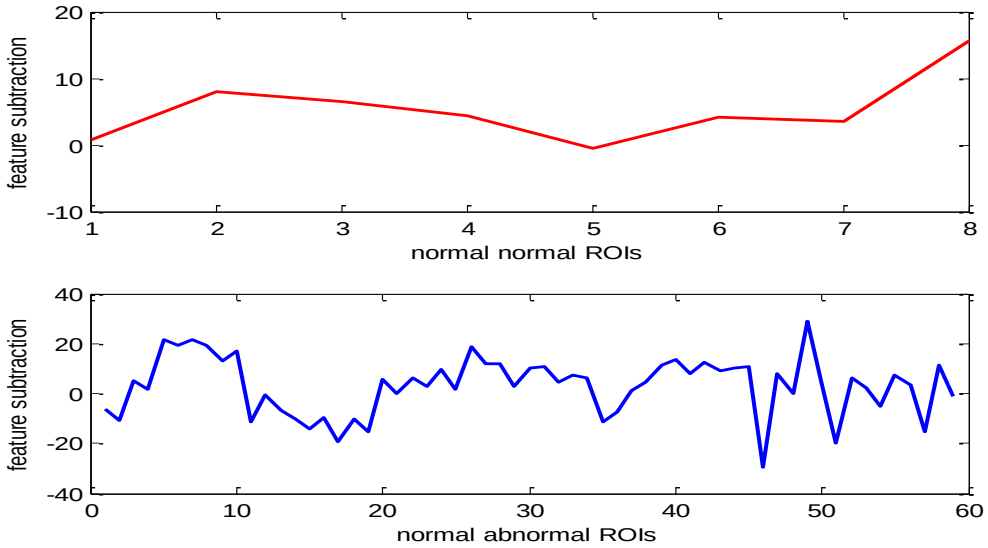

Figure 5.87 Comparison between standard deviation (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.

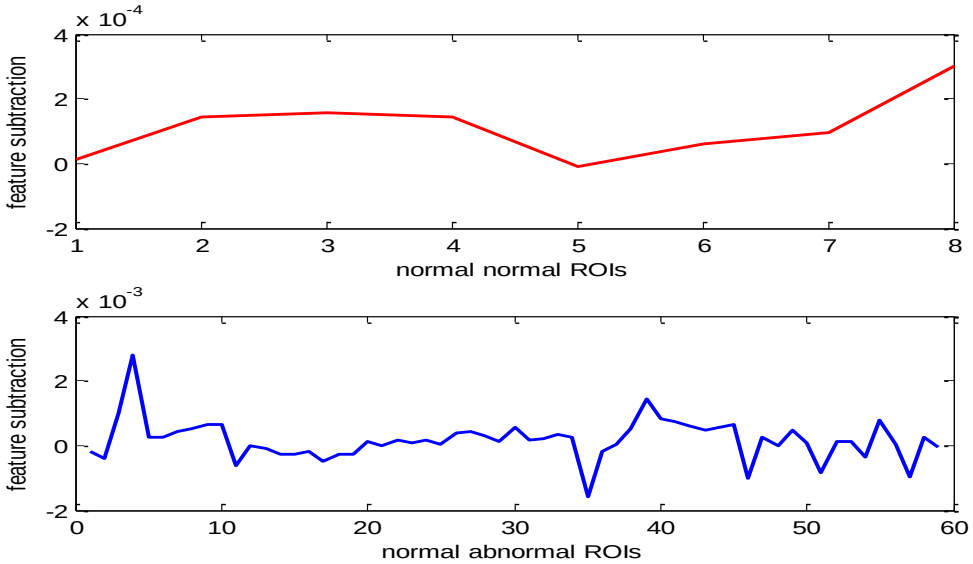

Figure 5.88 Comparison between smoothness subtraction for normal-normal ROIs and normal-abnormal ROIs.

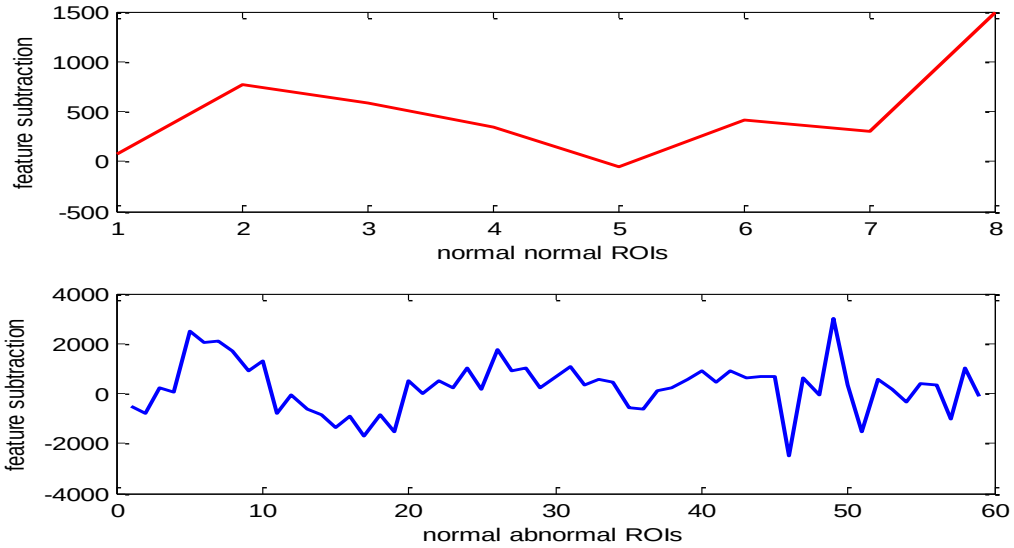

Figure 5.89Comparison between variance subtraction for normal-normal ROIs and normal-abnormal ROIs.

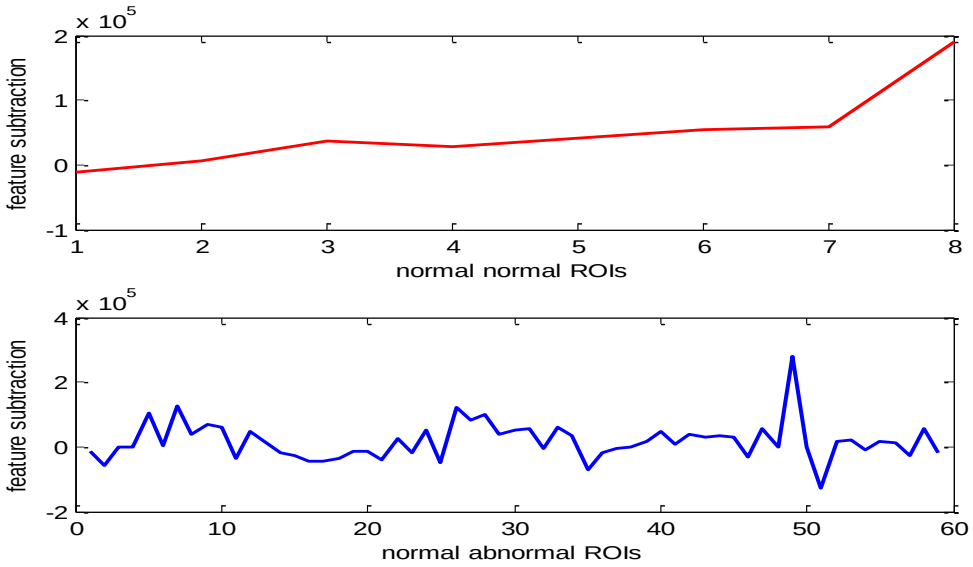

Figure 5.90 Comparison between moment subtraction for normal-normal ROIs and normal-abnormal ROIs.

