

A PROJECT REPORT ON  
**A NOVEL IMAGE ENHANCEMENT FOR ELECTRON MICROSCOPIC IMAGES**

**Submitted in partial fulfilment of the Requirement  
for the award of the degree of**

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IN  
ELECTRONICS AND COMMUNICATION ENGINEERING**

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## CERTIFICATE

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## **List of Abbreviations**

<b>EME</b>	-	Measure of Enhancement
<b>PSNR</b>	-	Peak Signal to Noise Ratio
<b>MSE</b>	-	Mean Squared Error
<b>CLAHE</b>	-	Contrast Limited Adaptive Histogram Equalization
<b>AHE</b>	-	Adaptive histogram equalization
<b>GHE</b>	-	Global Histogram Equalization
<b>LHE</b>	-	Local Histogram Equalization
<b>DCT</b>	-	Discrete Cosine Transform
<b>SVD</b>	-	Singular Value Decomposition
<b>IDCT</b>	-	Inverse Discrete Cosine Transform
<b>DWT</b>	-	Discrete Wavelet Transform

## List of Symbols

$\Sigma$	-	Summation
$\wedge$	-	Caret
$\div$	-	Division
$\pm$	-	Addition & Subtraction
$\square$	-	Square Brackets
$*$	-	Asterisk
$=$	-	Equal

## **ABSTRACT**

Electronic microscopic images play a vital role in medical pathology. These images are basically low contrast images. In order to extract the details from these images, it is necessary to enhance these images. In this work, an innovative image enhancement and feature extraction technique is proposed. This technique uses a modified sigmoid function that accommodates the original microscopic input image characteristics. A novel block-based input value coupled with the modified sigmoid function is used in this proposed technique in order to provide good contrast enhancement of an image. Singular value decomposition plays an important role after DCT because the singular value matrix determines the intensity values of the input microscopic images. Changes in the singular values have an immediate impact on the intensity of the microscopic input images. The proposed methodology essentially converts the input image into the SVD-DCT domain, normalizes the singular value matrix, and finally reconstructs the enhanced image using inverse DCT.

## CHAPTER-1

### INTRODUCTION

In the era of the internet and technology, the processing of images is done by using digital computers for various applications such as image enhancement, compression, face recognition and feature extraction. For improving the visual features of an image nowadays, image enhancement has become a very popular technique. This research proposes microscopic image enhancement for feature extraction using modified sigmoid function and two-dimensional discrete cosine transform (2D-DCT). Various image enhancement techniques work adaptively in many applications, while for colonies of micro-organisms, the subjective quality of an image becomes a paradigm. In the present era, adaptive image enhancement has become an emerging technique in microbiology, satellite imaging, real-time photography and medical science to extract the original and important features. Recently MARN technique was proposed which work on end-to-end model for improving low-contrast images and uses the low contrast picture along with the IA map as input to develop an image- to-illumination mapping that directs the model to anticipate very precise inverse illumination map for image enhancement.

#### **1.1 Image Enhancement:**

Image enhancement refers to the process of improving the visual quality of a digital image by manipulating its pixel values or applying mathematical operations to it. The goal of image enhancement is to improve the appearance of an image or make its features more visible for better interpretation and analysis. The techniques used in image enhancement can include adjustments to the brightness, contrast, sharpness, color balance, or the removal of noise and artifacts. Image enhancement can be done manually using software tools, or it can be

---

automated using algorithms based on signal processing or machine learning techniques. Image enhancement finds applications in various fields such as medical imaging, surveillance, remote sensing, photography, and microscopy, among others.

### **1.2 Electron Microscopy:**

Electron microscopy is a powerful tool used in various fields of science and technology to study the micro- and nano-structures of materials. However, electron microscopic images can often suffer from low contrast, poor resolution, and high noise levels. These limitations can hinder the interpretation and analysis of the images and reduce the accuracy of the results. Therefore, developing novel image enhancement techniques for electron microscopy is a critical area of research that can improve the quality and usefulness of these images. This proposed system aims to propose a novel image enhancement method for electron microscopic images that can overcome the current limitations and improve the visualization and analysis of micro- and nano-structures. The proposed method will leverage state-of-the-art image processing and machine learning techniques to enhance the contrast, resolution, and reduce the noise level of the images while preserving the structural details. The successful implementation of this project can have significant implications in various fields, including materials science, biology, and nanotechnology.

### **1.3 Need of Image Enhancement:**

Image enhancement is essential for improving the quality and usefulness of digital images in various fields. Here are some of the key reasons why image enhancement is necessary:

**Enhancing image visibility:** Sometimes, digital images can be of low quality, resulting in unclear, blurry, or noisy images. Image

enhancement can improve the visibility of important features in an image, making it easier to analyze and interpret.

**Removing artifacts and noise:** Digital images can contain artifacts, such as scratches, blurs, and other distortions. Additionally, images can be noisy due to various factors, including the environment, the imaging equipment, or the image acquisition process. Image enhancement techniques can remove or reduce these artifacts and noise to improve image quality.

**Highlighting specific features:** In some applications, specific features of an image need to be highlighted, such as edges or contours. Image enhancement techniques can be used to emphasize these features for easier analysis and interpretation.

**Improving image analysis and processing:** Image enhancement techniques can improve the accuracy and efficiency of image analysis and processing algorithms, which are commonly used in applications such as object recognition, segmentation, and tracking.

#### **1.4 Application of Image enhancement:**

**Medical imaging:** Image enhancement is used in medical imaging to improve the visualization of internal structures, such as bones, tissues, and organs, to aid in diagnosis and treatment planning. Examples of medical imaging techniques that use image enhancement include X-ray, CT scans, MRI, and ultrasound.

**Surveillance and security:** Image enhancement techniques are used in surveillance and security applications to improve the visibility of objects or persons of interest in low light conditions, noisy environments, or



poor-quality images. This can include facial recognition, object detection, and tracking.

**Photography:** Image enhancement is commonly used in photography to improve the visual quality of photographs, such as adjusting brightness, contrast, and color balance.

**Remote sensing:** Image enhancement is used in remote sensing applications, such as satellite imagery or aerial photography, to improve the visibility of specific features, such as land use, vegetation, or water bodies.

**Materials science:** Image enhancement techniques are used in materials science to analyze micro and nanostructures in materials, such as metals, semiconductors, and polymers, to better understand their properties and behavior.

**Art conservation:** Image enhancement techniques are used in art conservation to restore and preserve historic artwork, such as paintings and sculptures, by improving the visibility of details and reducing damage caused by aging and environmental factors.

### 1.5 Existing Methods:

In 2021, a multi-scale attention retina network (MARN) for low-light image enhancement is proposed. This technique overcomes the in accurate illumination estimation. Multi-scale attention retinex network consists of a multi-scale attention module and a feature fusion module. The former extracts multi-resolution features with attention-based feature aggregation, while the latter further merges the output features of the previous module with the input. LSB embedding position, and encrypt the message which control embedded position, so the hidden

information cannot be extracted without the corresponding private key. In order to prevent the forgery of the hidden information, a image segmentation method is performed which attempts to extract the image. The proposed pre-processing method improves crop image performance.

The initial conditions of the system are very important as they are the secret keys that should be known only to authorized persons. Without having information about these keys, the data cannot be decrypted by anyone. In fact, initial conditions of the system are sensitive particularly because hackers and unauthorized users usually apply a minute change to try and decrypt the secured content. The highly sensitive system means that changing small values will display profoundly strange attractors and as a result, hackers will be incapable of decrypting the original content. In addition, the strength of any cryptosystem is assessed by its computational complexity, while the transmission rate determines the efficiency of the whole system.

