BIOMEDICAL IMAGE PROCESSING USING DEEP LEARNING

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BIOMEDICAL IMAGE PROCESSING USING DEEP LEARNING

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of

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by

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DECLARATION

We, the undersigned, hereby declare that our B.Tech. final year Project entitled "**Biomedical Image Processing Using Deep Learning**" is original and is our own contribution. To the best of our knowledge, the work has not been submitted to any other Institute for the award of any degree or diploma. We declare that we have not indulged in any form of plagiarism to carry out this project and/or writing this project report. Whenever we have used materials (data, theoretical analysis, figures, and text) from other sources, we have given due credit to them by citing in the text of the report and giving their details in the references. Finally, we undertake the total responsibility of this work at any stage here after.

Signature of the Students

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RECOMMENDATION

This is to recommend that the work undertaken in this report entitled, "**Biomedical Image Processing Using Deep Learning**" has been carried out by "**Sumit, Sudipta, Shadman, Puja**" under my/our supervision and guidance during the academic year 2021-22. This may be accepted in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (Computer Science and Engineering).

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Prof. Dr. Chandan Koner
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APPROVAL

This is to certify that, **Sumit Raj**, **Sudipta J Giri**, **Shadman Tabraiz** and **Puja Dey** students in the Department of Computer Science & Engineering, worked on the project entitled " **Biomedical Image Processing Using Deep Learning** ".

I hereby recommend that the report prepared by them may be accepted in partial fulfillment of the requirement of the Degree of Bachelors of Technology in the Department of Computer Science and Engineering, Dr. B.C. Roy Engineering College, Durgapur.

Board of Examiners

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ACKNOWLEDGEMENT

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We deeply express our sincere thanks to Head of Department, **Prof. Dr. Chandan Koner**, for encouraging and allowing us to present the project on the topic " **Biomedical Image Processing Using Deep Learning** " at out department premises for partial fulfillment of the requirements leading to the award of the B.Tech, Degree.

Furthermore, we would also like to acknowledge the crucial role of our lecturers whose instructions and guidelines acted as a foundation stone for this project.

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ABSTRACT

Biomedical image processing is a very broad field; it covers biomedical signal gathering, image forming, picture processing, and image display to medical diagnosis based on features extracted from images. This article reviews this topic in both its fundamentals and applications.

In its fundamentals, some basic image processing techniques including outlining, deblurring, noise cleaning, filtering, search, classical analysis and texture analysis have been reviewed together with examples. The state-of-the-art image processing systems have been introduced and discussed in two categories: general purpose image processing systems and image analyzers. In order for these systems to be effective for biomedical applications, special biomedical image processing languages have to be developed. The combination of both hardware and software leads to clinical imaging devices. Two different types of clinical imaging devices have been discussed. There are radiological imagings which include radiography, thermography, ultrasound, nuclear medicine and CT. Among these, thermography is the most noninvasive but is limited in application due to the low energy of its source. X-ray CT is excellent for static anatomical images and is moving toward the measurement of dynamic function, whereas nuclear imaging is moving toward organ metabolism and ultrasound is toward tissue physical characteristics. Heart imaging is one of the most interesting and challenging research topics in biomedical image processing; current methods including the invasive-technique cineangiography, and noninvasive ultrasound, nuclear medicine, transmission, and emission CT methodologies have been reviewed. Two current federally funded research projects in heart imaging, the dynamic spatial reconstructor and the dynamic cardiac three-dimensional densitometer, should bring some fruitful results in the near future.

Miscrosopic imaging technique is very different from the radiological imaging technique in the sense that interaction between the operator and the imaging device is very essential. The white blood cell analyzer has been developed to the point that it becomes a daily clinical imaging device. An interactive chromosome karyotyper is being clinical evaluated and its preliminary indication is very encouraging. Tremendous efforts have been devoted to automation of cancer cytology; it is hoped that some prototypes will be available for clinical trials very soon. Automation of histology is still in its infancy; much work still needs to be done in this area. The 1970s have been very fruitful in utilizing the imaging technique in biomedical application; the computerized tomographic scanner and the white blood cell analyzer being the most successful imaging devices.

