FOUNDATION UNIVERSITY ISLAMABAD

Contrast Enhancement of Low Contrast Images

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DEDICATION

We dedicate our work to our beloved parents who have been a great support to us through our educational journey, and our teachers who guided us through this transitional time. Without their support and help, we might never have achieved our goals. We also dedicate this project to our project supervisor Dr. Sajid Ali Khan and our project coordinator Dr. Eid Rehman who provided us with the best kind of knowledge and guidance. It would be impossible to achieve our goals without all of you.

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Thanks to Almighty Allah for giving us power, strength, and knowledge to accomplish this task. While doing this project we learned how we can implement our ideas in practical life and how we can invent new things in the technology world. We are thankful for the help of Dr. Sajid Ali Khan from Foundation University Rawalpindi Campus, for their valuable input, guidance, motivation, cooperation, and constructive criticism throughout our project. He helped us in all the phases of this project. His supervision helped us a lot during times of difficulty. In the end, we would like to thank group members and other faculty members for their valuable advice and who have directly or indirectly helped us in the completion of our project. They provide help and support throughout this project.

STATEMENT OF ORIGINALITY

We namely **Ahmed Ali Khan, Salaar Imran,** and **Obaidullah Chaudhary** submitting a thesis titled "**CELCI: Contrast Enhancement of Low Contrast Digital Images"**. State that we clearly understand what plagiarism is and we have also read about it using online sources. As such, we claim that this entire work (code, reports, etc.) is our effort. We have not used/copy or pasted or paraphrased even a single line of code or sentence from any other source without giving a proper reference to it. Based on our confidence in our originality, we allow the University to run anti-plagiarism software on the same. We understand that if now, or in the future, ever it is found out that we have not been honest and have plagiarized, the university will take action and will result in disciplinary action, such as the cancellation of our degree and we can be liable for any subsequent punishments as deemed appropriate by the University as well as the Higher Education Commission Pakistan.

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It is certified that the Project titled **"CELCI: Contrast Enhancement of Low Contrast Digital Images",** presented on 28/07/2022 , has been duly approved by the evaluation committee.

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ABSTRACT

Digital images are usually of inferior quality and endure irregular lighting or illumination, failures of detail, and poor contrast. This becomes crucial when it is hard to differentiate the foreground of interest from the background, which makes the segmentation issue more serious and leads to misidentification. The fundamental thought of image enhancement is to build the contrast difference between light and dull areas to get better picture quality. The visual data of the picture will be increased to well explain and perceive, to deliver vibrant images for the eyes or help the features extraction process in the digital image processing. Digital image processing has a broad range of applications such as remote sensing, image, and data storage for transmission in business applications, medical imaging, acoustic imaging, forensic sciences, and industrial automation.

In this proposed system, we have developed an image enhancement technique that will not only improve the low-contrast picture but also preserve the image detail information. Moreover, the use of the fitness function will enable us to reduce the time complexity and increase accuracy. Our system CELCI: Contrast Enhancement of Low Contrast Digital Images allows the user to enhance the image with a hybrid approach.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

Terms	Descriptions
AHE	Adaptive Histogram Equalization
BBHE	Brightness Preserving Bi-Histogram Equalization
CELCI	Contrast Enhancement of low-contrast images
CLAHE	Contrast Limited Adaptive Histogram Equalization
DFD	Data Flow Diagram
DIP	Digital Image Processing
DWT	Discrete Wavelet Transformation
FR	Functional Requirements.
GA	Genetic Algorithm
GC	Gamma Correction
GUI	Graphical User Interface
HE	Histogram Equalization
NFR	Non-Functional Requirements
PSO	Particle Swarm Optimization

Chapter 1

INTRODUCTION

1.1 Introduction

The report contains a brief explanation of our project "**CELCI: Contrast Enhancement of Low Contrast Images"**. It covers the complete details about how the project will be completed with all the necessary diagrams. The main section is the introduction, which includes the brief description of existing system, problem definition and literature review. Further, it incorporates the user needs in which we will describe why the users of this system would require this software application. This document will cover all modules and functionalities of our system.

1.2 Existing System

Contrast Enhancement plays a vital role in image processing. Histogram Equalization-based techniques are widely used for contrast enhancement. However, they cause contrast over-stretching, which in return causes the loss of details and unnatural look to the target image. The traditional histogram equalization techniques have major problems; they enhanced the image with noisy and over-contrasted appearance. In the existing techniques, we analyzed that with the enhancement of pixels the noise is also enhanced. The solution for noise preservation is to convert the image from the spatial domain into a frequency domain. Our system will use to enhance the image without affecting the details of an image unlike existing techniques i.e. Global Histogram Equalization, Adaptive Histogram Equalization, and Contrast Limited Adaptive Histogram Equalization.

Table 1.1 Benchmarking for the proposed system

Features	HE	AHE	CLAHE	Our System
Enhancement	✔	✔	✔	✔
Brightness preservation	✘	✔	✔	✔
Controlling Noise	✘	✘	Partial	✔
Controlling Enhancement	✘	✘	Partial	✔
Wavelet Transformation	✘	✘	✘	✔

1.3 Literature Review

In this section, we are presenting the research work of some prominent authors in the same field and explaining various techniques used for Image Enhancement.

Madheswari Kanmani and Venkateswaran Narasimhan in 2017 have proposed an optimized contrast enhancement algorithm for color images that improves visual perception of information. As color plays an important cue in many application areas, to prevent unwanted artifacts on color, this method translates the color image into de-correlated lαβ color space based on the statistics of cone response to natural images. The key work of this algorithm is to use an Adaptive Gamma Correction Factor (AGCF) chosen by Particle Swarm Optimization (PSO) to improve the entropy and enhance the details of the image [1].

Tarik Arici et al in 2009 has proposed an optimized framework based on histogram equalization for image contrast enhancement. In this framework, contrast enhancement is posed as an optimization problem that minimizes a cost function. Histogram equalization is an effective technique for contrast enhancement. However, it usually results in excessive contrast enhancement, which in turn gives the processed image an unnatural look and creates visual artifacts. A low-complexity algorithm for contrast enhancement is introduced [2].

Yakun Chang et al in 2017 has proposed automatic Contrast-Limited Adaptive Histogram Equalization (CLAHE) for image contrast enhancement algorithm. The clip point will be set automatically for CLAHE based on textureness of a block. This method also introduces dual Gamma Correction (GC) into CLAHE to achieve contrast enhancement while preserving naturalness. Since automatic CLAHE adaptively enhances contrast in each block while boosting luminance, it is very effective in enhancing dark images and daylight ones with strong dark shadows [3].

Over recent years many algorithms and methods have been introduced for the image contrast enhancement. The only goal of all techniques related to the image contrast is to bring out the hidden details of the image. For better image quality, it is required to enhance the contrast of dark images.

1.3.1 Images comparison in terms of visual quality

The visual quality results obtained by Histogram Equalization (first column), Adaptive-HE (second column), Contrast Limited-AHE (third column), Gamma Correction (fourth column), Brightness Preserving Bi-HE (fifth column), DWT CLAHE (sixth column), DWT GC (seventh column), and Proposed Technique (eighth column) are given below: in figure 1.1