In the digital image application field, images with high contrast and bright colors are the crucial prerequisite for good understanding of the real scenes, such as detection and classification for underwater dam cracks, and multitarget detection under complex environment. The images having a higher contrast level usually display a larger degree of colorscale difference as compared to the lower contrast level ones. Light plays a crucial role in generating images of satisfactory quality in photography. Strong light causes an image to have a washed-out appearance; on the contrary, weak light leads to an image that is too dark to be visible. In these two cases, the contrasts of the images are low and their detailed textures are difficult to discern. The underwater images may lose contrast suffering from degradation due to poor visibility conditions and effects such as light absorption, light reflection, bending of light and scattering of light, which result in dimness and

distortion. Furthermore, the poor sensitivity charge-coupled device/complementary-metal-oxide-semiconductor in CCD/CMOS sensors leads to images with excessively narrow dynamic ranges and renders their details unclear. There are heuristically serious disagreements existing between the recorded color images and the direct observation of the real underwater scenes. The purpose of image enhancement is a process that allows image features to show up more visibly details and highlight the useful information by making best use of the color presented on the display devices. Image enhancement is used to improve the quality of an image for visual perception of human being.

### **1.6 Proposed Method:**

#### **Image Enhancement for Electron Microscopic Images**

The proposed technique uses MATLAB software for simulation and all experimental operations. Four distinct contrast actinomycetes, the microscopic images of size 512X512, are employed in our experimental study for feature extraction and image enhancement. Quality analysis criteria such as EME (Measure of Enhancement), MSE (Mean Square Error), and PSNR (Peak Signal to Noise Ratio) are used to assess the reliability and performance of the proposed image enhancement technique. As a result of these quality factors, the overall quality of the resultant enhanced microscopic image is significantly better than the original microscopic image, as seen by improved PSNR, EMF, and EME values. Initially, the image is taken as input and pre-processing is performed by using the Pixel Resize Method. In the pre-processing technique, various unwilling distortions are suppressed and the significant image features are used for further processing. The proposed system is analyzed to validate its performance efficiency, the main contributions of this work are as follows:

- A block-based adaptive contrast enhancement algorithm using a modified sigmoid function is used for the enhancement and features extraction of electron microscopic images.
- This algorithm is based on a modified sigmoid function that adapts according to the input microscopic image statistics.
- For feature extraction, the contrast of the image is very important and authentic property by which this work enhances the visual quality of the image.
- The major drawback of the sigmoid activation function is to create a vanishing gradient problem. This is the non-zero centered activation function and the model learning rate is very slow.
- The proposed technique increases the image's visual quality while simultaneously preserving significant features and maintaining the brightness level in microscopic images, as shown by the enhancement results.

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## CHAPTER-2

### LITERATURE SURVEY

In the field of image contrast enhancement, several methods have been proposed. Histogram Equalization (HE) is one of the most popular methods. It performs contrast enhancement by effectively spreading out the most frequent intensity values, i.e., stretching out the intensity range of the image. This method usually increases the global contrast of images when its usable data is represented by close contrast values. This allows for areas of lower local contrast to gain a higher contrast. Although, HE has limitations, i.e., the local contrast of an image cannot be equally enhanced, over-enhancement of noise and artifacts can be easily found in the local histogram equalization enhanced images.

#### **2.1 Transform Image Enhancement:**

Block wise transform image enhancement techniques are discussed. Previously, transform image enhancement has usually been based on the discrete Fourier transform applied to the whole image. Two major drawbacks with the DFT are high complexity of implementation involving complex multiplications and additions, with intermediate results being complex numbers, and the creation of severe block effects if image enhancement is done block wise. In addition, the quality of enhancement is not very satisfactory. It is shown that the best transforms for transform image coding, namely, the scrambled real discrete Fourier transform, the discrete cosine transform, and the discrete cosine-III transform, are also the best for image enhancement. Three techniques of enhancement discussed in detail are alpha-rooting, modified unsharp masking, and filtering motivated by the human visual system response HVS. With proper modifications, it is observed that unsharp masking and HVS-motivated filtering without nonlinearities

are basically equivalent. Block effects are completely removed by using an overlap save technique in addition to the best transform.

## **2.2 Smart Image Enhancement Using CLAHE:**

This paper proposes a scheme for adaptive image-contrast enhancement based on a generalization of histogram equalization HE. HE is a useful technique for improving image contrast, but its effect is too severe for many purposes. However, dramatically different results can be obtained with relatively minor modifications. A concise description of adaptive HE is set out, and this framework is used in a discussion of past suggestions for variations on HE. A key feature of this formalism is a "cumulation function," which is used to generate a grey level mapping from the local histogram. By choosing alternative forms of cumulation function one can achieve a wide variety of effects. A specific form is proposed. Through the variation of one or two parameters, the resulting process can produce a range of degrees of contrast enhancement, at one extreme leaving the image unchanged, at another yielding full adaptive equalization.

## **2.3 Histogram Specification:**

While in the continuous case, statistical models of histogram equalization/specification would yield exact results, their discrete counterparts fail. This is due to the fact that the cumulative distribution functions one deals with are not exactly invertible. Otherwise stated, exact histogram specification for discrete images is an ill-posed problem. Invertible cumulative distribution functions are obtained by translating the problem in a dimensional space and further inducing a strict ordering among image pixels. The proposed ordering refines the natural one. Experimental results and statistical models of the induced ordering

are presented and several applications are discussed: image enhancement, normalization, watermarking, etc.

## **2.4 Adaptive Histogram Equalization and its Variations:**

This work proposes an efficient algorithm for contrast enhancement of natural images. The contrast of images is very important characteristics by which the quality of images can be judged as good or poor. The proposed algorithm of two stages: In the first stage the poor quality of an image is processed by modified sigmoid function. In the second stage the output of the first stage is further processed by contrast limited adaptive histogram equalization to enhance contrast of images. In order to achieve better contrast enhancement of images, a novel mask based on input value together with the modified sigmoid formula that will be used as contrast enhancer in addition to contrast limited adaptive histogram equalization. This new contrast enhancement algorithm passes over the input image which operates on its pixels one by one in spatial domain. Simulation and experimental results on benchmark test images demonstrate that proposed algorithm provides better results as compared to other state-of-art contrast enhancement techniques. Proposed algorithm performs efficiently in different dark and bright images by adjusting their contrast very frequently. Proposed algorithm is very simple and efficient approach for contrast enhancement of image. This algorithm can be used in various applications where images are suffering from different contrast problems.

## **2.5 Various Types of Histogram Equalization Techniques:**

### **2.5.1 CLAHE (Contrast Limited Adaptive Histogram Equalization):**

CLAHE works on small areas of an image called tiles rather than the complete image. The surrounding tiles are blended using bilinear

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interpolation to remove the false boundaries. This algorithm can be used to improve image contrast. CLAHE can also be applied to color images, often to the luminance channel.

CLAHE was initially used to improve low-contrast medical images. CLAHE differs from ordinary AHE in that it limits contrast. To address the issue of noise amplification, the CLAHE implemented a clipping limit. Before computing the Cumulative Distribution Function, the CLAHE limits the amplification by clipping the histogram at a predefined value (CDF). The CLAHE technique divides an input original image into non-overlapping contextual regions known as sub-images, tiles, or blocks.

The CLAHE is defined by two parameters: Block Size (BS) and Clip Limit (CL). These two parameters primarily govern improved image quality. When CL is increased, the image becomes brighter because the input image has a very low intensity and a larger CL makes its histogram flatter.

CLAHE can also be applied to color images, often to the luminance channel. The results of equalizing only the luminance channel of an HSV image outperform equalizing all channels of a BGR image.

### **2.5.2 AHE (Adaptive histogram equalization):**

An image pre-processing technique used to improve contrast in images. It computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the luminance values of the image. It is therefore suitable for improving the local contrast and enhancing the definitions of edges in each region of an image. However, AHE tends to overamplify noise in relatively



homogeneous regions of an image. A variant of adaptive histogram equalization called contrast-limited adaptive histogram equalization (CLAHE) prevents this effect by limiting the amplification.

### ***2.5.3 GHE (Global Histogram Equalization):***

Global Histogram Equalization is a computer image processing technique used to improve contrast in images. It accomplishes this by effectively spreading out the most frequent intensity values, i.e., stretching out the intensity range of the 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.