CONTENTS

CHAPTER 1

INTRODUCTION

Image processing is one of the rapidly growing technologies of our time and it has become an integral part of the engineering and computer science disciplines. Image processing is a physical process used to convert an image signal,either digital or analog,into a physical image.The actual output itself can be an actual physical image or the characterstics of an image.

There are many types of image processing techniques are there like image enhancement,image restoration,image segmentation and many more which will be very helpful for image processing.

Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies.

Image reconstruction and modeling techniques allow instant processing of 2D signals to create 3D images. When the original CT scanner was invented in 1972, it literally took hours to acquire one slice of image data and more than 24 hours to reconstruct that data into a single image. Today, this acquisition and reconstruction occurs in less than a second.

Rather than simply eyeball an X-ray on a lightbox, image processing software helps to automatically identify and analyze what might not be apparent to the human eye. Computerized algorithms can provide temporal and spatial analysis to detect patterns and characteristics indicative of tumors and other ailments.

Depending on the imaging technique and what diagnosis is being considered, image processing and analysis can be used to determine the diameter, volume and vasculature of a tumor or organ; flow parameters of blood or other fluids and microscopic changes that have yet to raise any otherwise discernible flags.

1.1 Where Image Processing is used?

Image processing as a computer-based technology,plays an incresingly significant role in many fields of our daily life.Through image processing we can process and interpret all the information as if it processed in the human brain.

Some of the basic use of image processing are:

1) It is used in computerized photography(e.g.,photoshop).
2) In space image processing(e.g.,Hubble space telescope images,interplanetry probe images).
3)Medical/Biological image processing(e.g.,interpretation of X-ray,Blood/Cellular microscope images).
4) Automatic character recognition(Zip code,License plate recognition).
5) Finger print/Face/iris recognition.

The most important use of image processing is in the medical field.Some of the key roles of image processing in th medical field are:

1) Image processing in the medical field is the procedure used to obtain images for the body parts for the medical uses in order to identify and study diseases.
2)Medical imaging is developing in a fast manner due to rapid development in the image processing techniques including image recognition,analysis and enhancement.
3)Image processing helped in increasing the amount of detected issues.

Medical imaging is the process of producing visible images for the structures of the inner body for scientific and medical cause such as medical studies and treatments.

The image processing in the medical field creates data bank of the functions of all organs in order to make anomalies recognition much easier.

1.2 Medical Image Processing

Medical imaging is the process of producing visible images for the structures of the inner body for scientific and medical cause such as medical studies and treatments.

The image processing in the medical field creates data bank of the functions of all organs in order to make anomalies recognition much easier.

Biomedical imaging concentrates on the capture of images for both diagnostic and therapeutic purposes. Biomedical imaging technologies utilize either x-rays (CT scans), sound (ultrasound), magnetism (MRI), radioactive pharmaceuticals (nuclear medicine: SPECT, PET) or light (endoscopy, OCT) to assess the current condition of an organ or tissue and can monitor a patient over time over time for diagnostic and treatment evaluation.

Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies.

1.3 What are the benefits of Medical Image Processing?

The main benefit of medical image processing is that it allows for in-depth, but non-invasive exploration of internal anatomy. 3D models of the anatomies of interest can be created and studied to improve treatment outcomes for the patient, develop improved medical devices and drug delivery systems, or achieve more informed diagnoses. It has become one of the key tools leveraged for medical advancement in recent years.

The ever-improving quality of imaging coupled with advanced software tools facilitates accurate digital reproduction of anatomical structures at various scales, as well as with largely varying properties including bone and soft tissues. Measurement, statistical analysis, and creation of simulation models which incorporate real anatomical geometries provide the opportunity for more complete understanding, for example of interactions between patient anatomy and medical devices.

