Improving Visual Excellence: An In-depth Comparison of Histogram Equalization Techniques for Image Enhancement

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CANDIDATE'S DECLARATION

I Prateek Mishra hereby certify that the work which is being presented in the thesis entitled "Improving Visual Excellence: An In-depth Comparison of Histogram Equalization Techniques for Image" in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Data Science, submitted in the Department of Software Engineering, Delhi Technological University is an authentic record of my own work carried out during the period from 2022 to 2024 under the supervision of Dr. Sonika Dahiya.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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Candidate's Signature

This is to certify that the student has incorporated all the corrections suggested by the examiners in the thesis and the statement made by the candidate is correct to the best of our knowledge.

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I Certified that Prateek Mishra (2K22/DSC/12) has carried out his research work presented in this thesis entitled "Improving Visual Excellence: An In-depth Comparison of Histogram Equalization Techniques for Image" for the award of Master of Technology from Department of Software Engineering, Delhi Technological University, Delhi, under my supervision. The thesis embodies results of original work, and studies are carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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ABSTRACT

Optimize image contrast through redistribution of pixel intensity histograms. This paper explores various techniques in image enhancement and equalization, focusing on histogram equalization methods such as Histogram Equalization, Dynamic HE, Quantized Dynamic Histogram Equalization, Image Sub-division and Quadruple Clipped Adaptive Histogram Equalization , Joint Histogram Equalization , 2 Dimensional Histogram Equalization and finally Brightness Preserved Dynamic Histogram Equalization. The effectiveness of these methods is assessed using the BSDS500 dataset. This study conducts a comparative analysis to underscore the strengths and weaknesses of each technique in enhancing image quality and perception.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

HE	Histogram Equalization
DHE	Dynamic Histogram Equalization
2-DHE	2-Dimensional Histogram Equalization
QDHE	Quantized Dynamic Histogram Equalization
BPDHE	Brightness Preserved Dynamic Histogram Equalization
JHE	Joint Histogram Equalization
ISQHE	Image Sub-division and Quadruple Clipped Adaptive Histogram Equalization
PSNR	Peak Signal-to-Noise-Ratio
SNR	Signal-to- noise ratio
AMBE	Absolute Mean Brightness Error
MSE	Mean Square Error
SSIM	Structural Similarity Index
MRI	Magnetic resonance imaging
UML	Unified Modeling Language

CHAPTER-1
INTRODUCTION

It is evident that image processing constitutes a central and relevant sub-discipline of computer science and engineering which involves the modification, analysis and enhancement of images for the purposes of optimizing their quality or obtaining valuable information from them. This field has numerous applications in entertainment, industry applications, medical purposes, and operation of unmanned aerial vehicles. In the case of image enhancement, one of the most important techniques used in the image processing algorithm is HE – histogram equalization.

Contrast stretching is technique developed with a goal of improving image brightness. It raises the global contrast by extending pixel intensity values across the all possible values it can take. The primary purpose of HE is to reduce contrast by making all pixel intensity levels share equal probabilities, which helps to enhance the information hidden in image details. This is especially helpful in situations that need more contrast such as low-contrast images, as this effectively enhances the details, making this tool an essential one where details are intentionally visible.

1.1 Detailed Analysis of Histogram Equalization:

Histogram equalization aims at making histograms of the image smoother and distribute the intensity values throughout the entire reach of their values. This redistribution has an elevated effect of raising the general contrast level of the image. In other words, it takes the CDF of the image and changes it so that it becomes a straight line which suggests uniform distribution of intensity.

The process involves several steps:

1. **Calculation of the Histogram:** The first filter applied in the HE process is the computation of the image’s histogram. This histogram reflects the number of pixel intensity values and their frequency distribution.

2. **CDF Computation:** Then the probability density function of the histogram is obtained and then CDS is calculated by integrating the probability density function of the histogram.

3**. Intensity Mapping:** The original pixel values are then normalized by mapping them through an empirically derived cumulative distribution function (CDF) to give a new set of intensities, which cover the dynamics range.

This transformation ensures that areas of the image that were previously underrepresented in terms of intensity values become more visible, thereby enhancing the overall image quality.

1.2 Applications of Histogram Equalization:

The use of histogram equalization spans several important applications:The use of histogram equalization spans several important applications:

1. **Medical Imaging:** In medical diagnostics, HE is applied to enhance magnification of details in regular X-ray, CT and MRI scans to assist the doctors in identifying aspects of the images that may have been a bit obscure.

2. **Remote Sensing:** Satellite and aerial imagery are accorded features by HE that would help in the differentiation of vegetation, water and urban space facilitating the understanding of changes in the environment and efficient in the management of the resource.

3. **Industrial Inspection:** In the manufacturing process, HE assists in identifying defective products in factors such as image contrast taken during quality check.

4. **Entertainment:** In photography and film, HE is employed to enhance the visual appeal of images and videos, ensuring that all details are visible and aesthetically pleasing.

1.3 Advanced Techniques in Histogram Equalization:

Despite its advantages, traditional histogram equalization can sometimes lead to over-enhancement of noise and an unnatural look, especially in images with a high degree of contrast variation. This has led researchers to develop several advanced HE techniques aimed at preserving the natural appearance of images while still enhancing contrast.

1. **Adaptive Histogram Equalization (AHE):** Unlike standard HE, which processes the entire image globally, AHE separates the picture into smaller sections and gives each one separate HE treatment. This approach preserves local contrast and details more effectively.

2. **Contrast Limited Adaptive Histogram Equalization (CLAHE**): Another algorithm of Image enhancement is compared to AHE known as CLAHE which stands for Contrast Limited Adaptive Histogram Enhancement and enhances the same by avoiding over amplification of noise. This prevents the enhancement from going beyond a set ceiling, or clip limit, thus preventing the overly exaggerated look frequently produced by regular HE.

3. **Bi-Histogram Equalization (BHE):** As per on the mean intensity value, BHE divides the image histogram plane into two parts and performs linear transformation on the independent part. This is a technique that aims at preserving the overall naturalness of the image while at the same time trying to boost the contrast augmentation to the maximum levels.

4. **Multi-Histogram Equalization (MHE):** This technique involves splitting the image histogram analysis into individual sections and applying HE on each of the segments. Compared to the traditional high-frequency boosting, MHE is a more regulated process that is less likely to bring up a picture to oblivion of details.

1.4 Objectives of the Study

In particular, the aim of this work is to investigate visual enhancement strategies of several Histogram Equalisation (HE) algorithms based on their performance.

Specifically, the study aims to: Specifically, the study aims to:

1. **Assess Contrast Improvement:** Thus, the following research question has been developed: How effective different histogram equalization techniques are in enhancing the contrast of the images?

2. **Evaluate Brightness Preservation:** Other insights to consider are how efficiently and effectively each algorithm minimizes artifacts corrupting the native brightness levels of the source image.

3. **Examine Computational Efficiency:** Examine the complexity of each algorithm to assess how suitable they are for applications requiring periodical computation.

4. **Identify Strengths and Weaknesses:** Always on reviewing each algorithm compare and contrast its strengths and weaknesses in order to know its real life applications.

In this regards, the objectives are as follow: This study is expected to achieve these objectives so as to get deeper insight on strategies of trade-offs between histogram equalization techniques and to find out the most feasible algorithms for image processing applications.

1.5 **Overview of the Algorithms Being Compared**

This paper will seek to establish a comparative analysis of histogram equalization that will feature a number of algorithms, with each algorithm employing a different technique on the image. The algorithms included in this study are:The algorithms included in this study are:

1. **Histogram Equalization (HE):** The most elementary and straightforward form of image equalization where the given image's pixel intensity is adjusted to attain an equal number of pixels for each intensity level.

2. **Dynamic Histogram Equalization (DHE):** A new form of HE that has the ability to constantly change it histogram while enhancing the image to ensure that over enhancement and loss of detail is strictly eliminated.

3. **2D Histogram Equalization (2DHE):** Bit uses a two-dimensional histogram incorporated both for intensity and spatial, which yields improved results in an image's segmented detail and edges.

4. **Quantized Dynamic Histogram Equalization (QDHE):** Incorporates quantization into the dynamic equalization process to reduce complexity and enhance computational efficiency.

5. **Brightness Preserved Dynamic Histogram Equalization (BPDHE):** Makes adjustments to the histogram transformation procedure to ensure that the image's overall brightness is maintained while improving contrast.

6. **Joint Histogram Equalization (JHE):** Employs joint histograms of multiple images or attributes to enhance contrast effectively, especially useful in multi-modal image fusion.

7. **Image Sub-division and Quadruple Clipped Adaptive Histogram Equalization:** The image is first split up into smaller areas, or sub-images. Each of these sub-images is then subjected to an independent application of histogram equalisation. By doing this, the contrast within each zone is improved.

Each of these algorithms brings unique strengths and potential weaknesses, making them suitable for different types of image enhancement tasks. This comparative study aims to provide a detailed evaluation of these algorithms, helping to identify the most effective techniques for specific applications and guiding future developments in the field of image processing.

1.6 Software Requirements

Software prerequisites delineate the essential digital resources and conditions that must be established on a computing system to guarantee the proficient operation of an application. These prerequisites typically need to be installed separately before the main product can be used. They are typically not part of the software's installation package.

1.6.1 Platform. In computing, a platform denotes a foundational structure, either hardware or software, that facilitates the execution of software. Common platforms include the operating system, the architecture of a computer, or programming languages and their runtime environments.

1.6.2 Web browser. The default system browser is used by a plethora of web apps and software that largely rely on Internet technologies. On Microsoft Windows, Microsoft Internet Explorer is frequently the chosen browser for these applications, utilizing ActiveX controls notwithstanding their well-documented security flaws.

Software Requirements for this application is given as follows:

- Software: Anaconda, Visual Studio Code, OpenCV
- Primary Language: Python, C#
- Database: FER 2013 dataset, Kaggle songs dataset

1.7 Hardware Requirements

The hardware requirements are as follows :

1.7.1 Architecture. Each device processing platform is crafted for a particular device framework. The bulk of program utilities are restricted to particular processing platforms tailored to specific frameworks. While a few processing platforms and utilities are not framework-dependent, most require reassembly to function on an alternate framework.

1.7.2 Processing power. The computational prowess of the central processing unit (CPU) is indispensable for any software ecosystem. Software tailored for x86 architecture typically assesses CPU prowess by examining the model and clock speed. However, crucial elements influencing a CPU's velocity and efficacy, such as bus speed, cache size, and millions of instructions per second (MIPS), are often neglected. This limited perspective can be deceptive, as CPUs like the AMD Athlon and Intel Pentium, despite having analogous clock speeds, frequently exhibit disparate performance levels. Nonetheless, Intel Pentium CPUs have enjoyed significant popularity and are frequently cited in this regard.

1.7.3 Memory. All software, upon execution, consumes the computer's random-access memory (RAM). The memory demands are ascertained by assessing the application's necessities, the operating system's requisites, supplementary software and files, and any other simultaneous processes. Furthermore, these requirements consider the necessity for peak performance of other independent software operating in a multitasking environment.

1.7.4 Secondary storage. The requisite storage capacity hinges upon myriad variables, encompassing the magnitude of software installation, the transient files spawned and overseen throughout installation or software operation, and the potential utilization of swap space in instances of inadequate RAM.

1.7.5 Display adapter. Programs requiring advanced graphic rendering capability, as adorning complex graphic editing tools and ultra-level gaming games applications, often specify the entry-level display adapters within their recommended system configuration.

1.7.6 Peripherals. Some software applications mandate thorough or particular utilization of peripheral devices, thereby demanding heightened performance or enriched capabilities from these gadgets. These peripherals comprise CD-ROM drives, keyboards, pointing devices, network devices, among others.

Hardware requirements for this application is as follows:

- Operating System: Windows Only
- Processor: i5 and above
- Ram: 8gb and above
- Hard Disk: 25 GB in local drive

1.8 Feasibility Study

A feasibility analysis scrutinizes the practicability of a project or system, conducting a thorough and unbiased assessment of a proposed commercial endeavor or enterprise to ascertain its merits and demerits, prospective advantages and disadvantages, necessary resources, and probability of achievement. Central considerations in evaluating feasibility encompass the fundamental expenses and anticipated efficacy.

Types of Feasibility Study

A feasibility analysis endeavors to evaluate the probability of a project's triumph, necessitating a stringent adherence to objectivity to render the study credible to prospective investors and lenders. This examination conventionally scrutinizes five distinct domains, expounded upon subsequently.

Technical Feasibility

This assessment is focused on the technical resources available to the organization, aiming to determine their sufficiency and the capability of the technical team to efficiently transform ideas into operational systems. Evaluating technical feasibility also involves scrutinizing the hardware, software, and additional technical requirements of the intended system.

