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Identification of Ischemic Stroke Stages in CT scan Brain Images Using Imagej Software

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Abstract:-

Rationale and Objectives:

Ischemic strokes represent more than 80% of all stroke cases and are characterized by the occlusion of a blood vessel due to a thrombus or embolus. The temporal evolution of ischemic strokes occurs in four stages, i.e. Hyperacute, Acute, Subacute and Chronic. CT image by using *ImageJ* software help to identify stages of ischemic stroke in human brain as an alternative method in the CT diagnosis.

Materials and Methods:

Eighty samples of CT brain images were selected as research subjects in this study and confirmed examination by specialists in Department of Radiology at Saiful Anwar Public Hospital, Malang. Each CT scan brain image was analyzed using *ImageJ* version 1.48 software using standard Hounsfield unit.

Results:

The numerical values of gray scale for each stage of ischemic stroke stages have been identified using *ImageJ* software. They were as follows. The mean gray value level of normal cases was $\geq$ 29, of hyperacute was between 25 - 29, of acute cases was between 23 - 26, of subacute cases was between 20 - 23, and of chronic cases was $\leq$ 20.

Conclusions:

ImageJ is easy to use for identification of ischemic stroke stages in CT scan brain images. It has the ability to assess the density of each pixel and the density measurements have been calibrated to reflect the true Hounsfield unit values. The ratio of the accuracy of *imageJ* software in identification of ischemic stroke stages in CT scan brain images in this study was 90%.

Keywords:- CT scan images, Hounsfield Unit, Ischemic stroke, *ImageJ* software

I. INTRODUCTION

Annually, 15 million people worldwide suffer from a stroke. Of these, 5 million died and another 5 million are left permanently disabled, putting a burden on family and community [1]. Stroke is the most common cause of death in most industrialized countries. In year 2002, the mortality rate of stroke in Indonesia was 123,684 persons and Libya was 1,762 persons [2]. Stroke is the third leading cause of death in adults, and many stroke-related deaths occur shortly after the onset of symptoms. There are two types of "brain attacks" known as ischemic and hemorrhagic attacks. Hemorrhagic stroke occurs when a blood vessel in the brain breaks or ruptures spilling blood into the brain. Hemorrhagic strokes account for about 15% percent of all strokes, yet are responsible for more than 30% percent of all stroke deaths [3]. Ischemic strokes represent more than 80% of all cases and are characterized by the occlusion of a blood vessel due to a thrombus or embolus [4, 5]. In the case of stroke, however, blood clots are dangerous because they can block arteries and cut off blood flow to the brain, a process called ischemia [6]. The time for intervention can be as narrow as 3 hours.

CT scanning procedures are more prevalent in various medical centers and less expensive compared with magnetic resonance imaging. CT scan technology plays a key role by helping to discovery stroke in human brain. Therefore, developments has to be carried out facilitate diagnosis of stroke. Data analysis of brain CT image by using *ImageJ* software could help to identify ischemic stroke in human brain.

ImageJ is image analysis software that can be used in image processing and data analysis on CT images of the brain. *ImageJ* is a public domain Java image processing program. It can display, edit, analyze and process 8-bit, 16-bit and 32-bit images.

In this study, *ImageJ* software was used to assess the CT scan images in determination of brain ischemic stroke stages. It was aimed to provide an alternative method in CT scan diagnosis of ischemic stroke stages in the brain and shorten the time in diagnosing CT images as time is very important in the treatment of brain stroke.

Computed tomography

CT scan is a technique that produces anatomic pictures of the body (Fig1). It uses multiple X-rays and computer reconstruction to create cross-sectional images of internal structures [7]. Unenhanced CT can be performed quickly, can help identifying early signs of stroke, and can help ruling out hemorrhage. CT angiography and CT perfusion imaging, respectively, can depict intravascular thrombi and salvageable tissue indicated by a penumbra. These examinations are easy to perform on most helical CT scanners and are increasingly used in stroke imaging protocols to decide whether intervention is necessary.

