Studying the Effect of HIV/AIDS on Human Brain Using MRI

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Abstract— Human immunodeficiency virus (HIV) belongs to a subset of retroviruses called lentiviruses (or slow viruses), which means that there is an interval between the initial infection and the onset of symptoms. Upon entering the bloodstream, HIV infects the CD4+ T cells and begins to replicate rapidly. Acquired immunodeficiency syndrome (AIDS) is the final stage of HIV infection. The brain may be affected by a variety of abnormalities in association with HIV infection. About these issues, Researchers have found significant damage in the brains of HIV-positive patients whose viral load is effectively suppressed by anti-retroviral therapy. In one of the first studies of its kind, researchers from the San Francisco Veterans Affairs Medical Center (SFVAMC) used a combination of MRI brain imaging, recording of electrical brain activity, and behavioral tests to compare the size and function of brains of HIV-positive patients on antiretroviral therapy with those of healthy subjects.; The results of our study raise the concern of brain injury in HIV subjects who are on treatment, even among those who are virally suppressed [12],But It is unclear how HIV causes 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. The main core of this paper is to develop an algorithm which can be used to explore the effect of HIV/AIDS on human brain based on Magnetic Resonance Image (MRI) images, Compare the variations of brain cells between normal and abnormal cases and selecting the proper statistical features. This study, presented a statistical based method to study and analyze given MR brain images, statistical analysis using Statistical Package for the Social Sciences (SPSS) proves that the effectiveness of seventeen's of statistical 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 areas 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%. In this study, a computer-aided diagnostic system based on statistical features, used to study the effects of HIV on human brain in the digital 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.

Index Terms— HIV/AIDS, MRI,Brain damage, neurological changes.

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1 INTRODUCTION

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 [1-6]. Diagnosis of 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 neuroanatomic substrate for these neuropsychological deficits is unknown. Non-invasive neuroimaging technique may play an important role in the study of the patient with HIV infection. Recently, a variety of functional neuroimaging 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 [7-11].

2 PREVIOUS STUDIES

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 [22].

3 METHODS

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

3.1 Experimental data

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 (Table 1).

TABLE 1
SUMMARY OF PATIENT'S DATA

Case no.	Gender	Age	Detection date of disease	Medication	Stage
1	M	59	2004	ART	3
2	M	47	2001	ART	3
3	M	42	2000	ART	3
4	F	40	2003	ART	3
5	M	34	1997	ART	3
6	M	43	2004	ART	3
7	F	27	2012	ART	3
8	M	50	1997	ART	3
9	F	37	2010	ART	3
10	F	32	2006	ART	3

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 (figure 1). The region of interest (ROC) was the area which had abnormalities in the images, windows of 128*128 used (figure 2).

The MRI machine which used has the Standard composition of: 1.5-tesla actively shielded magnet with an active shield gradient coil.