1.4 How does medical image processing work?

The process of medical image processing begins by acquiring raw data from CT or MRI images and reconstructing them into a format suitable for use in relevant software. A 3D bitmap of greyscale intensities containing a voxel (3D pixels) grid creates the typical input for image processing. CT scan greyscale intensity depends on X-ray absorption, while in MRI it is determined by the strength of signals from proton particles during relaxation and after application of very strong magnetic fields.

For medical users, the reconstructed image volume is typically processed to segment out and edit different regions of anatomical interest, such as tissue and bone. In Synopsys Simpleware software, for example, users can carry out different image processing operations at the 2D and 3D level, including:

- Reducing and removing unwanted noise or artifacts with image filters
- Cropping and resampling input data to make it easier and faster to process images
- Using segmentation tools to identify different anatomical regions, including automated techniques using AI-based machine learning algorithms
- Applying measurement and statistics tools to quantify different parts of the image data, for example, centrelines
- Importing CAD models, such as implants or medical devices, to study how they interact with individual anatomies
- Exporting processed models for physics-based simulation, further design work, or for 3D printing physical replicas of the anatomy in question

CHAPTER 2

LITERATURE REVIEW

2.1 History of Medical Imaging

The concept of medical imaging began in 1895 with the invention of the x-ray by a German professor of physics, Wilhelm Rontgen. The concept of x-ray is based on the principle of passing ionizing radiation through the body and having the images projected on a photosensitive plate placed behind it. The different densities of the tissues within the body will be detected when the plate is developed and will be able to show abnormalities that may be present. In the early 1900's it was discovered that by using pharmaceutical contrast agents it would be possible to see organs and blood vessels.

In the 1950's nuclear medicine started to utilized to diagnose pathology in the body. This is based on having the patient infused with radionucleotides that are combined with pharmaceutical compounds that will find their way to organs or groups of cells that are more active than others. These images are recorded by a gamma camera and can detect medical problems earlier than other tests.

During the 1960's sonar was beginning to be used after having been used for many years as a war time tool to detect enemy ships during World War Two. High frequency sound waves are transmitted through a probe into the body and these sound waves are then bounced back to the probe where they are converted into electrical pulses showing us images on a screen.

In the 1970's Computed Tomography (CT scan) was developed. The concept of this technology is to take a serial series of images of slices of the body and to then put them back together with a computer to visualize internal structures of the body.

Also in the 1970's the technology of MRI was developed which works on the principle of nuclear magnetic relaxation times. With the very powerful magnetic forces that are used, the alignment of protons in the cells will be examined to determine if there is a problem with tissues in the body.

Medical imaging has improved immensely since the first x-rays were taken over 120 years ago. There is much more accuracy in diagnosing a medical problem and because of these advances, there is also much less need to perform exploratory surgery. This hopefully will lead to early diagnosis and better treatment options for many patients.

2.2 Proposed System

According to our research, many researchers fail to achieve decent results in their systems, and one of the most common reasons is that they do not perform any pre-processing on their images before feeding them to the system.

In this project, we're attempting to develop a system that includes a pre-processing stage prior to picture processing.

We will compare various pre-processing approaches and attempt to provide the best-resulted technique, which may be a single technique or a mix of several.

We have used Histogram equalization and opt to use more varieties of Histogram Equalization such as -

Typical Histogram Equalization (HE), Global Histogram Equalization (GHE),

Local Histogram Equalization (LHE), Dualistic Sub-Image Histogram Equalization

(DSIHE), Brightness Preserving Bi-Histogram Equalization (BBHE), and Recursive Sub-

Image Histogram Equalization (RSIHE) using different parametric quantities like

Peak Signal-to-Noise Ratio (PSNR),Mean Square Error (MSE), visual quality, complexity,

Etc.

Future more we have more focus on using CNN technology for our image processing .

CHAPTER 3

THEORETICAL STUDY

3.1 Goals of medical image analysis techniques:

● **Quantification:** Measuring the features on medical images, eg., helpng radiologist obtain measurements from medical images (e.g., area or volume).

* To make the features measurable, it is necessary to extract objects from images by segmentation.