The information obtained by combining various imaging techniques may help differentiating patients who do not need intravenous or intra-arterial therapy from those who do, and may alter clinical outcomes [8]. Computed Tomography (CT) is an imaging technique where digital geometry processing can be used to generate a 3D-image of brain's tissue and structures obtained from a large series of 2D X-ray images. X-ray scans furnish detailed images of an object such as dimensions, shape, internal defects and density for diagnostic and research purposes [9].

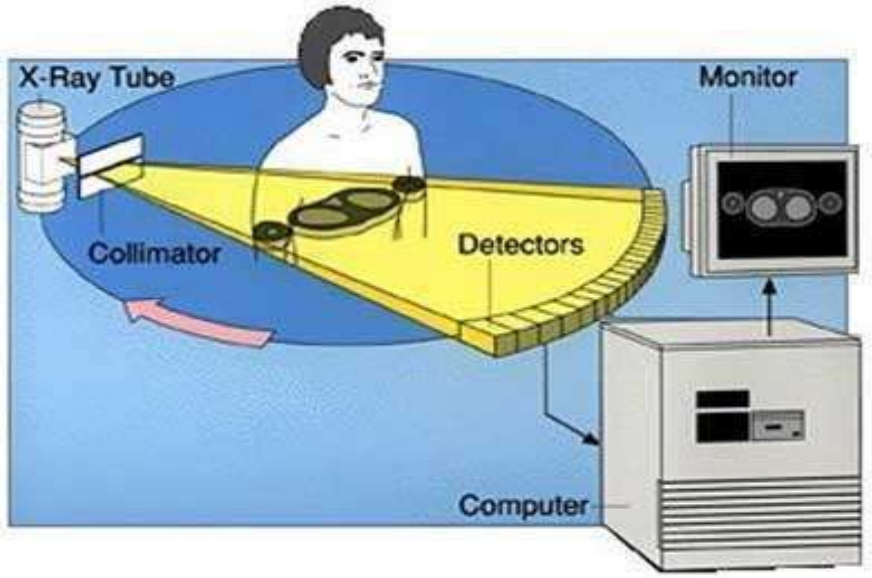

Figure 1 the tube and detector rotates 360°around the patient in CT scan device [14].

CT scan image is produced in the simplest case, the object (here a round cylinder) is linearly scanned by a thin, fan beam of x-ray. This produces a sort of shadow image (referred to as"attenuation profile" or" projection"), which is recorded by the detector and the image processor. Following further rotation of the tube and the detector by a small angle, the object is once again linearly scanned from another direction, thus producing a second shadow image. This procedure is repeated several times until the object has been scanned for a 180° rotation. The various attenuation profiles are further processed in the image processor. In the case of simple back projection, each attenuation profile in the scanning direction is added up in the image memory [10].

CT numbers are measured in HU = Hounsfield units

The CT number of water and air is defined as 0 HU and –1000 HU respectively; this scale has no limit in the positive range of values. Medical scanners typically work in a range of –1024 HU to +3071 HU. The CT image does not show these μ values directly, but the CT numbers according to Hounsfield:

CT number = $1000\ (\mu - \mu_{water}) / \mu_{water}$.

Where μ is the linear attenuation coefficients and μ_{water} is the linear attenuation coefficients of water.

Windowing in the CT image, density values are represented as gray scale values. However, since the human eye can discern only approx.80 gray scale values, not all possible density values can be displayed in discernible shades of gray. For this reason, the density range of diagnostic relevance is assigned the whole range of discernible gray values. This process is called windowing. To set the window, it is first defined which CT

number the central gray scale value is to be assigned to. By setting the window width, it is then defined which CT numbers above and below the central gray value can still be discriminated by varying shades of gray, with black representing tissue of the lowest density and white representing tissue of the highest density[10].

Image Processing using *ImageJ* software:

Image processing techniques can help to differentiate the abnormal tissue growth (tumors) in question from other tissues, providing more detailed information on head injuries, stroke, brain disease and internal structures than do regular X-ray CT scans by using suitable programs such as *ImageJ* software [9].