### ***2.5.4 LHE (Local Histogram Equalization):***

LHE can enhance the overall contrast more effectively. One of the drawbacks of histogram equalization is that it can change the mean brightness of an image significantly as a consequence of histogram flattening and sometimes this is not a desirable property when preserving the original mean brightness of a given image is necessary. Bi-Histogram Equalization was proposed to overcome this problem.

The histogram of an image gives important information about the grayscale and contrast of the image. If the entire histogram of an image is centered towards the left end of the x-axis, then it implies a dark image. If the histogram is more inclined towards the right end, it signifies a white or bright image. A narrow-width histogram plot at the center of the intensity axis shows a low-contrast image, as it has a few

---

levels of grayscale. On the other hand, an evenly distributed histogram over the entire x-axis gives a high-contrast effect to the image.

In image processing, there frequently arises the need to improve the contrast of the image. In such cases, we use an intensity transformation technique known as histogram equalization. Histogram equalization is the process of uniformly distributing the image histogram over the entire intensity axis by choosing a proper intensity transformation function. Hence, histogram equalization is an intensity transformation process.

## Chapter-3

### BASICS OF IMAGE ENHANCEMENT

The enhancement process of an image, complete information is lost from an image. In the last few years, Discrete Wavelet Transform (DWT) has become an authentic tool used to analyse the audio signal's features because of its time-dependent nature. Nowadays, DWT is widely used in image processing domains such as compression, remote sensing, enhancement and removing noise. In this work four important techniques such as CLAHE, Modified Sigmoid Function, 2D-DCT and SVD are combined for enhancement and feature.

#### 3.1 Image:

Figure 3.1 shows the example for an image. An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows.

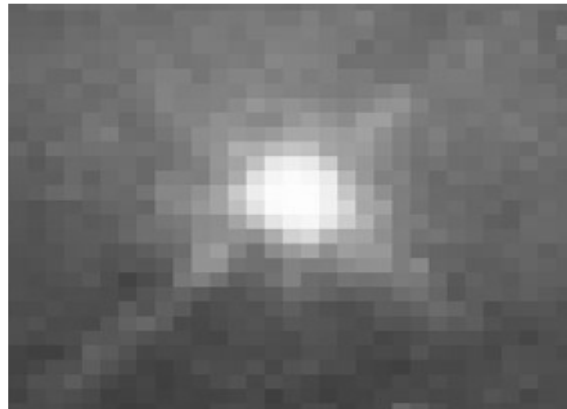


Fig 3.1: An image is an array or a matrix of pixels arranged in columns and rows

#### 3.1.1 Pixel:

A picture element is a single point in a graphic image. Every such information part is not actually a dot, nor a square except a conceptual

sample. Each element of the above matrix is known as pixel where, dark=0 and bright=1, as shown in the figure 3.2. A pixel with solely 1bit will signify a black and white picture. An image is represented as a matrix in digital image processing. In Digital Signal Processing we utilize only row matrices. Obviously happening images should be sampled and quantized to get digital image A free image should have 1024\*1024 pixels which is known as 1k\*1k=1mega pixel.

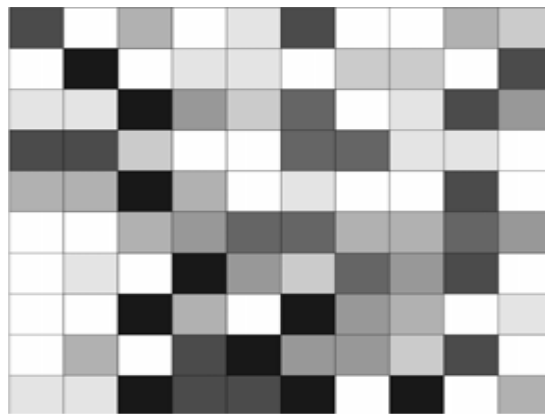


Fig3.2: Each pixel has a value from 0(black) to 255(bright).

### **3.2 Types of Images:**

#### **3.2.1 Gray Scale Image:**

Every pixel is a shade of gray, typically from 0(dark) to 255(bright). This extent implies that every pixel can be spoken to by eight bits, or precisely one byte. Other gray scale reaches are utilized, however for the most part they are a force of 2.

#### **3.2.2 Binary Image:**

Each pixel is just black or white. Since there are only possible values for each pixel (0,1), we only need 1 bit per pixel.

### **3.2.3 Indexed Image:**

An index image comprises of an array and a shading grid lattice. Pixels in the exhibit or immediate list into a shading guide. By tradition, this documentation utilizes the variable name  $x$  to allude to the exhibit and guide to allude to the shading guide.

### **3.2.4 RGB Image:**

Every pixel has a specific colour, that colour is depicted by the measure of red, green, and blue in it. On the off chance that each of these segments has an extent 0-255, this gives an aggregate of 2563 different conceivable hues. Such an image is a stack of three grids; speaking to the red, green and blue qualities for every pixel. This implies that for each pixel there relate three values.

## **3.3 Fractal Encoding:**

The Fractal compression is a lossy compression method for digital images, based on fractals. The method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image. With fractal compression, encoding is extremely computationally expensive because of the search used to find the self-similarities. Decoding, however is quite fast. While this asymmetry has so far made it impractical for real time applications, when video is archived for distribution from disk storage or file downloads fractal compression becomes more competitive.

### **3.3.1 Run length Encoding:**

Run-length encoding (RLE) is a very simple form of data compression in which runs of data (that is, sequences in which the same data value occurs in many consecutive data elements) are stored as a single data value and count, rather than as the original run. This is most useful on data that contains many such runs: for example, simple graphic images such as icons, line drawings, and animations. It is not useful with files that don't have many runs as it could greatly increase the file size.

RLE may also be used to refer to an early graphics file format supported by CompuServe for compressing black and white images, but was widely supplanted by their later Graphics Interchange Format. RLE also refers to a little-used image format in Windows 3.x, with the extension rule, which is a Run Length Encoded Bitmap, used to compress the Windows 3.x startup screen. Typical applications of this encoding are when the source information comprises long substrings of the same character or binary digit.

Run-length encoding performs lossless data compression and is well suited to palette-based bitmapped images such as computer icons. It does not work well at all on continuous-tone images such as photographs, although JPEG uses it quite effectively on the coefficients that remain after transforming and quantizing image blocks.

## **3.4 File Formats:**

### **3.4.1 GIF (Graphic Interchange Format):**

GIF works best for pictures with just a couple of particular hues, for example, line drawings and basic toons. GIF is valuable for toon

pictures that have under 256 hues, dark scale pictures and dark and white content.

Like JPEG, GIF is standard organization for web pictures. The essential confinement of GIF is that it meets expectations just on pictures with 8 bits for every pixel or less, which implies 256 or less hues. Most shading pictures are 24 bits for pixel. To store this GIF design, you should first over the picture from 24 bits to 8 bits. The change will bring about lost information and an extensive debasement in quality. PC screen that shows just 26 hues are less show GIE's well.

GIF is lossless picture record passion. With lossless pictures, the greater part of the information that was initially in the document stays after the record is uncompressed. GIF packs pictures utilizing LZW pressure. LZW pressure is named for the people who created it LIMPEL-ZEV WELCH. It was initially concerted to pack content for transmission over phone lines. This type of pressure is a lossless pressure structure with proportions differing relying upon the shading multifaceted nature of picture.

### ***3.4.2 JPEG (Joint photographic Experts Group):***

GIF works best for pictures with just a couple of unmistakable hues, for example, line drawings and straight forward kid's shows. GIF is valuable for toon pictures that have under 256 hues, dark scale pictures and dark and white content. Like JPEG, GIF is a standard configuration for web pictures.

The essential restriction of a GIF is that it lives up to expectations just on pictures with eight bits for every pixel or less, which implies 256 or less hues. Most shading pictures are 24 bits for every pixel. To store these in GIF position you should first change over the picture from 24

bits to 8 bits. The change will bring about lost information and an impressive debasement in quality. PC screen that shows just 26 hues are less show GIFS well.