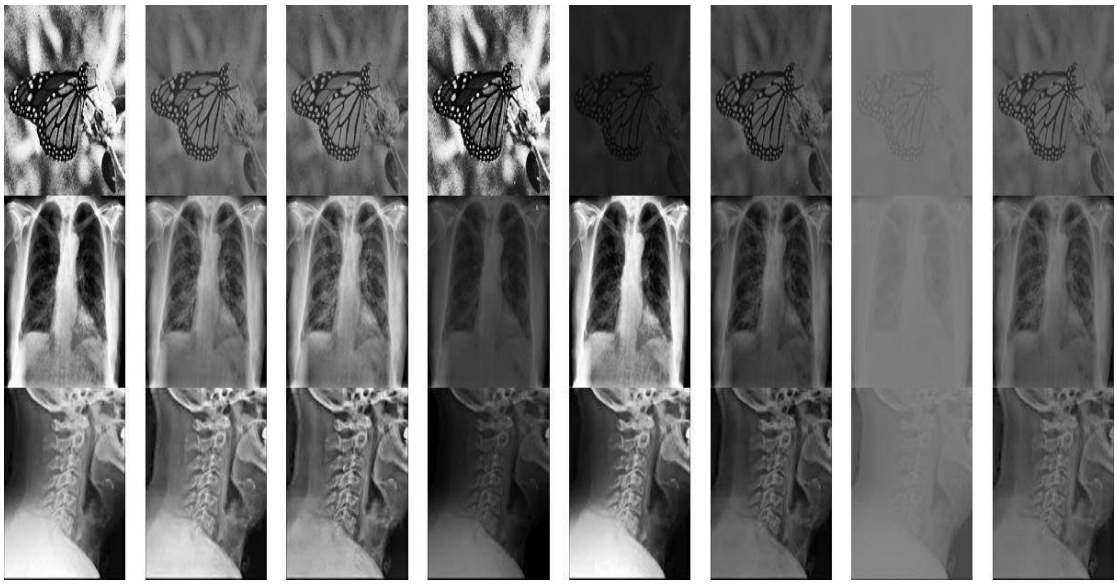

Figure 1.1 Enhancement of low-contrast images

1.3.2 Images comparison in terms of qualitative measures

Image contrast enhancement is examined by different enhancement assessment parameters. Table 1.2 shows the comparison of PSNR (Peak Signal-to-Noise Ratio), MSE (Mean Square Error), SSIM (Structural Similarity Index), RASE (Relative Average Spectral Error), SAM (Spectral Angle Mapper) and AMBE (Absolute Mean Brightness Error) of the proposed method with HE, AHE, CLAHE, GC, BBHE, 1-D CLAHE, and 1-D GC. The results indicate that the proposed method achieved highest score of PSNR for all the test images as compared to other methods. The calculated average value of PSNR is high thus indicate the absence of noise in the enhanced image. This indicates that the approach suggested is better to improve the contrast. It is clear from the review of the findings that the proposed method also preserved maximum brightness as compared to other methods due to the measures like MSE, SAM, and AMBE.

Table 1.2 Objection evaluation in terms of PSNR, MSE, SSIM, RASE, SAM, AMBE

Measure	Image	HE	AHE	CLAHE	GC	BBHE	1-D CLAHE	1-D GC	Proposed Technique
PSNR	Butterfly	9.45	19.47	19.43	15.23	10.20	25.54	16.51	26.58
	Chest X-ray	12.84	20.10	17.75	14.51	12.86	16.06	21.02	21.07
	Human Neck	14.49	16.05	19.38	15.51	16.44	18.96	16.52	21.10
MSE	Butterfly	74.27	107.10	99.30	157.62	107.15	82.14	116.33	93.88
	Chest X-ray	113.81	89.49	94.41	137.24	106.85	122.26	90.00	116.26
	Human Neck	100.07	109.79	104.64	120.31	87.79	94.63	102.19	92.30
SSIM	Butterfly	0.28	0.82	0.74	0.71	0.28	0.88	0.85	0.94
	Chest X-ray	0.58	0.82	0.75	0.82	0.58	0.82	0.86	0.94
	Human Neck	0.86	0.79	0.75	0.72	0.85	0.90	0.75	0.91
RASE	Butterfly	197.55	68.30	114.52	128.69	130.46	64.71	202.13	55.76
	Chest X-ray	102.57	40.98	92.81	104.48	76.35	154.92	84.43	82.92
	Human Neck	81.52	101.52	158.76	120.40	45.70	97.36	399.60	148.96
SAM	Butterfly	0.40	0.10	0.16	0.07	0.44	0.14	0.09	0.06
	Chest X-ray	0.32	0.17	0.18	0.11	0.32	0.19	0.15	0.08
	Human Neck	0.10	0.09	0.17	0.19	0.17	0.14	0.32	0.20
AMBE	Butterfly	55.37	23.97	20.72	44.03	43.07	9.91	37.52	10.25
	Chest X-ray	22.99	9.46	18.69	47.80	23.73	38.81	16.05	21.35
	Human Neck	36.83	35.29	19.31	41.08	19.78	22.30	24.41	5.41

1.4 Problem Definition

In this modern age, the use of digital devices and computers is getting more and more common. People require fast and easy access to any data or information whether it is in text, document or image form. Regarding images, it is known that if a digital image is of poor quality that is caused by poor image sensors, non-uniform exposure, short shutter cycle, and weather conditions such as heavy clouds, fog, and lack of sunlight or night scenes. Images captured under these circumstances contain contrast distortions, color fading, and low intensity would result in confusion of textures and the objects, poor performance of detection, segmentation, and annoying visual experience [4]. This is a major problem that many researchers and scientists have worked hard to eliminate through different methods and techniques which preserve the details of an image through traditional image enhancements techniques i.e. Histogram Equalization (HE), Adaptive Histogram Equalization (AHE), and Gamma Correction (GC) etc. There are numerous existing methods, some work better than others and some are still lacking in some aspects like controlling-over enhancement, low computational cost, and controlling noise. Existing techniques effectively enhance images to different extents but their performance lacks in one or more of the following areas. Either the restoration/enhancement results are not very accurate in terms of image quality assessment metrics such as PSNR, MSE, and AMBE etc. if the technique is simple to implement and does not require much knowledge about the physical process. The motivation and inspiration for this work has emerged from the necessity to develop some effective image enhancement methodology which provide accurate results and also computationally less expensive. To ensure that we get the best result for our image, our method is proposed to tackle this problem through the approach of hybrid method for contrast enhancement.

1.5 Context Diagram

Context diagrams show the communications between a system and different actor (outside factors) with which the system is intended to interact. Figure 1.2 is given below.

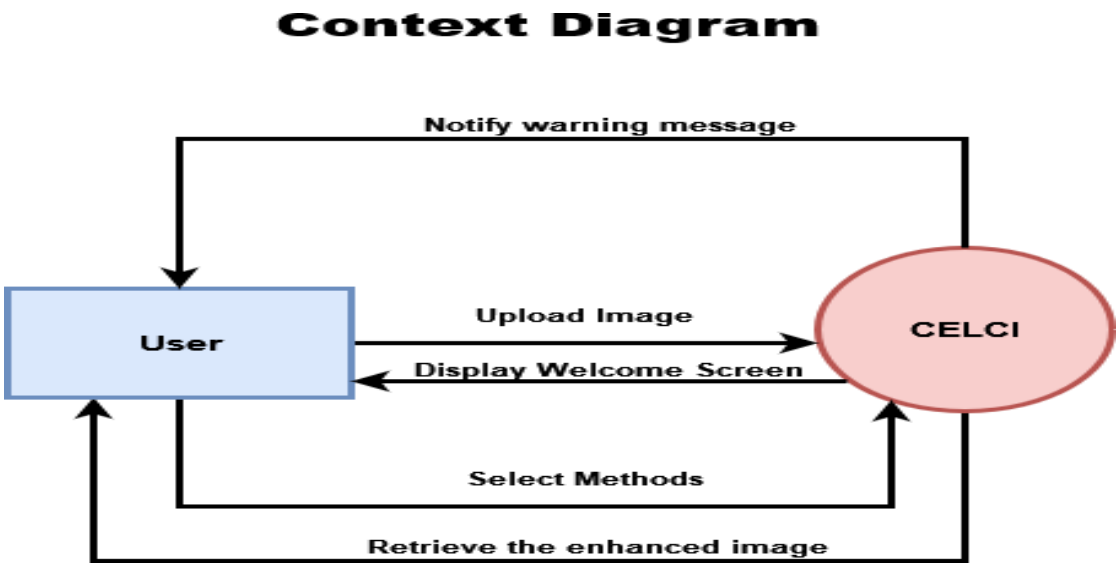

Figure 1.2 Context Diagram

1.6 User's Needs

This application is intended for users to use the interactive desktop application to enhance the images. At first user will be asked to browse the desired image for enhancement. Then user will have multiple methods to choose the method. All these methods will give different results. The proposed method will be named as Hybrid Contrast Enhancement**.** This method will enhance the image contrast without increasing the noise. This would give the user major advantage over a traditional contrast enhancement techniques.

Chapter 2

INTRODUCTION TO PROPOSED SYSTEM

2.1. Introduction

This chapter describes all the capabilities and facilities of the software CELCI (Contrast Enhancement of Low Contrast Images). It shows an overview of the project, the problem description, project objectives and scope, its features along with a context diagram of the project.

2.2. Project background or Overview

Our project "Contrast Enhancement of Low Contrast Images" is a Desktop-based application that aims to provide the enhancement of low contrast images. In our software application the users will be asked to input an image. The enhanced image will appear without noise enhancement and it will be more appealing than the original image. The traditional histogram equalization techniques did not work on the principles of DWT. However, we have proposed a hybrid method for contrast enhancement to preserve the details of an image.

2.3. Problem Description

Pictures captured with a camera have issues with uneven lighting and low contrast. They contain useful data, but they are not perceptible due to the lack of clarity and are easily affected by noise [5]. The issues in an image consist of too high or too low contrast. Transferring or compressing the image can lower the quality of the pixels. To ensure that the quality of the image doesn't degrade and the details are preserved, we require different techniques to be applied on an image to retain picture quality and contrast. The traditional techniques had major problems; they enhanced the image with noisy appearance of high computational cost. The proposed system for contrast enhancement will give a proper environment to overcome all the problems mentioned above.

