CHAPTER III

IMAGE PROCESSING FOR MEDICAL IMAGES

3.1 Image processing:

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Image Processing is manipulating data in the form of an image through several possible techniques. In this chapter, before the Medical image is processed for the research work, the necessary steps are to be done to get the accurate result.

3.2 Fundamental Steps in image processing:

There are 5 fundamental steps in Image Processing. They are:

![Fig. 3.1 Steps in Image Processing]

3.2.1 Image Acquisition:-

Image acquisition is done by:

- An image is captured by a sensor and digitized.
- If the output of the camera or sensor is not already in digital form, an analog-to-digital converter digitizes it.
Computer imaging systems are comprised of two primary component types, hardware and software [61]. The hardware components can be divided into the image acquisition subsystem, the computer itself and the display devices.

Additionally, the software is used to control the image acquisition and storage process. The image is fed into the system by means of camera, scanner, and video player. The process of transforming a standard video signal into digital image is called digitization. This transformation is necessary because the standard video signal is in analog form, and the computer requires a digitized or sampled version of data.

3.2.2 Preprocessing:-

The image which is taken through the image acquisition is in the form of raw data. So it should be preprocessed before any work is done on it [61]. There are two primary points done in this step, such as:

- Image Enhancement.
- Removing Noise.

*Image enhancement* methods have been designed to enhance the image, in such a way that the resultant image will be better than the original image. This method is used for the post processing step to generate a visually desirable image.

X-Ray images play a vital role in the detection of various diseases. But sometimes, these images are destroyed by various factors. Such as lack of brightness or increase of brightness.
Image enhancement is divided into two types:

- Spatial domain
- Frequency domain

The spatial domain operates on pixel values of the image [61]. It is used to enhance the contrast of the image. The frequency domain depends on the Fourier transform of the image. It is used to enhance the resolution of the image. Wavelet based enhancement techniques use the frequency domain. However, in medical images this preprocessing is not needed. But may be applied when the input image is of very poor quality. In paper [40] two types of histogram enhancement techniques are discussed, they are,

- Histogram Equalization.
- Contrast Limited Adaptive Histogram Equalization.

*Histogram* is the graphical representation of various intensities of an image. A Histogram with a small spread has low contrast and a Histogram with a wide spread has a high contrast [51]. An image with its Histogram clustered at the low end of the range is dark. Histogram with the values clustered at the high end of the range corresponds to a bright image.

It can also be modified by mapping functions such as stretch, slide and slide. But these functions will not produce a desired result. Histogram equalization is used to equalize the image with equal function [5]. As the image is lacking contrast, the intensity values are present in one side of the Histogram. So, various image enhancement techniques are used in order to enhance the contrast.
**Histogram equalization** is a popular technique for improving the appearance of a poor image. Its function is similar to that of a histogram stretch but provides more visually result across a wider range of images [52]. It is a technique where the histogram of the resultant image is as flat as possible.

It consists of four steps.

1. Finding the running sum of the histogram values.
2. Normalize the values from step 2.
3. Multiply the values from step 2 by the maximum gray values and round.
4. Map the gray-level values to the results from step 3 using a one-to-one correspondence.

In paper [42], Fuzzy histogram based color image retrieval technique is discussed which is discussed in this component.

![Fig 3.2 (a) Original Image (b) Histogram Equalized](image)

Histogram equalization is one of the spatially uniform operators. In this method, transformation is applied to all the pixels of the image. As a result the image becomes over enhanced and the resultant image will be very bright. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities [52] [75].
Histogram equalization may not always provide the desired effect because its goal is fixed to distribute the gray-level values as even as possible. A disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise, while decreasing the usable signal. The contrast is evenly spread from 0 to 255. So, as a result it is very bright. To avoid this over brightness to an image, the method of CLAHE is used.

**Contrast Limited Adaptive Histogram Equalization (CLAHE)** refers to modification of the gray-level values within an image based on some criterion that adjusts its parameters as local image characteristics change. It differs from ordinary histogram equalization in respect that the adaptive method performs several histogram, each to a distinct section of the image. But the ordinary histogram uses single histogram for an entire image. Histogram equalization performs histogram function for the entire image, while CLAHE operates on small regions in the image known as tiles [51] [52]. Each tiles contrast is enhanced with Adaptive Histogram equalization function. Then it combines neighboring tiles using bilinear interpolation to eliminate roughly added boundaries. This research work is discussed in the paper[51].
Image enhancement refers to accentuation, or sharpening, of images features such as edges, boundaries, or contrast to make a graphic display more useful for display and analysis. The enhancement process does not increase the inherent information content in the data. But it does increase the dynamic range of the chosen features so that they can be detected easily. Image enhancement includes gray level and contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification, pseudo coloring, and so on. The greatest difficulty in image enhancement is quantifying the criterion for enhancement [51]. Therefore, a large number of image enhancement techniques are empirical and require interactive procedures to obtain satisfactory results.
Noise removal is an important phase in image processing and it improves the quality of the image. But unlike image enhancement, knowledge of how the image was formed is used in an attempt to retrieve the ideal. Any image-forming system is not perfect, and will introduce artifacts into the final image that would not be present in an ideal image. A point spread function, called a filter, can be constructed that undoes the blurring [61]. By imaging the blurred image with the filter point spread function, the restored image is resulted. The filter point spread function is spread out more than the blurring point spread function, which brings more pixels into the averaging process. This is an example of a global operation, since perhaps all of the pixels of the blurred image can contribute to the value of a single pixel in the restored image.
The removal of noise in X-Ray images are discussed in the paper[ 52]. This type of deblurring is called inverse filtering, and is sensitive to the presence of noise in the blurred image. By modifying the deblurring filter according to the properties of the noise, performance can be improved.