3.2 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, number of 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), Information measures of correlation feature.
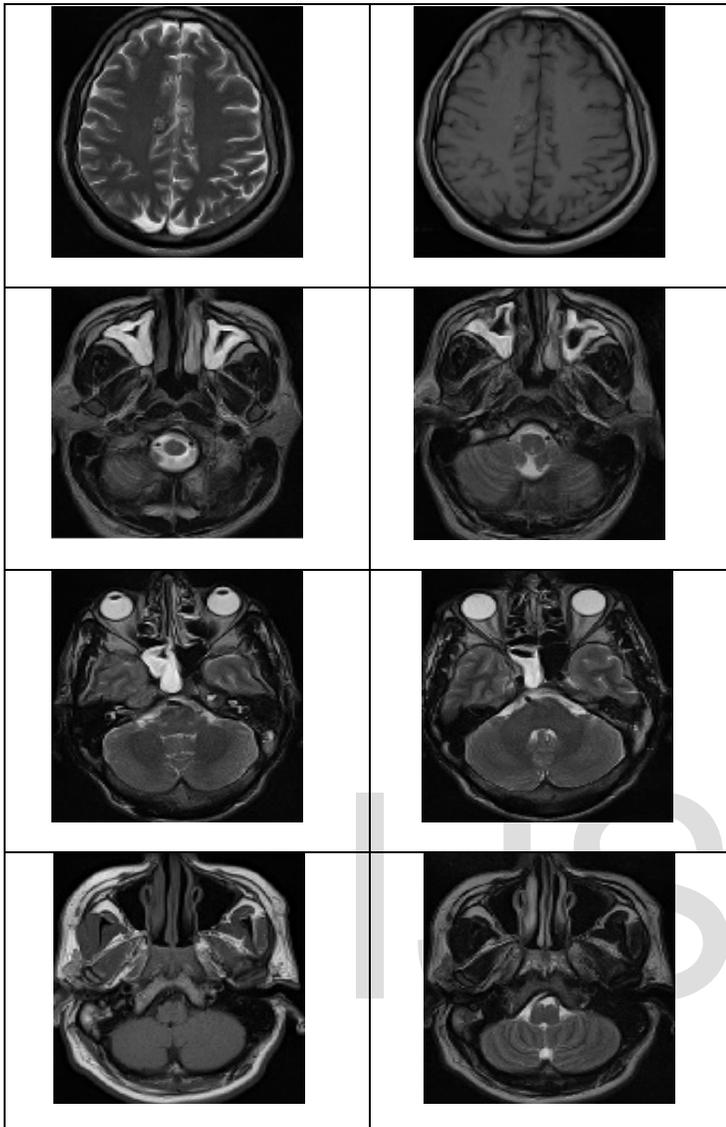
Fig.1. before selecting the ROI show different abnormalities brain images at T1 and T2.
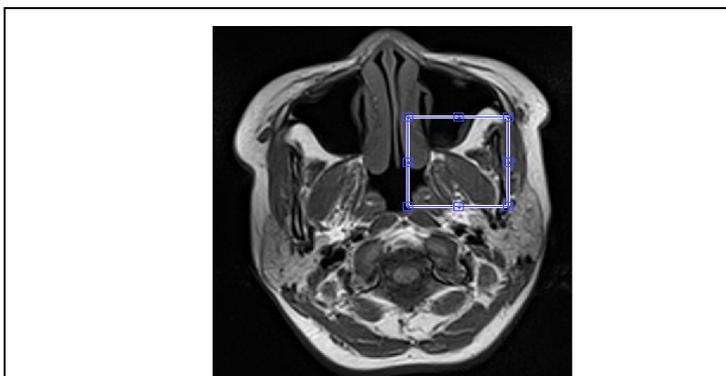

Fig.2. Selecting the ROI using 128*128 window

3.2.1 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:

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

3.2.2 Energy (EG)

The Energy feature (EG) returns the sum of squared elements in the SGLD matrix as expressed by equation 2:

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

3.2.3 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 equation 3:

$$IN = -\sum_{i=0}^{n=1}\sum_{j=0}^{n=1} p^2(i,j) \qquad 3$$

3.2.4 Inverse Difference Moment (IDM)

Inverse Difference Moment is also called the "Homogeneity". Mathematically, it can be written as equation 4:

$$IDM = \sum_{i=0}^{n-1}\sum_{j=0}^{n-1} \frac{1}{1+(i-j)^2} p(i,j) \qquad 4$$

3.2.5 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 (5):

$$CO = \frac{\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(i-\mu_x)(j-\mu_y)p(i,j)}{\sigma_x \sigma_y} \qquad 5$$

3.2.6 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 (equation 6).