2.4. Project Objectives

The objective of this project is the development of methodologies for image enhancement which is more accurate in terms of image quality assessment metrics and are less computationally intensive. The objectives for the proposal are given below:

1. To develop a system that will use to enhance low contrast images.
2. To develop a system that will act as a pre-processing module in any system that uses images as input and increases the image contrast before further process on the input images.
3. To develop a system for identifying any details in an image and magnifying that aspect for making it easier to extract useful information.
4. To develop a system that will assist any image domain expert with a better understanding of the output images.

2.5. Project Scope

The software will provide an enhanced image of a low contrast digital image to the end-users. A lot of information is lost due to the poor quality of the camera and images captured under bad weather conditions which shows a lack of clarity in digital images. So, the software is intended to minimize all of those negative points and enhance the image to a better quality. The intended system is generic and can be used easily by any person with basic knowledge of the computer system. The software can help in the medical field, science and development sector which focuses on image data study, etc. The software will be used for medical imaging, e.g. in CT and MRI facilitating the diagnosis and detection of any tumor or disease [6]. It will also support software development fields that deal specifically with image and data analysis through the images. The system will also be helpful for the researchers and software engineers, to spot the desired results in an image.

2.6. Product or Project features

There are 7 product/project features as of now which are shown and briefly explained in the given table 2.1.

Table 2.1 Product Features

Product Features	Description
Conversion of RGB images	In this feature, when a user inputs any type of image, the program checks if the image is in RGB or not, if it is then it proceeds to the next step, if not then it converts it into Gray level first before proceeding to the next step.
DWT-Processing	This feature converts the input image spatial domain to frequency domain, further dividing it into 4 components. After the conversion, it will apply contrast enhancement techniques on its main component which is a low-frequency component to enhance the image.
Contrast enhancement	In this step, different contrast enhancement methods will be applied to the image as per user interest.
Controlling Noise	This feature is related to the DWT-processing, as it is discussed earlier the frequency domain consists of 4 components, the noise will be controlled if the high-frequency components are separated i.e. HH, LH, and HL. These components contain different imagenoises detail.
Controlling Over-Enhancement	This feature is used to optimize the contrast enhancement to make the image look appealing. Sometimes an image looks so unnatural so that is why controlling over-enhancement will be used.
Image Detail Information Preservation	This feature is used to make image detail information secured for instance when the image is enhanced with noise then the enhanced image will not contain the image detail as per original image.
Reverse DWT	In this step, the image which was divided into High-Frequency components and Low-Frequency components then merged together for the conversion of an image into spatial domain.

Chapter 3

REQUIREMENT SPECIFICATIONS

3.1 Introduction

This chapter includes the functional requirements of the intended system, and all the non-functional requirements. It also includes some important diagrams that define the behavior of the system like the Data Flow Diagram Level 0, Data Flow Diagram Level 1, and Data Flow Diagram Level 2. User interfaces are also included in this chapter.

3.2 Functional requirements

Functional requirements are the product features that developers must implement to allow the user to achieve their tasks. It portrays or describes a system software or its part. A function is nothing but inputs to the software system, its behavior, and outputs. Table 3.1 shows all the functional requirement.

Table 3.1 Functional Requirements

Functional Requirement No#	Description
FR-1	The system should allow the user to input the image.
FR-2	The system must identify the image's nature.
FR-3	The system must display a warning message to the userabout colored images.
FR-4	The system must convert the image into a frequency domain.
FR-5	The system should allow the user to select DWT techniques that will be Used to enhance the LL component of an image
FR-6	The system should allow the user to select the displayedcontrast enhancement method.
FR-7	Users must be requested to select further contrast enhancement techniques according to the selected method.

FR-8	The system must separate High-level frequency domain image components.
FR-9	The system should merge together all the components offrequency domain image.
FR-10	The system must convert the merging of components into aspatial domain as an enhanced image.
FR-11	The system must display the enhanced image to the user.
FR-12	Users must save the enhanced image in the files.
FR-13	Users could be allowed to analyze the image and comparethe results with a referenced image.

3.2 System Sequence Diagram

As our development approach is structural, a state transition diagram does not apply to our system.

3.3 Domain Model

As our development approach is structural, there is no need to design a domain model for our system.

3.4 User Interface

The user interface is the interaction of the user and the system. Generally, the goal is to provide a front-end that makes it easy, efficient, and user-friendly to operate a machine in a way that produces the desired result. The following figures (3.1 - 3.3) are different user interfaces.

