Image Fusion Technique Implementation Using FPGA for Telemedicine Application

A Project Evaluation Report

B.Tech

in

Electronics and Communication Engineering

By

HARSH MISHRA (Roll No:-18010212)

To

Dr. Gaurav Saxena,Assistant Professor

ELECTRONICS AND COMMUNICATION ENGINEERING
Indian Institute of Information Technology Senapati, Manipur
Imphal, India - 795002

Dec 2021

BONAFIDE CERTIFICATE

This is to certify that the project titled **Image Fusion Technique Implementation Using FPGA for Telemedicine Application** is a bonafide record of the work done by

HARSH MISHRA (Roll No:-18010212)

in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics and Communication Engineering** of the **Indian Institute of Information Technology Senapati, Manipur**, during the year 2018-2022.

PROJECT GUIDE	**DEPARTMENT HOD**
Dr Gaurav Saxena ,Assistant Professor	Dr. RC Mishra,Assistant Professor

Project Evaluation held on **9 DEC 2021**

Dr. Nagesh ch.,Assistant Professor

Dr. Murli Manohar,Assistant Professor

Dr. subasit borah,Assistant Professor

ABSTRACT

FPGA Based Image fusion technique to analyze Medical images to diagnose various diseases. For medical diagnosis, Computed Tomography (CT) provides the best information on denser tissue with less distortion.

Magnetic Resonance Image (MRI) provides better information on soft tissue with more distortion. With different types equipment output medical images in clinical applications, the idea of combining images from different equipment become very important. Image fusion process is nothing but the integration of information from a number of registered input images without the distortion. Image fusion produces a single image by fusing information from a group of input source images together using either pixel, feature or decision level techniques. The fused image contains better information content for the scene than any one of the individual input images alone. The accuracy and overall detailed information of the image is increased. This system deals with the design of image fusion technique on FPGA using Discrete Wavelet Transform (DWT) technique. The system is then interfaced on FPGA with the help of Xilinx tool and that image is transferred to cloud using python scripting language and node MCU(optional).

Keywords :- Image Fusion ,DWT(Discrete Wavelet Transform), FPGA, MATLAB, Xilinx Vivado.

ACKNOWLEDGEMENTS

Dr Gaurav Saxena, Assistant Professor, Department of Electronics and Communication Engineering, for helping me and guiding me in the course of this project. Without his guidance, I would not have been able to get the idea of implementation of this project. His patience and genial attitude is and always will be a source of inspiration to us.

Dr. Ramesh Chandra Mishra, the Head of the Department, Department of Electronics and Communication Engineering, for allowing me to avail the facilities at the department.

I also thankful to the faculty and staff members of the Department of Electronics and Communication Engineering, my parents and my friends for their constant support and help.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Why we need Image Fusion?

As we know everyday the demand of high quality images wheather in terms of healthcare,photography,astronomy increases day by day.this problem has given a vital area of research to the researchers to improve the image fusion algorithm.image fusion topic is currently the hot topic in the field of research in last saveral years but still it requires very effective algorithm which is yet to be come.
Image fusion can be defined as the technique of blending two images or more images to generate a single fused image that is more clear and contains the more information that can be used for further processes or we can say that the fused image can be further used in the real time system such as its application in telemedicine,automobile,satellite communication etc.

1.1.1 Types of Fusion

1:- many images taken at different intervals of time to recognize the changes among the images is called as the Multitemporal fusion.
2:-the image acquired by varying the sensors is called as multimodal Fusion.
3:- Sensor which captures the images with different capturing points taken at similar instances is called as Multi-view fusion.

1.2 Levels of Image Fusion

there are mainly three levels of Fusion which are as follows:-
1:-Pixel-Level Fusion
2:-Feature-Level combination
3:-Decision-Level combination

1.2.1 Pixel-Level Fusion

it involves mix of the basis elements from numerous input images or simply two images or more combined to get the single informative image.

1.2.2 Feature-Level Combination

the feature sets originating from multiple originated sources are consolidated into a one feature set by the application of appropriate feature normalization, transformation, and reduction criteria.

1.2.3 Decision-Level Combination

it is also known as postdecision or post-detection fusion .merges the decisions for autonomous sensor detection/classification paths by Boolean (AND, OR,xor,xnor etc.) operators alternately via a heuristic score.
Here is an image of levels of fusion.

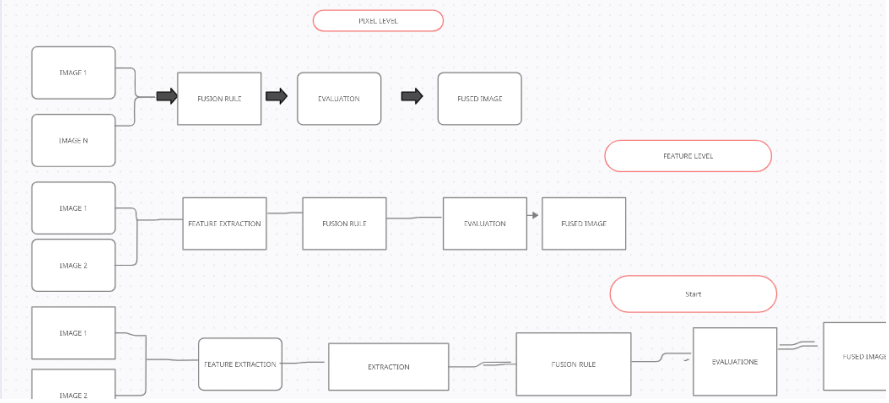

Figure 1.1: levels of fusion[1]

Pixel level image fusion uses various methods such as weighted average, Principal Component Analysis (PCA), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Stationary Wavelet Transform (SWT). The DWT method is important in an image fusion technique for its time frequency analysis. Wavelet transform fusion is defined as considering the wavelet transforms of two registered input images together with the fusion rule. The fused image is get back by taking inverse discrete wavelet trasform(IDWT).
The DWT combination methodology need less distortion for spectral feature. The features such as Critical sampling, localization and Multi -resolution will be provided for towards utilizing wavelet transform.Input images should be registered for fusion.