● **Computer Aided Diagnosis (CAD):** given measurements and features make a diagnosis. Help radiologists on their diagnosis procedure for accuracy and efficiency.

● Evaluation and validation techniques

3.2 General image analysis (regardless of its application) encompasses:

● Incorporation of prior knowledge

● Classification of features

● Matching of model to sub-images

● Description of shape

● Many other problems and approaches of AI.

3.3 About Digital Image Processing:

● What is an Image?

– Formal definition: A digital image is a multi-dimensional signal that is sampled in space and/or time and quantized in amplitude.

– Looser definition: An image is a “picture." The brightness values in the picture may represent distance, reflectivity, density, temperature, etc.

– The image may be 2-D (planar), 3-D (volumetric), or N-D.

– Image elements: An image may be composed of:

• 2-D: pixels = picture elements
• 3-D: voxels = volume elements
• 4-D and higher: hypervoxels = hypervolume elements

3.4 Techniques for Image Processing:

– Enhancement: Noise reduction

– Deblur

– Improve contrast

– Identify structures in image (segmentation):

– Identify homogeneous regions in an image (label image pixels = segmentation)

– Measure:
For example: Heart chamber volumes , Heart wall motion , Brain activity, Fetus size/gender , Lesion size and extent , …

– Visualize: For example: Surgical/Therapy planning , Image-guided surgery

3.5 Processing verse Analysis:

● **Medical image processing**: Deals with the development of problem specific approaches to enhance the rawmedical data for the purposes of selective visualisation as well as further analysis.

● **Medical image analysis**: Concentrates on the development of techniques to supplement the usuallyqualitative and frequently subjective assessment of medical images by humanexperts.

Provides quantitative, objective and reproducible information extracted from themedical images

3.6 Image Preprocessing:

As a Machine Learning Engineer, data pre-processing or data cleansing is a crucial step and most of the ML engineers spend a good amount of time in data pre-processing before building the model. Some examples for data pre-processing includes outlier detection, missing value treatments and remove the unwanted or noisy data.

CHAPTER 4

IMAGE PREPROCESSING TECHNIQUES

Pre-processing is a common name for operations with images at the lowest level of abstraction — both input and output are intensity images. These iconic images are of the same kind as the original data captured by the sensor, with an intensity image usually represented by a matrix of image function values (brightnesses).

The aim of pre-processing is to improve the quality of the image so that we can analyse it in a better way. By preprocessing we can suppress undesired distortions and enhance some features which are necessary for the particular application we are working for. Those features might vary for different applications.

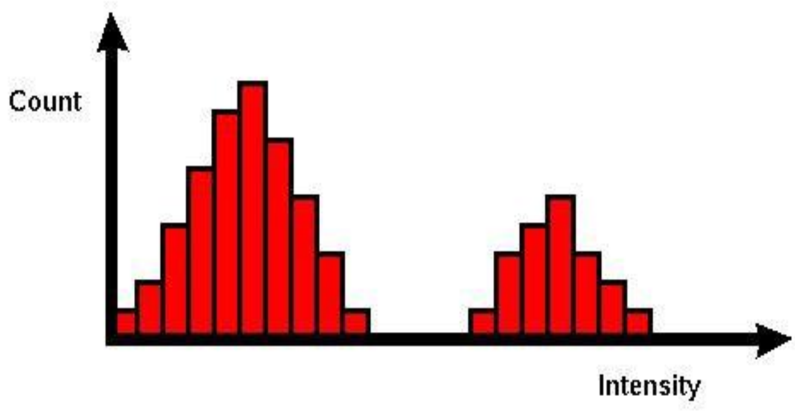
For example, if we are working on a project which can automate Vehicle Identification, then our main focus lies on the vehicle, its colour, the registration plate, etc., We do not focus on the road or the sky or something which isn't necessary for this particular application.