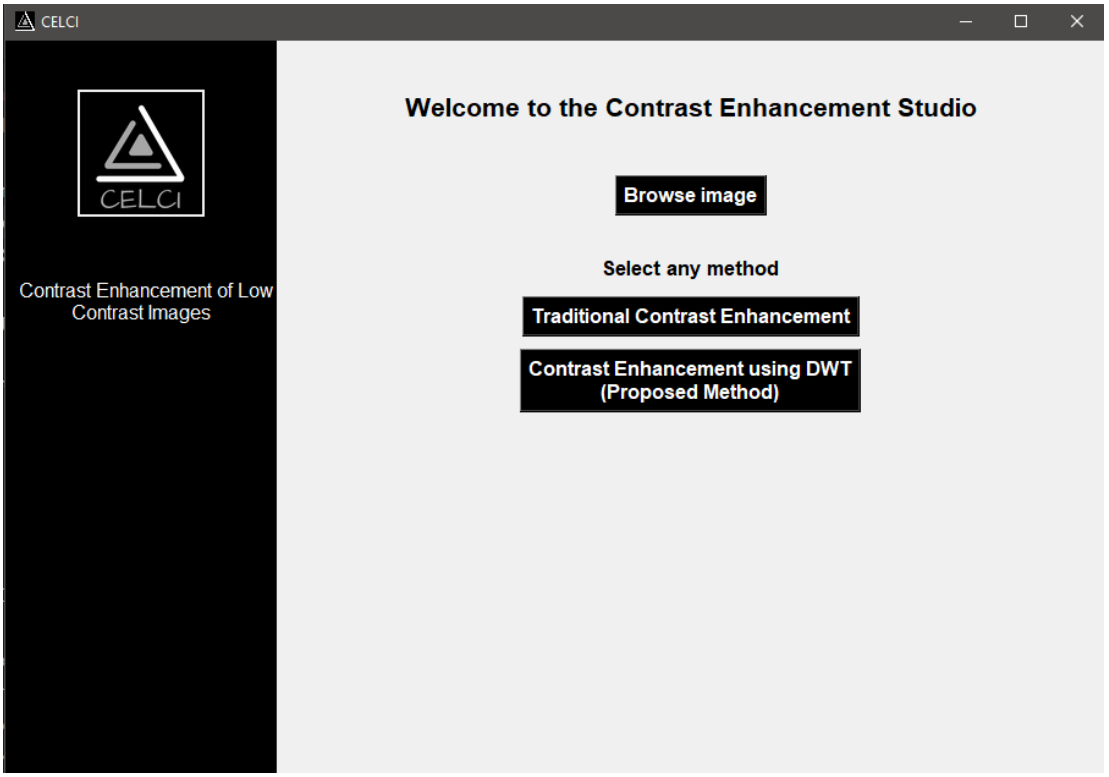

Figure 3.1 Main Menu - Window

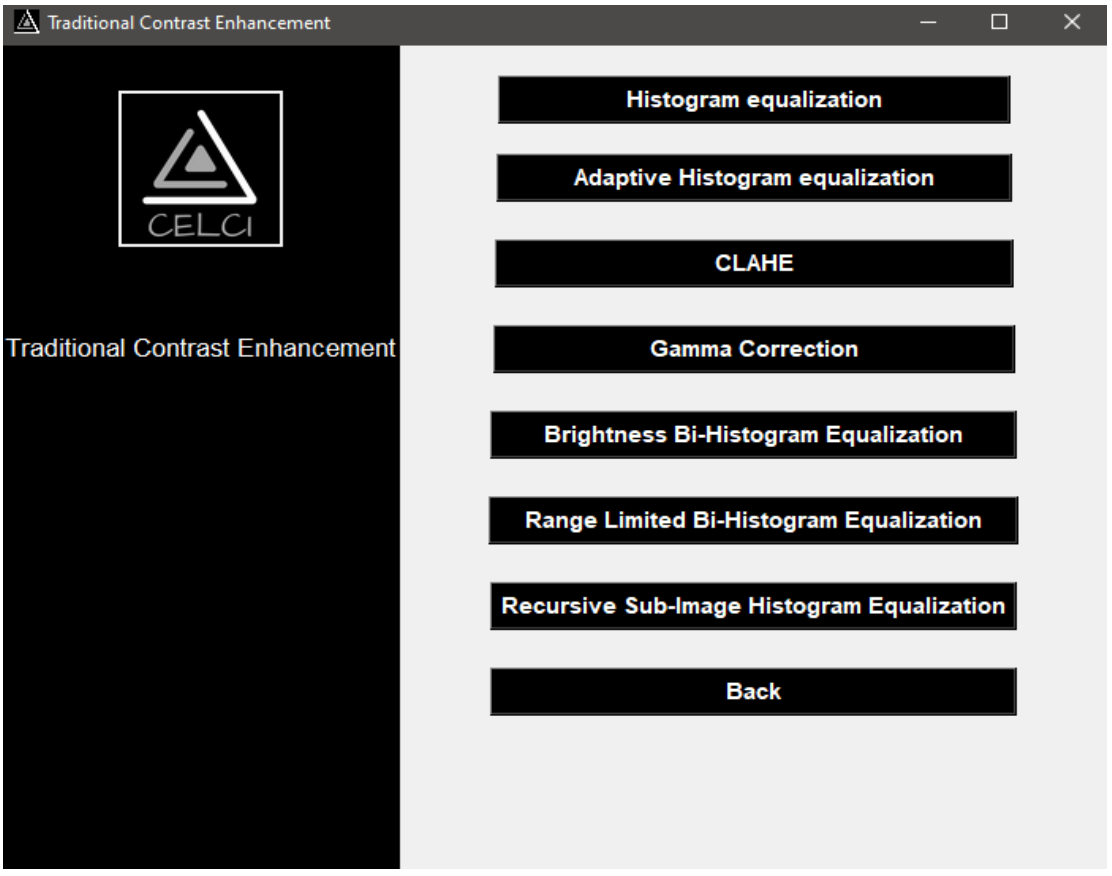

Figure 3.2 Traditional Contrast Enhancement - Window

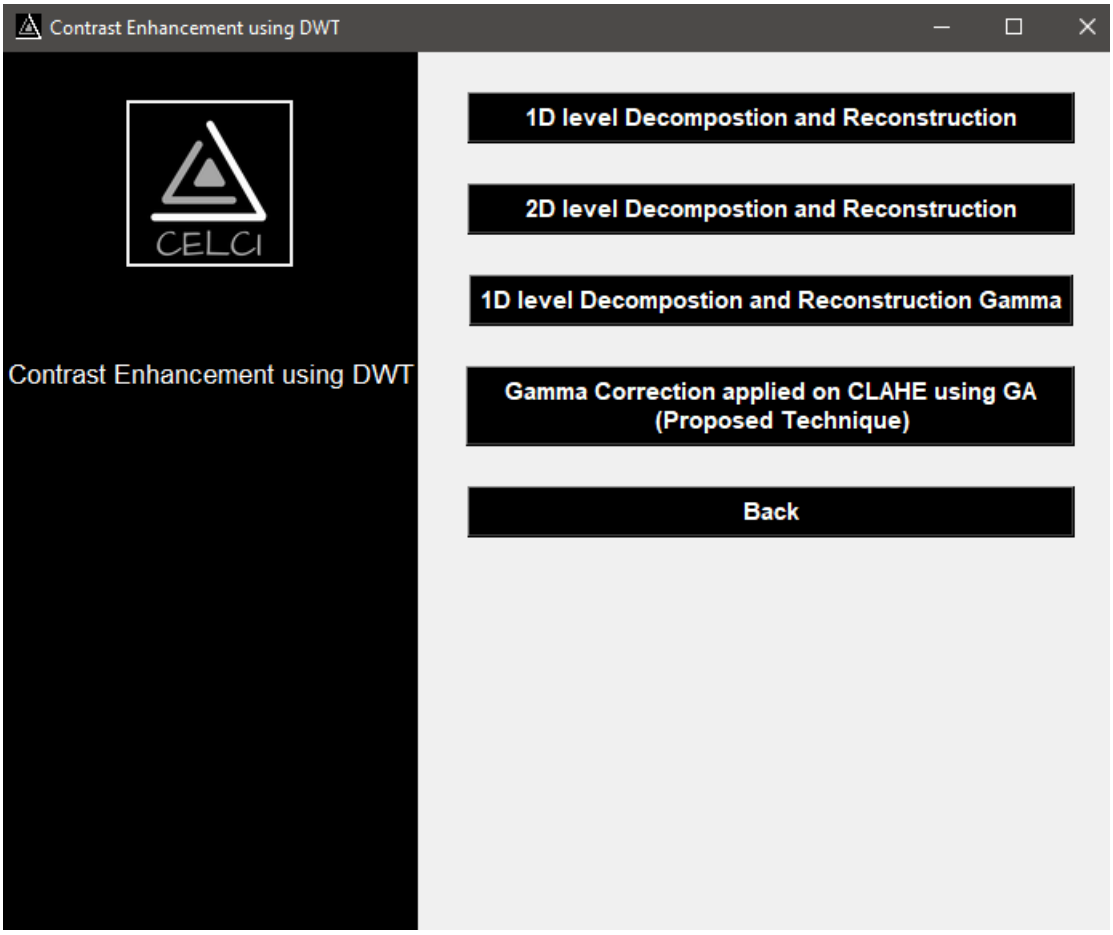

Figure 3.3 Contrast Enhancement using DWT - Window

3.5 Data model (ERD)

ERD is not applicable for our system, because our system doesn't contain a database.

3.6 Activity Diagram

As our development approach is structural, the activity diagram is not applicable to our system.

3.7 State transition diagram

As our development approach is structural, the state transition diagram does not apply to our system.