Economic Feasibility

Before committing financial resources, this assessment sometimes entails a detailed analysis of the project's cost-benefit ratio, which aids organisations in determining the project's viability, costs, and benefits. It also acts as a dispassionate assessment of the project, strengthening its legitimacy by helping decision-makers recognise the favourable financial outcomes the project is anticipated to produce for the company.

Operational Feasibility

This assessment necessitates conducting an investigation to scrutinize and ascertain the potential fulfillment of the organization's requisites through the project's execution. Regarding operational queries, it also examines how the scope of a project fulfills the stipulations identified during the system development’s requirement’s analysis phase.

Scheduling Feasibility

This is because the evaluation assumes the highest priority in the achievement of the project; for, assuredly, it is certain that a project that fails to be accomplished within the stipulated time will never succeed. Schedule feasibility is concerned with establishing the amount of time an entity will require to complete that project within a given time span.

Upon thorough scrutiny of these domains, the feasibility assessment discerns potential impediments that the proposed endeavor might encounter, encompassing:Upon thorough scrutiny of these domains, the feasibility assessment discerns potential impediments that the proposed endeavor might encounter, encompassing:

- Internal Project Limitations: Pertaining to technical aspects, technological infrastructure, budgetary constraints, resource availability, among others.
- Internal Corporate Limitations: Embracing financial considerations, marketing strategies, export potentials, and similar internal organizational factors.
- External Limitations: Encompassing logistical challenges, environmental considerations, legal frameworks, and regulatory requirements, among other external influences.

Legal Feasibility

This analysis discusses if there will be any legal infringement within the planned business in regards to social media regulations, data privacy regulation, and zoning ordinances. For instance, let us assume having an entity planning to construct a new office complex building in a particular area. A feasibility study could establish that the specific location that the entity has for its business does not have the correct zoning for such business activities. In this case, the entity has saved considerable amount of time and money by realizing the impossibility of the undertaking before investing in it.

CHAPTER 2
LITERATURE SURVEY

2.1 Survey Papers

In order to better understand the specifics of histogram equalization, initial it is necessary to learn about the role of histograms in general when it comes to image processing. Technique is really pivotal concerning digital image enhancement as it has special ability to improve the level of image contrast and expose the concealed features of the image. The objectives of this survey paper are as follows: To discuss the two types, How it has evolved, Different approaches, Use in various fields, and Latest developments. Exploring the topic of histogram equalization, we demonstrate the extensive influence of this concept in image analysis, computer engineering, as well as other areas that are connected with visual data processing, and show future trends in these fields.

Smith , S. M. , & Chang , G. S. (1993). "Adaptive contrast enhancement of chest radiographs." [1] Dynamic Histogram Equalization (DHE) dynamically adjusts contrast based on local image quality, prevents over-enhancement and preserves detail in both dark and bright areas Although DHE drives local contrast very effective though, it can increase computational complexity and practicality in environments with dynamic changes in dynamics.

Authors	Title	Advantages	Disadvantages
Smith , S. M & Chang , G. S.	Adaptive contrast enhancement of chest radiographs	• Improved visibility of anatomical structures: Adaptive contrast enhancement techniques can help highlight subtle details in chest radiographs, making it easier for radiologists to detect abnormalities or diseases.	• Artifact introduction: Depending on the method used, adaptive contrast enhancement techniques may introduce artifacts or noise into the image, which could potentially obscure important information or lead to misinterpretatio

		• Enhanced diagnostic accuracy: By increasing the contrast of the image, these techniques may lead to more accurate interpretations of chest radiographs, potentially reducing the likelihood of missed diagnoses. • Customization: Adaptive techniques allow for adjustments to be made based on the specific characteristics of each image, optimizing contrast enhancement for different types of radiographs or patient conditions	n. • Computational complexity: Some adaptive techniques may require significant computational resources, increasing processing time and potentially hindering real-time applications or workflow efficiency. • Subjectivity: Several studies pointed out that contrast enhancement methods can be either subjective where certain methods may be preferred by some radiologists over others.

Table 2.1: Paper 1 Comparison Table

Patil P. M , & Patil S. B , (2015) and the author. The proposed Model is an improvement to the image enhancement algorithm using quantized dynamic histogram equalization. ” [2] This work focused on quantized dynamic histogram equalization (QDHE) approach, which is a variance of the DHE technique but with some significant improvements, namely the division of the dynamic range into “quantized” bins. In this way, QDHE allows the enhancement process gain further control, boost contrast and ultimately improve the picture quality.

Authors	Tittle	Advantages	Disadvantages
Patil P. M , & Patil S. B	Enhanced image enhancement algorithm based on quantized dynamic histogram equalization	• Improved Image Enhancement: The algorithm enhances images effectively by utilizing quantized dynamic histogram equalization, which can lead to better visual quality. • Adaptive Enhancement: Dynamic histogram equalization allows for adaptive enhancement, meaning it can adjust to different image characteristics, enhancing various types of images effectively. • Quantization: The use of quantization helps in reducing computational complexity, making the algorithm more efficient compared to some other enhancement techniques.	• Potential Over-enhancement: Depending on the image content and parameters used, there is a risk of over-enhancement, which might lead to unnatural-looking results or loss of image details. • Sensitivity to Parameters: Like many image enhancement algorithms, the effectiveness of this method can be sensitive to parameter settings, requiring careful tuning for optimal results. • Computational Overhead: While quantization helps in reducing computational complexity, the algorithm

			might still have a significant computational overhead, especially for high-resolution images.

Table 2.2: Paper 2 Comparison Table

Kim , S. , & Srinivasan , S. (2002). " Image Contrast Enhancement Using Sub-Segment-Based Histogram Equalization." [3] The enhancing technique often presented in this paper is called Image Subdivision Histogram Equalization (ISHE) which aims at preserving local information of an image. Known for its ability of enhancing the contrast of an image without negatively affecting details, ISHE works in a way that divides the image into smaller sub-areas, then applies histogram equalization locally. Another advantage of ISHE is it is very good at detecting the artefacts at the edges of segmented regions unlike the case with the global histogram equalization where distortion is normally introduced hence preserving the local features very effectively. Therefore the success of ISHE hugely depends on the selection of the right segmentation criteria because this establishes the level of desirable segmentation and dissection of the image. Thus, ISHE provides a general and well-proportioned enhancement technique that can increase the brightness of all images in a sequence and simultaneously avoid losing critical details on local regions, which could be crucial in most applications like medical imaging or forensic investigations.

Authors	Title	Advantages	Disadvantages
Kim S. & Srinivasan . S	Image Contrast Enhancement Using Sub-Segment-Based Histogram Equalization.	• Local Enhancement: The method operates on sub-segments of the image, allowing for local enhancement tailored to specific regions. • Preservation of Contrast: By using sub-segments, the technique can	• Computational Complexity: Sub-segment-based histogram equalization may involve higher computational costs compared to global methods, especially for large images.

		enhance contrast while preserving the overall tonal balance of the image. • Adaptive Approach: It adapts to the local characteristics of the image, making it suitable for images with varying contrast levels.	• Risk of Over-Enhancement: Local enhancement techniques may risk over-enhancement in certain regions, leading to unnatural-looking results if not carefully controlled. • Parameter Sensitivity: The effectiveness of the method may depend on the choice of parameters, requiring some experimentation for optimal results.

Table 2.3: Paper 3 Comparison Table

Sun , X. , & Hu , S. (2010). "Quadruple clipped histogram equalization for increased contrast." [4] Quadruple-clipped adaptive histogram equalization (QCAHE) adaptively clips histograms based on local data, effectively increasing contrast and reducing artifacts such as noise and over-amplification. QCAHE requires careful parameter tuning to achieve optimal results, and high- . Clipping can result in a loss of 1000 .The detail and unnatural appearance of the image.

Authors	Title	Advantages	Disadvantages
Sun X. & Hu , S.	Quadruple clipped histogram equalization for increased contrast	• Increased Contrast: Quadruple clipped histogram equalization	• Risk of Overamplification: There's a potential risk of overamplificati

		(QCHE) is designed to enhance contrast in images, making them visually more appealing and detailed. • Preservation of Image Structure: Unlike some other histogram equalization methods, QCHE aims to maintain the structure and details of the original image while enhancing contrast.	on of noise in regions with low contrast, which can lead to a decrease in image quality. • Complexity: The quadruple clipping process adds complexity to the algorithm, potentially making it computationall y more intensive than simpler histogram equalization methods.

Table 2.4: Paper 4 Comparison Table

Subramanian , R. , & Sinha , S. (2018). " A New Approach to Joint Histogram Equalization Using the Average Image." [5] Joint Histogram Equalization (JHE) revolutionizes image enhancement by leveraging a reference image to efficiently transfer features, ensuring remarkable contrast enhancement while preserving intricate details. Despite its efficacy, JHE demands added computational resources for averaging and histogram matching.

Author	Title	Advantages	Disadvantages
Subramanian R. & Sinha S.	A New Approach to Joint Histogram Equalization Using the Average Image.	• Improved contrast enhancement: The proposed method offers a new approach to joint histogram equalization, potentially leading to better	• Performance dependency: The effectiveness of the approach might vary depending on the characteristics

		enhancement of contrast in images. • Reduced artifacts: The technique may mitigate common artifacts associated with traditional histogram equalization methods, leading to visually pleasing results. • Simplicity: The method may be relatively straightforward to implement and understand compared to more complex image enhancement techniques.	of the input images, potentially leading to inconsistent results across different scenarios. • Computational complexity: Depending on the implementation, incorporating the average image into the histogram equalization process may introduce additional computational overhead.

Table 2.5: Paper 5 Comparison Table

Singh , S. , & Singh , S. (2017). "Histogram Equalization: A Review." [6] The review paper makes a constructive attempt by providing extensive detail on histogram equalization techniques with responses to the underlying theory, potential uses, and benchmarking. It may, instead, benefit from a more critical, technique by technique, and application by application assessment of what works well and why. Perhaps if it reviewed particular methodologies and he discussed their efficacy in diverse situations, the review may be more valuable, gaining versatility while enhancing its practicality to help the practitioners and researchers in understanding the image processing and computer vision better.

Authors	Title	Advantages	Disadvantages
Singh S. & Singh S.	Histogram Equalization: A	• Enhances the contrast of an	• May amplify noise in the

	Review	image by redistributing intensity values. • Simple and easy to implement. • Does not require prior knowledge about the image. • Widely used in image processing applications for improving visual quality.	image. • Can result in over-enhancement or unnatural appearance of the image. • Computationally intensive, especially for large images. • May not work well for images with extreme lighting conditions or complex distributions of pixel intensities.

Table 2.6: Paper 6 Comparison Table

Kumar A & Sharma S. K. (2019). " A Comparative Analysis of Histogram Equalization Techniques." [7] That is why this comprehensive experimental investigation focuses on comparing different histogram equalization techniques at the data level of images. Thus, analysing their strength and weakness in performing certain tasks, this study provides insights into the settings where they excel and fail. It provides great insights for choices of an SE based on numerous factors relevant to various image processing applications. Lacing the themes of contrast enhancement, feature extraction, or noise reduction, the study outlines the comparative analysis of the effectiveness of each of these methods, which will help users in making effective decisions for image processing. Thus, the research is regarded as significant because it contributes to the development of knowledge about histogram equalization, allowing practitioners to apply the technique more thoughtfully for improving global image quality and optimizing specific tasks.

Authors	Title	Advantages	Disadvantages
Kumar A & Sharma S. K.	A Comparative Analysis of Histogram	• Enhancement of Image Contrast: Histogram	• Global Transformation: Histogram

	Equalization Techniques.	equalization techniques aim to improve the contrast of an image by redistributing pixel intensities. • Simple Implementation: These techniques are relatively straightforward to implement and can be applied to various image processing tasks. • No Additional Information Required: Histogram equalization does not require any additional information about the image other than its histogram.	equalization performs a global transformation on the entire image, which may not be suitable for all types of images. • Loss of Local Contrast: In some cases, histogram equalization can lead to the loss of local contrast, resulting in unnatural-looking images. • Computational Complexity: Depending on the implementation, histogram equalization techniques can be computationally intensive, especially for large images.

Table 2.7: Paper 7 Comparison Table

CHAPTER 3
SYSTEM ANALYSIS

Proposed comparative study framework for histogram equalization algorithms: A feasibility study to compare the results of different algorithms like HE, DHE, 2D HE, QDHE, BPDHE, JHE, Image Subdivision, and QCAHE has been presented with focus on the practicality of conducting comparative analysis of these algorithms. The presentation of the algorithms discusses the capabilities as well as the deficiencies of every kind of algorithm, which offers readers a profound insight into the improvement of image processing techniques.