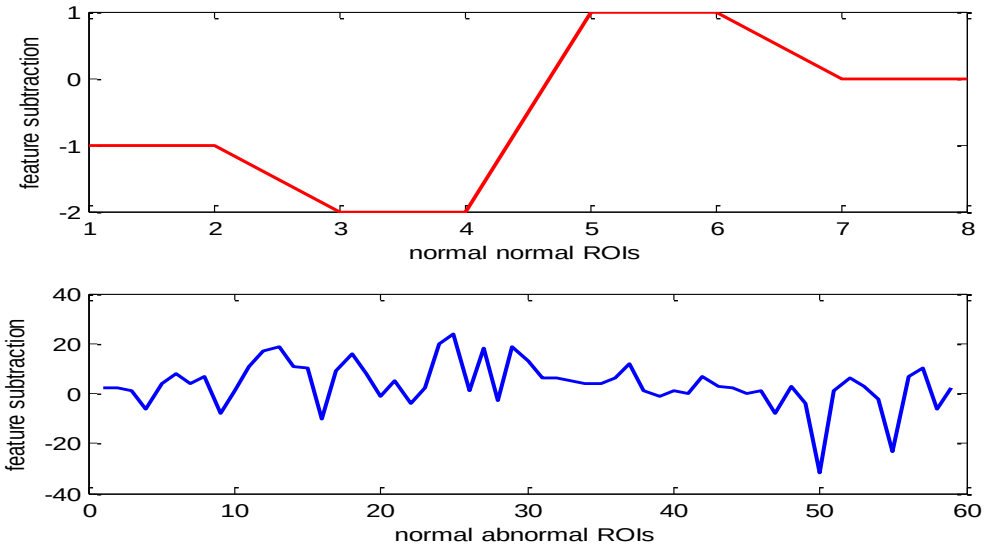

Figure 5.91 Comparison between percentile (0.1) subtraction for normal-normal ROIs and normal-abnormal ROIs.

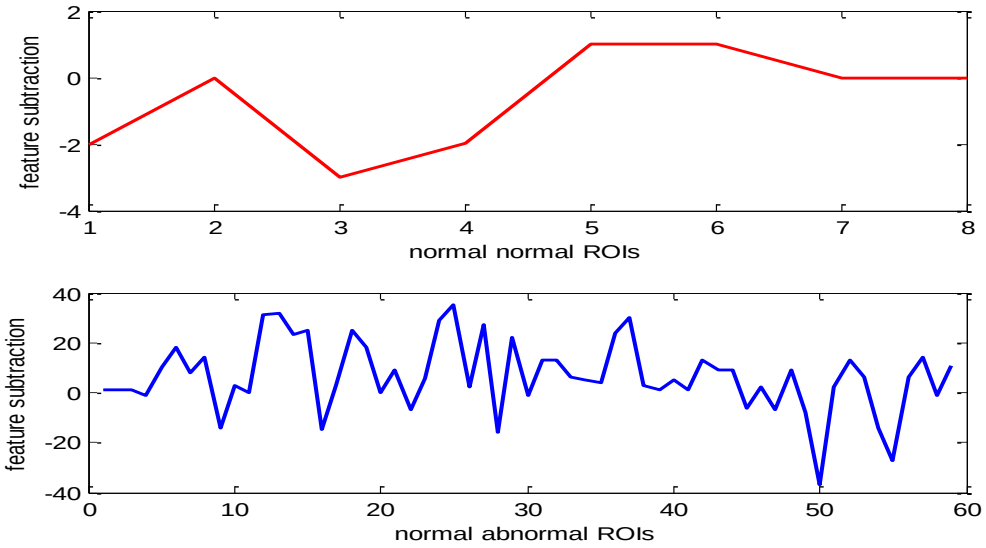

Figure 5.92 Comparison between percentile (0.2) subtraction for normal-normal ROIs and normal-abnormal ROIs.

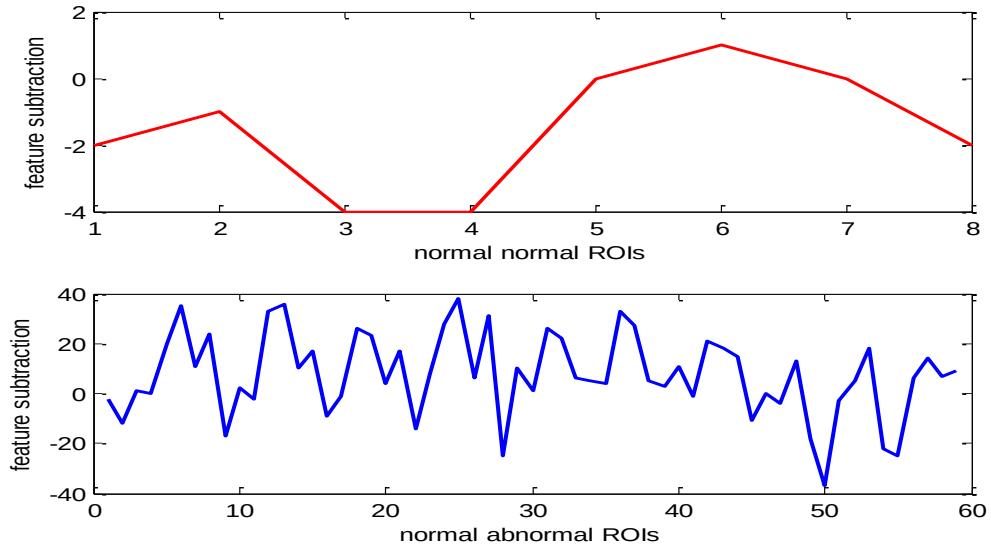

Figure 5.93 Comparison between percentile (0.3) subtraction for normal-normal ROIs and normal-abnormal ROIs.

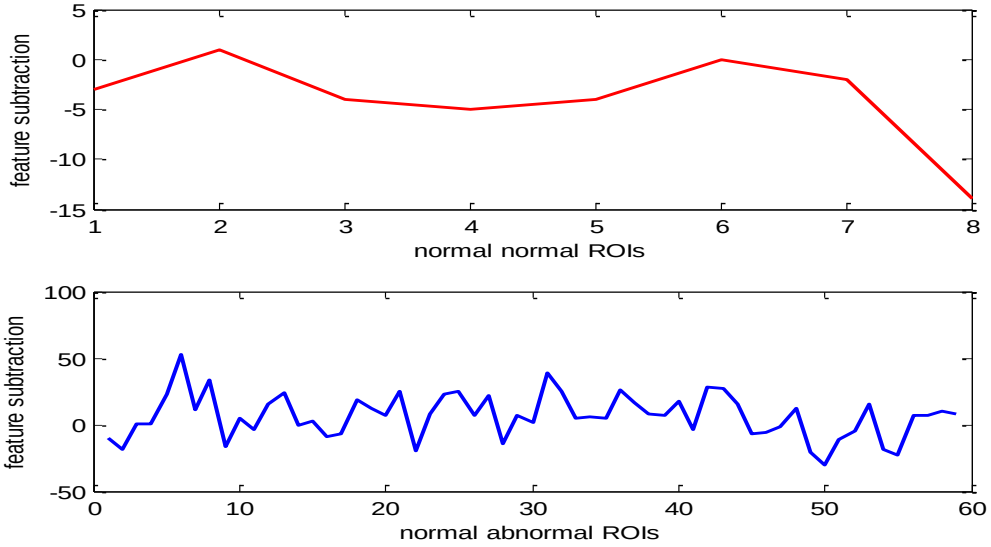

Figure 5.94 Comparison between percentile (0.4) subtraction for normal-normal ROIs and normal-abnormal ROIs.

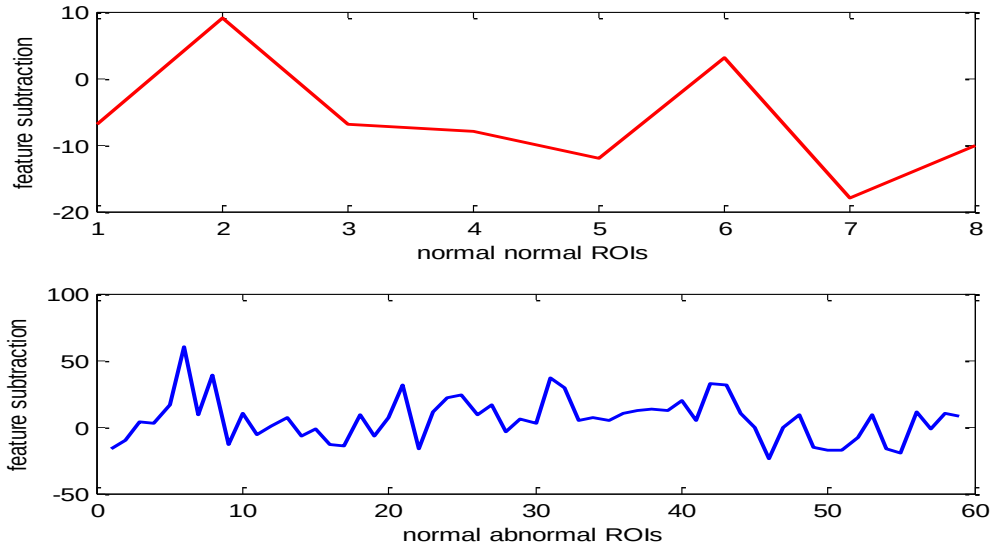

Figure 5.95 Comparison between percentile (0.5) subtraction for normal-normal ROIs and normal-abnormal ROIs.