ImageJ is a public domain Java image processing and analysis program inspired by National Institute of Health (NIH) Image for the Macintosh. It runs, either as an online applet or as a downloadable application, on any computer with a Java 1.5 or later virtual machine. Downloadable distributions are available for Windows, Mac OSX and Linux. It can display, edit, analyze, process, save and print 8–bit, 16–bit and 32–bit images. It can read many image formats including TIFF, GIF, JPEG, BMP, DICOM, FITS and 'raw'. It supports 'stacks' and (hyperstacks), a series of images that share a single window. It is multithreaded, so time-consuming operations such as image file reading can be performed in parallel with other operations. It can calculate area and pixel value statistics of user-defined selections. It can create density histograms and line profile plots. It supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection and median filtering. It does geometric transformations such as scaling, rotation and flips. Image can be zoomed up to 32:1 and down to 1:32. All analysis and processing functions are available at any magnification factor. The program supports any number of windows (images) simultaneously, limited only by available memory [12]. *ImageJ* is freely available, so practitioners can install and use the software legally and without license charges on any computer. *ImageJ* is thus an ideal platform for education and self-training in digital image processing but is also in regular use for serious research and application development at many laboratories around the world, particularly in biological and medical imaging [11].

II. MATERIALS AND METHODS

CT Images and acquisition Protocol:

Our study employed analysis image method. The study was conducted in Saiful Anwar Public Hospital and the Biophysics Laboratory of Brawijaya University, Malang, Indonesia from January to May 2014. Eighty CT brain images of stroke patients were selected as the subjects in this study comprised of 55% women (age from 18 to 88 years old) and 45% men (age 16 to 88 years old). All samples were selected randomly and the results were cross checked and confirmed by the specialist examination in the Department of Radiology at Saiful Anwar Hospital, Malang. All scans were performed using General Electric Medical Systems (Bright Speed) CT scanner and all images were saved as DICOM images (16 bit). The brain protocol utilized a standard CT procedure of 150 mA, 140 kV, and 10 mm slice thickness.

NIH ImageJ Analysis Protocol:

ImageJ is a public domain image processing program. It has become a standard tool in many laboratories around the world because it is free, open source, and very well supported. The website address is http://imagej.nih.gov/ij/. ImageJ is based on Java/JavaScript (Sun Microsystems) and will run on any platform.

Each CT scan brain image was analyzed using *ImageJ* version 1.48 software using standard Hounsfield unit ranges by delineating Regions of Interest (ROI) with a mouse computer interface by using the region selection tools in the *imageJ*'s Menu toolbar. The NIH-*ImageJ* software has the ability to assess the density of each pixel and through recent advances in the NIH-*ImageJ* software package; the density measurements have been calibrated to reflect the true Hounsfield unit values.

Used Plot Profile it displays a two-dimensional graph of the intensities of pixels along a line within the image. The x-axis represents distance along the line and the y-axis is the pixel intensity and used to calculate (Mean gray value) Average gray value within the selection area for each Regions of Interest (ROI). This is the sum of the gray values of all the pixels in the selection divided by the number of pixels.

Specifically, reliability estimates for repeated measurements were obtained on eighty CT scan brain images we conducted analyses to these images to obtain numerical values of the image related to ischemic stroke in brain define a specific region of interest (ROI) within the image from comparing result data analysis of CT scan brain images can help to identification ischemic stroke in human brain.

III. RESULT AND DISCUSSIONS

Group (A) Normal CTscan brain images:

There were ten normal CTscan brain images for patients underwent examinations in Radiology Department, Saiful Anwar Hospital, Malang by radiologists after the confirmation of diagnose it (Normal CT scan images). Conducted the measurement using the straight-line tool *ImageJ* Software to measure gray value of pixels on along a line within the image (fig 2). It is used to calculate the mean and average gray values within the selected area for each Region of Interest (ROI). This is the sum of the gray values of all the pixels in the selection divided by the number of pixels.