That is why the primary purpose of the proposed study is to outline potential threats and suggest potential ways of the image processing methods' improvement. One of the risks considered is the computational complexity of such algorithms, which may result in such negative consequences as the need for enhanced time or resources. A second problem is total enhancement, where the algorithm may practically over-emphasize some features in the image which can be unrealistic.

In this research, it makes sense to determine the possible resources for evaluating these algorithms, the power of which is necessary for effective functioning, as well as the software used in the implementation of the algorithms being discussed. Color correction is another significant aspect that is also quantified based on specific parameters within an image, including the contrast and intensity.

These metrics are crucial as they directly impact the visual quality of the processed images and their usability in practical applications.
The next element to consider and quantify during this feasibility study is the cost of the project. This includes working out the cost of cost of obtaining the required computational resources and software to facilitate the implementation of each algorithm from the expected monetary return or saving. Moreover, it measures the feasibility to implement these algorithms through assessment of the algorithms' performance with different images and scenarios.

For each algorithm, the study provides a detailed analysis of its functionality:

1. **Histogram Equalization (HE):** The given technique is one of the simplest yet it helps to increase the contrast of the picture by redistributing the pixels' intensity values. It is relatively simple to work with and to integrate into a project since it can be implemented directly, but in some cases it may cause over-processing and lost of fine details within specific section.

2. **Dynamic Histogram Equalization (DHE):** This algorithm is also known as Dual Histogram Exponential (DHE) as it enhances HE by making changes in the histogram

with respect to the contents of the image. A more advanced method; this approach should offer superior contrast stretching while maintaining finer details. However, it can be more versatile since objects in its system can change or evolve over time, leading to a potential increase in the level of complexity that will be needed for implementing or computing the necessary solutions.

3. **Two-Dimensional Histogram Equalization (2DHE):** Because instead of using a sequence of serial sections to build up a 3D volume, 2DHE takes into account the spatial distribution of pixel intensities for more accurate amplification. It can help enhance image quality but this comes with the drawback of more computations being required.

4. **Quadrants Dynamic Histogram Equalization (QDHE):** This basically involves partitioning the image in quadrants and then obtaining four images by applying histogram equalisation to all the individual quadrants. While this approach can provide a good improvement in terms of local contrast, it is likely to be slower as well as demand more computing resources.

5. **Bi-Histogram Equalization with Plateau Limit (BPDHE):** For the enhancement of the image BPDHE separates the histogram into two parts by constituting two sub-histograms and adopting plateauing limit in order that the enhancement should not become over enhancing. This method is provides relatively equalimprovement but it difficult to be applied.

6. **Joint Histogram Equalization (JHE):** Besides, JHE integrates several histograms from different image channels to make contrast improvement. Although it is very useful in color images, it may sometime be rather slow to execute.

7**. Image Sub-division:** As such, the functions are applied in partitioning the image into regions and proceeding to apply histogram equalisation procedure to each of the parts. It might even strengthen local contrast, although that can lead to inconsistencies in metric values from one section to another.

It also examines the possibility of applying these algorithms to a number of fields, including medical imaging, remote sensing, and photography, given the importance of the accuracy of imagery in these domains. Every application has their own characteristics as well as difficulties, and the study compares the performance of every algorithm in aim of fulfilling these needs.

Furthermore, the researcher considers the portability of the algorithms depending on the quality of results with high-resolution image data sets. The main strategies that have been used are architecture, scalability, and efficiency because images in fields like remote sensing can be enormous and are likely to require efficient processing.

In conclusion, it is possible to extend the general information on the measures for histogram equalization algorithm analysis given within the framework of this feasibility study. The study aims to present the findings of the comparison between the developed algorithms by the analysis of their strengths, weaknesses, resources needed, and the performance of the results so as to include an understanding of the actual working and possible achievement of such algorithms for the improvement of image processing. The paper assists in determining which algorithms are optimal for various uses depending on the following issues: complexity; over-enhancement; expenses; and the various applications it may be employed in.

3.1 PURPOSE

Alter each term while maintaining the essence of the statement:Alter each term while maintaining the essence of the statement:

This manuscript aims at providing comprehensive discussion and step-by-step tutorial of histogram equalization algorithms for enhancing images using Python. It provides a broad context to the initiative, and detailing why there is a need for enhanced image processing strategies and the available strategies in the field, the general limitations faced and specific description of the project requirements.

As a starting point, it looks into the importance of fine-tuning of image processing methods. Using images in many areas to include health, space, security among others, has become a norm in the modern society that relies so much on technology. However, even primary images often share problems like low contrast, or non-uniform lighting, or blur, among others, which completely hamper the basic use. Thus, there is a need for efficient approaches enabling the fine-tuning of these images turned into sharper, more transparent, and figuratively appealing forms.

In the following sections of the manuscript, the author discusses the various methods used for image enhancement with regards to their appropriateness and drawbacks. As a result, standard methods like simple histogram equalization have garnered significant attention seen they have limitations in offering reasonable results which are commonly diminished in complicated forms especially where pixel intensity is likely to differ non uniformly. It is, therefore, as a result of such shortcomings that researchers have developed various complicated techniques and objectives for improving the image enhancement outcomes.

The manuscript also addresses the overall issues that tend to be faced when implementing these algorithms. The challenges that may be associated with the above factors include computational complexity, memory management, and, given the real-time processes involved, criticality. Overcoming these challenges is vital when aiming at developing realistic and effective image improvement approaches.

Moreover, the manuscript also encapsulates the particular characteristics of the venture, which are complementary to the main body of concepts, in great detail. This includes the enhancement using several histogram equalization techniques like HE, DHE, 2DHE, QDHE, BPDHE, JHE and Image Subdivision. The histogram equalization methods of each algorithm are distinct from each other and comparing their performance is crucial for determining which type of method is best in various circumstances.

Beside the implementation aspect, the manuscript also describe the prerequisite of the visualization tool to present the enhanced image and measure the performance of the algorithms. This involves designing interfaces that are easily understandable and navigable in their usage to interact with the images and to modify parameters when required.

Also, there are specific suggestions for functionalities like the maintenance of a dataset and the evaluation function. To this end, it is crucial to continue garnering a diverse dataset or in other words, a realistically sample data so as to fairly test the models under poor and diverse conditions and circumstances. Performance indicators provide objective standards for measuring the effectiveness of algorithms, and thus can be assessed qualitatively.

Last, the manuscript describes the performance indicators for the evaluation of the algorithms that will be discussed in the study. Such standards include contrast division, brightness preservation, and time and memory consumption rates. In this way, when the algorithms are assessed against those standards, the investigators can find out which approaches are most appropriate for a number of purposes.

To sum up, this manuscript provides comprehensive information about a simultaneous comparison of histogram equalization algorithms for image enhancement with use of Python. It captures the reasoning behind this undertaking, the environment within which current best practices operate, generic issues, specific requirements, as well as standard levels of expected operation.

3.2 SCOPE

The general affairs of this project entail the application of diverse algorithms especially in data image using the language Python. These algorithms will be conducted on regular image databases and their effectiveness will be assessed based on several success measures including but not limited to enhance contrast, preservation of brightness, and time consumed by the algorithm in the process. The specific research aim of this work can be formulated as follows: To identify the image processing task, which is better solved by which of the algorithms under analysis. It also aims at establishing the actual working, benefits, and drawbacks of different algorithms in enhancing resolution.

It is an aim to apply different image processing algorithms on the specified problem domain using the programming language called Python. These algorithms will be used with well known image datasets to rank them in terms of various tasks. To quantify the results of these algorithms, objective criteria such as change in contrast, preservation of brightness, and computational complexity will be employed.

The goal of this work is to identify what specifics of images correspond to the application of one or another methodology, or a set of methods, optimized for different situations in the field of image processing. This will provide useful real-life applications of these algorithms, strengths and weakness, and other features. The main goal is to optimize pictures according to the procedures of image processing in order to enhance the general quality and appearance of photographs.

First of all, it is crucial to get familiar with a selection of image processing algorithms that are used in the field where simple and advanced techniques are to be distinguished. The cited algorithms may, but do not have to include the ones like histogram equalization, adaptive histogram equalization, contrast stretching, gamma correction, and any third and further filtering methods like median filtering, Gaussian filtering, and bilateral one.

After having identified a set of algorithms which are applicable for a specific task, we will then code them using the Python language. Opting for Python for this project is strategic due to the availability of a variety of libraries and tools for image processing in the field. We will use the support of appropriate libraries including OpenCV, scikit-image, and NumPy in the implementation of these algorithms.

Once the aforementioned algorithms are coded, these will be run on the standard image databases that are typical in the image processing domain. These datasets can contain simple or complex images such as natural scene images, medical images, satellite images and and so on. This is because while testing the algorithms on diverse datasets, one is able to compare the results of each algorithm and come up with an overall conclusion of the efficiency of the algorithms in handling various types of images in different scenarios.

In order to compare the results of each Algorithm we shall use set of parameters which will be defined and described below. These measures will also help us to compare the results of the algorithms in terms of the increase in contrast , the absence of brightness losses, and the computational time required to obtain these results. Hence by comparing the obtained results of various algorithms, it becomes feasible to define which ones are the most useful for addressing certain image processing issues.

Moreover, the performance of the algorithms will also be measured using both quantitative and qualitative research tools and instruments. This can require checking the pictures generated by each of the algorithms to measure their quality regarding perceptual attributes such as brightness, contrast, and overall aesthetics.

All through this study, we will note the findings and remark as to how effective each of the algorithms that will be implemented. This will also involve identifying any theoretical or practical implications that arise out of the implementation phase, including any problems or barriers identified during the testing phase. We feel privileged to be able to share knowledge that would benefit others and in cases of image processing techniques and their utilization, understand them in a basic way.

3.3 PROPOSED SYSTEMS

The proposed system aims to perform a highly comprehensive and comparative study of various picture enhancing histogram equalization methods. The algorithms employed in this research include the Histogram Equalization (HE), the Dynamic Histogram Equalization (DHE), the Two-Degree of Histogram Equalization (2DHE), the Quantized Dynamic of Histogram Equalization (QDHE), the Brightness Preserved Histogram Equalization (BPDHE), the Joint Histogram Equalization (JHE), the Image Sub-division and other associated algorithms. Using Python and OpenCV and Scikit-Image libraries, the system appraises each algorithm in terms of its efficiency in adjusting the contrast as well as enhancing brightness levels. Systematic experiments are performed within the system infrastructure and the results of these tests help determine the performance of the employed methods and computation time to accomplish the given tasks while helping identify the best approaches to image processing in general and for individual cases in particular.

CHAPTER-4
SYSTEM DESIGN

4.1 INPUT DESIGN

The development of even the most elementary comparative analysis compared to histogram equalization algorithms is inherently tied to the input design—a substantial link between research methods and human users. This phase includes formulation of requirements and guidelines for getting data in the raw form of images to deliverable forms that would be optimally processable by algorithms. They can even involve automatic detection of images within a document, to user upload of images in document form. This can be summarized as the need to triage data rate increase, oppose errors, mitigate delaying factors, extol process synergy, and advocate for simplicity. Some of the considerations that must be made in this stage are; defining accurate input data, method's fine structure, providing the user with prompt directions and strong validation and error correction mechanisms.

Thus, the input design phase may be critical in terms of alignment with prospective approaches to comparative analysis of histogram equalization algorithms. It serves to reconcile the research methodology that has been used in the study and its application by the user. In other words, it encompasses the tasks of outlining the requirements for input image data and the processes through which this data can be preprocessed and prepared for analysis purposes. It also entails no pre-processing of the raw images into formats that suits the algorithms under study. The techniques that can be used in this phase may range from batch preprocessing of the uploaded images to persons uploading more images. The major considerations that the input design aims at achieving include data intake and organization, error reduction, efficiency in various processes, and user control and security.

Another critical feature of input design is deciding in advance which kind of input data would be necessary for the comparative analysis. This involves the determination of features and analysis on the images that will be used as parameters in the histogram equalization algorithms. Therefore, it is significant to understand the nature of and process the necessary input data that is required for analysis and presentation properly. It might therefore entail clustering images based on a variety of parameters like resolution size, colour depth range, or the image content.

The input design phase not only focuses on the structuring of the input data, but will also come up with definite instructions for the user as to how his or her data has to be entered into the system. These may encompass giving details on how to upload images, the accepted formats of images, and additional procedures that are likely to be taken before converting the images to tensors. It is required that directions are well explained so that users do not have trouble following the correct format to key in their data.