### **3.4.3 TIFF (Tagged Image Format File):**

TIFF has risen as the standard chronicling picture document position for library use. Its qualities are that the organisation is extensible, new pictures sorts can be presented without discrediting more established sorts and convenient, it is an autonomous of equipment and are that the organization is extensible, new picture sorts can be presented without working framework sorts. There are numerous sorts of TIFF documents: the most widely recognized ones are portrayed beneath. Uncompressed TIFF pictures are put away in an uncompressed crude organization. This is the essential arrangement for archival pictures on the grounds that the information is left unaltered.

### **3.4.4 PS (Post Script):**

Post script, a standard vector format. It has numerous sub-standards and can be difficult to transport across platforms and operating systems.

### **3.4.5 PSD (Photo Shop Document):**

PSD is a dedicated Photoshop format that keeps all the information in an image including all the layers.

## **3.5 Applications of Image Enhancement:**

There are different types of image enhancement in which some are image restoration and image compression.



### **3.5.1 Image Enhancement:**

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories:

- Spatial domain methods, which operate directly on pixels.
- Frequency domain method, which operate on the Fourier transform of an image. The spatial domain refers to the image plane itself and approaches in this category or based on direct manipulation of pixels in image. The frequency domain processing techniques are based on modifying the Fourier transformation of an image.

### **3.5.2 Image Restoration:**

As an image's enhancement, the ultimate goal of restoration techniques is to improve an image in some sense. For the purpose of differentiation, we consider restoration to be a process that attempt to reconstruct or recover an image that has been degraded by using some a priori knowledge of the degradation phenomenon. Thus, restoration techniques are oriented toward modelling the image.

### **3.5.3 Image Compression:**

The quality of a compression method often is measured by the Peak image-to-noise ratio. It measures the amount of noise introduced through a lossy compression of the image; however, the subjective judgment of the viewer also is regarded as an important measure, perhaps, being the most important measure.

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level.

The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages. There are several different ways in which image files can be compressed. For Internet use, the two most common compressed graphic image formats are the JPEG format and the GIF format. The JPEG method is more often used for photographs, while the GIF method is commonly used for line art and other images in which geometric shapes are relatively simple.

Other techniques for image compression include the use of fractals and wavelets. These methods have not gained widespread acceptance for use on the Internet as of this writing. However, both methods offer promise because they offer higher compression ratios than the JPEG or GIF methods for some types of images. Another new method that may in time replace the GIF format is the PNG format. A text file or program can be compressed without the introduction of errors, but only up to a certain extent. This is called lossless compression.

Compression techniques mainly fall into two categories:

1) Loss less

Loss-less compress any data. While there have been many claims through the years of companies achieving "perfect compression" where an arbitrary number  $N$  of random bits can always be compressed to  $N - 1$  bits, these kinds of claims can be safely discarded without even looking at any further details regarding the purported compression scheme.

## 2) Lossy

Lossy compression can be thought of as an application of transform coding – in the case of multimedia data, perceptual coding: it transforms the raw data to a domain that more accurately reflects the information content. For example, rather than expressing a sound file as the amplitude levels over time.

### **3.5.4 Image Segmentation:**

Image Segmentation is the process of partitioning a digital image into multiple regions or set of pixels. Partitions are different objects in image which have the same texture or colour.

### **3.6 Image Processing Task:**

#### **3.6.1 Acquiring the image:**

First, we need to produce a digital image from a paper envelope. This can be done using either a CCD camera, or a scanner.

#### **3.6.2 Pre-processing:**

This is the step taken before the major image processing task. The problem here is to perform some basic tasks in order to render the resulting image more suitable for the job to follow. In this case it may involve enhancing the contrast, removing noise, or identifying regions likely to contain the postcode.

#### **3.6.3 Representation and description:**

These terms refer to extracting the features which allow us to differentiate between objects. Here we will be looking for curves, holes and corners which allow us to distinguish the different digits which constitute a postcode.

### **3.7 Practical Applications of Image Processing:**

Image processing has a gigantic scope of utilizations, each region of science and innovation can make utilization of image handling strategies. Here is a short run down just to give some sign of the scope of image handling applications.

#### **3.7.1. Document Processing:**

It is utilized as a part of filtering, and transmission for changing over paper archives to an advanced image structure, compacting the image, and putting away it in an attractive tape. It is likewise utilized as a part of archive perusing for consequently identifying and perceiving printed qualities.

#### **3.7.2. Medical Applications:**

Investigation and understanding of images acquired from X-beams, MRI or CAT examines, examination of cell images, of chromosome karyo types. In restorative applications, one is worried with preparing of midsection X-beams, cineangiograms projection images of trans axial tomography and other medicine of images that happen in radiology, atomic attractive reverberation (NMR) and ultrasonic checking. These images may be utilized for patients screening and observing or for location of tumors or other sickness in patients.

Inspection and interpretation of images obtained from X-rays, MRI or CAT scans, analysis of cell images, of chromosome karyo types. In medical applications, one is concerned with processing of chest X-rays, cineangiograms, projection images of trans axial tomography and other medical images that occur in radiology, nuclear magnetic

resonance (NMR) and ultra-sonic scanning. These images may be used for patient screening and monitoring or for detection of tumors or other disease in patients.

### **3.7.3. Defence/Intelligence:**

It is utilized as a part of observation photographic understanding for programmed elucidation of earth satellite imagery to search of delicate target or military dangers and target wing and direction for perceiving and following focuses progressively brilliant bomb and rocket direction frame works.

### **3.7.4. Radar Imaging System:**

Radar and sonar pictures or utilized for location and acknowledgement of different sort of target or in direction and moving of air ship or rocket frameworks.

### **3.7.5. Agriculture:**

Satellite/airborne perspectives of area, for instance to decide the amount of area is being utilized for purposes, or to examine the suitability of distinctive locales for distinctive yields, view of leafy foods recognizing great and crisp produce from old.

## **3.8 Image Resolution:**

Image resolution is an umbrella term that describes the detail an image holds. The term applies to raster digital images, film images, and other types of images. Higher resolution means more image detail. Image resolution can be measured in various ways. Basically, resolution quantifies how close lines can be to each other and still be visibly resolved. Resolution units can be tied to physical sizes (e.g., lines per mm, lines per inch), to overall size of a picture (lines per picture height,

also known simply as lines, TV line so TVL), or to angular subtenant. Line pairs are often used instead of lines; a line pair comprises a dark line and an adjacent light line. A line is either a dark line or a light line. A resolution of 10 lines per mm means 5 ark lines alternating with 5 light lines, or 5 lines pairs per mm (5 LP/mm). Photographic lens and film resolution are most often quoted in line pairs per millimeter.

### **3.9 Normalization:**

In image preparing, standardization is a procedure that progressions the scope of pixel force values. Applications in corporate photos with poor difference because of glare, for instance. Standardization is in some cases called complexity extending or histogram extending. In more broad-fields of information handling, for example, computerized sign preparing, it is alluded to as dynamic reach development.

The reason for element range development in the different applications is as a rule to bring the image, or other sort of sign, in to a range that is more recognizable or typical to the sense, subsequently the term standardization. Regularly, the inspiration is to accomplish consistency in element range for an arrangement of information, flags, or images to maintain a strategic distance from mental diversion.

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## CHAPTER-4

### PROJECT DESCRIPTION

The proposed technique uses a modified sigmoid function that accommodates the original microscopic input image characteristics. A novel block-based input value coupled with the modified sigmoid function is used in the proposed technique to provide good contrast enhancement of an image, resulting in localised contrast enhancement. Singular value decomposition played an important role after DCT because the singular value matrix determines the intensity values of the provided microscopic image.

#### 4.1 Introduction:

In the era of the internet and technology, the processing of images is done by using digital computers for various applications such as image enhancement, compression, face recognition and feature extraction. For improving the visual features of an image nowadays, image enhancement has become a very popular technique. Various image enhancement techniques work adaptively in many applications, while for colonies of micro-organisms, the subjective quality of an image becomes a paradigm. In the present era, adaptive image enhancement has become an emerging technique in microbiology, satellite imaging, real-time photography and medical science to extract the original and important features.