3.8 Data Flow Diagram Level 0

The following figure 3.4 representing DFD level 0

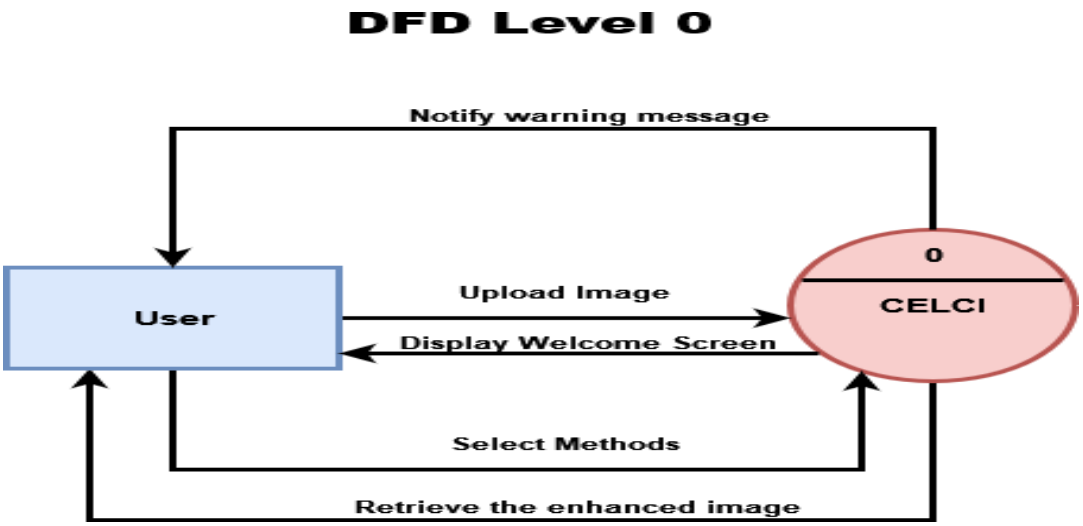

Figure 3.4 DFD Level 0

3.9 Data Flow Diagram Level 1

The following figure 3.5 representing DFD level 1

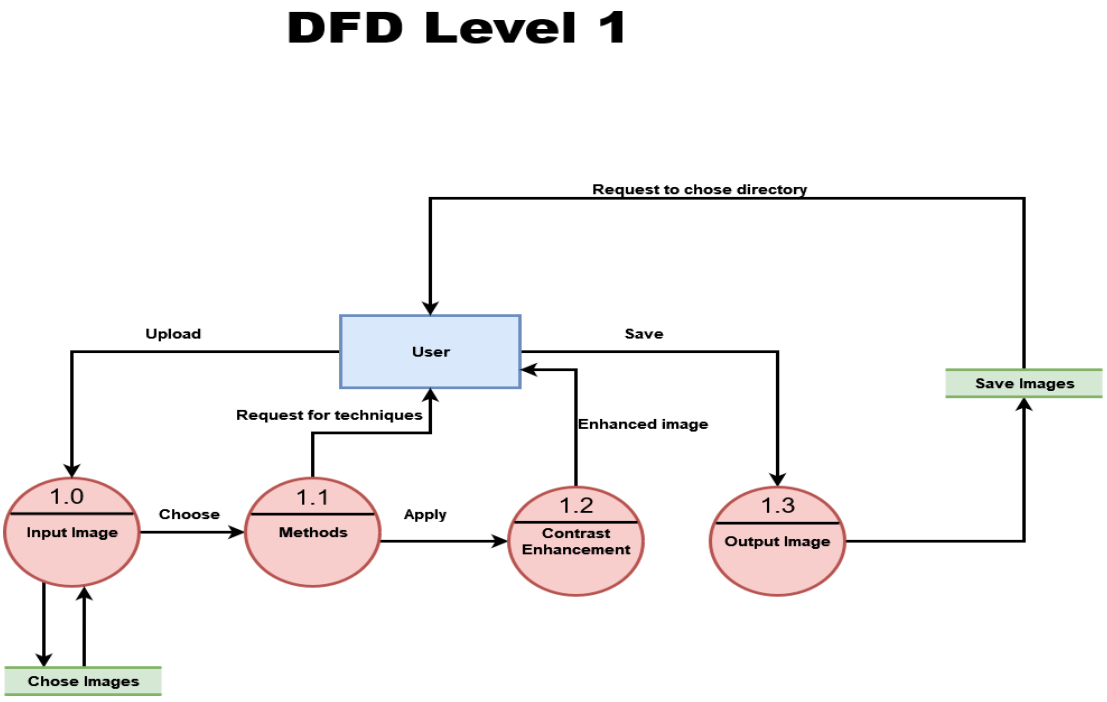

Figure 3.5 DFD Level 1

3.10 Data Flow Diagram Level 2

The following Figure 3.6 representing DFD level 3

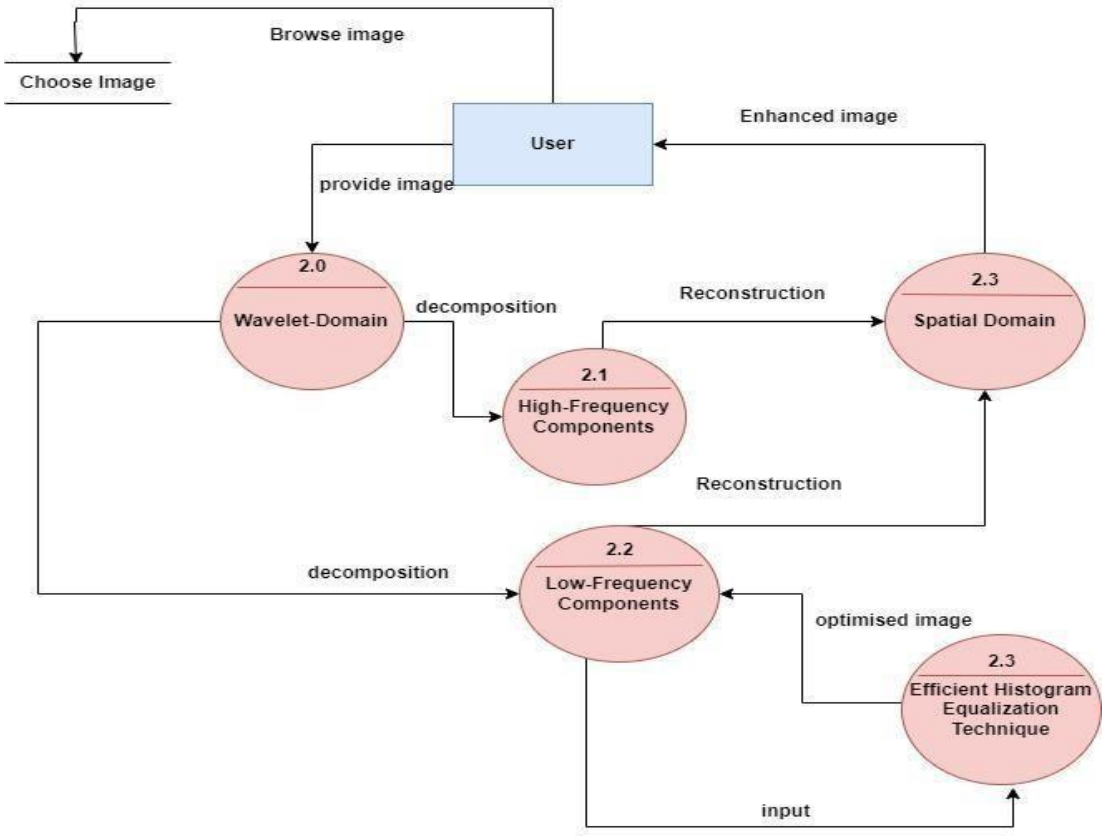

Figure 3.6 DFD Level 2

3.11 Non-functional requirements

Non-Functional Requirements are the constraints or pre-requisites that are imposed on the system.

3.11.1 Performance Requirements

The system must be interactive, and the time delays must be minimal. As a result, there are no instant delays in any system action-response.

3.11.2 Response Time

1. The response time of the user interaction with buttons to perform actions (opening of file directory, popping any error message, moving to the next page) must be equal to 1 second.

2. The system should not exceed the time limit of 2 seconds to display the enhanced image.
3. Enhanced image can be saved in the file with 0.5 seconds of response time.

3.11.3 Safety Requirements

1. The user must save the image before closing the application if a user didn't click on the save button then the enhanced image will be lost.
2. It is advised for the users to must have a system with a Graphics Card and a minimum of 6 GB RAM to use the application smoothly and effectively.
3. User must input a gray-level image (Black and White image) for the enhanced results, if a user tries to enhance a colored image, a warning message will pop up the user.

3.11.4 Security Requirements

Access permissions for the particular system information may only be changed by the system's data administrator just to make the application away from the hackers or attackers.

3.11.5 Availability

If the colored image is inserted the application will display a warning box to the user for Converting an input image to a black and white image that is where system availability is ensured for the user, and the image still will be enhanced.

3.11.6 Correctness

The image should be correctly selected by the user. If the image size is too large or small, then it is the responsibility of the application to change the size of an image correctly.

3.11.7 Flexibility

The system should be flexible enough to allow users to select, save, and compare the enhanced image.

3.11.8 Reliability

As the system provides the right tools for discussion and problem solving, it must be made sure that the system is reliable in its operations and for securing the sensitive details and allowing users to save images before closing the application.

Chapter 4

DESIGN SPECIFICATIONS

4.1. Introduction

In this chapter, a brief explanation of the system design will be given. A design specification describes the detailed operation and attributes of a system and is used as the basis of the design concept. This design is based on analyzing and concluding the facts on during research phase.

4.2. System Architect

A system architecture consists of system components and the sub-systems developed, that will work together to implement the overall system. The Architecture of the CELCI System has been divided into modules that are interlinked with each other. An image is decomposed into *low-level* frequency components and *high-level* frequency components. *Low-level* frequency components help our system to control the over-enhanced artifacts and on the other hand, *high-level* frequency components are kept constant to reduce noisy details of the original image. Then *high-level* frequency component will be merged with the *low-level* frequency component to form an image, here the image is in the frequency domain, and it will be converted back to the spatial domain image by applying reverse DWT. The system is designed in a way that, image details should be preserved.

4.3. Design Methodology

The system is designed in python language by using the Structural approach. As our development approach is structural, UML diagrams are not intended for our system. Our system is based on the desktop application, and it will allow the users to input the image, then they will get the enhanced image which will be more appealing than the original image. We have used tkinter for the graphical user interface in our system.