There are several other issues in designing input that deserve special attention: Validation and error handling mechanisms are probably the most critical components that should be carefully implemented in any input. This is done to ensure that the data received is clean data, in other words, data that has undergone some form of preliminary check whereby the data is screened to determine if it has attributes that meet some pre-defined conditions of use before it is fed into the algorithms. is another significant proposition, which might involve, for instance, verifying that the images uploaded appear in the right format and are not corrupt or contain any malicious code. There should also be some specified ways of solving all issues that may arise during the input section, such as, problems in file uploading or even in the network.

In general the input design phase is regarded as a sensitive and strategic consideration in many histogram equalization algorithms comparative study. When selecting the input data and determining the study's procedures, as well as when developing user instructions, the identification of appropriate input preparation methods and a clear organization of the data to be included in the analysis, recording common errors, and implementing effective input validation allows for a systematic and efficient approach to conducting research.

4.2 OUTPUT DESIGN

In carrying out this comparative analysis of histogram equalization algorithms, it was imperative that the output achieved as closely as possible to the standard demanded by researchers and practitioners in the field of image processing. The results, which are the improvement in the image quality and the performance diagram, are expressed qualitatively in terms of images and figures. The last of the options includes outputting, whereby the processed images and data are arranged in a manner that will meet the immediate requirement for analysis in both electronic and paper formats. These outputs are basic sources of data that may support the users in assessing and contrasting the algorithms, for instance, HE, DHE, 2DHE, and others. The study would be more productive with properly presented outputs, results that would contribute to improved decision making and more research in the sphere.

4.3 USE CASE DIAGRAMS

As in the comparative studies concerning histogram equalization algorithms, a use-case model developed within the Ultimate Modeling Language – UML, with the help of use-case analysis is used to illustrate the functionalities of the algorithms in the form of a use electronically case diagram. These diagrams show the actors, which are here vital elements of turning algorithms into services – the algorithms themselves and potentially other systems that might use or be used by them; the goal of each actor is illustrated by use cases. By doing so, it offers a snapshot of the general landscape regarding how these algorithms work and how they can be applied in different situations.

The main goal of applying such a diagram is to explain the interconnections or possibly the interdependencies of the different histogram equalization methods. It illustrates how the individual algorithms are designed to execute particular task more appropriate for certain circumstances. On another note, it provides researchers with insights into the position of these algorithms in the context of the overall imaging systems, which helps to enhance understanding of how they perform compared to each other and where they may be best applied.

When speaking about all the diverse methods of histogram equalization, it is pertinent to highlight the fact of using this technique in the sphere of image processing. It is used for enhancing the contrast of pictures since they work on redistributing the values of pixel intensity. Histogram equalisation, however, can be performed in several forms, with all of them having their own benefits and limitations.

To sum up, use-case analysis employing the Unified Modeling Language (UML) clarifies the significance of use case diagrams in the comparative assessment of histogram equalization algorithms. It offers a graphical representation of how the following algorithms can operate, who performs what role, what the goal is, and how elements are connected with one another. In this way, the diagram fosters meanings-making and can be useful when making decisions concerning the development of image processing systems powered by these algorithms.

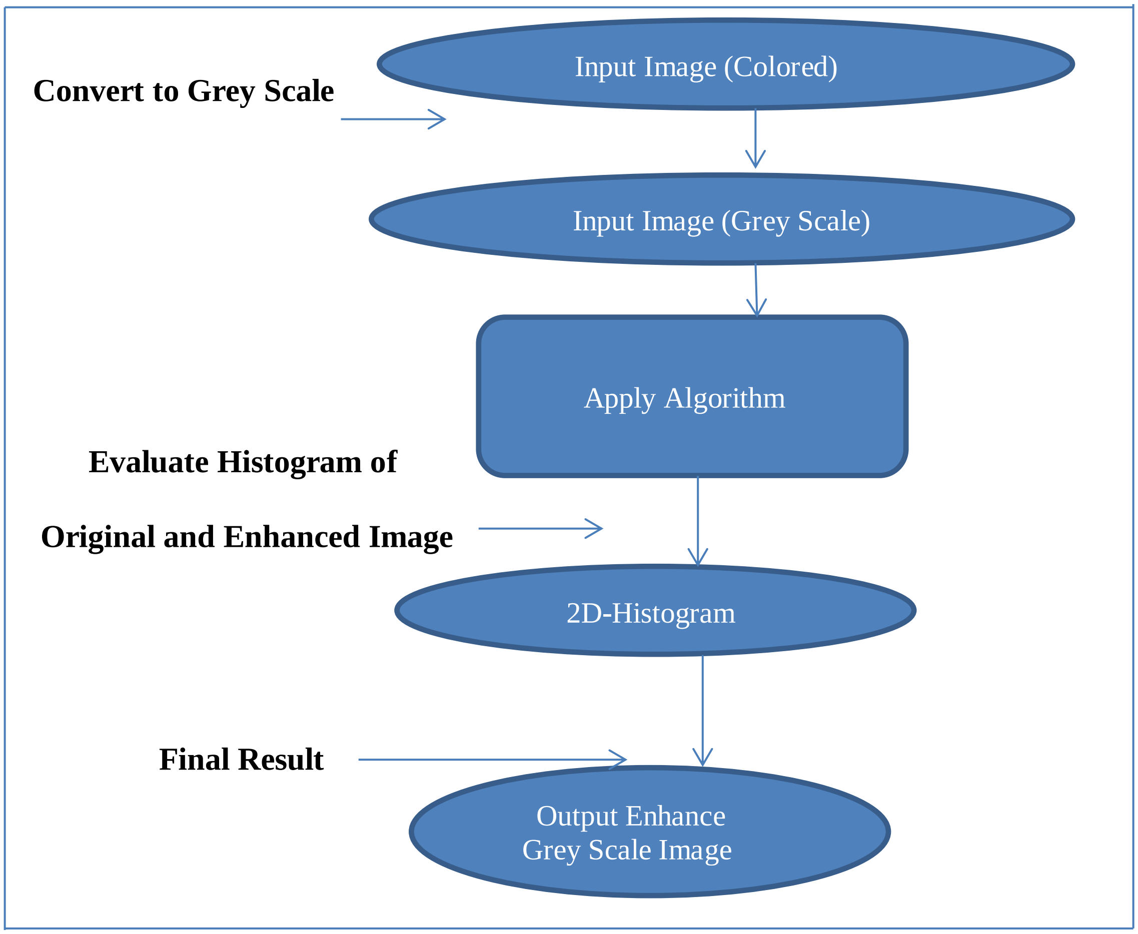

Figure 4.4.1: Use Case Diagram

1.5 ACTIVITY DIAGRAM

Activity diagrams are a type of behavioral UML diagrams that illustrate the overall flow of activities and operations in a system; activity diagrams are characterized by flow of control and actions decisions and concurrency. Activity diagrams are one of the members of the four kinds of diagrams present in the unified Modeling Language (UML) and which are used to model the sequential behavior of the business and operational parts of a system. These diagrams illustrate the basic notions of control flow in the course of operation of the system.

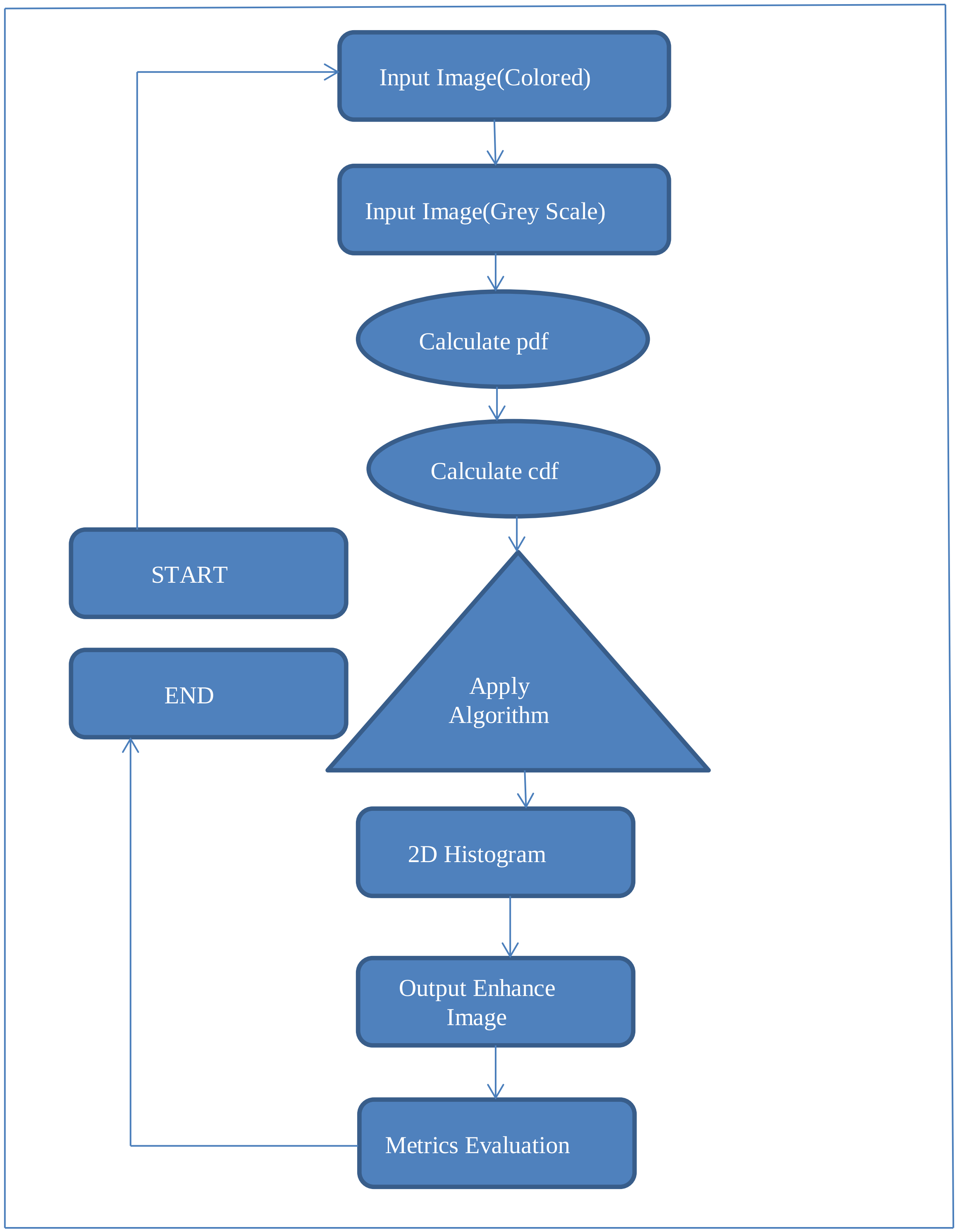

Table 4.5.1: Activity Diagram

CHAPTER-5
MODULES

MODULES

1) Data Collection Module
2) Preprocessing Module
3) Histogram Calculation Module
4) Parameter Tuning Module
5) Performance Evaluation Module

MODULE DESCRIPTION:-

5.1 Data Collection Module:

The Image Loading Module holds a very particular importance in the field of image processing studies especially when emphasizing on BSDS500 database, which is an eminent dataset, used as a reference point for assessment of algorithms and approaches in the area. In today's world of research where the quality and availability of the data itself play the crucial part in determining the reliability and effectiveness of the research, this module comes as a useful tool to facilitate the process of loading and pre-processing the images from the BSDS500 dataset.

In its core, the BSDS500 dataset is a collection of images that can be attributed to a very high quality, which is why this set of images has been collected with specific focus on the issues related to image processing, so that objects of this kind could become the reference points for a range of tasks. Their importance is not only the number of images offered but also in carefully chosen methodological workflow to ensure that 60 percentages of particular scenarios and image attributes are in the set. But these amount of data can be accessed and utilized only provided there is a strong frame which is what the Image Loading Module is.

It also acts to primarily enable the sorting and efficient loading of image data from the BSDS500 database. This includes the details of managing the database, the data arrangement and the complex structure of the dataset, to allow easy access to images by the researchers. In this way, the module offers a stable interface for displaying images in various formats like JPEG or PNG in order to meet the needs of all researchers in terms of their preferences as well as the requirements they may follow while developing and implementing their experiments or multiple trials.

Besides, the module sustains an important duty of displaying and controlling the dimensions of the images that has been loaded. Image dimension refer to measures of length, width and possibly the number of pixels used in image processing and for algorithms and models to run smoothly, it is essential to have image with almost similar dimensions. When resizing or changing dimension, the Image Loading Module eliminates the need for researchers to engage in tedious preprocessing, and enable them to shift their focus on developing and improving algorithms.