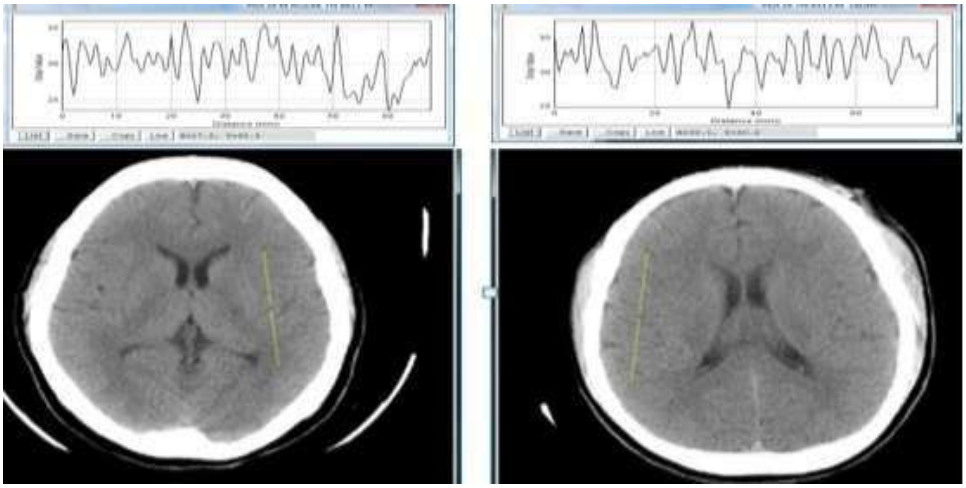

Figure 2 Two samples from group A (normal CT scan images) with *ImageJ* profile and plot profile for a two-dimensional graph of the intensities of pixels along a line within the images.

The profile number in the cases of Normal (group A) is not significantly different. It is shown in the graph above. Profile number of cases of Normal has a gray value level between (29.034 - 32.291). So for the case of Normal the *ImageJ* measurement results showed the number for mean gray value level between (29 -33). However all numbers level above (29). So for the results of normal case *ImageJ* measurement showed the number for mean gray value level ≥ 29.

Group (B) Hyperacute ischemic stroke in CT scan images

This group consisted of ten images with hyperacute ischemic stroke CT scan brain for patients underwent examinations in Radiology Department, Saiful Anwar Hospital, Malang after confirmation of diagnose by radiologists were Hyperacute ischemic stroke CT scan images. Conducted the measurement using the straight-line tool *ImageJ* Software to measure gray value of pixels on along a line within the image (fig 3). It used to calculate (Mean gray value) Average gray value within the selection area for each Regions of Interest (ROI).

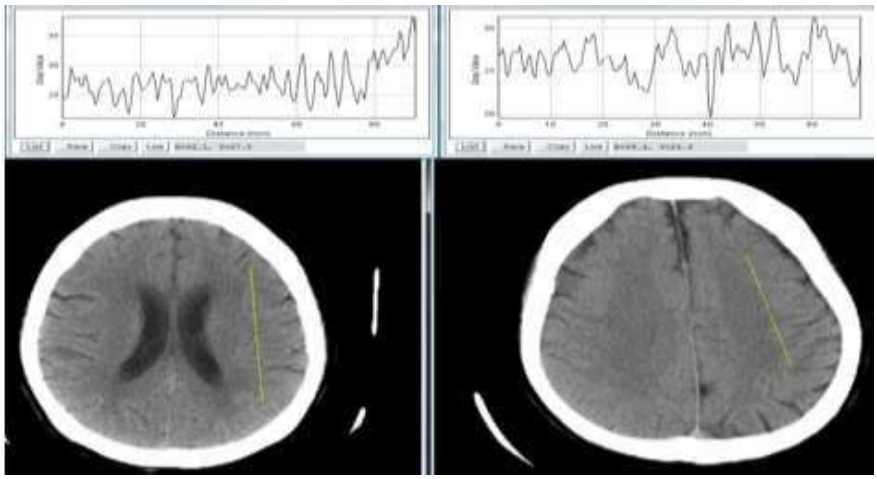

Figure 3 two samples from group B (hyperacute ischemic stroke in CT scan images) With *ImageJ* profile and plot profile for a two-dimensional graph of the intensities of pixels along a line within the images.