Some common techniques used for Image Preprocessing:

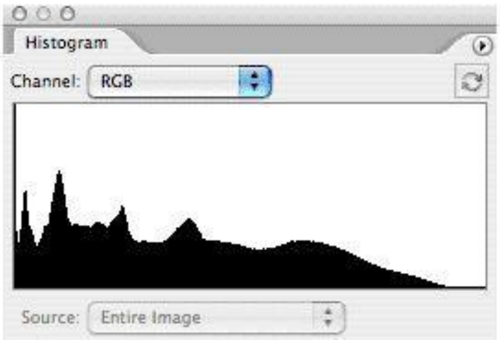
4.1 Histogram Equalization

What is a Histogram of An Image?

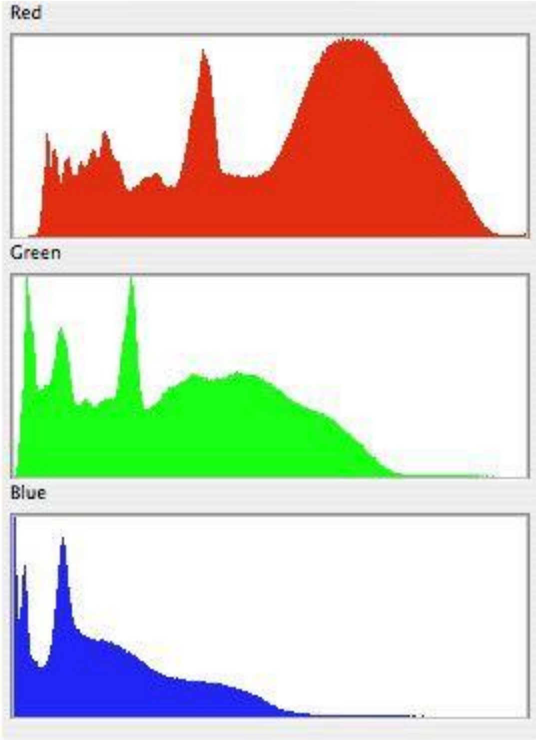
-A histogram of an image is the graphical interpretation of the image’s pixel intensity values. It can be interpreted as the data structure that stores the frequencies of all the pixel intensity levels in the image.



As we can see in the image above, the X-axis represents the pixel intensity levels of the image. The intensity level usually ranges from 0 to 255. For a gray-scale image, there is only one histogram, whereas an RGB colored image will have three 2-D histograms — one for each color. The Y-axis of the histogram indicates the frequency or the number of pixels that have specific intensity values.



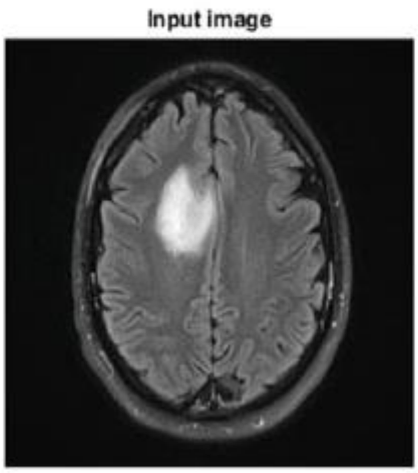
Histogram of Grey Scale Image



Histogram of RGB Image

Histogram Equalization is an image processing technique that adjusts the contrast of an image by using its histogram. To enhance the image's contrast, it spreads out the most frequent pixel intensity values or stretches out the intensity range of the image. By accomplishing this, histogram equalization allows the image's areas with lower contrast to gain a higher contrast.

Histogram Equalization can be used when you have images that look washed out because they do not have sufficient contrast. In such photographs, the light and dark areas blend together creating a flatter image that lacks highlights and shadows. Let's take a look at an example –



Low Contrast Photograph

In terms of Photography, this image is, without a doubt, a beautiful bokeh shot of a flower. However, for computer vision and image processing tasks, this photograph doesn’t provide much information since most of its areas are blurry due to lack of contrast.

But not to be worried. We can use histogram equalization to overcome this problem. Let’s take a look!

How to Use Histogram Equalization?