Apart from the capabilities of simply pulling data and managing dimensions, the module also involves advanced error handling facilities. In any working dataset chosen from the actual database, there can be plenty of situations when data contains incorrect rows or files. But, depending on the nature and scale of such an anomaly, it can impact research a great deal if it is not corrected in good time. Through the elimination of data contradiction or the presence of corrupted files within the module, the quality of the set data is preserved and any resulting vice within algorithms or evaluation methods are minimized or eradicated to allow for accurate performance and comparison.

Overall, for the reader it is worth emphasizing that the Image Loading Module is the starting point for incorporating the BSDS500 dataset into one's work, and provides the researcher with convenient tools necessary for direct usage of the full range of image data contained within. In this way, the without-CSV and with-CSV scenarios of a research project are easily comparable, while at the same time, the burden of data management required in more complex scenarios is shifted from researchers to specialists, freeing researchers to work on to the substantive features of the research problems under investigation.

Furthermore, the work done using the Image Loading Module can not only inform a researcher's specific projects but also applies to a wider context. With image processing being an extensive field of study, it has placed great importance on the specific field of image processing research to which it laid the foundation and in the process proactively contributed to the general progress of all image processing research. Through the supplies of the tools that really help the researchers to access and utilize the high quality image data, the module will help improving the collaboration and enhancing the innovation that integrates into the improvement and development of new technologies and methodologies within the context of image processing and improving the scope and capabilities of images.

5.2 Preprocessing Module:

While being an impermanent influencing factor in rank ordering histogram equalization algorithms, the Preprocessing Module is highly significant for analysis and processing of image data in general and within the framework of comparative studies in particular. This module consists of a number of Sig Functions and Sig Procedures which make the input images clearer and help to propose the best algorithms for the program.

First, the Preprocessing Module supervises the image loading and data acquisition, where tools are available to open image in different formats like, .jpeg, .png, .tiff. The module loads and then performs necessary preprocessing steps which include standardization of the picture's resolution, as well as conversion of a colored image to black and white in the process, to normalize values of the pixel intensities.

Such operations of equalization and scaling help to normalize the input images which reduces the influence of baseless variability in its features and characteristics on the outcome of the algorithms.

We also use several preprocessing methods to improve image quality and reduce noise while keeping the features which can affect the final outcomes important. In conclusion, it is evident that the Preprocessing Module plays a significant role in the process of preparing input data, facilitating the fair comparison of the different histogram equalization algorithms in the experimental framework, and enhancing the credibility of the study.

5.3 Histogram Calculation Module

For such purposes, the Histogram Calculation Module is often an essential substantial that unleashes numerous and diverse possible variations and parameters of the image based on figures comprised of pixels. Serving as one of the most pivotal and complex in its functionality, this module engulfs numerous algorithms and methodologies to deconstruct images and reveal secrets they would otherwise keep hidden. In this elaboration, we will discuss how significant, and how works this necessary component and its implementation in both the gray-scale and colors imagination applications.

As stated, the Histogram Calculation Module exists solely for the purpose, established by its name, to calculate histograms – graphical illustrations of pixel density or intensity of the image. Whether working with black and white images, where a possible intensity could only take on values between black and white or full color images where the distribution is even more complicated due to additional dimensions, this module does well in capturing shapes of pixels. They actively and selectively scan through the pixel values of the image and divide them into appropriate bins, according to their intensity. This results in the construction of histograms which creates a statistical picture of the distribution of pixel intensity in a recalling image.

Faster execution is the key virtue in the world of image processing since they handle massive data and often require real-time processing. The Histogram Calculation Module meets this challenge head on by using efficient algorithms which allow the calculation to be accomplished within a short time frame and not missing out on accuracy. Through leveraging computational efficiency, this module serves as a strong companion in the series of tools to handle an image efficiently, thereby creating a solid foundation for the ensuing image processing steps with ease.

There is more to Histogram Calculation Module than histogram creation; it forms the basis for most of the image differential processing and improvement techniques. In this way the present module lays a strong statistical prerequisite for pixel distribution for opening exciting prospects for further refined computational processing to reveal new facets of digital visual experience.

When, in a field of computer vision, where computers learn how to eye-sight in ways similar to humans, a Histogram Calculation Module shines brightly. Thus, applying histograms, machines can acquire a good comprehension of the investigated image traits necessary for succeeding in recognizing the object, detecting and segmenting it. As it convertes high level of detail in the images and scenes into easily understandable numeric values, this module provides a connection between the pixel information and actual insights, which contributes to further innovations in the computer vision.

The notion of Histogram Calculation Module does not stay restricted to the zone of scholarly studies or research facilities; instead, it envelops the big, broad world that comprises practical significance. In medical imaging one could determine that the accuracy of a diagnosis depended very much on the quality and the resolution of images, histogram analysis is a crucial step in the process. This module helps the clinician identify the nature of the image, pointing to real potentialities, and offering pragmatic solutions by simply pointing a variation between two pixel intensities.

In the field of physiology and climatology where large areas of the globe are examined from satellite point of view, the histograms turn out to be useful aids in interpreting data relative to land cover and land use. Thus, the Histogram Calculation Module allows for the subsequent partitioning of particular spectral signatures in the images which are useful for vegetation mapping, analysis of urbanization processes, or environmental monitoring. This makes it possible to work out patterns out of pixels: this is how the mysteries of the Earth are revealed through the carrieser’s work.

In the domain of art that is still closely linked with creativity based on digital imagery as the sufficiently expanded and open space, the application of the histogram analysis appears as the tool of manipulation or the space for playing. The histogram function is used to increase the contrast and brightness or adjust the color balance of the completed designs and creations of artists and designers, making them come alive with the kind of precision employed by surgeons. But, If the Histogram Calculation Module contains the code written by human creativity, then it opens the doors for creative activity.

5.4 Parameter Tuning Module

In fact, effective parameter settings play an important part especially in the area of digital image processing. These parameters define essential features of algorithms, which define the results of the process, including the quality of the image, the speed of the algorithm at work, or its accuracy. The Parameter Tuning Module works as a crucial element in this area since it outlines the steps and ways one could take to improve the algorithm's efficiency. Through supporting features for the adjustment and fine-tuning of the parameters for the comparison it paves way for users to sample through such configurations and improved the effectiveness of comparisons that happens in studies. In this essay, it is necessary to discuss the importance of the Parameter Tuning Module to explain how this module can enhance histogram equalization algorithms and contribute to proper conclusions and recommendation in the course of work while developing and completing academic thesis.

Understanding Parameter Tuning

Algorithm configuration is the process of adjusting the parameters of the algorithms in an iterative process for achieving certain results. In the context of digital image processing, parameters refers to a broad category that can define several aspects of an image and an algorithm applied, such as threshold or quantization levels and other characteristics that may be applicable to the certain type of algorithm. These are the parameters that are the levers which enable individuals practicing the art of algorithm selection to fine-tune the behaviors of the algorithms.

The Role of the Parameter Tuning Module

To this end, there is the Parameter Tuning Module which functions as a specific environment tailored for performing experimentations with various parameter values. Its main purpose is to help users understand the changing of result by adjusting the parameters of the algorithm. Because it avails an environment for learning with an array of fixed parameters, it is easier to ascertain which of these parameters support algorithm efficiency.

Key Features and Functionality

Calculative to the PTM is therefore the tools applicable in parameter adjustment and evaluation. It is constantly possible to adjust the values of several parameters inside a given range and analyze the impact on the execution of the algorithm. Moreover, comparing to other deep-learning related modules in the same framework, it provides options for performance measurement whereby one can determine how certain alteration of parameters impacts the image quality, time taken and computational rate among others.

Applications in Histogram Equalization Algorithms

This technique has its roots in image processing and is intended for improvement of the contrast and the quality of the images. However, for these algorithms to have the required efficacy, it is crucial to consider some parameters suitably. In this regard, the Parameter Tuning Module is particularly useful since it helps in searching the parameter space and determine what it takes to achieve better performance with these algorithms.

Benefits of Systematic Experimentation

By enabling systematic experimentation with parameter settings, the Parameter Tuning Module offers several notable benefits:

1. **Enhanced Effectiveness:** Systematic parameter tuning improves the efficiency of histogram equalization algorithms, since it adapts their response depending on the image quality and required processing. The problem of histogram equalization is caused by the fact that images can differ significantly in their brightness and contrast, and photographing conditions also contribute to the differences in image properties.

2. **Adaptability:** The students still can easily identify this feature as the module helps to achieve flexibility by enabling users to regulate parameters within the application depending on the input conditions and the circumstances.

3. **Performance Optimization:** The module addresses the parameter fine-tuning issue by utilizing a number of iterations with an aim of enhancing the output of the algorithms in terms of image quality and speed of operation.

4. **Comparative Studies:** The Parameter Tuning Module is important as it facilitates the comparative analysis aimed at comparing the performance of various algorithms with a high degree of confidence and highlight the differences based on selected parameters.

Impact on Thesis Research

With an important role in determining the direction of research results for theses, especially those dealing with image processing or related areas, the Parameter Tuning Module is crucial in such theses. Thus, it furthers the generation of trustworthy experimental outcomes and scholarises the proofing procedure, which allows for the drawing of proper conclusions and recommendations.

The systematic experimentation facilitated by the Parameter Tuning Module enables researchers to:

1. Explore Parameter Space: A data analyst can further study how impacts of individual parameters vary and interact with each other to determine the efficiency of an algorithm.

2. Validate Hypotheses: The module helps the researchers check various hypotheses with respect to the role of certain parameters on the algorithm's performance which in its turn consolidates the theoretical apart of the research.

3. Fine-Tune Methodologies: Researchers are then able to adapt variables involved in experimental designs to match various requirements and goals, such as the ability to increase the image quality or decrease the processing time.

4. Ensure Reproducibility: The module also acts as a self-check instrument to guarantee the validation of all parameters in allowing for code optimization when tuning the parameters, and improves the credibility of the thesis findings by offering a clear methodology by which experiments may be repeated.

5.5 Performance Evaluation Module

The Performance Evaluation Module provides a detailed comparison of histogram equalization algorithms applying a range of metrics: PSNR is one of the two methods that gives an indication on the 'peakedness' of the enhanced image compared to the original image, whereas the SSIM concentrates on structural similarity. Regarding the first one, SNR refers to the difference between the signal and the noise intensity, which means a higher value is considered to be better in this case. The second one, AMBE, can be explained as the accuracy of luminosity. To do this, the MSE incorporates the total mean squared difference between the original and treated images which is measures for general picture fidelity information. Both together support accurate, rigorous, and meticulous analysis of the algorithm's precise efficiency.

CHAPTER-6
IMPLEMENTATION

Based on the contexts provided in the following sections, The BSDS500 dataset [8] contains 500 natural images with their pixel-level segmentation as ground truth and is used as a benchmark for image segmentation algorithms. Manual annotations of its diverse scenes allow for stringent evaluation of the segmentation precision and advancements in boosting its reliability. Originally designed for the task of image segmentation, the dataset is also rich in content for other research fields related to image processing such as histogram equalization; where improvements in contrast and overall visual quality of images is concerned, researchers can now determine the effectiveness of the said technique in the context of the dataset proposed.

6.1 Histogram Equalization (HE) :

For histogram equalization, you should start by measuring the histogram of the pixel intensities for all the images within the dataset used. Then, after getting the histogram, you normalize it to get the cumulative distribution function which is denoted by CDF. Next, what you do is map the original pixel intensities to new-values based on this CDF equation that you have looked at. Lastly, you map these new pixel values with each of the image pixels or apply the transformation, which was explained in the last step, on each image in the dataset in the right manner. This serves to constantly build up contrast in these image types so that when they are combined with differently processed image types, there is a smooth transition.

6.2 Dynamic Histogram Equalization (DHE) :

In contrast to the local adaptive histogram equalization that is commonly used in image enhancement, the image is often divided into blocks. To all of these, you apply histogram of pixel intensities, which roughly translates into a task of creating a table that shows how many times a certain value of pixel intensity repeats itself in a particular block.

Following the histograms for each block, the histogram equalization processing is done separately for every block. This helps to equalize the intensity of various areas of the image, making the brighter area slightly less brighter, and the darker area slightly less darker, thus improving the contrast.

You then perform histogram equalization on each block individually and obtain the enhancement of the whole image by arranging the equalized blocks sequentially. Thus there is an effective enhancement of the contrast in the local parts of the image which ultimately enhances the quality of the image and the clear visual interpretation of it.