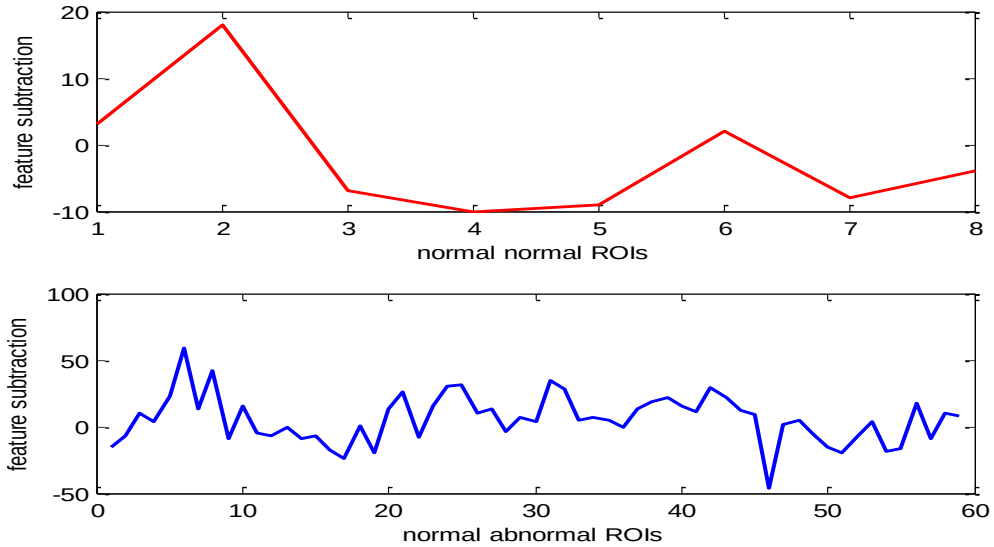

Figure 5.96 Comparison between percentile (0.6) subtraction for normal-normal ROIs and normal-abnormal ROIs.

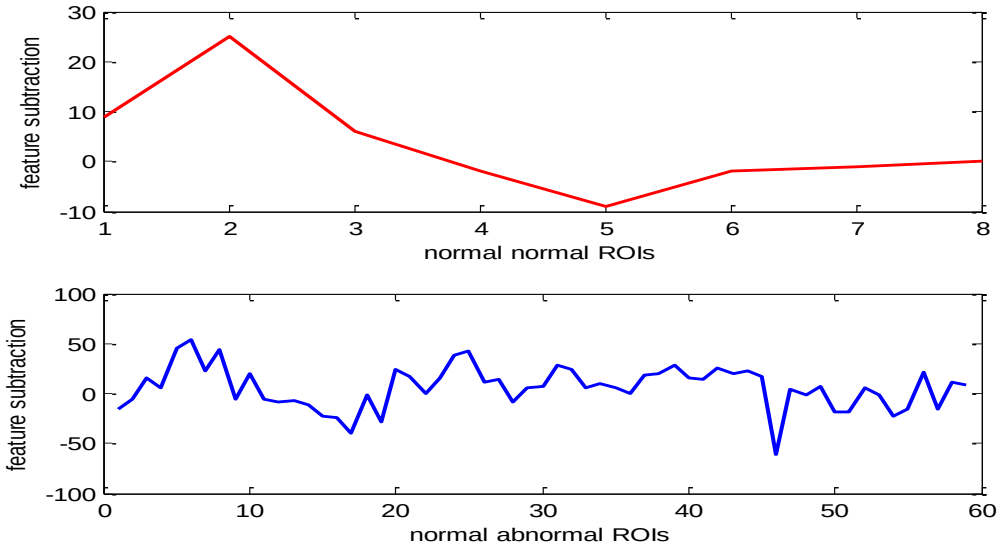

Figure 5.97 Comparison between percentile (0.7) subtraction for normal-normal ROIs and normal-abnormal ROIs.

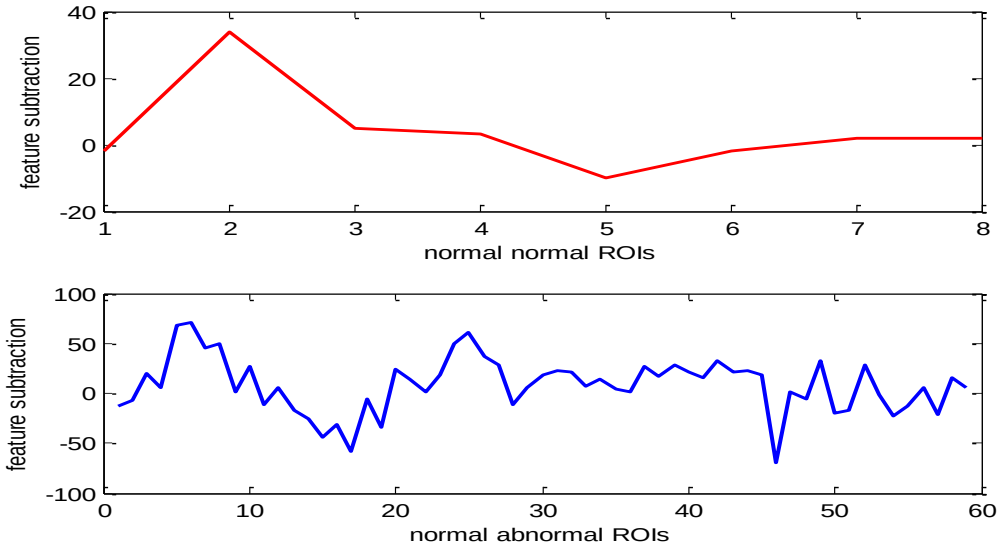

Figure 5.98 Comparison between percentile (0.8) subtraction for normal-normal ROIs and normal-abnormal ROIs.

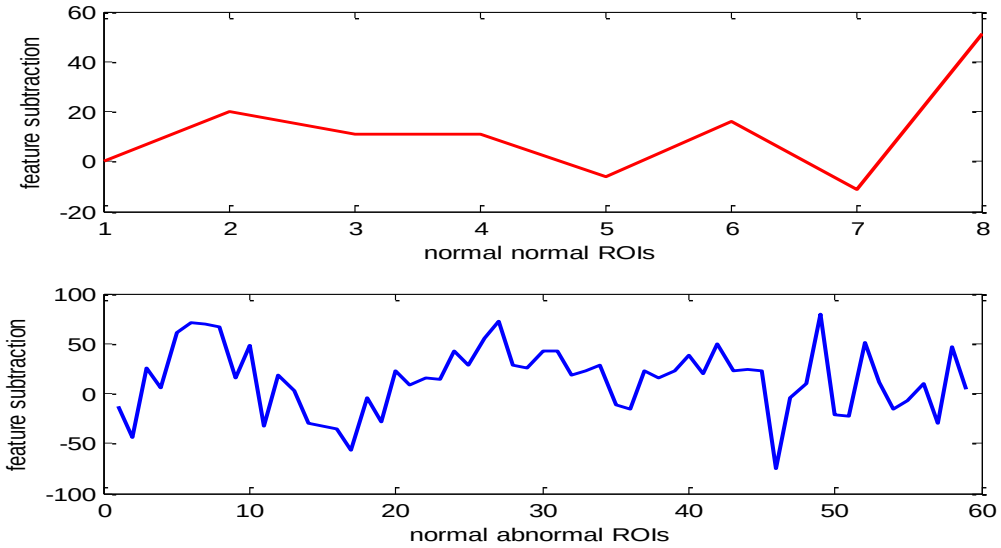

Figure 5.99 Comparison between percentile (0.9) subtraction for normal-normal ROIs and normal-abnormal ROIs.

Then figures from 5.60 to 5.99 shown the subtraction for all the forty statistical features used in this research.

For example figure 5.60 show the energy feature at angle zero, calculated the value for each region of interest for the healthy group, and also calculated the energy value for each region of interest for infected group, then mathematically subtract the normal group from the abnormal group, plot the result as it represented on figures.

When take a look on these figures will observe that there were significant variations between the two categories.