4.3.1 Tools and Technologies

Tools and Technologies that are used:

1. Python
2. Image processing libraries (Opencv, Skimage, PIL, Numpy, Pywt)
3. Visual Studio Code
4. Tkinter

4.3.2 Design and Implementation Constraints

1. Since it is a Desktop-Application based system it will require a personal computer.
2. The system will only be applicable for the Gray-level images
3. Since it is the project in the domain of image processing, it is recommended for the users to must have the system with a Graphics Card and minimum of 6 GB of RAM to use the application smoothly and effectively

4.4. High Level Design

High-level design explains the architecture that would be used for developing a software product. It is covering the architecture of the system and explains how the system and the related modules work. It is helpful for both the client and the developer for understanding the functionalities of the system. Figure 4.1 shows block diagram

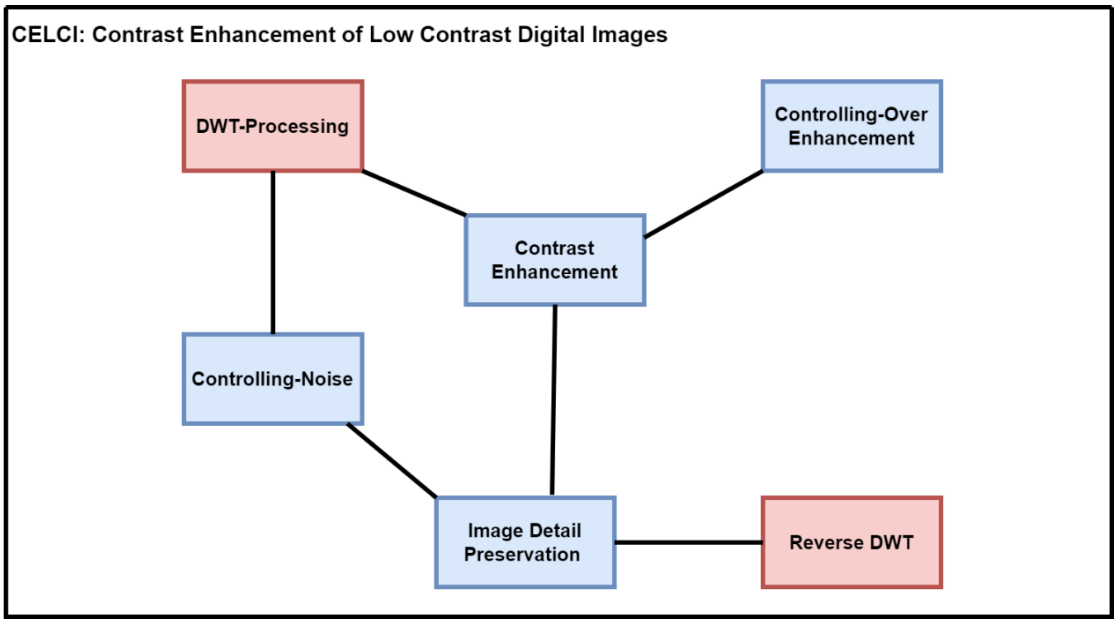

Figure 4.1. Block Diagram

4.5. Data Design

Data Design is the first design activity in the process. During this design, Data types are specified along with their integrity, rules, and constraints. The system is designed in a way that it doesn't contain databases, so ERD is not applicable in our system.

4.6. Detail Design or Interaction Diagram (Sequence diagram or Collaboration diagram, Package diagram)

As our system development approach is structural, so all these mentioned diagrams are UML diagram that is not intended for our system.

4.7. Class Diagram

As our system development approach is structural, the class diagram is not applicable for our system.

4.8. Deployment Diagram

As our system development approach is structural, the deployment diagram is not applicable for our system.

Chapter 5

TESTING SPECIFICATION

5.1. Introduction

This chapter contains an overview of the different testing that has been performed on the system. This includes white-box testing, black-box testing, the interface test, etc. All these types of testing contain various types within them, and we will perform some of them on the system.

5.2. Test Design

Test design is an act of creating and writing the test suits for testing the software. The purpose to use the test design for the test case is to assure whether the system is performing all the functionality, and the obtained result is correct according to our assumptions or not. It requires a detailed analysis and understanding of the requirements.

5.2.1 White Box Testing

White box testing is a technique to test internal functionality and whole code thoroughly. This testing is performed to find all logical errors, bugs, or any loopholes in the system. The primary focus in white box testing was to verify the flow of inputs and outputs of results were compared against criteria. This testing technique also helped us improve designs and strengthen security.

5.2.2 Black Box Test Cases

Black box testing is a technique that is used to test the system without knowing its internal functionality, code structure, or the implementation details. The black box testing tests how the system works for an end-user. The following are the test designs for black-box test cases, created as per the functionality of the system. The internal structure of code is not been used for test case design.

Table 5.1. Test Case 1

TC-ID	TC:1.0
TC-Name	Image Identification
Purpose	To check the detection of RGB image
User-Input	The user inserts RGB format
System-Output	The system gives an error that the image is in RGB format
Expected Result	The system gives an error that the image is in RGB format
Created By	Ahmed Ali Khan
Executed By	Ahmed Ali Khan
Date	19th March,2022

Table 5.2. Test Case 2

TC-ID	TC:2.0
TC-Name	Image Format Conversion
Purpose	To check the conversion of RGB images into Gray-scale
User-Input	The user clicks on the yes button for the conversion
System-Output	The image is successfully converted into Gray-scale
Expected Result	The image is successfully converted into Gray-scale
Created By	Ahmed Ali Khan
Executed By	Ahmed Ali Khan
Date	19th March,2022

Table 5.3. Test Case 3

TC-ID	TC:3.0
TC-Name	Contrast Enhancement
Purpose	To check the techniques of image enhancement
User-Input	User clicks on different enhancement techniques.
System-Output	The enhanced image is shown successfully.
Expected Result	The enhanced image is shown successfully.
Created By	Ahmed Ali Khan
Executed By	Salaar Imran
Date	19th March,2022

Table 5.4. Test Case 4

TC-ID	TC:4.0
TC-Name	Storing/Saving of image
Purpose	To check the enhanced image-saving functionality
User-Input	User saves the image in their files
System-Output	The image is saved successfully
Expected Result	The image is saved successfully
Created By	Salaar Imran
Executed By	Obaidullah Chaudhry
Date	19th March,2022

5.2.3 GUI test cases

In software engineering, GUI testing is the process of testing a product's graphical user interface (GUI) to ensure that it meets its required specifications and designs. It is the testing of the product's User Interface (UI), its size and different sections of the screen, and whether the font is readable or not. Following figures showing all the interfaces starting from (5.1 Main Menu – 5.5 Qualitative Measures).