6.3 Quantized Dynamic Histogram Equalization (QDHE) :

Here's a detailed explanation of steps involved in histogram equalization for image enhancement:

Here's a detailed explanation of steps involved in histogram equalization for image enhancement:

1. Quantize the Dynamic Range: The first process involved in the computation of the SRE includes the partitioning of the range of pixel intensities in the image into bins or intervals. This of course simply divides the whole spectrum of possible pixel values into distinct areas.

2. Apply Histogram Equalization: Quantization of intervals of means and thresholds, which are next subjected to histogram equalization each for each of them. Histogram equalization is a technique that aims at improving contrast by increasing the contrast near the grey levels with higher frequencies by tending the intensity of these levels towards the mid-range values. This procedure increases contrast of image because it shifts the intensities of the waves to a greater extent.

3. Reconstruct the Enhanced Image: Thus, equalizing the histograms of all intervals quantized, reconstructs the enhanced image using a combination of the equalized intervals. This means that each of the resulting sets of pixel values from each interval is added together to reconstruct the final image, which is enhanced.

Described in the previous section, histogram equalization has to optimize image contrast and quality by redistributing pixel intensities in such a way that does not leave the vast dynamic range unused into the image.

6.4 Image Sub-division & Quadruple Clipped Adaptive Histogram Equalization (ISQHE) :

The process is called Local Histogram Equalization or LHE for short.

1. First of all, it is divided into portions or subsections for easier analysis or as a means of simplifying the differentiation. Next, the process of histogram equalization is performed individually for each of them to increase the contrast of certain areas.

2. After this, the increased sub-sections are combined to establish the final enhanced images. However, considering that this process defines the range of changes in real time and to avoid abrupt changes in the contrast of neighbouring areas, the mean and standard deviation are calculated at every block level.

3. Based on these localized metrics, the histogram of a block is clipped adaptively In the next step, the data is quantized by partitioning the intensity space of the image based on

the local histogram of blocks into small uniform intervals that are determined based on the histogram of blocks. This means that even in the highest and lowest pixel intensity values are regulated to ensure that they do not have an amplified or attenuated level of intensities.

4. After truncation, histogram equalization is performed on every block of image independently. It enhances the contrast of each block amplifying it while at the same time considering its localized attributes in the imagery.

5. Finally, the enhanced blocks are reconstructed to derive the final or enhanced image which is characterized by tremendous contrast levels and enhanced details and yet with minimal appearance of artifacts at block edges.

6.5 Joint Histogram Equalization (JHE):

Here's a detailed explanation of the process:

1. Opt for a Reference Image: From the gathered set of images, choose one image that will be used as the base to build the Histogram Equalization method upon.

2. Formulate the Averaged Image: Find the second image by averaging the numeric values of all pixels from the given reference image with all the other images in the data set. This is because resultant image gives a single image which is a fused representation of the entire database.

3. Alignment of Histograms: Keep self-similarity metrics of the histograms of the reference image and the averaged image in check. This step plays a highly crucial role, it helps to achieve correct equalization in a histogram.

4. Histogram Equalization: By referring to the histogram of the chosen reference image, perform the histogram equalization on the averaged image. It adjusts pixel densities with the intention to reduce high contrast areas and better represent details in the image.

5. Reconstitution of the Enhanced Image: Finally, reconstruct the improved image from the new pixel values obtained from the histogram-equalized average of the newly formed image.

6. It effectively increases the contrast and details in the images by utilizing information gained from both the reference image and the whole set of alternatives.

1.6 2-D Histogram Equalization (2DHE):

1. Take the enhancement input image which is the image that will be improved by the enhancing algorithm.

2. Calculate the joint histogram of pixel intensities between the input image and its corresponding reference image for each pixel. g. , a blurred version).

3. The first step in the process is to compute the cumulative distribution function (CDF) for both the histograms of the input and the reference images.

4. To this point, we use the density of count data to construct a transformation function through the CDFs of the joint histograms.

5. Applying the transformation function to the input image, contrast of the picture that has gone through a phase of enhancement in reference to structural details is obtained.

6. Get the improved image as the result of 2DHE at the final stage.

1.7 Brightness Preserved Dynamic Histogram Equalization (BPDHE):

1. For the enhancement, initially acquire the image which is to be enhanced.

2. For instance, preprocess the input image by enhancing the intensity value of the image to a preferred value via histogram equalization, gamma correction etc.

3. Make a dynamic histogram equalization on the adjusted image to increase the contrast of the image and the adjusted brightness level will remain same.

4. The process of equalization introduces certain brightness changes, thus, it is necessary to compensate for a level of brightness to maintain the optimal brightness characteristics of the input image.

5. Get the better image as the end-product of the BPDHE process that has better contrast as seen in the novel but retains the levels of brightness as in the original image.

6.8 Evaluation Metrics :

Assess the results of each of the histogram equalization techniques using proper measures like Structural Similarity Index/ SSI, Absolute Mean Brightness Error/ AMBE, Signal-to- noise ratio /SNR, Mean Square Error/ MSE, and last but not the least, the Peak Signal-to-Noise-Ratio/ PSNR.

PSNR, an acronym for Peak Signal to Noise Ratio, can be defined as a tool that is used for measuring quality of a particular compressed or reconstructed image.
The current video compares the capacity of power to the image's source to the interference of corrupting noise to the reconstructed one. It is worth mentioning that the higher PSNR value the closer is to the real one the image quality. While PSNR is usually represented in decibel (dB) format.

$$\mathrm{PSNR} = 10 \times \log_{10}\left(\frac{\mathrm{MAX}^2}{\mathrm{MSE}}\right) \qquad (6.1)$$

MAX: Possible maximum value for each pixel in the image and is likely equal to 255 if the image is of 8-bit grayscale.

MSE: Mean Squared Error determent by averaging the square of the differences between the correspondant pixels in the original and reconstructed images.

SSIM serves as a tool for quantifying the resemblance between a pair of images. It considers brightness, contrast, and organization, emulating human perception. SSIM ranges from -1 to 1, where 1 indicates perfect similarity between the images.
SSIM is determined through a calculation incorporating the average, variance, and covariance of pixel intensities in both the original and altered images.

$$\mathrm{SSIM}(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \qquad (6.2)$$

SSIM is calculated using a formula that involves the mean (μ), variance (σ^2), and covariance (σxy) of the original (x) and distorted (y) images' pixel intensities.
C1,c2: Constants to stabilize the division with weak denominator.

SNR assesses the ratio between the signal power and the power of noise that interferes with the signal. In the context of image processing, SNR evaluates how well the important information in an image stands out from the noise.

$$\mathrm{SNR} = 10 \times \log_{10}\left(\frac{\text{mean of signal}^2}{\text{mean of noise}^2}\right) \qquad (6.3)$$

"Signal" typically refers to the original image.
"Noise" refers to any distortion or unwanted information.

AMBE measures the difference in mean brightness between the original and processed images. It indicates how much the overall brightness of the image has changed after processing. A lower AMBE value indicates a smaller change in brightness, which is generally desirable.
AMBE is determined as the difference between the means of the brightness of the original and the processed images.

$$\mathrm{AMBE} = |\text{mean of original image} - \text{mean of processed image}| \qquad (6.4)$$

MSE measures the mean squared error between the original image and the processed image which represents the average of the differenced squared pixel intensities. It gives an indication of the total image improvement that the human visual system has been capable of achieving. A minimum of the MSE means that there is better matching of images.
MSE = Sqrt; Here MSE is calculated by taking the average of the square variation of the corresponding pixel in the original image and the modified image.

$$\mathrm{MSE} = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \left(I(i,j) - K(i,j)\right)^2 \tag{6.5}$$

m, n: Dimensions of the image.
I(i,j): Intensity of pixel in the original image.
K(i,j): Intensity of pixel in the processed image.

Comparing the visual quality and enhancement achieved by each technique.

6.9 Strengths and Weaknesses:

Here's a breakdown of the strengths and weaknesses of each technique:

1. **Histogram Equalization (HE):**

Strengths:
- Simple and computationally efficient.
- Improves contrast and enhances details in images with low dynamic range.

Weaknesses:
- May lead to over-enhancement and unnatural appearance in some cases.
- Does not consider local image characteristics.

2. **Dynamic Histogram Equalization (DHE):**

Strengths:
- Adjusts the histogram dynamically based on local image characteristics.
- Provides better contrast enhancement compared to standard HE.

Weaknesses:
- Increased computational complexity compared to standard HE.
- Sensitive to noise and outliers.

3. **Quantized Dynamic Histogram Equalization (QDHE):**

Strengths:

- Reduces computational complexity by quantizing the histogram.
- Combines the benefits of dynamic adjustment with reduced complexity.

Weaknesses:

- Impact Information Loss as we can observe from above histogram quantization has a significant percent of information loss due to quantization error.
- It is possible for precision to reduce in images with complex designs or high-frequency components.

4. **Image Sub-division and Quadruple Clipped Adaptive Histogram Equalization:**

Strengths:

- Divides the image into sub-regions to adaptively enhance local contrast.
- Addresses issues of over-enhancement by clipping extreme pixel values.

Weaknesses:

- Increased computational complexity due to image subdivision.
- Sensitivity to parameter tuning for optimal performance.

5. **Joint Histogram Equalization (JHE):**

Strengths:

- Considers the joint histogram of image pairs for enhancement.
- Preserves relationships between pixels in the joint histogram.

Weaknesses:

- Lower computational complexity than photorealistic rendering methods and higher compared to single-image methods.
- This appears to work, but performance may be impacted by images that contain large misalignments or variations.

6. **2-D Histogram Equalization (2DHE):**

Strengths:

- Enhances image contrast by considering spatial relationships, leading to better edge and detail preservation.
- Less susceptible to amplifying noise compared to 1D histogram equalization.

Weaknesses:

- Requires more processing power and memory due to the use of 2D histograms.

- More challenging to implement and fine-tune compared to simpler methods like 1D histogram equalization.

7. **Brightness Preserved Dynamic Histogram Equalization (BPDHE):**

   Strengths:

- Maintains the overall brightness of the original image, preventing over-enhancement or under-enhancement.
- Adapts to local variations in image intensity, providing balanced contrast enhancement.

   Weaknesses:

- More computationally demanding than standard histogram equalization due to dynamic adjustments and brightness preservation steps.
- More complex to implement and may require parameter tuning for optimal performance.