The profile number in the cases of Hyperacute ischemic stroke (group B) is not significantly different. It is shown in the graph above. Profile numbers of cases of Hyperacute ischemic stroke have a gray value level between (25.691 - 28.587). So for the case of Hyperacute ischemic stroke the *imageJ* measurement results showed the number for mean gray value level between (25 - 29).

Group (C) acute ischemic stroke in CT scan brain images:

Ten images with acute ischemic stroke CT scan brain this group for patients underwent to examinations by radiologists in Radiology department, Saiful Anwar Hospital, Malang. after the confirmation of diagnose it (acute ischemic stroke CT scan images). Conducted the measurement using the straight-line tool *ImageJ* Software to measure gray value level of pixels on along a line within the image (fig4). It used to calculate (Mean gray value) Average gray value within the selection area for each Regions of Interest (ROI).

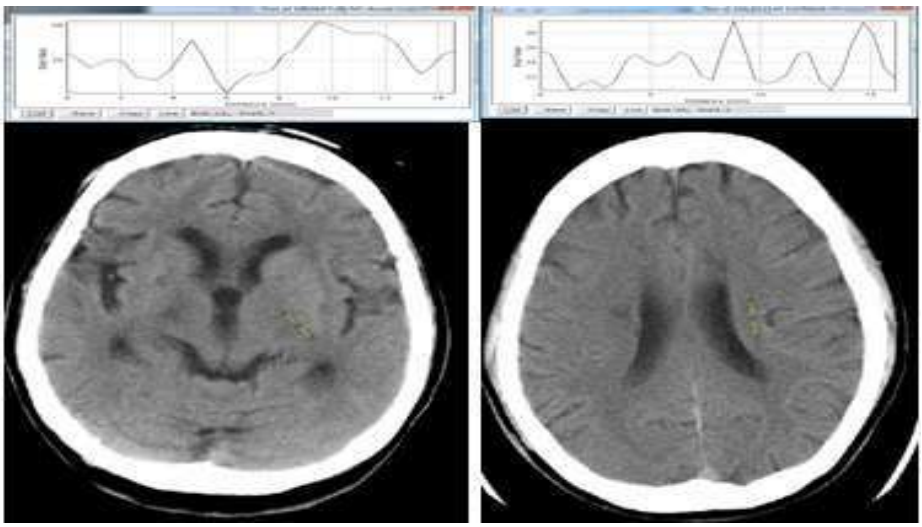

Figure 4 two samples from group C (acute ischemic stroke CT scan images) with *ImageJ* profile and plot profile for a two-dimensional graph of the intensities of pixels along a line within the images.

The profile number in the cases of acute ischemic stroke (group C) is not significantly different. It is shown in the graph above. Profile numbers of cases of acute ischemic stroke have a gray value level between (23.362 - 25.950). So for the case of acute ischemic stroke the *ImageJ* measurement results showed the number for mean gray value level between (23- 26).

Group (D) Subacute ischemic stroke in CT scan brain images:

Ten images with subacute ischemic stroke CT scan brain this group for patients underwent to examinations by radiologists in Radiology department, Saiful Anwar Hospital, Malang. after the confirmation of diagnose it (Subacute ischemic stroke CT scan images).Conducted the measurement using the straight-line tool *ImageJ* Software to measure gray value level of pixels on along a line within the image (fig5). It used to calculate (Mean gray value) Average gray value within the selection area for each Regions of Interest (RO).