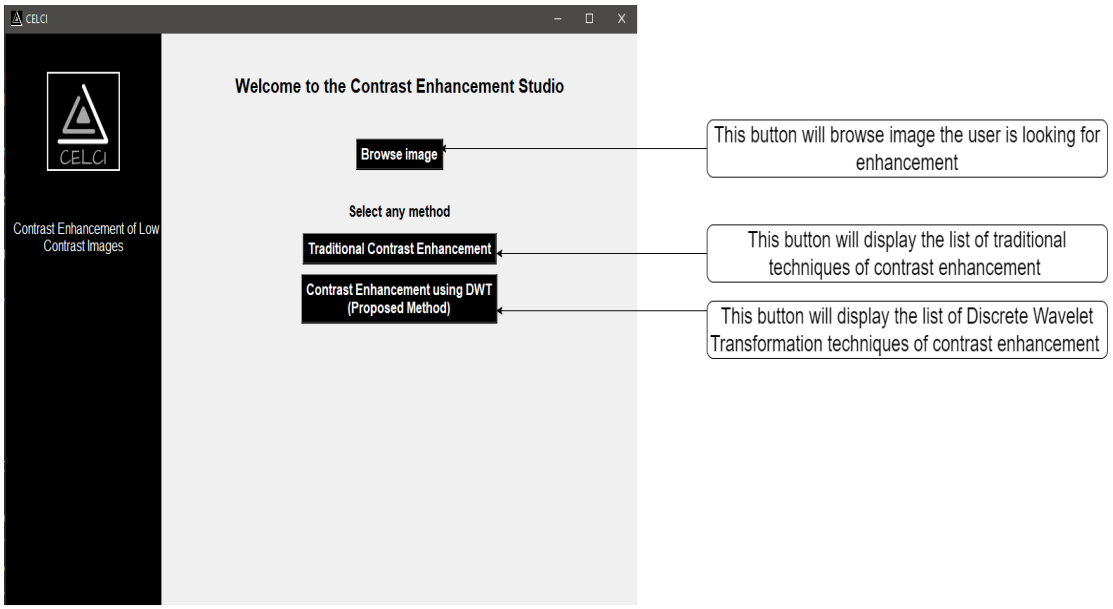

Figure 5.1 Main Menu – UI

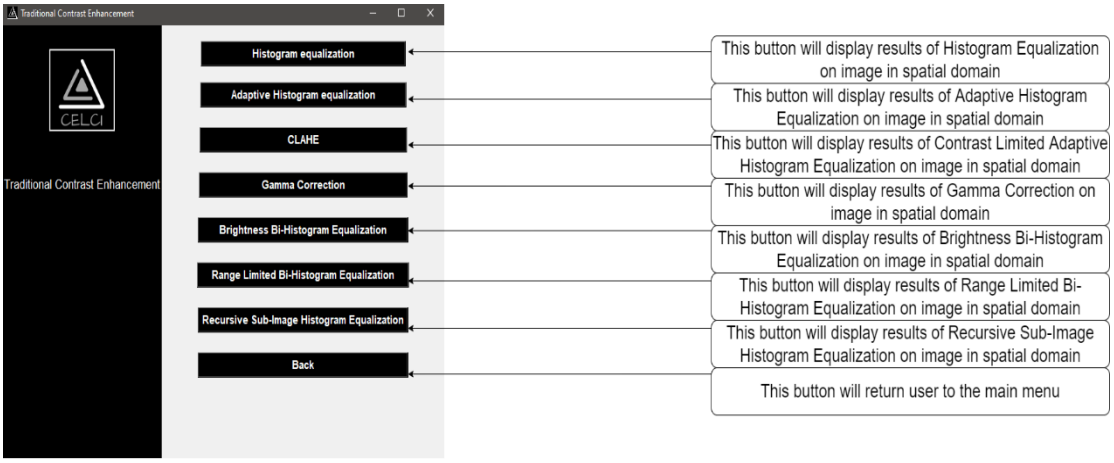

Figure 5.2 Traditional Contrast Enhancement – UI

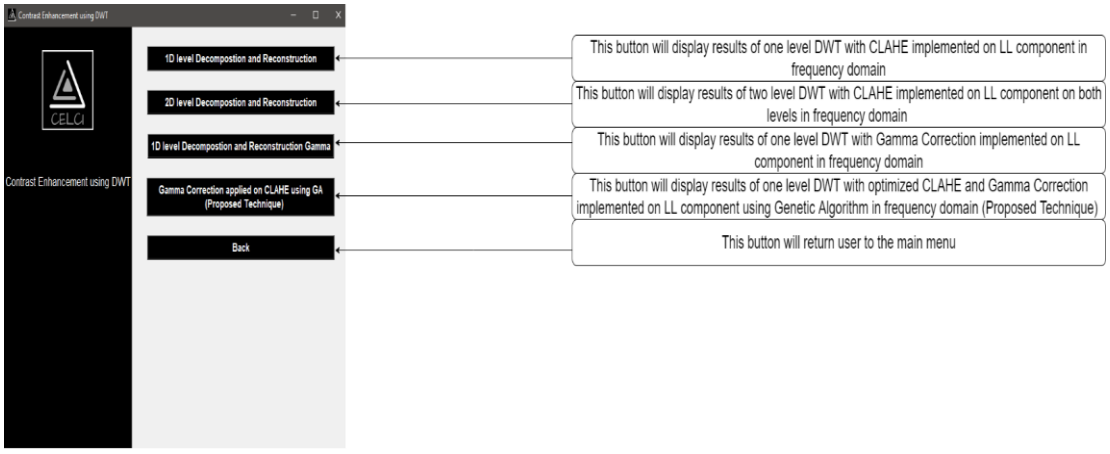

Figure 5.3 Contrast Enhancement using DWT – UI

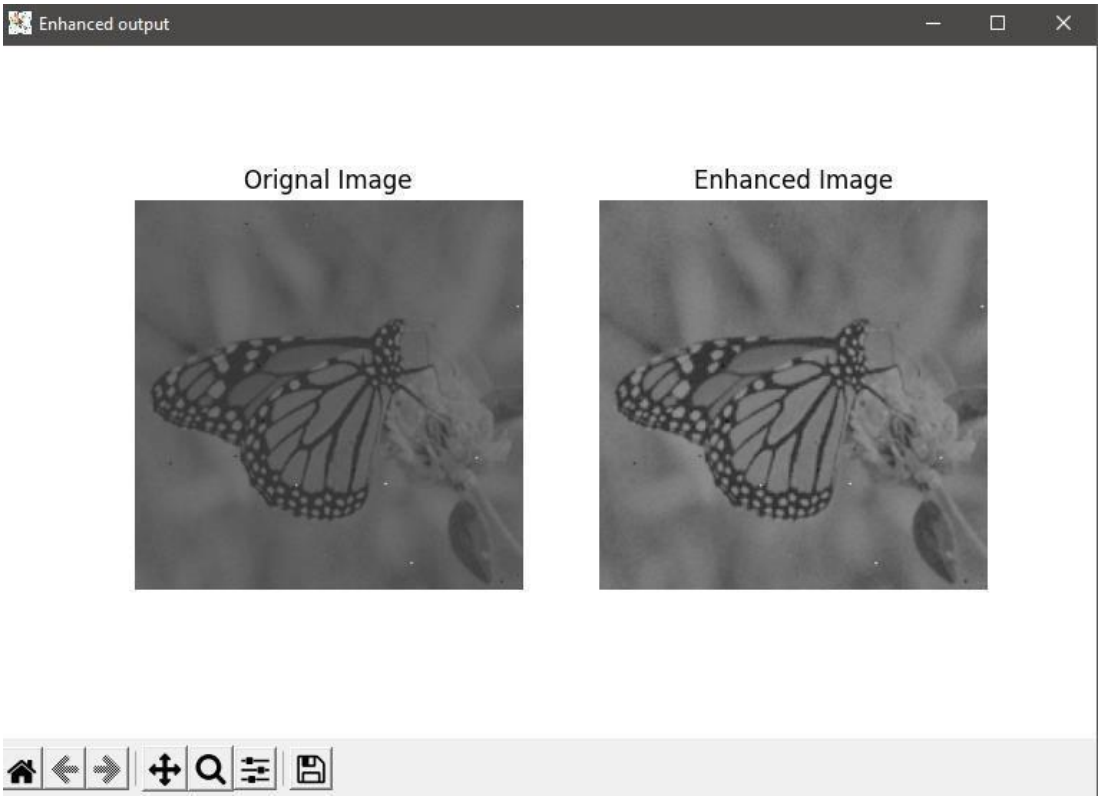

Figure 5.4 Enhanced Output – UI

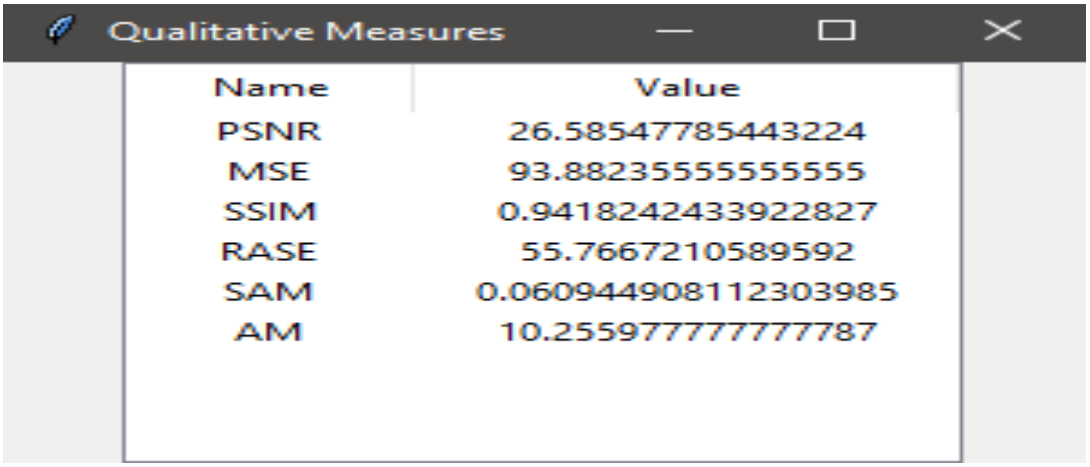

Figure 5.5 Qualitative Measures – UI

5.2.4 Other NFR test cases

This testing is a specification of the other inputs, implementation requirements, testing process, and expected results that define a single test to be implemented to achieve a particular software testing Objective, such as to exercise a specific program path or to verify compliance with a particular requirement. Given below are some non-functional testing of the system.

5.2.5 Usability testing

After the implementation, we test the usability of the system. The interface of the system was tested by multiple individuals and the results turned out successful. The users understood the working of the system and were able to use it with ease.

5.2.6 Software performance testing

When each module is complete and ready for testing, then performance testing for the system will be done. Firstly, the performance of each module will be done separately, then in collaboration with other modules, the performance of the overall system will be evaluated based on the time needed to get the results and display them.

5.2.7 Compatibility testing

Compatibility testing is non-functional testing conducted on the application to evaluate the application's compatibility within different environments. Our Desktop application is only compatible with Windows 10 operating, as the software is made on that platform which supports most of its libraries. It can be of two types – forward compatibility testing and backward compatibility testing.

1. Operating system Compatibility Testing - Windows 10
2. Platform Compatibility Testing – Visual Studio Code

5.2.8 Load testing

Load testing means testing the system under excessive load, to check its performance in critical situations. As our Desktop application is easy to use, the user needs to insert the picture to get the enhanced image, so there is no excessive load in our system.

5.2.9 Security testing

The goal of system testing is to detect faults that can only be exposed by testing the entire integrated system or some major part of it. System testing is mainly concerned with areas such as performance, validation, security, stress, and configuration. System testing focuses on function, performance, reliability and how the particular installation is done.