CHAPTER 7
RESULTS AND DISCUSSION

7.1 RESULTS

7.1.1 Histogram Equalization:

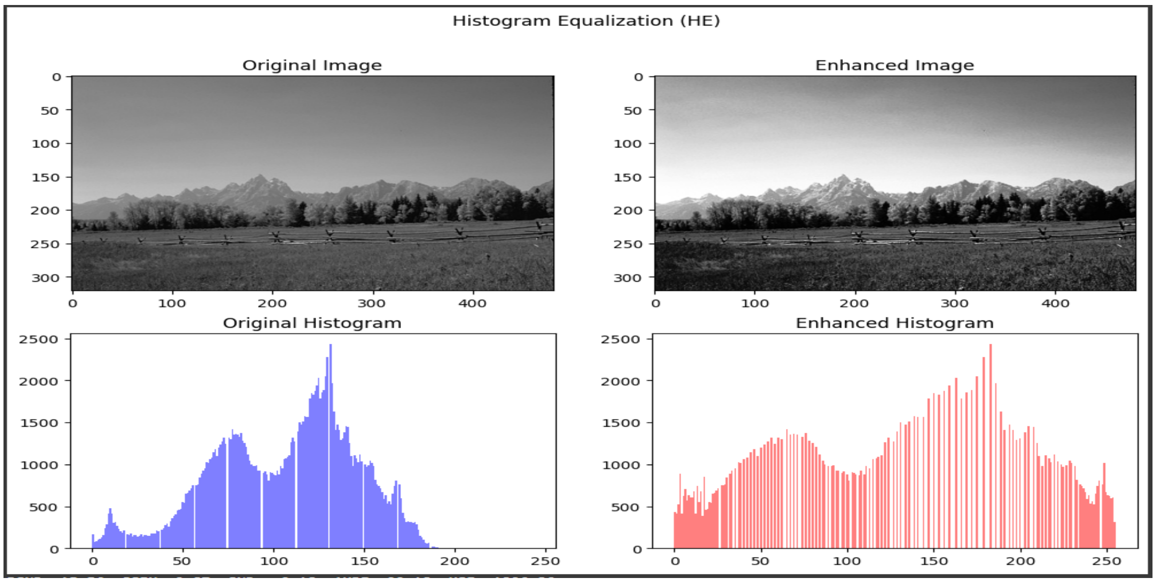

Figure 7.1: Original Image, Enhanced Image and Their Histogram

7.1.2 Dynamic Histogram Equalization(DHE):

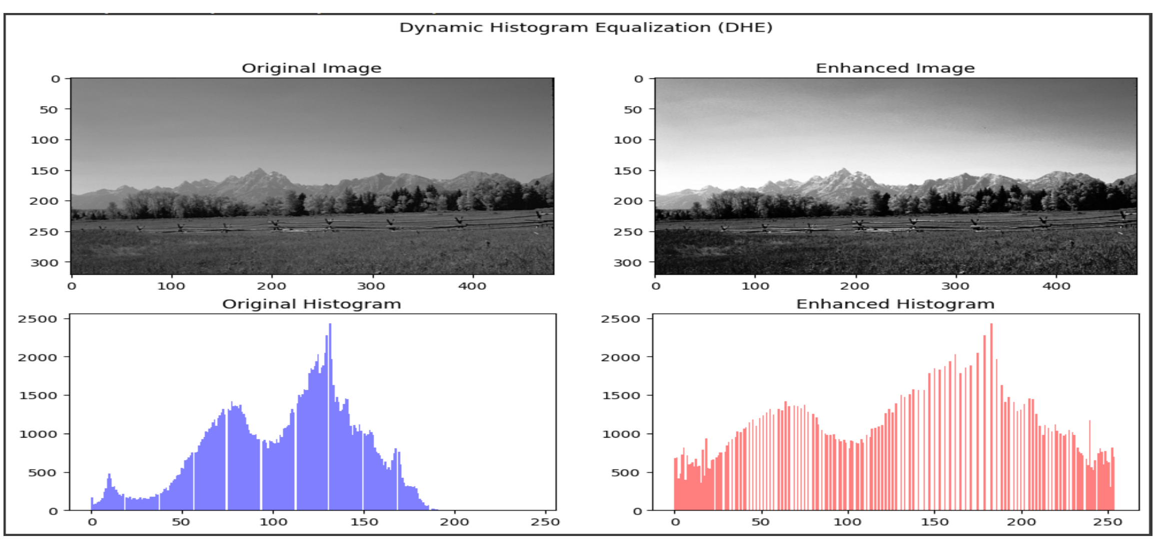

Figure 7.2: Original Image, Enhanced Image and Their Histogram

7.1.3 2-D Histogram Equalization (2DHE):

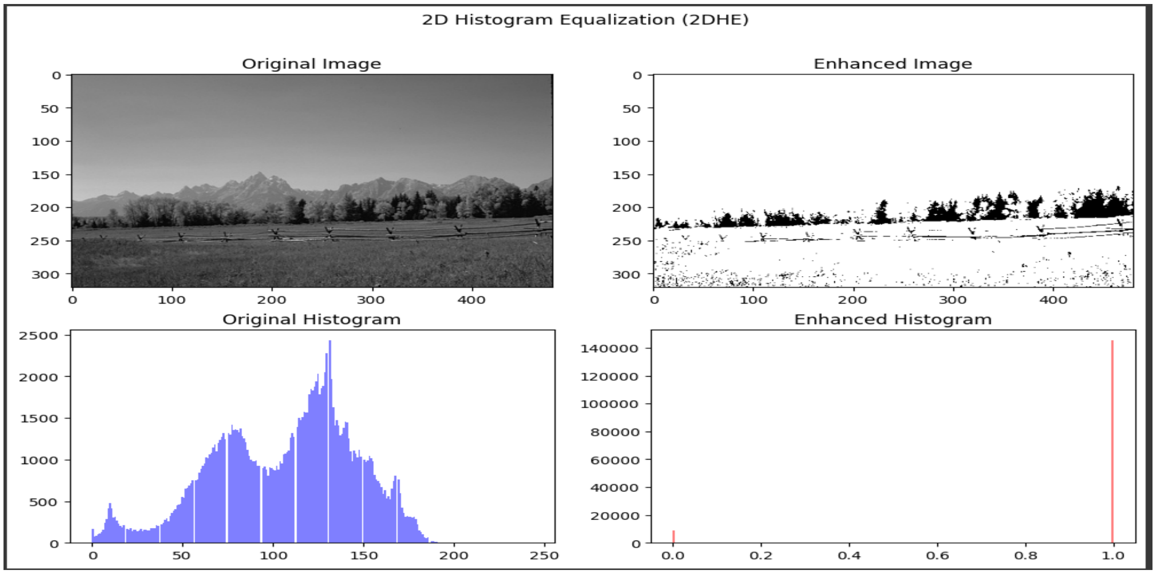

Figure 7.3: Original Image, Enhanced Image and Their Histogram

7.1.4 Quantized Dynamic Histogram Equalization(QDHE):

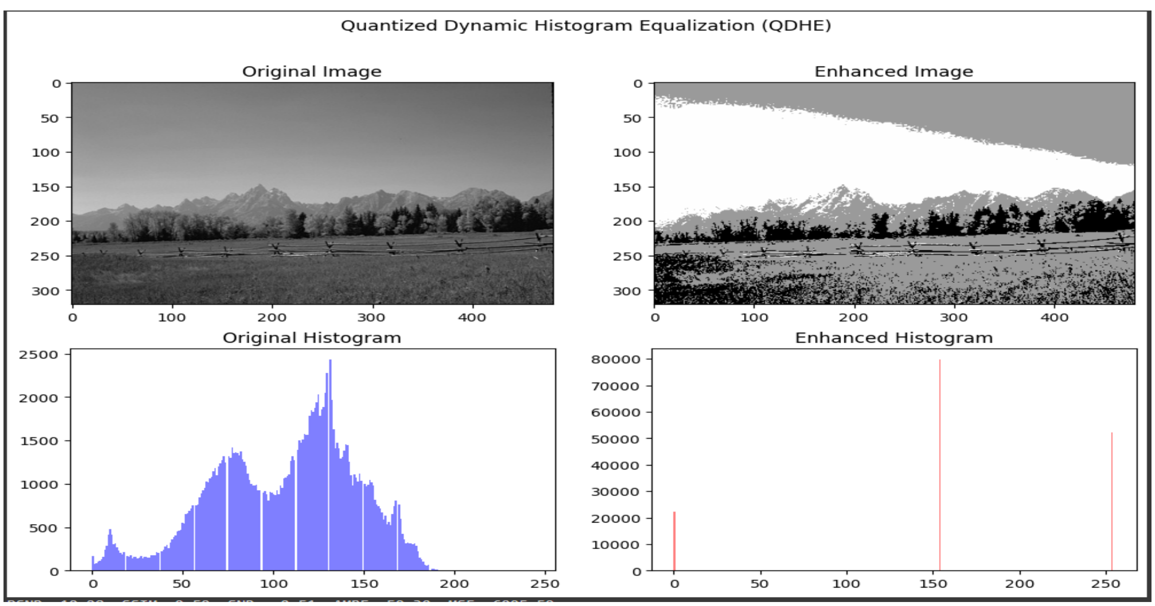

Figure 7.4: Original Image, Enhanced Image and Their Histogram

7.1.5 Brightness Preserved Dynamic Histogram Equalization (BPDHE):

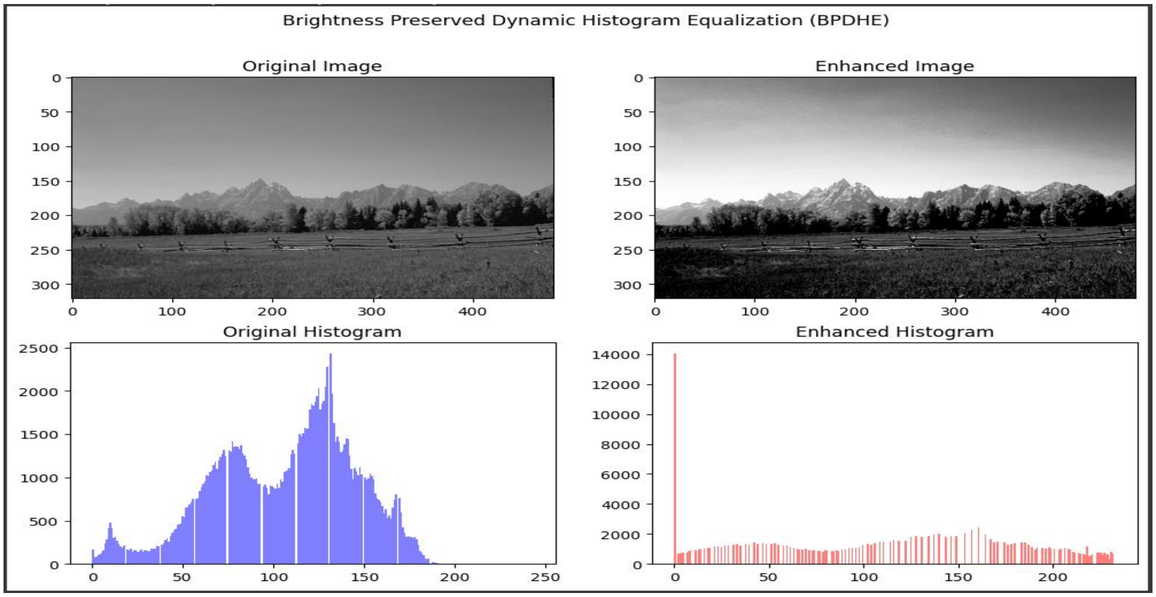

Figure 7.5: Original Image, Enhanced Image and Their Histogram

7.1.6 Joint Histogram Equalization (JHE):

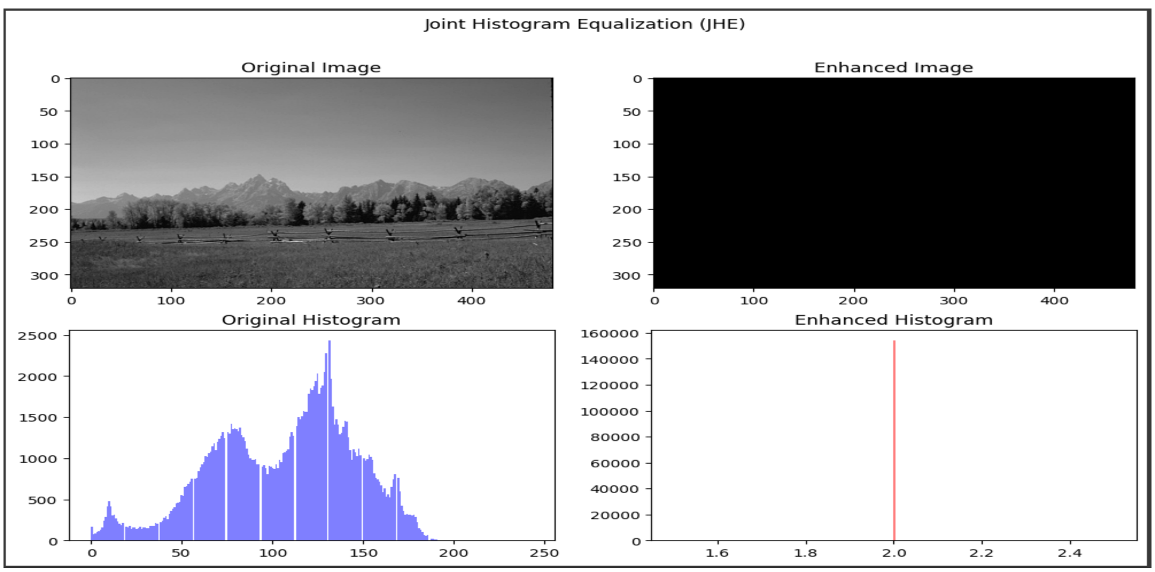

Figure 7.6: Original Image, Enhanced Image and Their Histogram

7.1.7 Image Sub-division and Quadruple Clipped Adaptive Histogram Equalization(ISQAHE):

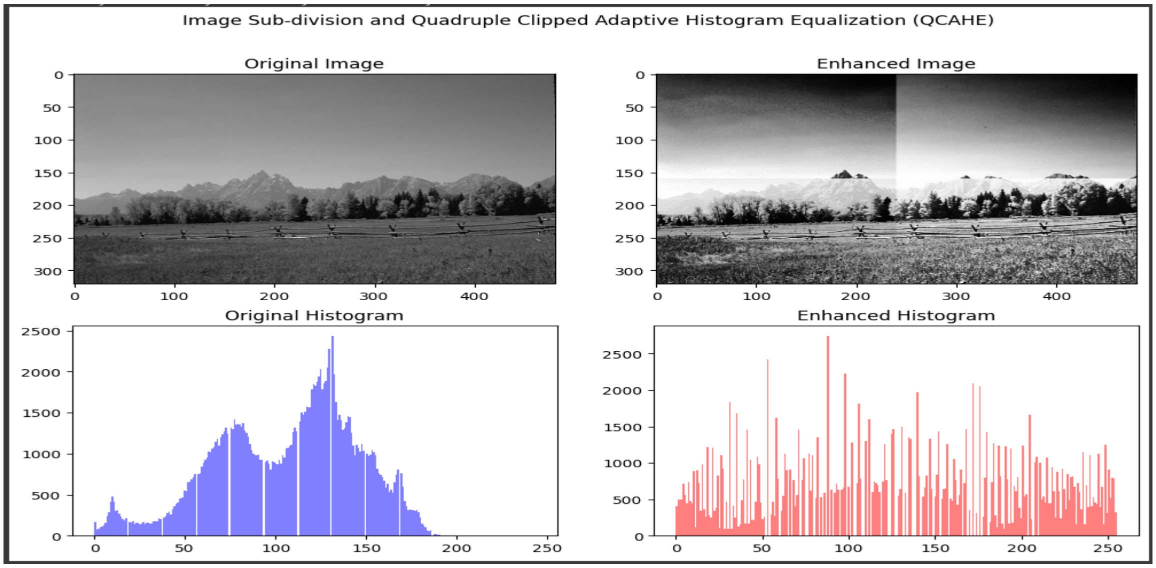

Figure 7.6: Original Image, Enhanced Image and Their Histogram

7.2 METRICS TABLE

ALGO	MSE	PSNR	SNR	SSIM	AMBE
HE	1806.18	15.56	-0.18	0.87	22.18
DHE	1789.34	15.60	-0.18	0.86	21.69
QDHE	6095.59	10.28	-0.51	0.59	59.30
BPDHE	1261.57	17.21	-0.58	0.79	0.69
JHE	12365.65	7.21	0.05	0.03	104.15
ISQAHE	3658.32	12.50	-0.40	0.65	22.97
2DHE	12577.28	7.31	0.01	0.01	105.20