Then in the same way figure 5.61 show the correlation feature at zero degree, and so on for rest of figures.

Notice that there was second figures appears above in red color and named normal-normal ROIs, this group just to check the difference when plot the subtraction

between normal vs. abnormal, and between normal vs. normal ,also observed the difference at scales in the check group graphs that it were magnified to make it clearly in comparison.

Hypothesis Test using independent samples T Test for means of two groups normal and abnormal for all 40 properties

H_0: $M_1 = M_2$

H_1: $M_1 \neq M_2$

From the tables test the significance value for hypothesis is 0.026 it's less than 0.05 then we reject H0 and accept H1 (the test is significance)

Properties have a significance test are colored with blue under Sig. P value column.

Table 5.1 Independent samples tests for (V1_V10)

Feature		F test	Sig.	T test	Degree of freedom	Sig. P value
V1	Equal variances assumed	7.221	.008	-2.280	116	0.024
	Equal variances not assumed			-2.280	66.116	**0.026**
V2	Equal variances assumed	1.667	0.199	1.341	116	0.183
	Equal variances not assumed			1.341	113.227	0.183
V3	Equal variances assumed	2.051	0.155	0.152	116	0.879
	Equal variances not assumed			0.152	111.190	0.879
V4	Equal variances assumed	3.346	0.070	2.260	116	**0.026**
	Equal variances not assumed			2.260	111.283	0.026
V5	Equal variances assumed	3.622	0.060	-2.165	116	0.**032**
	Equal variances not assumed			-2.165	110.363	0.033
V6	Equal variances assumed	0.335	0.564	2.937	116	**0.004**
	Equal variances not assumed			2.937	115.831	0.004
V7	Equal variances assumed	0.634	0.428	1.584	116	0.116
	Equal variances not assumed			1.584	111.962	0.116
V8	Equal variances assumed	1.197	0.276	2.569	116	**0.011**
	Equal variances not assumed			2.569	112.770	0.012
V9	Equal variances assumed	3.593	0.061	0.789	116	0.432
	Equal variances not assumed			0.789	112.005	0.432
V10	Equal variances assumed	2.162	0.144	-0.125	116	0.901
	Equal variances not assumed			-0.125	110.925	0.901

Table 5.2 Independent samples tests for (V11_V20)

Features		F test	Sig.	T test	Degree of freedom	Sig. P value
V11	Equal variances assumed	5.540	0.020	1.090	116	0.278
	Equal variances not assumed			1.090	110.041	0.278
V12	Equal variances assumed	2.402	0.124	0.357	116	0.722
	Equal variances not assumed			0.357	111.623	0.722
V13	Equal variances assumed	1.345	0.249	1.649	116	0.102
	Equal variances not assumed			1.649	115.999	0.102
V14	Equal variances assumed	7.381	0.008	-2.325	116	0.022
	Equal variances not assumed			-2.325	66.301	**0.023**
V15	Equal variances assumed	0.002	0.964	-0.654	116	0.514
	Equal variances not assumed			-0.654	114.755	0.514
V16	Equal variances assumed	0.204	0.652	1.229	116	0.222
	Equal variances not assumed			1.229	115.999	0.222
V17	Equal variances assumed	3.753	0.055	2.475	116	**0.015**
	Equal variances not assumed			2.475	109.017	0.015
V18	Equal variances assumed	4.161	0.044	-2.213	116	0.029
	Equal variances not assumed			-2.213	104.464	**0.029**
V19	Equal variances assumed	0.339	0.562	2.929	116	**0.004**
	Equal variances not assumed			2.929	115.838	0.004
V20	Equal variances assumed	0.552	0.459	1.560	116	0.122
	Equal variances not assumed			1.560	112.109	0.122

Table 5.3 Independent samples tests for (V21_V30)

Features		F test	Sig.	T test	Degree of freedom	Sig. P value
V21	Equal variances assumed	1.192	0.277	2.570	116	**0.011**
	Equal variances not assumed			2.570	112.626	0.011
V22	Equal variances assumed	3.494	0.064	1.442	116	0.152
	Equal variances not assumed			1.442	111.670	0.152
V23	Equal variances assumed	0.001	0.971	1.231	116	0.221
	Equal variances not assumed			1.231	115.873	0.221
V24	Equal variances assumed	5.928	0.016	1.703	116	0.091
	Equal variances not assumed			1.703	103.105	0.092
V25	Equal variances assumed	5.563	0.020	0.930	116	0.354
	Equal variances not assumed			0.930	102.678	0.355
V26	Equal variances assumed	1.254	0.265	0.959	116	0.339
	Equal variances not assumed			0.959	113.350	0.340
V27	Equal variances assumed	0.318	0.574	2.926	116	**0.004**
	Equal variances not assumed			2.926	115.855	0.004
V28	Equal variances assumed	0.000	0.999	1.496	116	0.137
	Equal variances not assumed			1.496	115.496	0.137
V29	Equal variances assumed	0.439	0.509	0.758	116	0.450
	Equal variances not assumed			0.758	106.908	0.450
V30	Equal variances assumed	0.539	0.464	1.571	116	0.119
	Equal variances not assumed			1.571	112.210	0.119

Table 5.4 Independent samples tests for (V31_V40)

Features		F test	Sig.	T test	Degree of freedom	Sig. P value
V31	Equal variances assumed	2.295	0.132	1.965	116	0.052
	Equal variances not assumed			1.965	104.334	0.052
V32	Equal variances assumed	0.004	0.950	1.500	116	0.136
	Equal variances not assumed			1.500	115.766	0.136
V33	Equal variances assumed	0.177	0.675	2.440	116	**0.016**
	Equal variances not assumed			2.440	115.023	0.016
V34	Equal variances assumed	0.756	0.386	2.761	116	0**.007**
	Equal variances not assumed			2.761	114.572	0.007
V35	Equal variances assumed	0.878	0.351	2.509	116	**0.013**
	Equal variances not assumed			2.509	114.976	0.014
V36	Equal variances assumed	0.129	0.721	2.250	116	**0.026**
	Equal variances not assumed			2.250	115.655	0.026
V37	Equal variances assumed	0.148	0.701	2.037	116	**0.044**
	Equal variances not assumed			2.037	115.999	0.044
V38	Equal variances assumed	0.611	0.436	1.837	116	0.069
	Equal variances not assumed			1.837	115.462	0.069
V39	Equal variances assumed	0.907	0.343	1.877	116	0.063
	Equal variances not assumed			1.877	113.887	0.063
V40	Equal variances assumed	1.294	0.258	2.466	116	**0.015**
	Equal variances not assumed			2.466	113.918	0.015

For the purpose of analyzing this features values, SPSS program was used.

Independent samples t-test is usually adopted to compare means between two groups on a categorical variable in a survey.

In this study the groups were negative and positive HIV/AIDS cases.

Test for significance of difference

- the null hypothesis is: -infected and non-infected had no difference in brain cells
- 2 rows contain the same nature of informtion: **t**, **df**, **Sig. (2-tailed)** .
    - Equal variances assumed Ho
    - Equal variances not assumed H1
- as you may notice, we have to choose one row of information to believe , but which one?
- **Equal variances assumed** or **Equal variances not assumed**?
    - variances here refer to the variance of each group mean
    - rule of decision:
        - the null hypothesis is: the variances of the means (2 groups) are equal
        - looking at table 5.1 , the significance corresponds to the F-value (in sig. column), if the significance level is greater than 0.05, **the null hypothesis is accepted**

          if the significance level is less than or equal to 0.05, the null hypothesis is rejected

      the significance level is 0.008, therefore null hypothesis was rejected.

we have to choose **Equal variances not assumed** for information on t-test.