$$VA = \sum_{i=0}^{n-1}(i-\mu)^2 p_x(i) \qquad 6$$

3.2.7 Sum Average (SA)

$$SA = \sum_{k=0}^{2n-2} k p_{x+y}(k) \qquad 7$$

3.2.8 Sum Entropy (SE)

$$SE = -\sum_{k=0}^{2n-2} p_{x+y}(k)\log_2 p_{x+y}(k) \qquad 8$$

3.2.9 Sum Variance (SV)

$$SV = \sum_{k=0}^{2n-2} (k-SA)^2 p_{x+y}(k) \qquad 9$$

3.2.10 Difference Entropy (DE)

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

3.2.11 Difference Average (DA)

$$DA = -\sum_{k=0}^{n-1} k p_{x-y}(k) \qquad 11$$

3.2.12 Difference Variance (DV)

$$DV = \sum_{k=0}^{n-1} (k - DA)^2 p_{x-y}(k) \qquad 12$$

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).

$$p_x(i) = \sum_{i=0}^{n-1} p(i,j) \qquad 12\text{-}1$$

$$p_y(j) = \sum_{i=0}^{n-1} p(i,j) \qquad 12\text{-}2$$

$$p_y(K) = \sum_{i=0}^{n-1} p(i,j) \qquad 12\text{-}3$$

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

$$p_{X-Y}(K) = \sum_{i=0}^{n-1} \sum_{J=0}^{N-1} p(i,j) \qquad 12\text{-}4$$

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

3.2.13 Information measures of correlation feature 1

$$f_{12} = \frac{HXY - HXY1}{\max(HX, HY)} \qquad 13$$

3.2.14 Information measures of correlation feature 2

$$f_{13} = (1 - \exp[-2(HXY2 - HXY)])^{\frac{1}{2}} \qquad 14$$

3.2.15 Mean

Calculate the average or mean value of array.

3.2.16 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.

3.2.17 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.

3.2.18 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.

3.2.19 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.

3.2.20 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.

4 RESULTS AND DISCUSSIONS

From the radiologist consultant, notices that there are different findings in brain, the following are the summary of MRI report for each case:

- Right mastoiditis

- Incidentally left maxillary polyp and right sided chonca ballosa.

- Ethmoidal, left maxillary sinusitis noted.

- Incidental finding there is mucosal thickening noted of the left maxillary sinus, inferior nasal tubinates and anterior ethemoidal cells.

- Features suggestive of vascular lesion.

- Pre-ventricular high signal spot are noted in T2 consistent with small vessels disease.

- A lesion in the right para sagittal parietal lobe, well define measuring 1.3 cm of heterogeneous signal intensity in T1 and T2 and shows minimal peripheral enhancement after contrast and the area of signal void with spots of high signal intensity in all sequence, features suggestive of cavernous angioma.

- Right polyploid sphenoidal sinusitis.

- Diffuse widening of dipolic sapace of fatty signal, normal variant, exclude blood disease.

Features extraction method and statistical analysis for two different types of MRI brain images, normal image and HIV/AIDS cases image are presented here. The feature extraction method was: Features based on First and second order statistics.

4.1 Statistical analysis

Hypothesis Test using independent samples T Test for means of two groups normal and abnormal for all 40 properties (equations 15,16)

$$H0: M1 = M2 \qquad 15$$

$$H1: M1 \neq M2 \qquad 16$$

From the tables test the significant value for hypothesis is less

than 0.05 then we reject H0 and accept H1 (the test is significant).

4.2 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.

4.3 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.

4.4 Sensitivity of the test:

The probability of the test is it has ability to find the positive cases through disease (up normal).(equation 17)

$$P\,(test\,+ve\,\&\,disease\,+ve)/\,p\,(disease) \qquad 17$$

4.5 Specificity of the test:

The probability of the test is it has ability to find the negative cases through the normal cases.(equation 18)

$$P\,(test\,\text{-}ve\,\&\,disease\,\text{-}ve)/\,p(disease) \qquad 18$$

4.6 Prevalence:

The proportion of the prevalence of the disease is calcualted as equation 19.