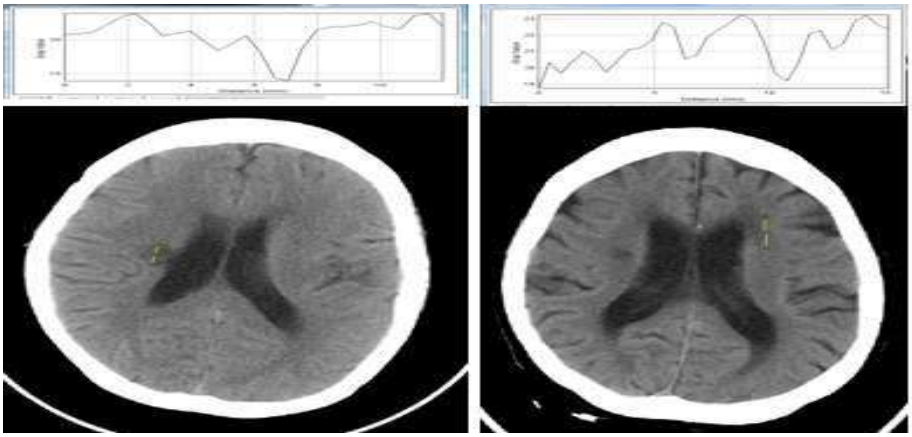

Figure 5 two samples from group D (Subacute ischemic stroke CT scan images) with *ImageJ* profile and plot profile for a two-dimensional graph of the intensities of pixels along a line within the images.

The profile number in the cases of Subacute ischemic stroke (group D) is not significantly different. It is shown in the graph above. Profile number of cases of Subacute ischemic stroke have a gray value level between (20.910 - 22.579). So for the case of Subacute ischemic stroke the *ImageJ* measurement results showed the number for mean gray value level between (20 - 23).

Group (E) chronic ischemic stroke in CTscan brain images:

Also in this group used ten images for chronic ischemic stroke CTscan brain for patients underwent to examinations in Radiology department,Saiful Anwar Hospital, Malang by radiologists after the confirmation diagnose of them. It were (Chronic ischemic stroke CT scan images) for each image conducted measurement using the straight-line tool *ImageJ* Software to measure gray value of pixels on along a line within the image (fig 6). It used to calculate (Mean gray value) Average gray value within the selection area for each Regions of Interest (ROI). This is the sum of the gray values of all the pixels in the selection divided by the number of pixels.

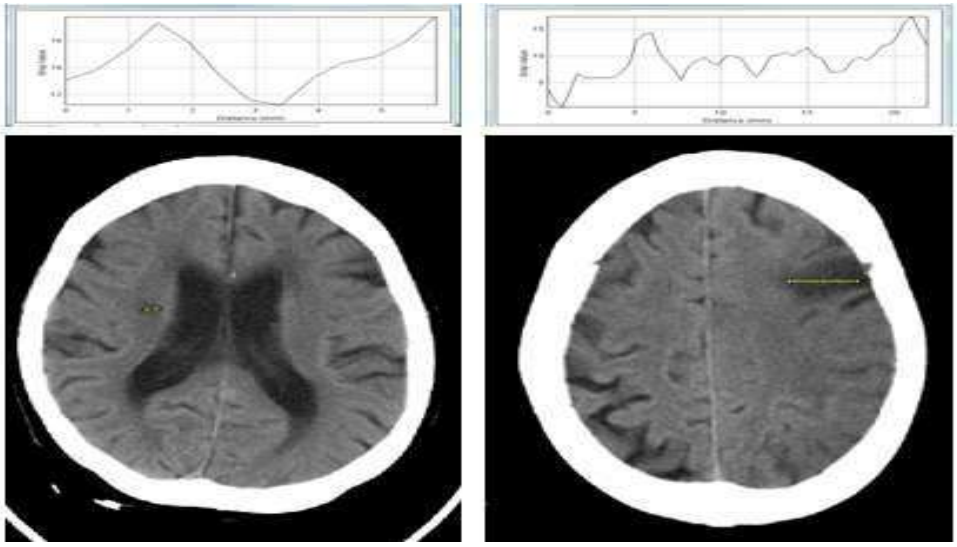

Figure 6 two samples from group E (Chronic ischemic stroke CT scan images) with *ImageJ* profile and plot profile for a two-dimensional graph of the intensities of pixels along a line within the images.

The profile number in the cases of chronic ischemic stroke (group E) is significantly different. It is shown in the graph above. Profile numbers of cases of chronic ischemic stroke have a gray value level between (9.104 -20.00).However all numbers under level (20). So for the case of chronic ischemic stroke the *ImageJ* measurement results showed the number for mean gray value level under level ≤ 20.