Results of this independent tests prove that there is seventeen statistical features was significant, these significant features shown in the charts from 5.1 to 5.17

The following chart shows the significant features:

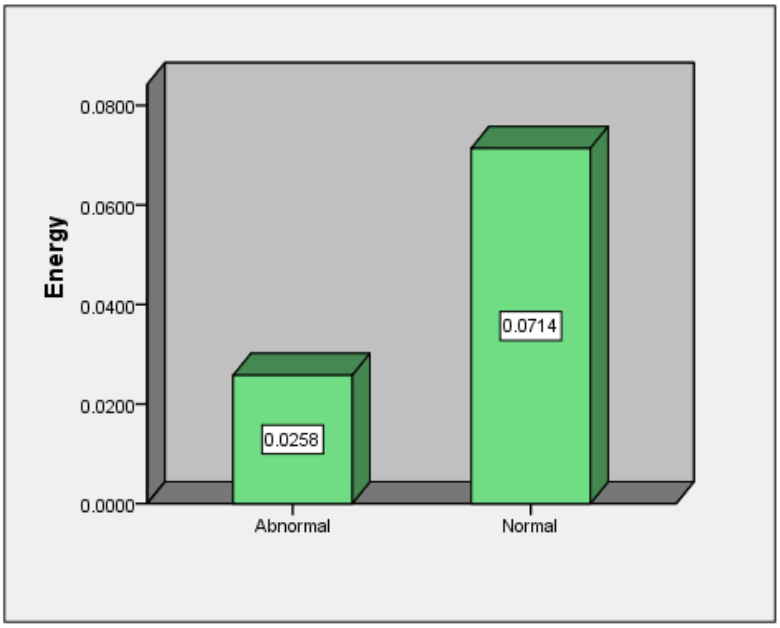

Chart 5.1 significance of Energy Feature

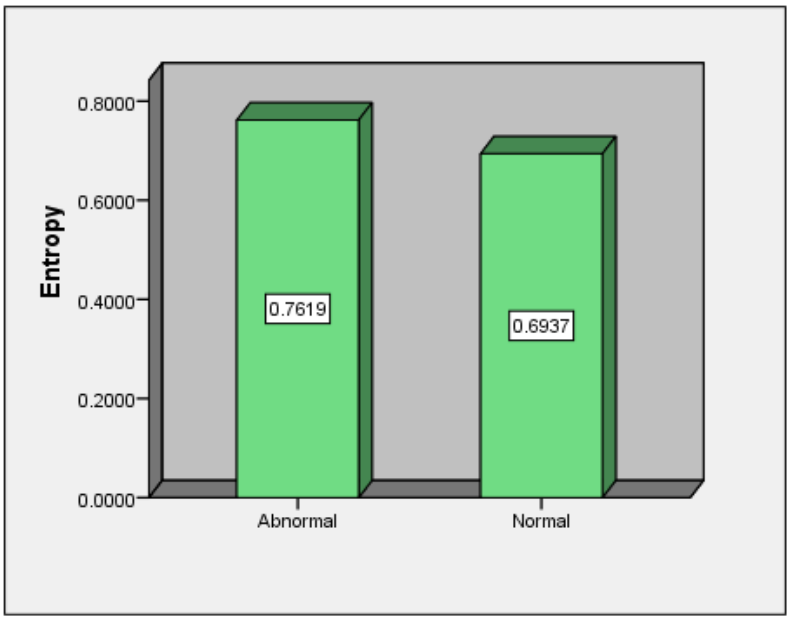

Chart 5.2 significance of Entropy Feature

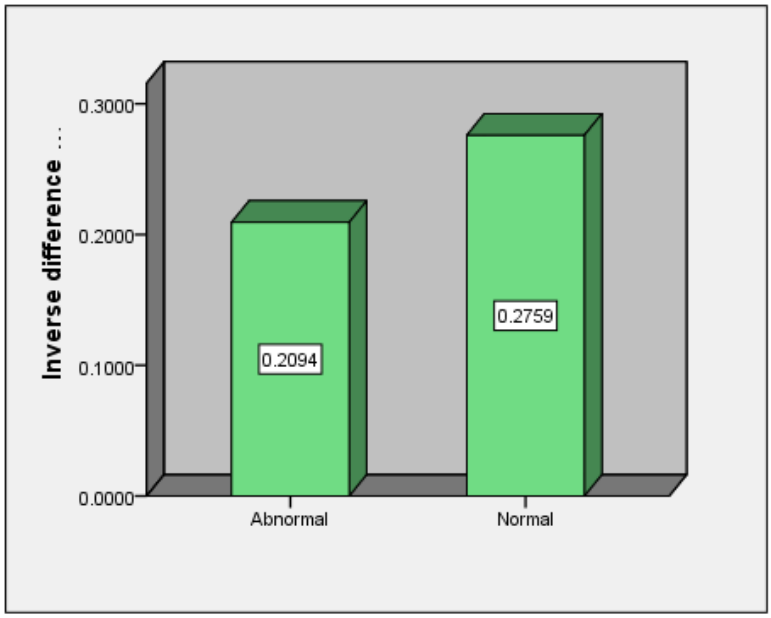

Chart 5.3 significance of Inverse different moment Feature

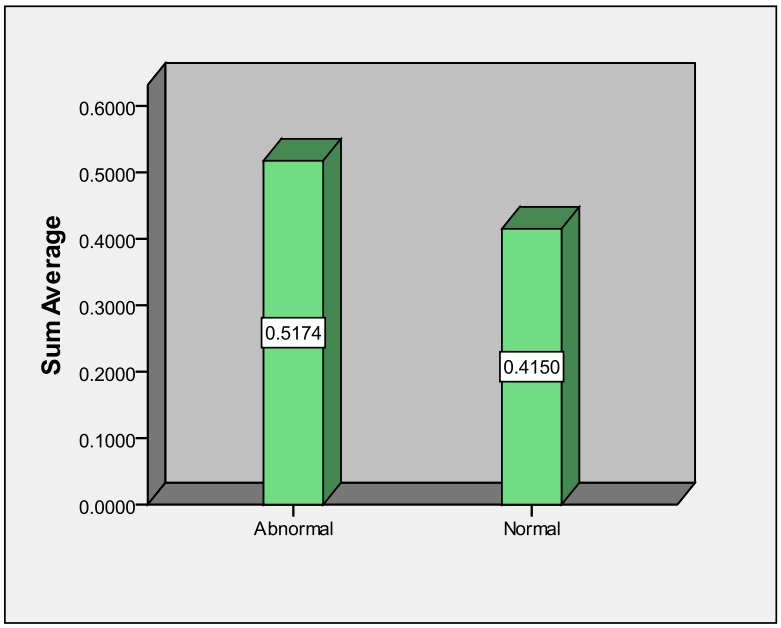

Chart 5.4 significance of Sum average Feature

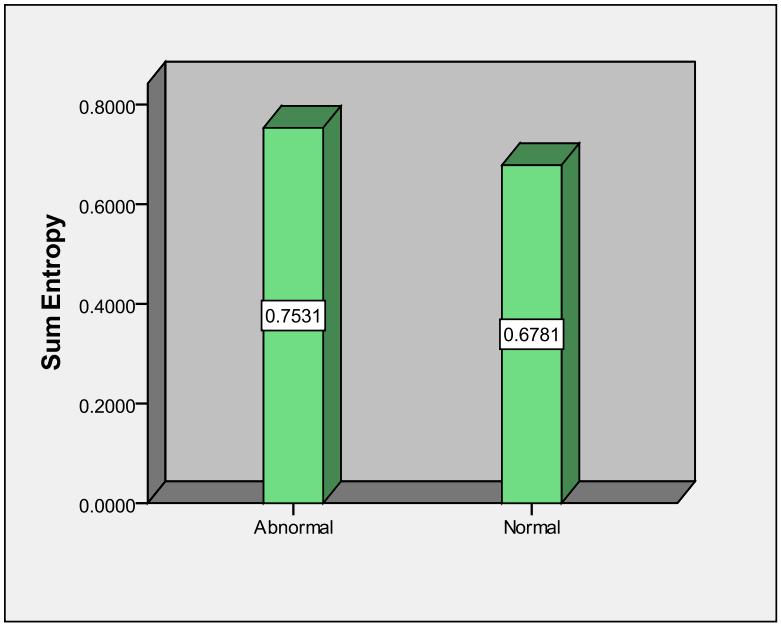

Chart 5.5 significance of Sum entropy Feature

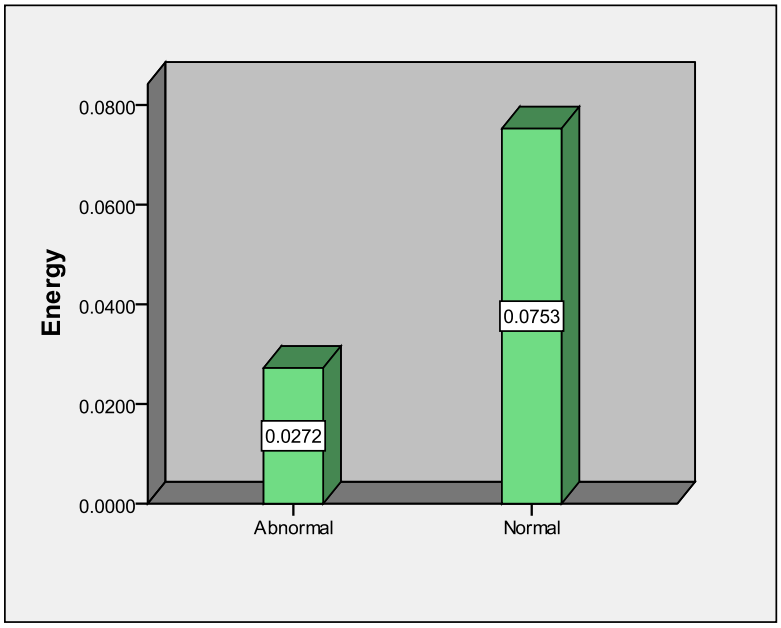

Chart 5.6 significance of Energy Feature

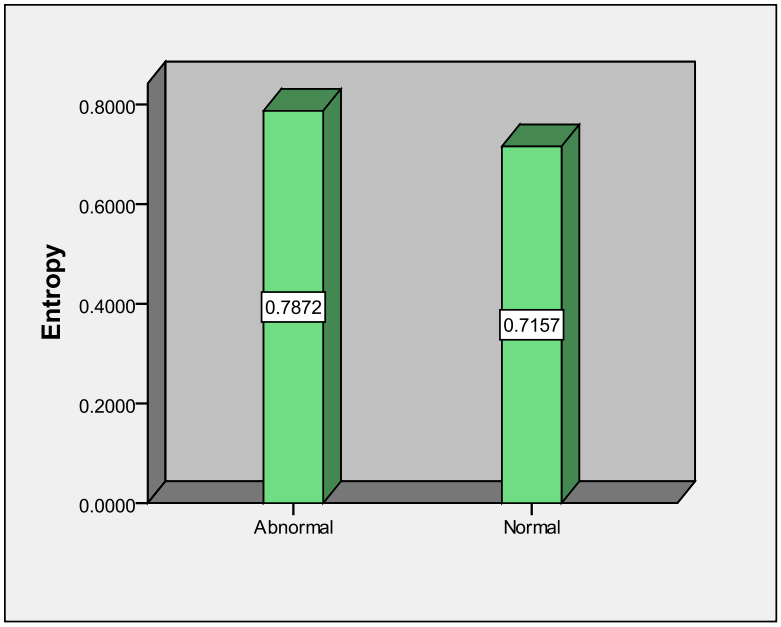

Chart 5.7 significance of Entropy Feature

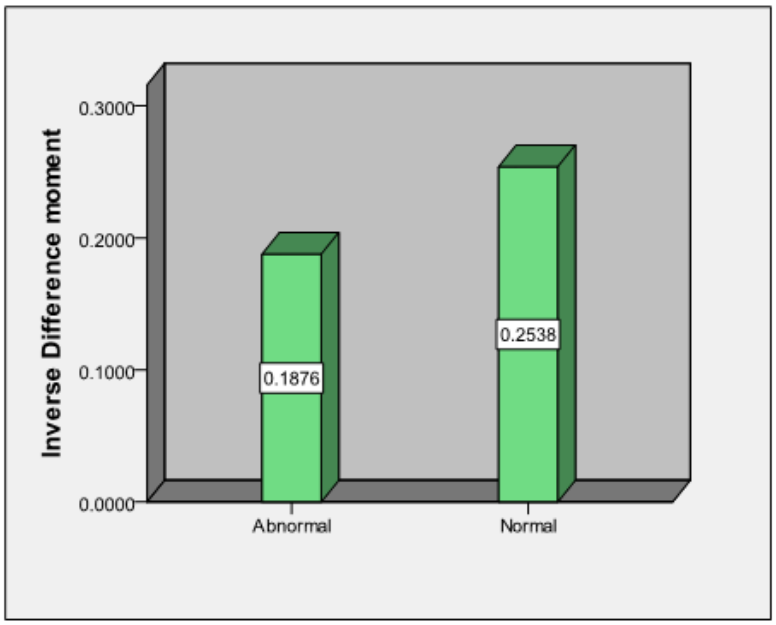

Chart 5.8 significance of Inverse different moment Feature

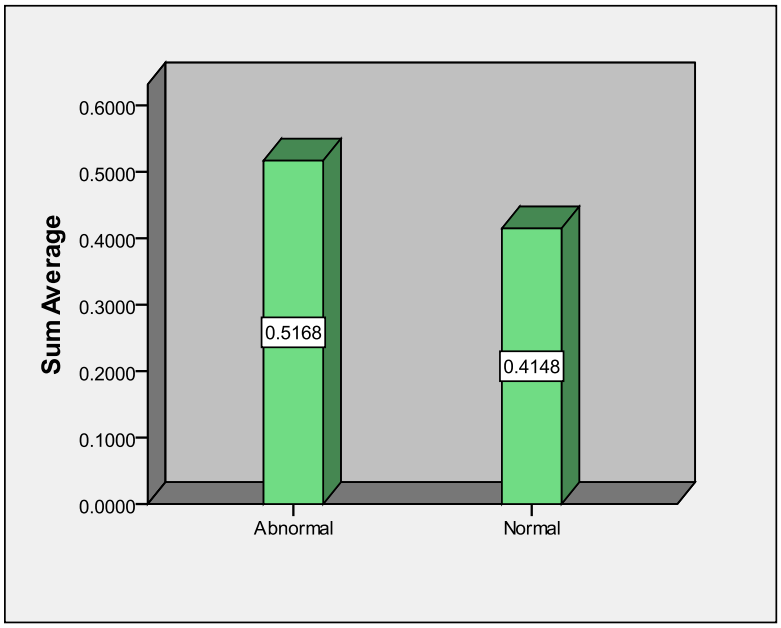

Chart 5.9 significance of Sum average Feature

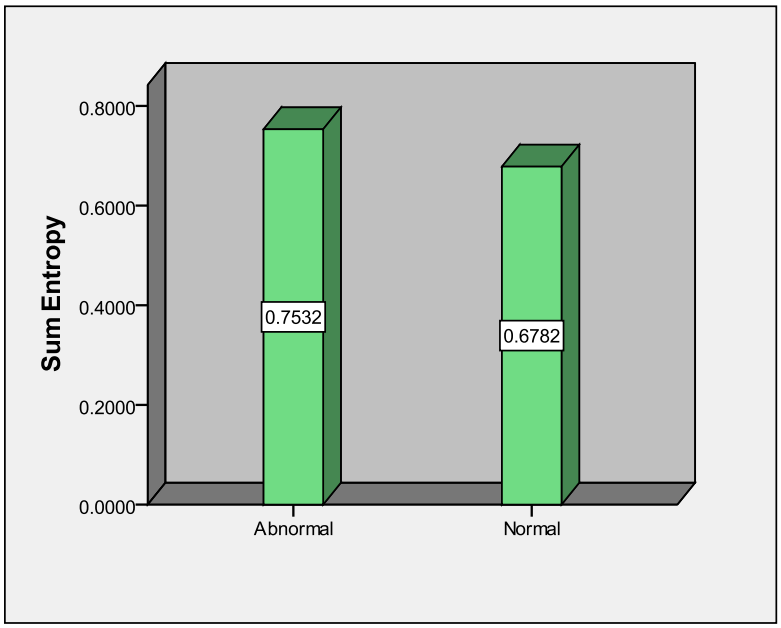

Chart 5.10 significance of Sum entropy Feature

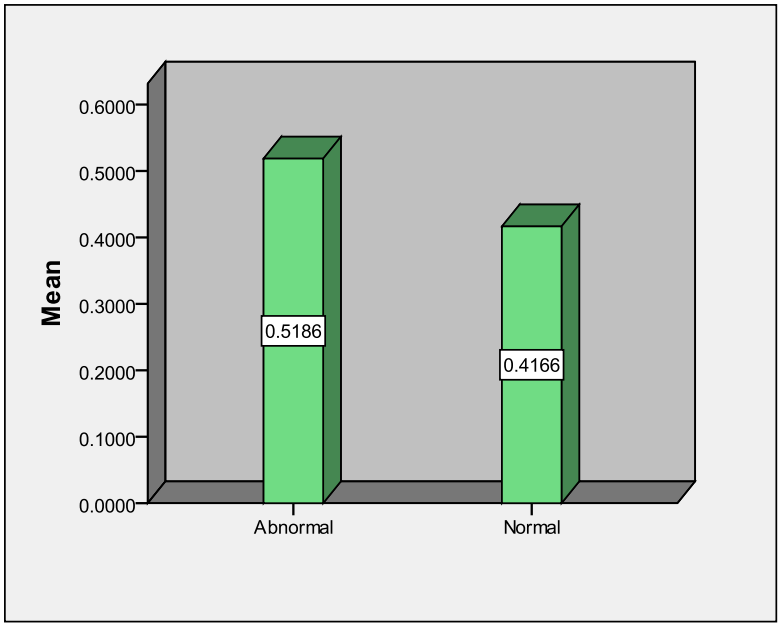

Chart 5.11 significance of Mean Feature

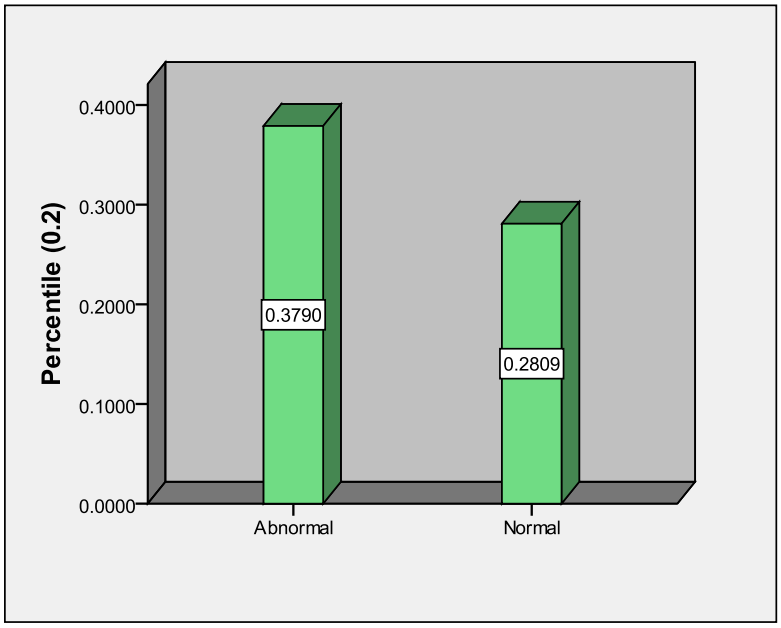