In digital image processing we process the images according to our need. Image enhancement means to improve the visual quality of an image which depends on the application circumstances. In this work, an electron microscopic image enhancement for feature extraction using block based adaptive contrast enhancement using modified sigmoid

function algorithm is proposed. Adaptive image enhancement and feature extraction techniques are widely used in applications, where subjective quality of an image is important perspective for colony of micro-organism. In recent days, adaptive image enhancement has emerged as effective tool in the field of medical science and microbiology to extract the features from an image. The value of EMF is enhanced by reducing the size of block of modified sigmoid function. The proposed algorithm avoids the excessive enhancement and makes the contrast enhancement adjustable and maintain the brightness level adaptively.

#### 4.2 Algorithm for Image Enhancement:

Step 1: BEGIN Algorithm

Step 2: Read the low contrast microscopic image into MATLAB.

Step 3: Now, equalize the electron microscopic image using CLAHE.

Step 4: Apply modified sigmoid function to the microscopic image.

Step 5: Now, perform global histogram equalization using GHE technique

Step 6: Determine the DCT for improved contrast of the microscopic image.

Step 7: Now, find out the value of variables  $\hat{D}$  and  $D$  in the DCT processed microscopic image.

Step 8: Then SVD is utilized to acquire  $U$ ,  $\Sigma$ ,  $V$  and locate the greater component in  $\Sigma$ .

Step 9: Find the  $\max(\Sigma_D)$  and  $\max(\Sigma\hat{D})$  by using singular value decomposition method.

Step 10: Find  $\xi$  with the help of Equation.

Step 11: Now, find the new value of  $\max(\Sigma\hat{D})$

Step 12: Now compute IDCT.

Step 13: Resultant enhanced microscopic image.

Step 14: END Algorithm



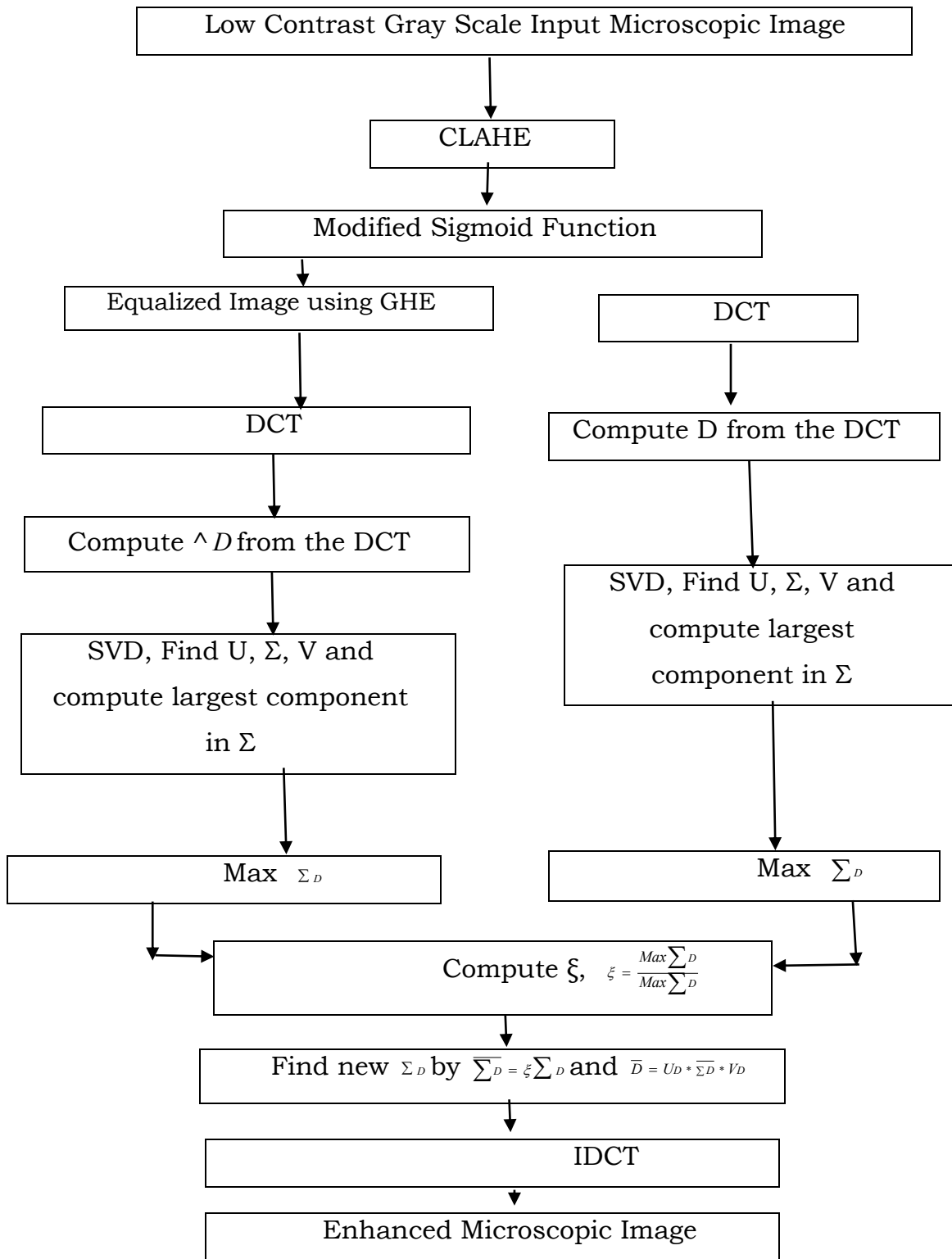


Fig 4.1: Block Diagram Image Enhancement and Feature Extraction

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### **4.3 DCT (Discrete Cosine Transform):**

The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The `dct2` function computes the two-dimensional discrete cosine transform (DCT) of an image. The DCT has the property that, for a typical image, most of the visually significant information about the image is concentrated in just a few coefficients of the DCT. For this reason, the DCT is often used in image compression applications. For example, the DCT is at the heart of the international standard lossy image compression algorithm known as JPEG.

### **4.4 SVD (Singular Value Decomposition):**

The process of Singular Value Decomposition involves breaking down a matrix  $A$  into the form. This computation allows us to retain the important singular values that the image requires while also releasing the values that are not as necessary in retaining the quality of the image.

Digital images require large amounts of memory, and often we would like to reduce the required memory storage and still retain as much of the image quality as possible. We can consider using the singular value decomposition (SVD) to manipulate these large sets of data, which will allow us to identify the components of the image which contribute the least to overall image quality. In this paper we explore the SVD in general as well as how computing the SVD and removing the singular values can reduce the size of stored images.

#### 4.5 IDCT (Inverse Discrete Cosine Transform):

The inverse discrete cosine transform (IDCT) decodes an image into the spatial domain from a representation of the data better suited to compaction. IDCT-based decoding forms the basis for current image and video decompression standards. In H.263, the input to the IDCT comes after the dequantization step and zig-zag positioning. An 8x8 block of input values range from -2048 to 2047 and output values in the range -256 to 255. This information is used to reconstruct the image. An original image has no prediction applied and is labeled as an I-picture (INTRA) in the standard. Its pixel values range from 0 to 255. A difference image (INTER) has prediction applied and is labeled either as a P-picture or B-picture (when bi-directional prediction occurs). Its pixel values range from - 255 to 255. The actual formula used depends on whether QP is even or odd, which is specified by the standard to prevent the accumulation of IDCT mismatch errors.

#### 4.6 Sigmoid Function

The sigmoid term comes from the shape of the sigmoid function waveform, formed like the letter “S” in the English alphabet. This function is a version of the logistic function that is given

$$f(x) = \frac{1}{1 + e^{-\frac{(x-\alpha)}{\beta}}} \quad (4.6.1)$$

It effectively transforms entire range of  $x$  into [0 1] domain, then uses  $a$  and  $\beta$  to get the sigmoid function's center and width, respectively.