-Before we get started, we need to import the OpenCV-Python package, a Python library that is designed to solve computer vision problems. In addition to OpenCV-Python, we will also import NumPy and Matplotlib to demonstrate the histogram equalization.

```
import cv2 as cv
import numpy as np
from matplotlib import pyplot as plt
```

Next, we will assign a variable to the location of an image and utilize .imread() method to read the image.

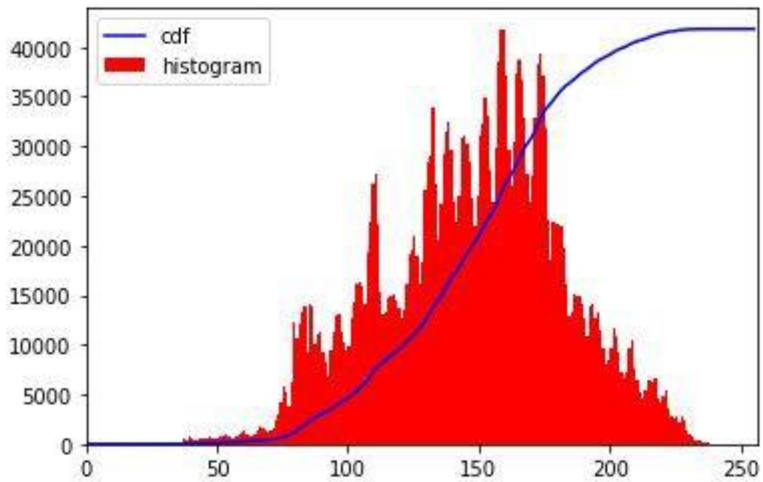
```
path = "...\brain.jpg"
img = cv.imread(path)
```

Then, we will use .imshow() method to view the image. Since I am using Jupyter Notebook, I will also add .waitKey(0) and .destroyAllWindows() methods to prevent my notebook from crashing while displaying the image. The image will appear in a separate window of your browser.

```
cv.imshow('image',img)
cv.waitKey(0)
cv.destroyAllWindows()
```

Now that our test image has been read, we can use the following code to view its histogram.

```
hist,bins=np.histogram(img.flatten(),256,[0,256])
cdf=hist.cumsum()
cdf_normalized=cdf*float(hist.max())/cdf.max()
plt.plot(cdf_normalized,color='b')
plt.hist(img.flatten(),256,[0,256],color='r')
plt.xlim([0,256])
plt.legend(('cdf','histogram'), loc = 'upper left')
plt.show()
```



Histogram of the Test Image

As displayed in the histogram above, the majority of the pixel intensity ranges between 125 and 175, peaking around at 150. However, you can also see that the far left and right areas do not have any pixel intensity values. This reveals that our test image has poor contrast.

To fix this, we will utilize OpenCV-Python's .equalizeHist() method to spreads out the pixel intensity values. We will assign the resulting image as the variable 'equ'.

```
equ = cv.equalizeHist(img)
```

Now, let's view this image.

```
cv.imshow('equ.png',equ)
cv.waitKey(0)
cv.destroyAllWindows()
```

If you compare the two images above, you will find that the histogram equalized image has better contrast. It has areas that are darker as well as brighter than the original image.