Improving the appearance of an image can be done by the following:

- If an image has known faults then these may often be corrected. A blurred image may be ‘deblurred’ or a noisy image may have noise removed.
- It is based on mathematical or probabilistic models of image degradation.

Fig 3.7 (a) Noisy Image

Fig 3.7 (b) Noise removal applied
There are various types of filters applied to denoise different types of noises. Most of the medical images are free from noise because these noises may cause dangerous effects in the results.

3.2.3 Image Segmentation:

Segmentation refers to the process of partitioning a digital image into multiple segments such as sets of pixels, also known as super pixels. The goal of segmentation is to simplify the representation of an image into something that is more meaningful and easier to analyze [1]. Image segmentation is typically used to locate objects and boundaries such as lines, curves in images.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image [72]. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. There are various methods in image segmentation as shown below:

- Clustering Method
- Histogram based Method
- Edge Detection
- Threshold Method
- Region Growing Method
- Graph Partitioning Method
- Level Set Method
- Watershed Transformation
- Model Based Segmentation
- Neural Network Segmentation

The goal of image segmentation is to divide an image into consistent parts that correlate to object within the image. Once these objects have been extracted from the scene, information about them, such as their location, orientation and area are used towards a specific application. Image segmentation falls into two category [1], such as:

- Based on abrupt changes in intensity
- Segmentation methods

*Image thresholding* is the process, where all pixels in the image less than some value T are set to zero or alternatively all pixels greater than some value T are set to zero [61]. Gray level thresholding is the simplest possible segmentation process and it is formed by the importance of Sobel edge detector. The general idea in this concept is to separate the object from the background, so that the details are much clearer.

Fig 3.8 (a) Original Image  
(b) Segmented Image
3.2.4 Feature Extraction:-

The goal in image analysis is to extract information useful for solving application based problems. This is done by reducing the amount of image data with the tools, including image segmentation and transforms. After performing these operations modify the image from the lowest level of pixel data into higher level representation.

Feature Extraction can be useful for solving computer imaging problems. Image segmentation allows us to look at object features, and the image transforms provide us with features based on spatial frequency information [61].

The object features of interest include the geometrics properties of binary objects, histogram feature, and color features. Feature extraction is a part of data reduction process and is followed by feature analysis. One of the important aspects of feature analysis is to determine exactly the importance of each feature. So the analysis is not complete until it is found out.

The following are the important concepts:

- Feature Vector and Feature Spaces.
- Binary Object Features.
- Histogram Features.
- Color Features.
- Spectral Features.
In the paper [54], the concept of extracting the lung border to diagnose the severity of the infection is proposed.

3.2.5 Classification:-

Classification, which is related to image analysis involves taking the features extracted from the image and using them to classify image objects automatically [61]. This is done by developing classification algorithms that use the feature information. The primary use of classification in image analysis is for computer vision and image compression applications development.

It can be considered a part of feature analysis, or as a post preprocessing step to feature extraction and analysis. Classification is the final step in the development of a computer vision in order to facilitate the computer to perform accurate vision related task.

There are 2 sub ways of classification step:

- Supervised Classification
- Unsupervised Classification
Supervised Classification, is adopted with a view to determine a decision rule for classification, spectral characteristics or features with respect to the population of each class are necessary [20] [37]. The spectral features can be measured using ground-based spectrometers. Due to atmospheric effects, direct use of spectral features measured on the ground is not always available. For this reason, sampling of training data from clearly identified training areas, corresponding to defined classes is usually made for estimating the population statistics.

The supervised classification methods are given below:

1. Minimum Distance to Mean
2. Maximum Likelihood
3. Mahalanobis.
4. Stepwise Linear
5. Suits’ Maximum Relative
6. Back Propagation

The decision rules for the supervised classification process are multi-level:

- Non-parametric
- Parametric

Unsupervised classification methods are algorithms that analyze and classify a large number of raster cells [21]. These processes require set values for a few processing parameters, but the classification process then proceeds with no user intervention.
The success of the unsupervised methods is based on the premise that the input raster dataset includes natural statistical groups of spectral patterns that represent particular types of physical features [25].

All of the unsupervised classification methods, except Simple One-Pass Clustering, use an interactive process to analyze a set of sample input cells and determine a set of class centers and associated statistical properties. In the paper [55], the concept of unsupervised clustering algorithm is explained with chest X-Ray images. The entire input raster set is then processed, and a classification rule is used to assign each raster cell to one of the defined classes.

![Original Image](image1.png) ![Classified Image](image2.png)

Fig 3.10 (a) Original Image (b) Classified Image

The unsupervised classification Methods are mentioned as follows:

1. Simple One-Pass Clustering
2. K Means
3. Fuzzy C Means
4. Minimum Distribution Angle
5. Isodata Classification
6. Self-Organization and
To develop a classification algorithm, the data are divided into a training set and a test set. This is done so that one set of image to develop the classification scheme and a separate set to test the classification algorithm. In order to work properly, both the training and test sets should represent the image that will be seen in the application domain. Every image has to be preprocessed, so that the manipulation on that image will be very accurate. This chapter dealt with this preprocessing steps undergone to process with the next step of colorization.