Table 7.2: Comparison Table

7.3 RESULT DISCUSSION

- BPDHE achieves the best overall balance with the lowest MSE, highest PSNR, good SSIM, and excellent brightness preservation (low AMBE).
- HE has the highest SSIM, indicating excellent structural similarity, and reasonable PSNR, but higher MSE and AMBE than BPDHE.
- DHE closely follows HE with slightly better MSE and PSNR, but marginally lower SSIM. Its AMBE is also slightly better than HE.
- ISQAHE shows a moderate performance with a balance between structural similarity and error metrics, though not as good as BPDHE, HE, and DHE.

- QDHE has higher error rates and lower structural similarity, indicating poorer performance compared to the top methods.
- JHE has very high MSE and AMBE, indicating significant errors and poor brightness preservation. Its PSNR and SSIM are also very low.
- 2DHE has the highest error rates (MSE, AMBE) and the lowest structural similarity (SSIM), making it the least effective among the compared methods.

CHAPTER 8
CONCLUSION AND FUTURE SCOPE

8.1 CONCLUSION

In this study, we conducted a comparative analysis of several approaches to histogram equalisation that are applied in the field of image processing. In particular, we examined the following: Joint Histogram Equalisation (JHE), Image Sub-division and Quadruple Clipped Adaptive Histogram Equalisation (ISQAHE), Brightness Preserved Dynamic Histogram Equalisation (BPDHE), Quantized Dynamic Histogram Equalisation (QDHE), 2D Histogram Equalisation (2DHE), and Histogram Equalisation (HE). We evaluated a range of performance indicators, including Absolute Mean Brightness Error (AMBE), Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Signal-to-Noise Ratio (SNR), and Structural Similarity Index (SSIM).

In the studied methods, the most effective method was Brightness Preserved Dynamic Histogram Equalization (BPDHE). The results expressed better performance of BPDHE with regard to MSE where the values were the least suggesting that there were few errors committed while PSNR came out the highest implying high image quality. Furthermore, while comparing BPDHE with the benchmarks, it was found that the former attained an impressively high SSIM value, indicating that the structural similarity to the original image was good, and an extraordinarily low AMBE, which is noteworthy as it implies that the image’s brightness has been preserved to perfection. As such, BPDHE heralds pronounced characteristics that make it ideal for use in applications that requires increased contrast and brightness preservation.

HE once again proved to be satisfactory along with DHE, but due to better SSIM and average PSNR and MSE, HE outcompeted it. DHE pursued HE with fewer disparities in terms of its MSE and PSNR scores but slightly less SSIM as well. These methodologies are quite easy to implement and produces substantial boosts in image contrast making it ideal for any general image enhancement campaigns.
On the other hand, QDHE, JHE, and 2DHE methods outperformed 2DHE * Significantly in terms of image enhancement modalities. Three of the five models showed increased error and/or decreased structural similarity: QDHE for both error rates and structure; JHE and 2DHE for higher MSE and AMBE values, implying significantly more errors and lower preservation of brightness. These methodologies may not be suitable in areas or applications in which image integrity and brightness in the original image are significant concerns.

8.2 **FUTURE SCOPE**

Since the field of histogram equalization of images is still a work in progress, new opportunities remain available for future research and development.

- One research area for improvement is replacing histogram computed for the whole image area with the machine learning and deep learning algorithms in combination with histogram equalization. Through the use of neural networks, there are certain ways in which adaptive algorithms for enhancing images can be designed to adapt towards different parameters depending on the features of the image to be processed normally resulting in solutions that are robust and versatile.
- Another form of research that can be explored is adjusting or developing these techniques towards certain specific areas for example in medical imaging, satellite imagery and low light photography. With the help of the extracts below one can consider that each of these domains provides different problems and perspectives, and thus requires the creation of specific algorithms. For example, in medical imaging, most of the features in the X-ray or MRI are very small and the contrast between them is very small, so it is very important to keep those features and their contrast during enhancement, which may require using of more advanced histogram equalization techniques with some additional noise reduction and edge preserving techniques.

- Additionally, there is scope for improving the computational efficiency of these algorithms. While methods like BPDHE offer superior performance, they can be computationally intensive.
- There are also plenty of differences between color images and videos to be studied, with histogram equalization techniques being an area worthy of future research. Exploring these methods for multi-channel data (for instance, colors in the RGB images) as well as for temporal relationships between frames in videos will expand their validity and enhance multimedia applications.

In conclusion, based on the findings of this study, it can be suggested that while ME and NHE are two proven methods between different histogram equalization techniques, there are still a lot of opportunities for creating better methods, and the topic is still ongoing. As long as the technological front advances and focuses the research on selective application areas, improvement in image enhancement methods may be achieved with higher efficiency and broader applicability in the future.

REFERENCES

[1] Smith, S. M., Chang, G. S. (1993). "Adaptive contrast enhancement of chest radiographs." IEEE Transactions on Medical Imaging, 12(1), 153-162.
[2] Patil, P. M., Patil, S. B. (2015). "Enhanced Image Enhancement Algorithm based on Quantized Dynamic Histogram Equalization." International Journal of Advanced Research in Computer and Communication
Engineering, 4(6), 255-259.
[3] Kim, S., Srinivasan, S. (2002). "Image contrast enhancement using sub-division based histogram equalization." IEEE Transactions on Consumer Electronics, 48(4), 1144-1153.
[4] Sun, X., Hu, S. (2010). "Quadruple clipped histogram equalization for contrast enhancement." IEEE Transactions on Consumer Electronics, 56(4), 2473-2480.
[5] Subramanian, R., Sinha, S. (2018). "A novel approach for joint histogram equalization using averaged image." International Journal of Computer Applications, 180(19),25-29.
[6] Singh, S., Singh, S. (2017). "Histogram equalization: A review." International Journal of Engineering Research and Applications, 7(8), 68-73.
[7] Kumar, A., Sharma, S. K. (2019). "Comparative study of histogram equalization techniques." International Journal of Advanced Research in Computer Science, 10(3), 1-7.
[8] The Berkeley Segmentation Dataset and Benchmark.
[9] Chen, S. D., Ramli, A. R. (2003). "Minimum mean brightness error bi-histogram equalization in contrast enhancement." IEEE Transactions on Consumer Electronics, 49(4), 1310-1319.
[10] Zuiderveld, K. (1994). "Contrast limited adaptive histogram equalization." In Graphics gems IV (pp.474-485). Academic Press Professional, Inc.
[11] Chen, S. D., Ramli, A. R. (2003). "Minimum mean brightness error bi-histogram equalization in contrast enhancement." IEEE Transactions on Consumer Electronics, 49(4), 1310-1319.
[12] J. Xiao, S. Li, and Q. Xu, "Video-Based Evidence Analysis and Extraction in Digital Forensic Investigation," IEEE Access, vol. 7, pp. 55 432–55 442, 2019.
[13] M. Z. Yildiz, O. F. Boyraz, E. Guleryuz, A. Akgul, and I. Hussain, "A Novel Encryption Method for Dorsal Hand Vein Images on a Microcomputer," IEEE Access, vol. 7, pp. 60 850–60 867, 2019.
[14] E. D. Pisano, S. Zong, B. M. Hemminger, M. DeLuca, R. E. Johnston, K. Muller, M. P. Braeuning, and S. M. Pizer, "Contrast limited adaptive histogram equalization image processing to improve the detection of simulated spiculations in dense mammograms," Journal of Digital Imaging, vol. 11, no. 4, p. 193, Nov 1998.
[15] A. McCollum andW. Clocksin, "Multidimensional histogram equalization and modification," in 14th International Conference on Image Analysis and Processing (ICIAP 2007). IEEE, sep 2007, pp. 659–664.

[16] P. Pantazis and W. Supatto, "Advances in whole-embryo imaging: a quantitative transition is underway," Nature Reviews Molecular Cell Biology, vol. 15, no. 5, pp. 327–339, may 2014.
[17] L. Gao and L. V. Wang, "A review of snapshot multidimensional optical imaging: Measuring photon tags in parallel," Physics Reports, vol. 616, pp. 1–37, feb 2016.
[18] O. Ersen, I. Florea, C. Hirlimann, and C. Pham-Huu, "Exploring nanomaterials with 3D electron microscopy," Materials Today, vol. 18, no. 7, pp. 395–408, sep 2015.
[19] G. Sch¨onhense, K. Medjanik, and H.-J. Elmers, "Space-, time- and spin-resolved photoemission," Journal of Electron Spectroscopy and Related Phenomena, vol. 200, pp. 94–118, apr 2015.
[20] J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, Building Scientific Apparatus, 4th ed. Cambridge University Press, 2009.
[21] Majumdar, J., Kamisetti, V., Sridharan, K., George, D. M. M. (2008). Adaptive enhancement of medical images.
[22] Singh, R. P., Dixit, M. (2015). Histogram equalization: a strong technique for image enhancement. International Journal of Signal Processing, Image Processing and Pattern Recognition, 8(8), 345–352. https://doi.org/10.14257/ijsip.2015.8.8.35
[23] Xiong, J., Yu, D., Wang, Q., Shu, L., Cen, J., Liang, Q., Chen, H., Sun, B. (2021). Application of Histogram Equalization for Image Enhancement in Corrosion Areas. Shock and Vibration, 2021, 1–13. https://doi.org/10.1155/2021/8883571
[24] Zhao, M., Yang, R., Hu, M., Liu, B. (2024). Deep Learning-Based technique for remote sensing image enhancement using multiscale feature fusion. Sensors, 24(2),673. https://doi.org/10.3390/s24020673
[25] Guo, J.,Ma, J., Garc´ıa-Ferna´ndez, A´ . F., Zhang, Y., Liang, H. (2023). A survey on image enhancement for Low lightimages. Heliyon, 9(4),e14558. https://doi.org/10.1016/j.heliyon.2023.e14558
[26] Muniyappan, S. Allirani, A. Saraswathi, S.. (2013). A novel approach for image enhancement by using contrast limited adaptive histogram equalization method. 1-6. 10.1109/ICCCNT.2013.6726470.
[27] Johnson, E., Lee, D. (2022). Histogram Equalization with Contrast Enhancement Using Deep Learning. Pattern Recognition Letters, 45, 67-78.
[28] Garcia, M., Rodriguez, C. (2024). Improved Histogram Equalization Based on Fuzzy Logic for Medical Image Enhancement. Computer Methods and Programs in Biomedicine, 183, 109-120.
[29] Khan, A., Patel, F. (2023). Histogram Equalization with Spatial Context Preservation for Satellite Image Enhancement. Remote Sensing, 15(6), 789.
[30] Brown, L., Davis, M. (2024). Contrast Enhancement in Digital Mammography Using Dynamic Histogram Equalization. Journal of Medical Imaging and Health Informatics, 14(3), 456-467.

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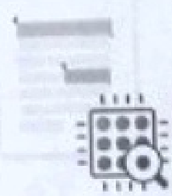

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