$$Prevalence = probability\ of\ disease\ /\ N\ (total\ cases) \qquad 19$$

When the statistical features values for the whole 59 ROIs for each group was represented as frequency histogram they showed a clear variations between normal and infected cases, number of examples shown in figure 3 to 6 . The previous figures illustrate 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.
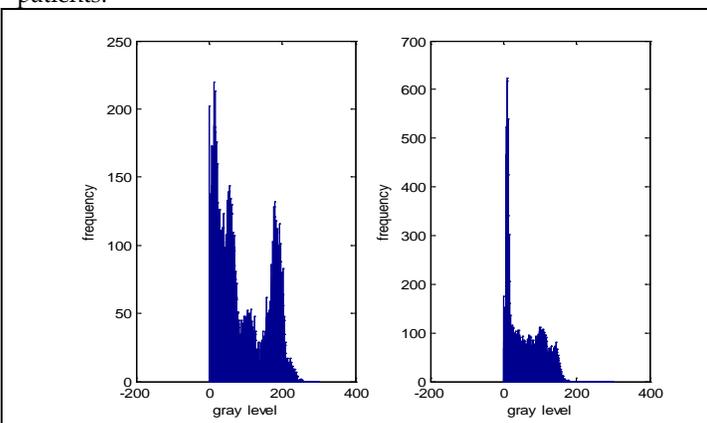

Fig.3. Comparison between histogram of ROI 5 of normal group against histogram of ROI5 of abnormal group.
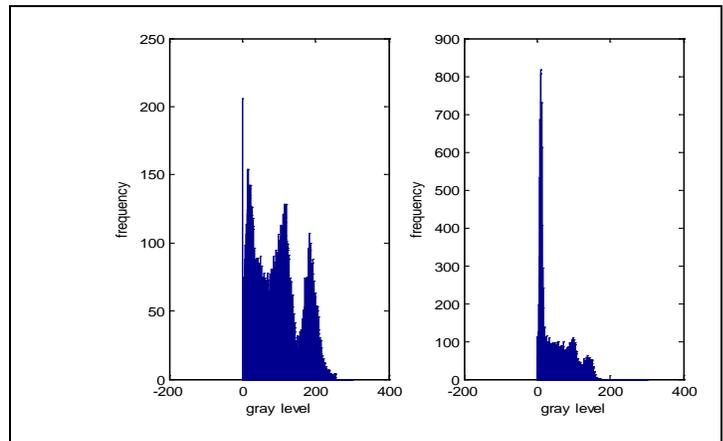

Fig.4. Comparison between histogram of ROI 6 of normal group against histogram of ROI 6 of abnormal group.
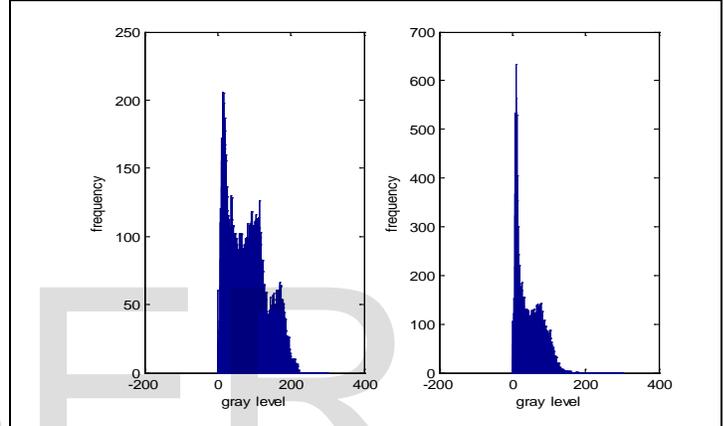