This modified sigmoid function applied on the entire image, starting at the top left corner. The user determines the size of the window or block, and blocks of smaller sizes result in more image enhancement. The modified sigmoid function works pixel by pixel adaptively on the complete image. Hence, it efficiently smoothens the local histogram and

enhances the image quality. Each pixel of the image created after applying the modified sigmoid function ( $O_s(k, l)$ ) has same intensity value like input image ( $f(k, l)$ ) and added to the mask. If ( $f(k, l)$ ) is the input microscopic image then modified sigmoid function is defined as given below.

$$fm(k,l) = k1 * \frac{f(k,l)}{1 - \exp(k1 * (f(k,l)) + k1 * k2)} \quad (4.6.2)$$

where, ( $fm(k, l)$ ) represents the modified sigmoid function, ( $Ps(k, l)$ ) is obtained processed image,  $k1$  and  $k2$  are the two essential control parameters. These control parameters control the actual contrast and normalize the greyscale values. The starting value of  $k2$  is set to 0.5, that is the grey scale's middle value. On the other hand, various microscopic images require different greyscale values to be enhanced. As a result, in our simulation work, an acceptable range of values for  $k2$  must be chosen. The values of  $k1$  and  $k2$  should be in the range of 1 to 25 and 0 to 1 respectively for effective contrast enhancement of a microscopic input image.

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## CHAPTER 5

### Simulation and Work

The main tools required for implementing this work can be classified into two categories

1. Hardware requirement
2. Software requirement

#### 5.1 Hardware Requirement

PC With MATLAB Software

Processor: Intel

Mother board: Intel RAM: 512MB

Hard disk: 80GB

#### 5.2 Software Requirement

##### 5.2.1 MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation visualization and programming in an easy-to-use environment. MATLAB stands for matrix laboratory. It was written originally to provide easy access to matrix software developed by LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is therefore built on a foundation of sophisticated matrix in which the basic element in matrix that does not require pre-dimensioning which to solve many technical computing problems especially those with matrix and vector formulations, in a fraction of time. MATLAB features of applications specific solutions called toolbox. Very important to most users of MATLAB, toolboxes allow learning and applying specialized technology. These are comprehensive collections of

MATLAB functions that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control system, neural networks, fuzzy logic, wavelets, simulation and many others.

### ***5.2.2 Typical Uses Of MATLAB***

The typical using areas of MATLAB are

- Math and computation
- Algorithm and development
- Data acquisition
- Data analysis, exploration and visualization
- Scientific and engineering graphics
- Modelling
- Simulation
- Prototyping
- Application development and including graphical user interface building.

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar noninteractive language such as C or FORTRON. MATLAB features a family of add-on application-specific solutions called toolbox. Very important to most users of MATLAB, toolbox allows you to learn and apply specialized technology. Toolbox is comprehensive collections of MATLAB functions that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available

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include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation and many others.

### **5.2.3 Features Of MATLAB**

- Advance algorithm for high performance numerical computation, especially in the field matrix algebra.
- A large collection of predefined mathematical functions and the ability to define one's own functions.
- Two- and three-dimensional graphics for plotting and displaying data
- Powerful, matrix or vector oriented high-level programming language for individual applications.
- Toolboxes available for solving advanced problems in several application areas.

### **5.2.4 Basic Building Blocks Of MATLAB**

The basic building block of MATLAB is matrix. The fundamental data type is the array. Vectors, scalars, real matrices and complex matrix are handled as specific class of this basic data type. The built-in functions are optimized for vectors operations. No dimension statements are requiring Med for vectors of arrays.

### **5.3 MATLAB Window**

- The MATLAB works based on five windows
- Command window
- Work space window
- Current directory window

- Command history window
- Editor window
- Graphics window
- Online-help window

### **5.3.1 Command Window**

The command window is where the user types MATLAB commands and expressions at the prompt (`>>`) and where the output of those commands is displayed. It is opened when the application program is launched. All commands including user-written programs are typed in this window at MATLAB prompt for execution.

### **5.3.2 Work Space Window**

MATLAB defines the workspace as the set of variables that the user creates in a work session. The workspace browser shows these variables and some information about them. Double clicking on a variable in the work space browser launches the array editor, which can be used to obtain information.

### **5.3.3 Current Directory Window**

The current directory tab shows the contents of the current directory, whose path is shown in the current directory window. For example, in the windows operating system the path might be as follows: `c\MATLAB\work`, indicating that directory “work” is a sub directory of the main directory “MATLAB”, which is installed in drive c. Clicking on the arrow in the current directory window shows a list of recently used paths. MATLAB uses a search path to find M-files and other MATLAB



related files. Any file run in MATLAB must reside in the current directory that is on search path.

#### **5.3.4 Command History Window**

The command history window contains a record of the commands a user has entered in the command window, including both current and previous MATLAB sessions. Previously entered MATLAB commands can be selected and re-executed from the command history window by right clicking on a command. This is useful to select various options in addition to executing the commands and is useful feature when experimenting with various commands in work sessions.

#### **5.3.5 Editor Window**

The MATLAB editor is both a text editor specialized for creating M-files and a graphical MATLAB debugger. The editor can appear in a window by itself, or it can be a sub window in the desktop. In this window one can write, edit, create and save programs in files called M-files.

MATLAB editor window has numerous pull-down menus for tasks such as saving, viewing and debugging files. Because it performs some simple checks and also uses color to differentiate between various elements of code, this text editor is recommended as the tool of choice for writing and editing M-files.

MATLAB editor window has numerous pull-down menus for tasks such as savings, viewing and debugging files. Because it performs some simple checks and also uses color to differentiate between various elements of code, this editor is recommended as the tool of choice for writing and editing M-files.

### **5.3.6 Graphics or Figure Window**

The output of all graphic commands typed in the command window is seen in this window.

### **5.3.7 Online Help Window**

MATLAB provides online help for its built-in functions and programming language constructs. The principal way to get help online is to use the MATLAB help browser, opened as a separate window either by clicking on the question mark symbol on the desktop toolbar, or by typing help browser at the prompt in the command window. The help browser is a web browser integrated into the MATLAB desktop that displays a hypertext markup language document. The help browser consists of two panes, the help navigator plane, used to find information, and the display plane, used to view this information. Self-explanatory tabs other than navigator plane are used to perform a search.

## **5.4 MATLAB Files**

MATLAB has three types of files for storing information. They are Files and MAT- files.

### **5.4.1 M-Files**

These are standard ASCII text file with 'm' extension to the file name and creating own matrices using m-files which are text files containing MATLAB code. MATLAB editor or another editor is used to create a file containing the same statements which are typed at the MATLAB command line and save the file under a name that ends in m. There are two types of m-files.

### **5.4.2 Script Files**

M-files with a set of MATLAB commands in it and is executed by typing name of file on the command line. These files work on global variables currently in that environment.

### **5.4.3 Function Files**

A function file is also an M-file except that the variables in a function file are all local. This type of files begins with a function definition line.

### **5.4.4 Mat-Files**

These are binary files with mat extension to that file created by MATLAB when the data is saved. The data written in a special format that only MATLAB can read. These are located into MATLAB with load command.

## **5.5 MATLAB System**

The MATLAB system consists of five main parts:

### **5.5.1 Development Environment**

This is the set of tools and facilities that help you see use MATLAB functions and files. Many of these tools are graphical user interface. It includes the MATLAB desktop and command window, a command history, an editor and debugger, and browser for viewing help, the work space, files and search path.

### **5.5.2 MATLAB Mathematical Function**

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine and complex arithmetic to more many functions like matrix inverse, matrix Eigen values, Bessel functions and fast Fourier transforms.

### **5.5.3 MATLAB Language**

This is a high-level matrix or array language with control flow statements, functions, data structures, input or output and object-oriented programming features. It allows both programming in the small to rapidly create quick and dirty throw-away programs, and programming in the large to create complete large and complex application programs.