Chart 5.12 significance of Percentile (0.2) Feature

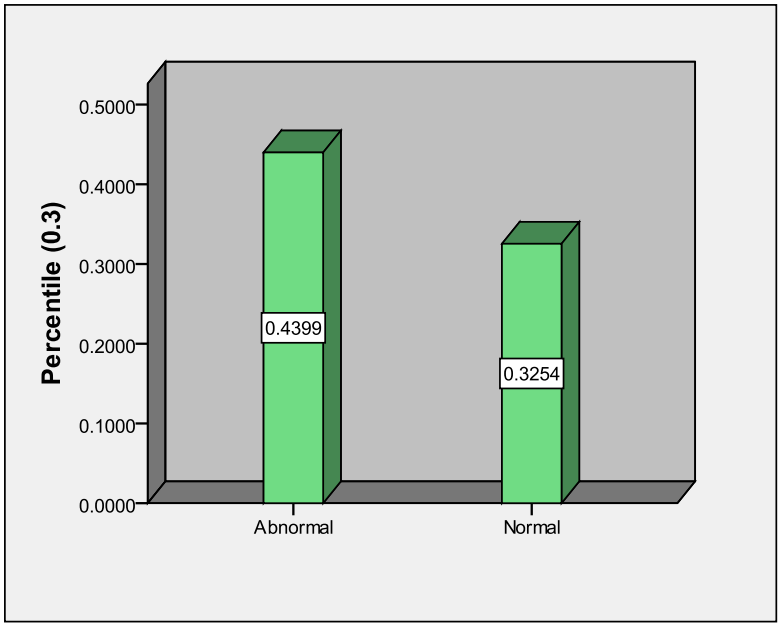

Chart 5.13 significance of Percentile (0.3) Feature

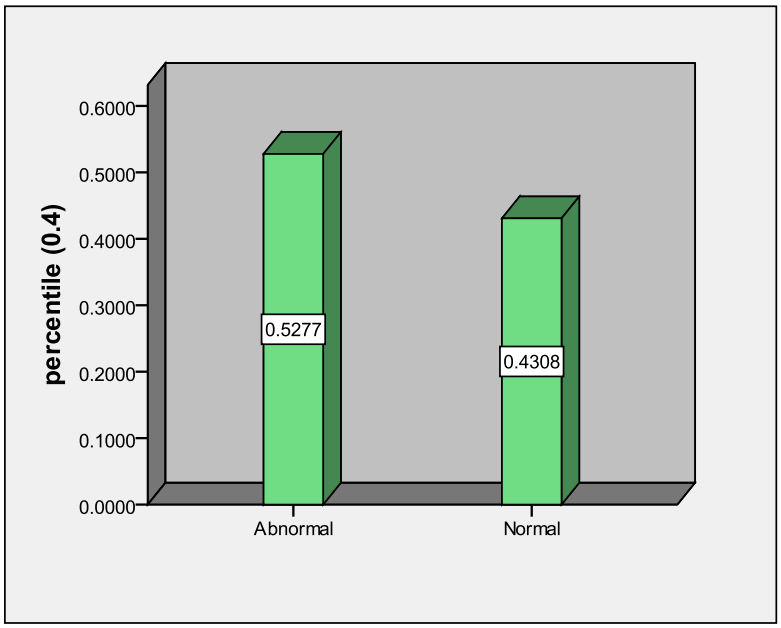

Chart 5.14 significance of Percentile (0.4) Feature

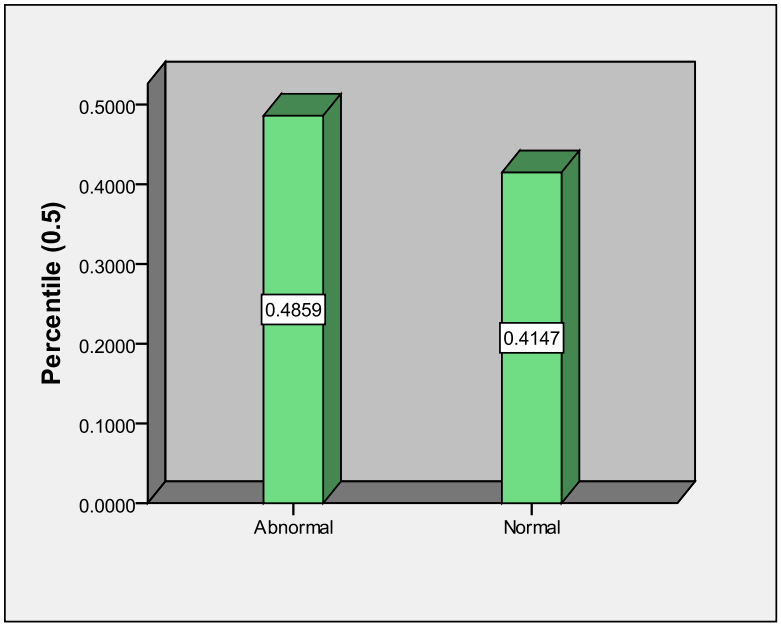

Chart 5.15 significance of Percentile (0.5) Feature

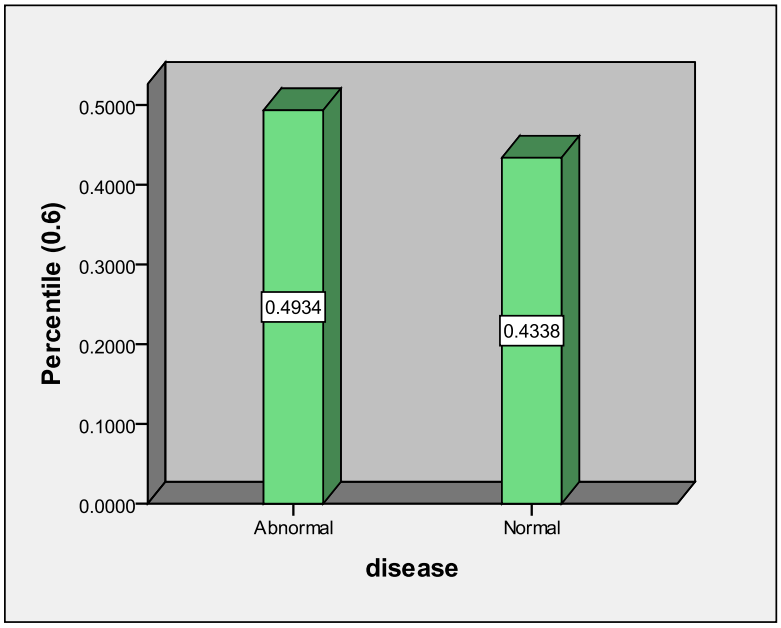

Chart 5.16 significance of Percentile (0.6) Feature

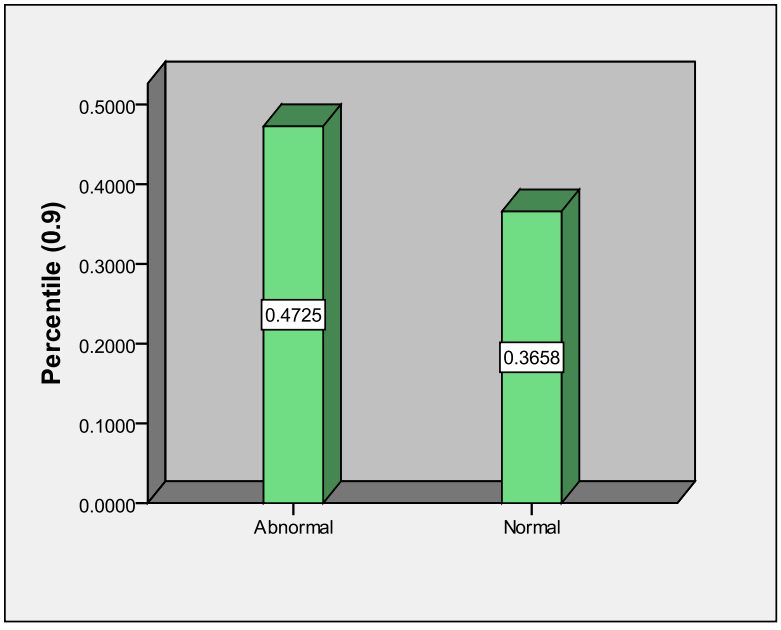

Chart 5.17 significance of Percentile (0.9) Feature

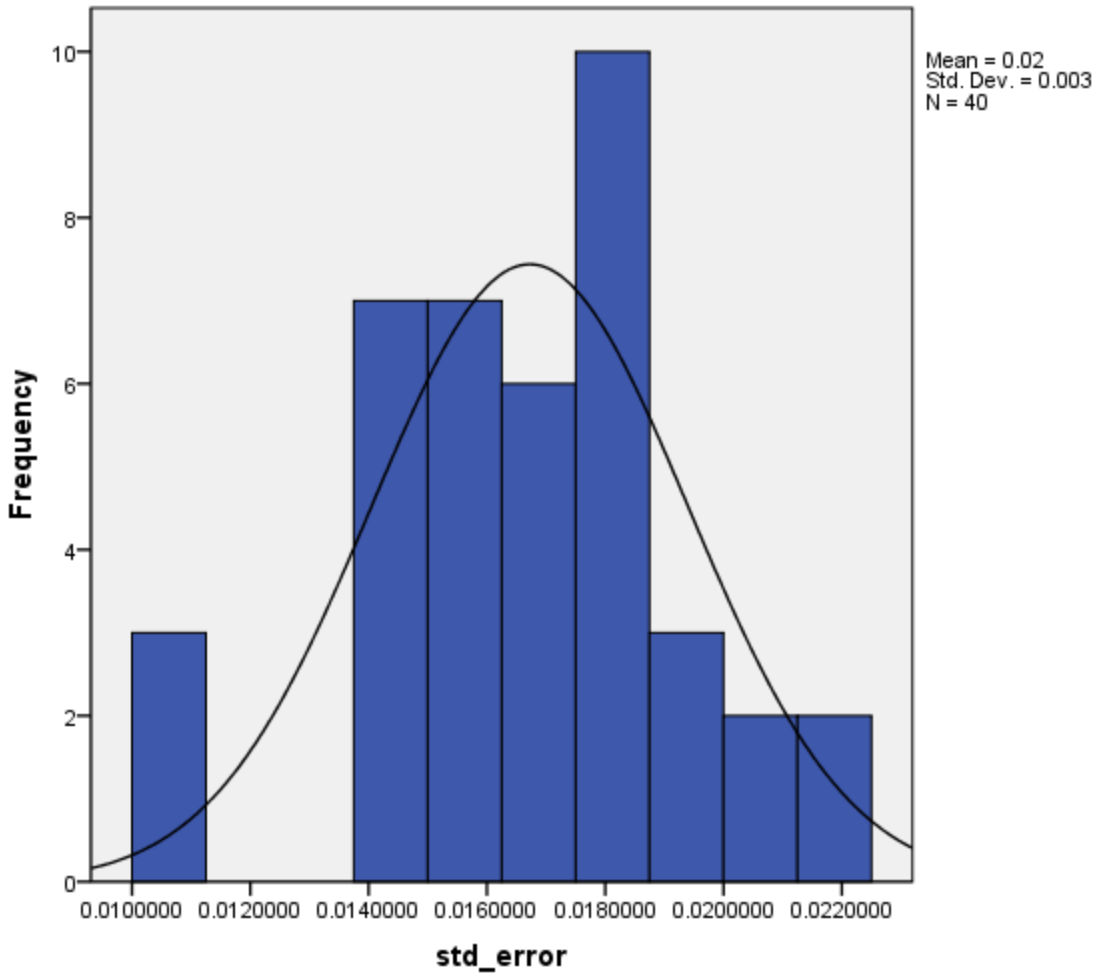

Chart 5.18 illustrates the Standard Error of all statistical features used in this study.

Predictive positive:

Is the probability of disease from the expected number for who have positive test

= Probability of (disease +ve & test +ve)/ probability of test positive.

Predictive negative:

Is the probability of no disease among the persons who have negative test

= Probability of (no disease & test –ve)/ probability of test negative.

Sensitivity of the test:

The probability of the test is it has ability to find the positive cases through disease (up normal)

P (test +ve & disease +ve)/ p (disease).

Specificity of the test:

The probability of the test is it has ability to find the negative cases through the normal cases