Fig. 5. Comparison between histogram of ROI 8 of normal group against histogram of ROI 8 of abnormal group.
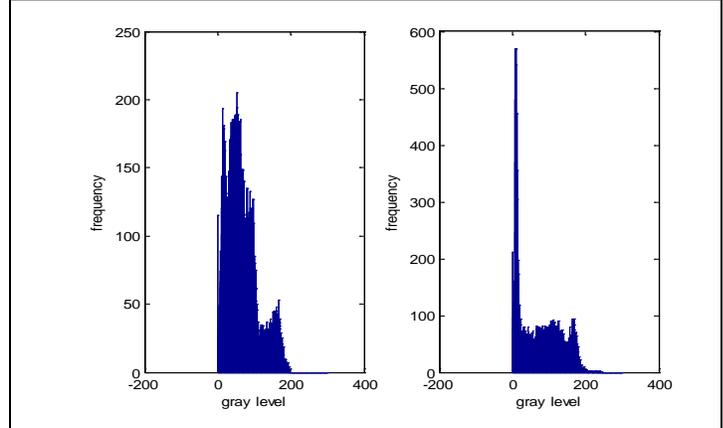

Fig. 6. Comparison between histogram of ROI 19 of normal group against histogram of ROI 19 of abnormal group.

In addition to that, a comparison between groups have been done by subtracting the values of normal cases from abnormal, this way prove that there was a considerable changes, Notice that there was a second group of normal vs. normal cases (appears with red color) used to ensure more clarification and to check the comparison results. Figures from 7 to 11 illustrate it.

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.
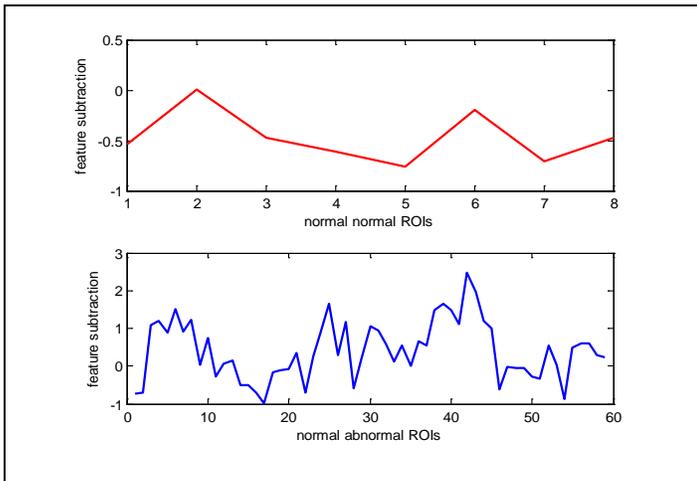

Fig. 7. Comparison between Entropy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.
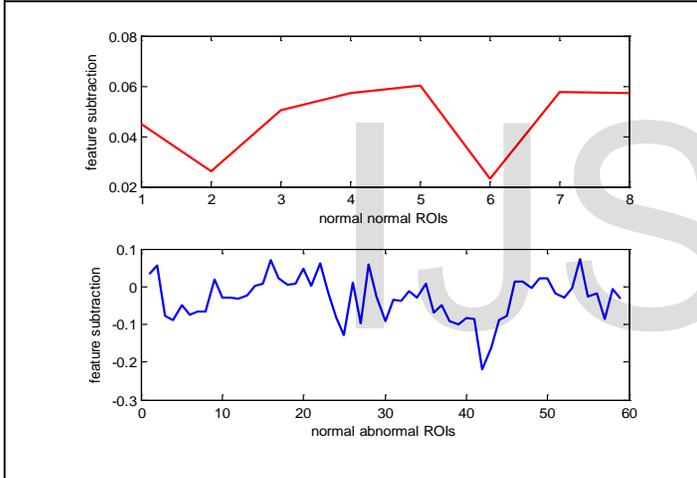