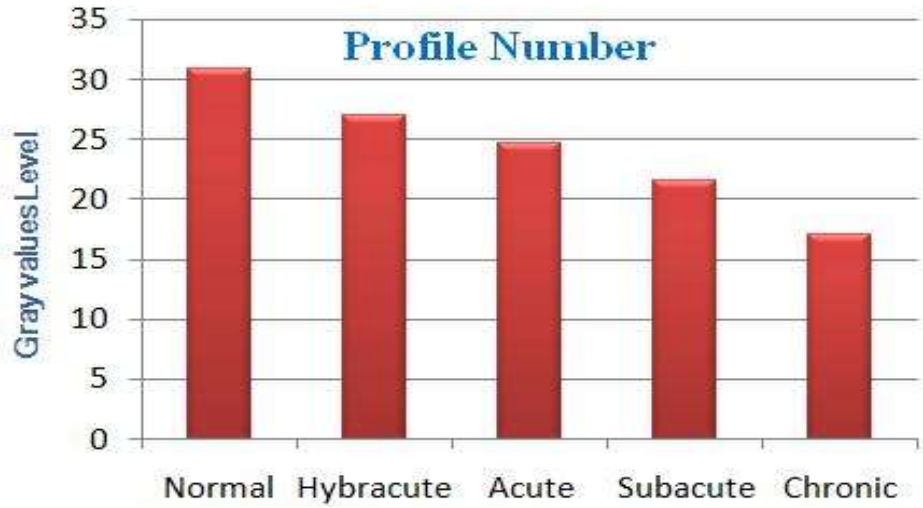

Figure 7 Normal, Hyperacute, Acute, Subacute and Chronic cases with Profile Number.

Figure 7 shows Linear regression to determine the strength of the association between the results measurements for the five groups [(A) Normal CT scan brain images, (B) Hyperacute ischemic stroke, (C) acute ischemic stroke, (D) Subacute ischemic stroke and (E) Chronic ischemic stroke in CT scan brain images] the results of measurements obtained to profile number for mean gray value level for each group. The data have been processed using *imageJ* software.

The reliability of *imageJ* measurements:

The reliability of using *imageJ* softwaer measurements was determined by comparing between reliability for repeated measurements and radiologists diagnose were obtained on 50 groups of CT brain images. Specifically, conducted measurements using *imageJ* software for another three groups randomly selected (Each group had ten CT brain images) unknown diagnosis the same way as the previous measurements in preliminary work to know the usefulness of the results were obtained from using *imageJ* softwaer to identification of ischemic stroke stages in CT scan brain images

First group randomly selected:

The result in this group was identical between *imageJ* measurements and diagnoses of radiologists. The result in this group was 100%.

The second Group randomly selected:

With the exception of one Sample was not identical because there was error. The measurement does not include the whole area of the stroke. However the other nine cases were identical between *imageJ* measurements and diagnoses of radiologists. The result in this group was 90%.

Third group randomly selected:

The measurements for the third group was ten cases randomly selected using *imageJ* software to identification of ischemic stroke stages in CT scan brain images comparing with diagnosis of radiologists to each case. With the exception of two Samples were not identical because there was error. The measurements were outside the area of the stroke. However the other eight cases were identical between *imageJ* measurements and diagnoses of radiologists. The result in this group was 80%.

IV. CONCLUSIONS

1- Practical understanding how imageJ software supports unenhanced CT scan. It is essential for the management of stroke patient. Due to its wide spread availability and speed, unenhanced CT scan remains the initial study of choice for evaluating stroke image patient.

2- ImageJ is easy to use and can process with CT images. It has the ability to assess the density of each pixel and through recent advances in the ImageJ software package; the density measurements have been calibrated to reflect the true Hounsfield unit values. To get good results to identification of ischemic stroke stages in CT scan brain images using imageJ that requires sufficient medical experience.

3- The mean gray values levels of normal was between levels (29 - 33). So normal $\geq$ 29, hyperacute was between levels (25 - 29), Acute was between levels (23 - 26), subacute was between levels (20 - 23) and chronic was between levels (9 - 20). So chronic $\leq$ 20.

4- The accuracy of using imageJ software in identification of ischemic stroke stages in CT scan brain images was 90%.

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