### **5.5.4 Gui Construction**

MATLAB has extensive facilities for displaying vectors and matrices as graphs, as well as annotating and printing these graphs. It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, and animation and presentation graphics. It also includes low-level functions that allow you to fully customize the appearance of graphics as well as to build complete graphical user interface on your MATLAB applications.

### **5.5.5 MATLAB Application Program Interface**

It is a library that allows you to write C and FORTRAN programs that interact with MATLAB. It includes facilities for calling routines from

MATLAB, calling MATLAB as a computational engine and for reading and writing MAT files.

## 5.6 MATLAB Working Environment

### 5.6.1 MATLAB Desktop

MATLAB desktop is the main MATLAB application window. The desktop contains five sub windows, the command window, workspace browser, current directory window, command history window, and one or more figure windows which are shown only when the user displays a graphic, as shown in the figure 5.1.

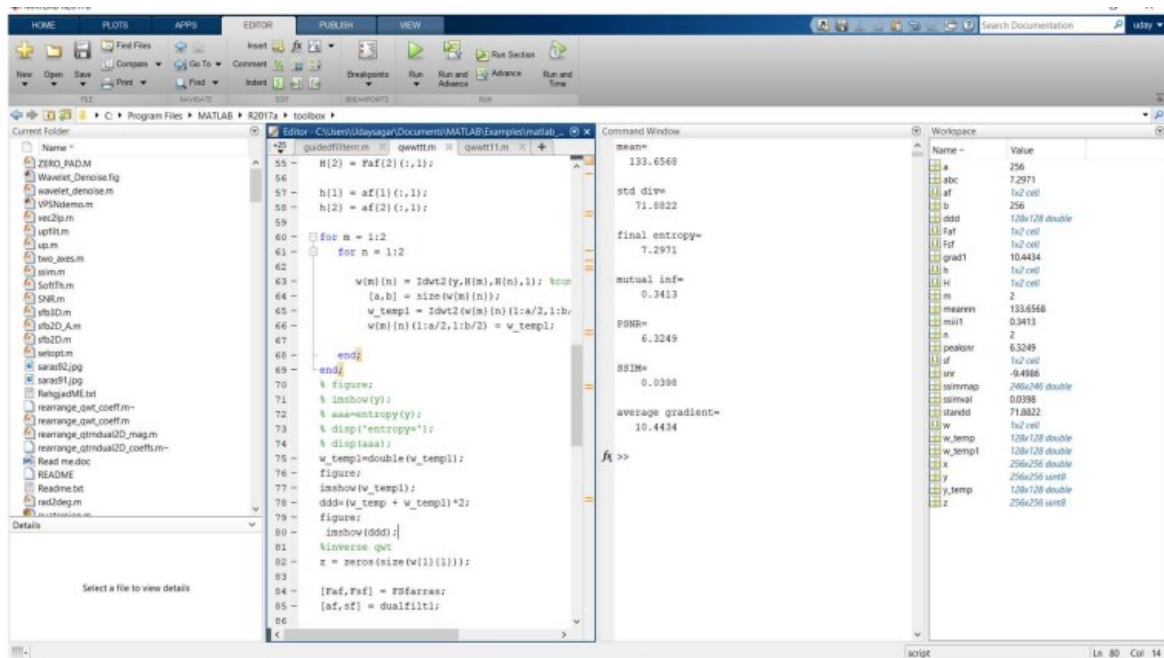


Fig 5.1: Representation of MATLAB window

The command window is where the user types MATLAB commands and expressions at the prompt (`>>`) and where the output of those commands is displayed. MATLAB defines the workspace as the set of variables that the user creates in a work session. The workspace shows these variables and some information about them. Double clicking on a variable in the workspace browser launches the array

editor, which can be used to obtain information and income instances edit certain properties of the variable.

The current directory tab above the workspace tab shows the contents of the current directory, whose path is shown in the current directory window. For example, in the windows operating system the path might be as follows C:\MATLAB\work, indicating that directory work is a subdirectory of the main directory MATLAB which is installed in drive. Clicking on the arrow in the current directory window shows a list of recently used paths. Clicking on the button to the right of the window allows the user to change the current directory.

MATLAB uses a search path to find M-Files and other related files, which are organize in directories in the computer file system. Any file run in MATLAB must reside in the current directory that is on search path. By default, the files supplied with MATLAB and math works toolboxes are included in the search path. The easiest ways to see which directories the search path is soon or add to modify as search path is to select set path from the file menu the desktop and then use the set path dialog box. It is good practice to add any commonly used directories to the search path to avoid repeatedly having the change the current directory.

The command history window contains a record of the commands a user has entered in the command window including both current and previous MATLAB sessions. Previously entered MATLAB commands can be selected and re-executed from the command history window by right clicking on a command or sequence of commands.

This action launches a menu from which to select various options in addition to executing the commands. This is useful to select various

options in addition to executing the commands. This is a useful feature when experimenting with various commands in a work session.

### **5.6.2 Using MATLAB Editor to Create M-Files**

The MATLAB editor is both a text editor specialized for creating m-files and a graphical MATLAB debugger. The editor can appear in window by itself, or it can be a sub window in the desktop. M-files are denoted by the extension '.m'.

The MATLAB editor window has numerous pull-down menus for tasks such as savings, viewing and debugging files. Because it performs some simple checks and also uses color to differentiate various elements of code, this text editor is recommended as the tool of choice for writing and editing m-functions.

To open the editor type, `edit` at the prompt opens the m-file filenames in an editor window is ready for editing. As noted, that the file must be in the current directory or in a directory in the search path.

### **5.6.3 Getting Help**

The principal way to get help online is to use the MATLAB help browser, opened as a separate window either by clicking on the questions mark symbol on the desktop toolbar or by typing `help browser` at the prompt in the command window. The help browser is a web browser integrated into the MATLAB desktop that displays a hypertext markup language document. The help browser consists of two windows, the help navigator window, used to find information and the display window, used to view the information. Self-explanatory tabs other than navigator pane are used to perform a search.

## CHAPTER-6

### Results and Discussions

The Proposed technique effectiveness and efficiency are evaluated on various images with varying contrast and resolution. The proposed technique is implemented in MATLAB software for simulation and all experimental operations. Quality analysis criteria such as EME (Measure of Enhancement), MSE (Mean Square Error), and PSNR (Peak Signal to Noise Ratio) are used to assess the reliability and performance of the proposed image enhancement technique. As a result of these quality factors, the overall quality of the resultant enhanced microscopic image is significantly better than the original microscopic image, as seen by improved PSNR, MSE, and EME values.

#### 6.1 Performance Para metrics

##### 6.1.1 EME (Measure of Enhancement):

The EME measure is suitable for images with attributes like noncomplex segments, uniform background in segments, small targets in segments, nonperiodic pattern in segments, and little to no randomness in segments. Image enhancement is the procedure of improving the quality and information content of original data before processing.

$$EME = \left( \frac{1}{S1 * S2} \right) \sum_{t=1}^{s1} \sum_{s=1}^{s2} \left[ 20 \ln \left( \frac{f_{\max, s, t}}{f_{\min, s, t}} \right) \right] \quad (6.1)$$

where, an input image  $f(k, l)$  is partitioned into  $s1 \times s2$  blocks, The pixel's lowest and largest values for each block are  $f_{\min, s, t}$  and  $f_{\max, s, t}$  respectively.