Fig. 8.Comparison between Inverse Difference Moment (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.
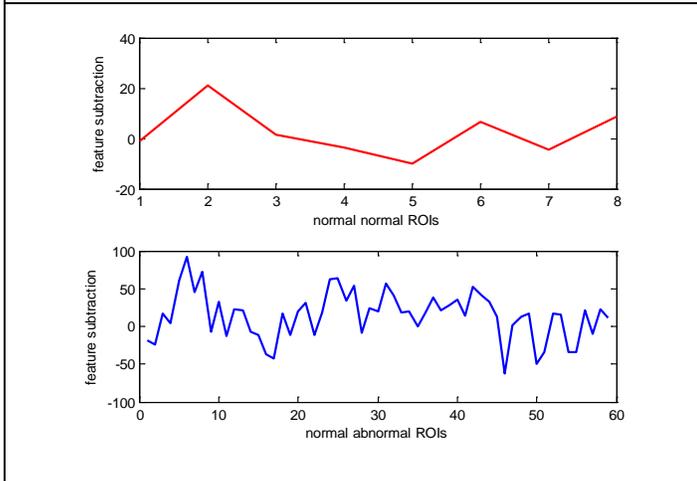

Fig.9.Comparison between Sum Average (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.
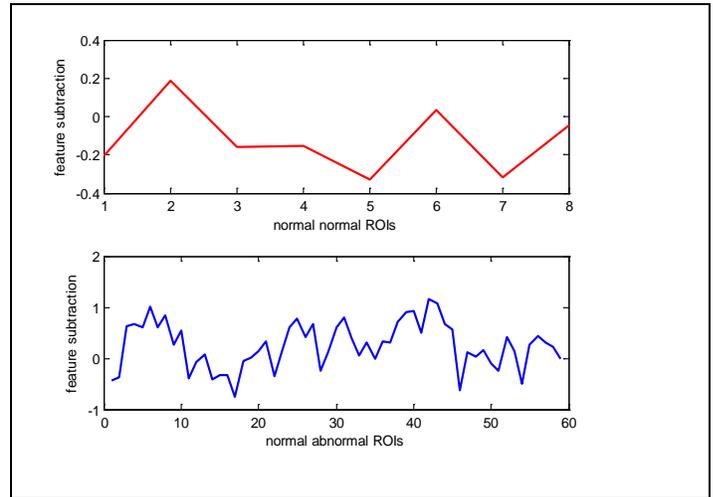

Fig.10. Comparison between Sum Entropy (theta=0) subtraction for normal-normal ROIs and normal-abnormal ROIs.
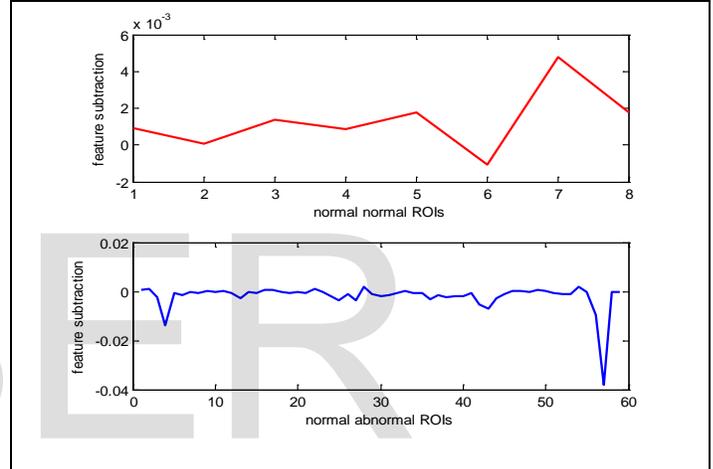

Fig.11. Comparison between Energy (theta=90) subtraction for normal-normal ROIs and normal-abnormal ROIs.

Furthermore, statistical analysis techniques using SPSS program were applied for the purpose of data analyzing, table 1 calculates Sensitivity, Specificity, Predictive positive, Predictive negative and overall performance.

TABLE 2.

CALCULATING SENSITIVITY, SPECIFICITY, PREDICTIVE POSITIVE, PREDICTIVE NEGATIVE AND OVERALL PERFORMANCE

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

- 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%

5 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 digital 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).

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