P (test -ve & disease -ve)/ p(disease).

Prevalence:

The proportion of the prevalence of the disease

Prevalence = probability of disease / N (total cases)

Observed				Predicted	
		Predicted test			
		Abnormal +ve	Normal -ve		Percentage Correct
disease	Abnormal	49	10	59	83.1
	Normal	7	52	59	88.1
Overall Percentage		56	62	118	85.6

Table5.5 calculating Sensitivity, Specificity, Predictive positive, Predictive negative and overall performance

Sensitivity= 49/59 = 0.831 = 83.1%

Specificity = 52/59 = 0.881 = 88.1%

Predictive positive = 49/56 = 87.5%

Predictive negative = 52/62 = 83.9%

Overall performance =85.6%.

Prevalence = 59/118 = 50%.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In this study, a computer-aided diagnostic system based on statistical features, used to assess the effects of HIV on human brain cells in the digitized MRI studies.

This study shows the effectiveness of seventeen's features derived from forty of statistical features for assessment the normal and abnormal brain tissues on digital MRI.

The statistical features achieved the best results which used for implementation algorithm for brain cell changes detection for positive HIV patients in comparison to negative cases with sensitivity of 83.1%, specificity of 88.1% , positive predictive of 87.5%, negative predictive of 83.9% and the overall performance of 85.6%.

About seventeen's from forty statistical features were significant to distinguish the abnormalities in brain cell for AIDS cases, they gives p value less than 0.05. These features are: energy, entropy, inverse different moment, sum average, sum entropy (at angles zero and 90), mean, and percentile (0.2, 0.3, 0.4, 0.5, 0.6, and 0.9).

6.2 Recommendations and Future Work

Following the investigations described in this thesis, the main lines of the research re-mains open and a number of projects could be taken up:

-Increase the sample size will give a valuable result.

-perform the CD4 counts for HIV patients before capturing MRI images will be more appropriate, in this research we used the last counts for patient and it's not updated.

-Further EEG procedures in addition to MRI, might be useful for clear understanding HIV/AIDS -related neurological conditions.

-Apply the texture features algorithm on real applications for classifications, for example neural networks. In this thesis, we just investigated in the algorithm and did not apply it for any classification application.

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