5.2.10 Installation testing

Most application systems have setup processes that are needed before they may be used for their principal purpose. Testing these processes to achieve an installed software system that could be utilized is called installation testing. These procedures might involve partial or full upgrades and install/uninstall procedures.

5.2.11 Acceptance test cases

Software acceptability is that there a system is tested for acceptability. The purpose of this test is to assess the system's compliance with all the business requirements and evaluate whether it is acceptable for delivery.

5.3 Defect or Bug sheet

The defect is defined as a deviation from the expected and actual result of the application. It is also defined as the irregularity from the specification as mentioned in the product functional specification document. Defects solved by the developer in the development phase.

5.4 Test report

It's a document that records data obtained from a test experiment in an organized manner, describes the environmental or operating conditions, and reveals the comparison of test results with evaluation objectives. Given below is the table of test verified test cases.

Table 5.5. Test Report

Testing Activity	Count
Test Executed	**10**
Tests Passed	10
Test Failed	0
Pending	0
In Progress	0

5.4.1 Summary of test report

The objective of this report was to tell that the performance of the software system meets all the requirements. All modules have been successfully tested in the first phase there are no pending, in progress, blocked, or deferred test cases in our test report.

Chapter 6

CONCLUSION

6.1. Introduction

In this chapter, we provide an ending and conclusion to all the work that we have done. This chapter is about an overall summary of a project that all information that we have gathered during research and implementation work It also mentions future work that can enhance the usability and benefits of this system.

6.1.1. Overview of the Project and Product

Contrast Enhancement for Low Contrast Digital Image is a desktop application that works on the system and principles of Discrete Wavelet Transformation (DWT). The traditional contrast enhancement techniques enhance the image with a noisy and over-contrasted appearance. Previous histogram equalization techniques did not work on the principles of DWT. However, we have proposed a hybrid method for contrast enhancement to preserve the details of an image. The image is decomposed into a wavelet domain that divides the image into 2 components i.e high-level frequency components (HL, HH) and low-level frequency components (LH, LL). The LL component is an approximate image to the input image used for the contrast enhancement. The rest of the components have noisy details which are kept constant. The LL component will be taken as an input image for enhancement. Then enhanced LL component is integrated with LH, HL, and HH components. The reconstructed image is then brought back to the spatial domain by applying inverse DWT. The output is an enhanced image with better visual perception than existing techniques. The intended system is generic and can be used easily by any person with basic knowledge of the computer system. The system will allow the user to input the image then they'll get the enhanced image without noise enhancement and it will be more appealing than the original image. So, the only requirement for the user is to input the desired image.

6.1.2. Contribution and Originality

Our contribution to the system is valuable as we have come up with an idea that was not implemented and the proposed technique is introduced for the contribution of contrast enhancement. It is observed that the proposed method enhanced the image without enhancing the noise which was a problem in the existing techniques. In existing techniques, we analyzed that with the enhancement of pixels the noise is also enhanced. The solution for noise preservation is to decompose the image using DWT.

6.2. Conclusion

The development of the CELCI was a great challenge for us. But with the grace of ALL MIGHTY ALLAH, the system would prove to be a great success INSHALLAH and the end-users all across the world would hugely benefit from this system and enhance their pictures according to the requirements.

6.2.1. Benefits

The basic advantages of our system are:

1. Easy to use.
2. Image details preserved
3. Enhanced image had better visual quality than the original image
4. Different methods are given for the users

6.2.2. Limitations

The Limitations of our system are:

1. Since it is a Desktop-Application based project it will require a personal computer.
2. The system will only be applicable for the Gray-level images.
3. The system will not be applicable for the enhancement of the video.
4. Since it is a project in the domain of image processing, it is recommended for the users to must have the system with a graphics card and minimum 6 GB of RAM to use the application smoothly and effectively.

6.3. Future Work

For now, the system only operates for gray scale level images but in the future, there is expansion of the same techniques on RGB or colored images as well. We will expand our work to process real-time videos. This will make the system more beneficial for the domain experts.

Appendix – Installation Manual

Step 1: User is required to open the rar file of CELCI.

Screen:

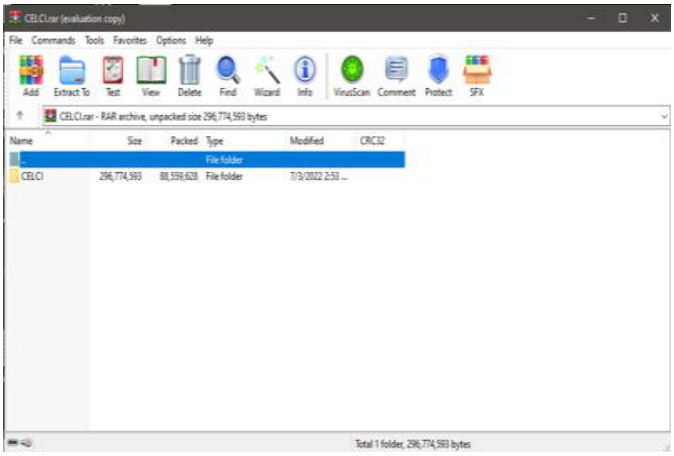

Figure 5.6 RAR File of CELCI

Step 2: After opening the rar file, then user needs to select the destination path to extract the files including exe file of CELCI.

Screen:

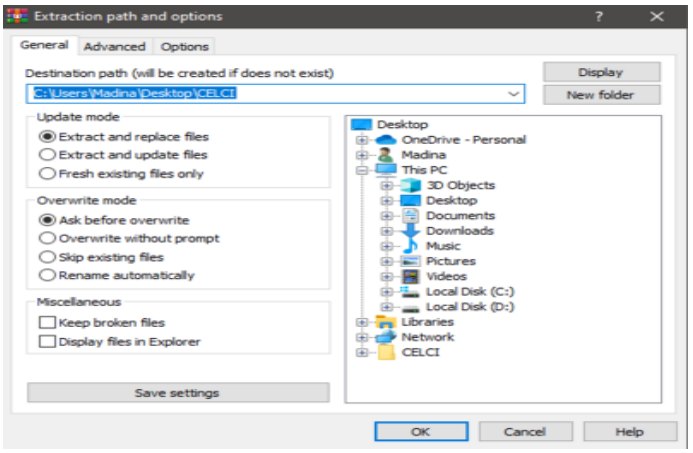

Figure 5.7 Extraction of files

Step 3: Once the files are extracted using WinRAR, then the user is required to open the containing folder of files and search the exe file of CELCI.

Screen:

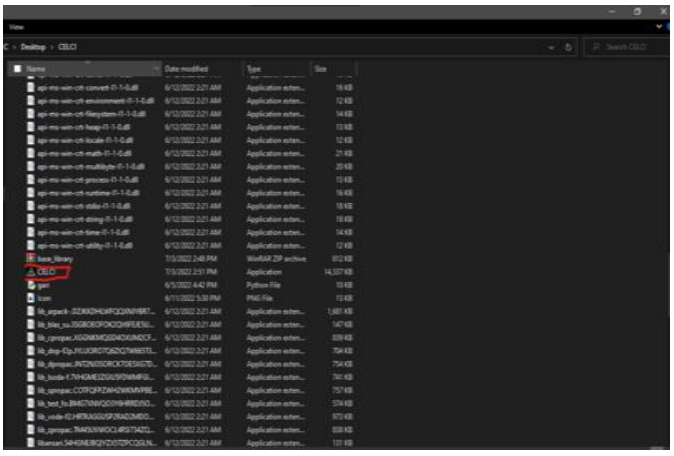

Figure 5.8 Searching of CELCI.exe

Step 4: CELCI exe file with the logo, should be selected by the user to run the application successfully.

Screen:

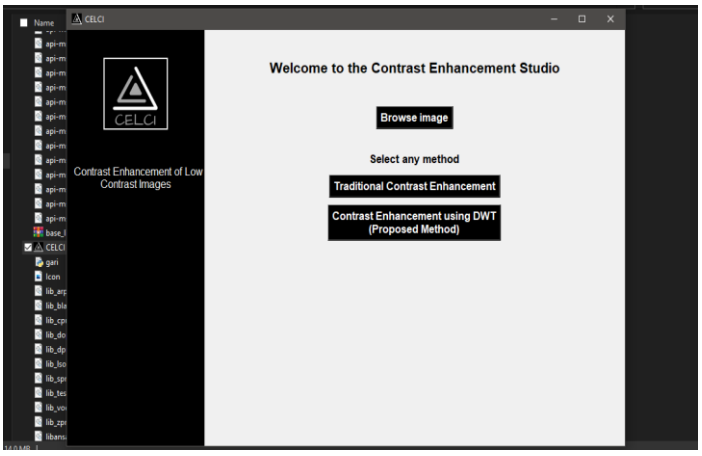

Figure 5.9 Opening of CELCI.exe

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