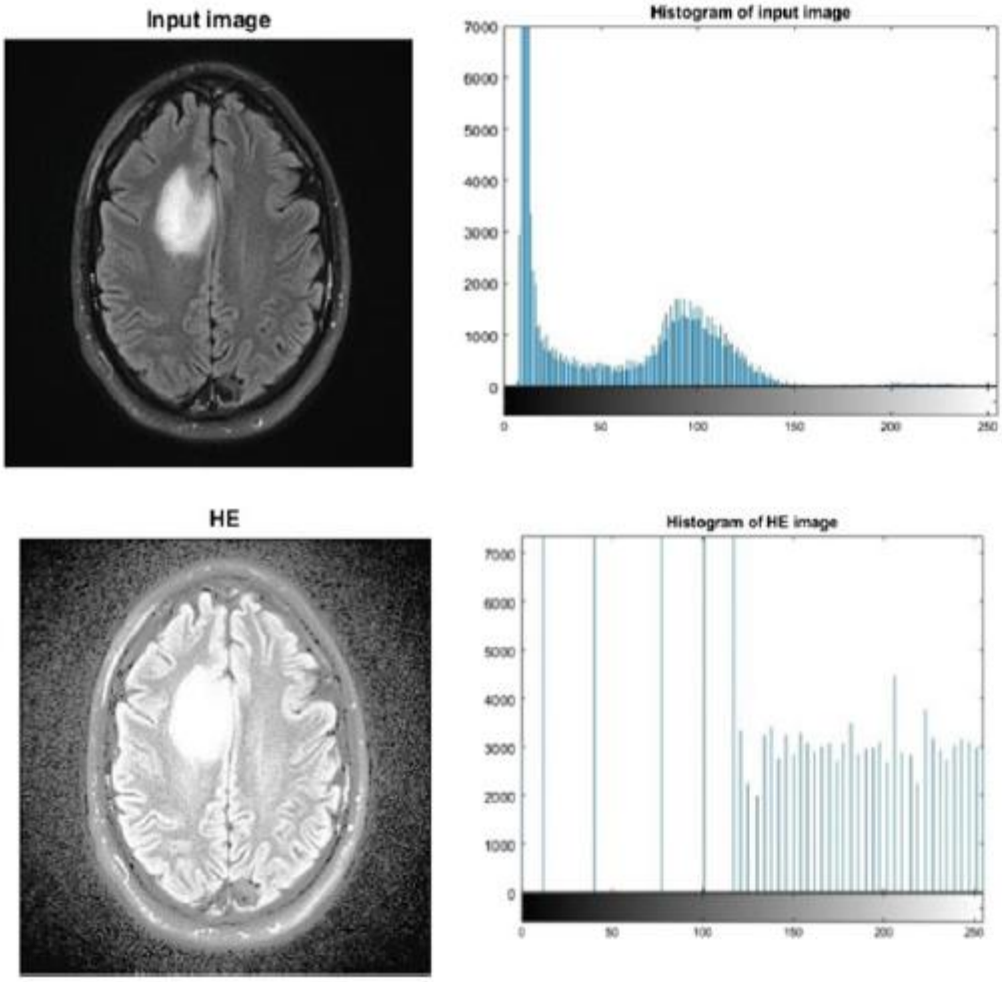


Fig. 1 Histogram equalization for brain tumor

Comparison between Original and Histogram Equalized Images

In addition to the ordinary histogram equalization, there are two advanced histogram equalization techniques called –

1. Adaptive Histogram Equalization (AHE)
2. Contrastive Limited Adaptive Equalization

Demerits of Histogram Equalization:

The brightness of an image can be changed after the histogram equalization, which is mainly due to the flattening property of the histogram equalization.

A pixel can be very bright, bright, dim or dark. The dynamic range of an image is the range which includes the brightest bright to the darkest dark present in the image.

Generally, histogram equalization flattens the density distribution of the resultant image and enhances the contrast of the image as a consequence, since histogram equalization has an effect of stretching dynamic range.

In short, brightness will not be preserved.

CHAPTER 5

CONCLUSIONS AND FUTURE SCOPE

As we have seen from the images that after preprocessing an image (Histogram Equalization, in this case), the image gets enhanced and its histogram has also been equalized. Thus by various such techniques, we can improve the efficiency of programs that work using those images which will eventually lead to a more accurate result!

We'll analyse different pre-processing ways and try to come up with the optimum methodology, which might be a single technique or a combination of several.

We've used Histogram Equalization and have chosen to use more types of Histogram Equalization, such as Typical Histogram Equalization (HE), Global Histogram Equalization (GHE), Local Histogram Equalization (LHE), and Dualistic Sub-Image Histogram Equalization (DSIHE), etc ... all of which use different parametric quantities.

After that, we'll compare image processing techniques such as picture enhancement, restoration, and segmentation.

In the future, we will place a greater emphasis on leveraging CNN technology for image processing.

--------------*THE END*------------