### 6.1.2 MSE (Mean Squared Error):

In statistics, the mean squared error (MSE) of an estimator measures the average of the squares of the "errors", that is, the difference between the estimator and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate. The MSE is the second moment (about the origin) of the error, and thus incorporates both the variance of the estimator and its bias. For an unbiased estimator, the MSE is the variance of the estimator. Like the variance, MSE has the same units of measurement as the square of the quantity being estimated. In an analogy to standard deviation, taking the square root of MSE yields the root-mean-square error or root-mean-square deviation (RMSE or RMSD), which has the same units as the quantity being estimated; for an unbiased estimator, the RMSE is the square root of the variance, known as the standard deviation.

$$MSE = \frac{1}{n^2} \sum_{k,l=0}^{n-1} [f(k,l) - g(k,l)]^2 \quad (6.3)$$

**f** represents the matrix data of our original image.

**g** represents the matrix data of our degraded image in question.

**m** represents the numbers of rows of pixels of the images and **i** represents the index of that row.

**n** represents the number of columns of pixels of the image and **j** represents the index of that column.

### 6.1.3 PSK (Peak Signal to Noise Ratio):

Peak image-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a

image and the power of corrupting noise that affects the fidelity of its representation. Because many images have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. PSNR is most commonly used to measure the quality of reconstruction of lossy compression codecs (e.g., for image compression). The image in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs, PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality, in some cases it may not. One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content.

$$PSNR = 10 * \log\left(\frac{255^2}{MSE}\right) \quad (6.2)$$

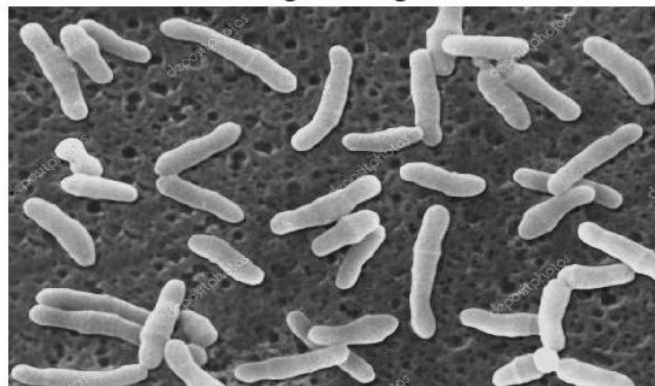
## 6.2 Result

Image Enhancement of microscopic Images using Sigmoid function and 2D-DCT are performed using MATLAB software for simulation and all experimental operations. The technique was employed on microscopic image, as shown in figure 6.2(a) and resultant image obtained by applying the CLAHE technique is as shown in figure 6.2(b). The proposed technique was applied to improve the visual quality of input image. Figure 6.2(c) represents the equalized image after applying the sigmoid function on figure 6.2(b) and figure 6.2(d) is the obtained enhanced image.

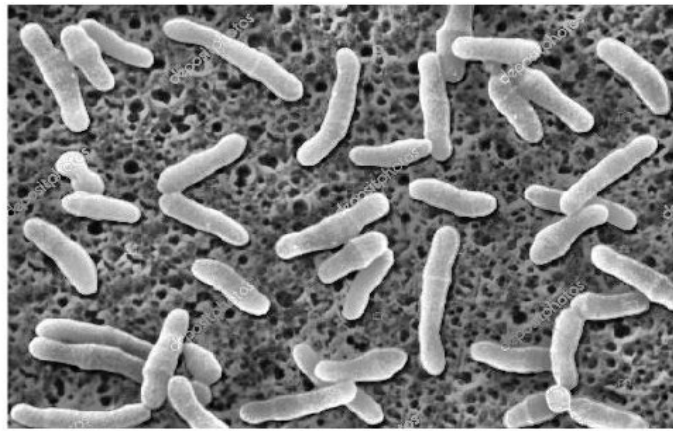
The proposed system technique is applied on the pepper image also. The resultant images are shown in the figure 6.3. The input is shown in figure 6.3(a).



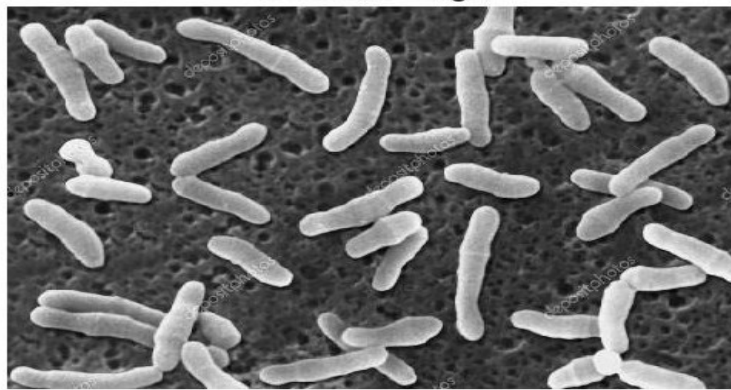
Fig 6.1: Microscopic Image as Input



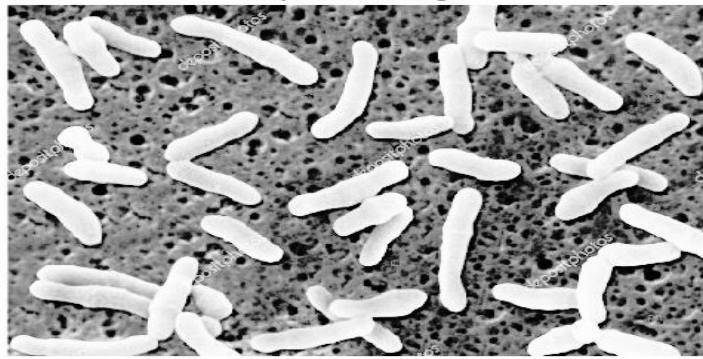
**a)**



**b)**



**c)**



d)

Fig 6.2: Results of Enhancement process using Modified sigmoid function

- a) Original Image      b) Enhanced Image using  
c) Equalized Image      d) Enhanced Image



**a)**



**b)**



**c)**







d)

Fig 6.3: Resultant images of pepper after performing Enhancement process using Modified Sigmoid function

- a) Original Image      b) Enhanced Image using CLAHE  
 c) Equalized Image      d) Enhanced Image

The results after applying the proposed technique are tabulated in table 6.1. Table 6.1 shows the MSE, PSNR values for various images. The proposed technique increases the image quality while simultaneously preserving significant features and maintaining the brightness level in images.

Images	MSE (Mean Squared Error)	PSNR (Peak Signal-to-Noise Ratio)
<b>Image 1</b> 	796.88	19.12 dB
<b>Image2</b> 	358.81	22.58 dB

6.1 Table of Results

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## Chapter -7

### CONCLUSION AND FUTURE SCOPE

#### 7.1 Conclusion:

This work mainly consists of Adaptive contrast enhancement technique with modified sigmoid function and DCT for microscopic image enhancement and feature extraction. This method has been tried on various microscopic and other images with varying contrast and resolution. The proposed work's subjective and qualitative enhancing efficiency has been assessed. Based on MSE, PSNR, EME, the proposed technique's enhancement results are compared to those of other existing enhancement techniques for electron microscopic images. As a result, we can infer that the proposed algorithm outperforms other current image-enhancing approaches for smaller block size in terms of superiority and resilience. The findings depicts that the proposed strategy for contrast enhancement and feature extraction of electron microscopic images works efficiently and effectively. After enhancing electron microscopic pictures of actinomycetes, numerous highly significant and authentic properties such as long \_lament, coil or spiral, spore and rod form structures are extracted for feature extraction. This proposed technique can be applied to various images, including satellite images, radar photos, cardiac ECHO images, X-ray images, MRI images, electron microscope images, micro-organism images, and real-life photographic images with poor contrast issues during acquisition.

#### 7.2 Future Scope:

- Electron microscopic images can suffer from various types of image artifacts and noise, which can reduce their quality and make it difficult to interpret the images accurately.



- One novel approach to enhancing electron microscopic images is to use deep learning-based methods. Deep learning is a type of machine learning that can learn complex patterns and relationships in data through multiple layers of neural networks.
- One potential approach is to use a generative adversarial network (GAN) to enhance electron microscopic images. GANs consist of two neural networks, a generator and a discriminator, that work together to generate realistic images from a given input.
- This proposed technique can be applied to various images, including satellite images, radar photos, cardiac ECHO images, X-ray images, MRI images, electron microscope images, micro-organism images, and real-life photographic images with poor contrast issues during acquisition.
- In the case of electron microscopic images, the generator network could be trained on a large dataset of high-quality images to learn the underlying patterns and structures in the images.
- The discriminator network could then be used to evaluate the quality of the generated images and provide feedback to the generator, helping it to improve its output.

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