1.3 Image Fusion in Field of Helthcare

Since last few decades, with the introduction of these multisensory imaging techniques, image fusion has been an emerging field of research in remote sensing,

medical imaging, night vision, military and civilian avionics, autonomous vehicle navigation, remote sensing, concealed weapons detection, various security and surveillance systems applications.Now a days if we use these technology in terms of telemedicine for healthcare system then it can be quite beneficial for society and livings of people of the india.

There has been a lot of development in dedicated real time imaging systems with the high spatial, spectral resolution as well as faster sensor technology.my idea is quite different in terms of implementation on FPGA as well as showing the output of images or in medical terms we can reduce the cost of printing of Xray and MRI,CT scan,ultrasound of pregnent women. this technology helps people both in terms of cost and easyness. on the other hand in current scenario of covid we don't have to go to hospital again and again.

1.3.1 Block Diagram

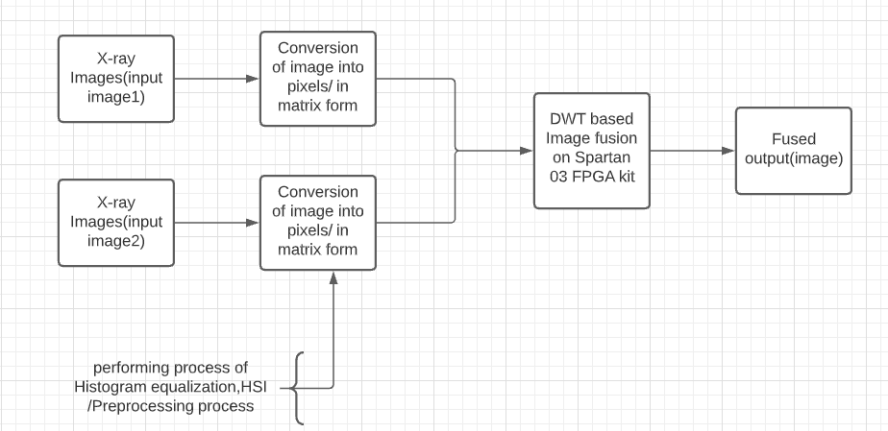

Figure 1.2: Stage-1 of system[1]

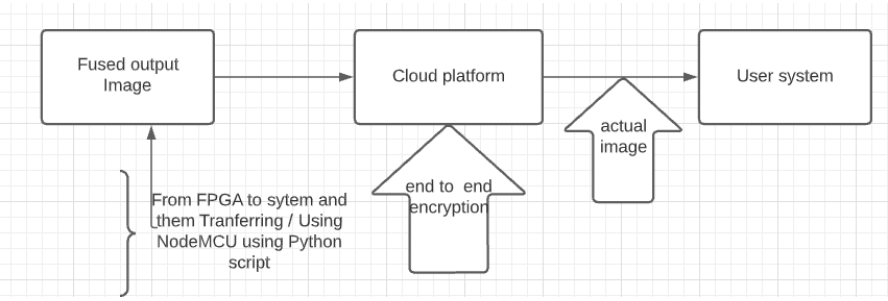

Figure 1.3: Stage-2 of system[1]

The block diagram shown above states that how the two images are fused together using Discrete Wavelet Transform (DWT) technique. The block diagram of the fusion system consist of images 1 and 2, DWT technique, Spartan-3E FPGA kit and fused image block.this whole consist of stage 1 of this system.

now the fused image can be send to the cloud application using scripting language and hence it can be restored by recepient system with their unique end to end encription.this whole process will come under the stage 2 of the system.

CHAPTER 2

Literature Work/Theory Involved

2.1 Preprocessing of Image

Pre-processing is a operations with which images at the lowest level of information and having very dull intensity is converted into required aspect ratio. In more simple words pre-processing is an improvement of the image data that remove the unwanted distortions .

2.1.1 Classification of Preprocessing of Image

Correction:-
there may be some defects in the images that should be corrected prior to feature measurement and analysis such as Sensor corrections,Lighting corrections,Noise, Geometric corrections,Color corrections.

Enhancements:-
Enhancements are used to rectify the measurement methods, rather than to fix problems. image processing enhancements include sharpening and color balancing.some examples of this are Scale-space pyramids,Illumination,Blur and focus enhancements.

Filtering:-
filtering is a special function used in preprocessing of image generally the low pass filter to remove the ringing effect. This effect is caused by distortion or loss of high frequency information in image.

2.2 Discrete Wavelet Transform

A discrete wavelet transform (DWT) is a transformation technique that decomposes a given signal into a number of sets, where each set is a time series of coefficients describing the time evolution of the signal in the corresponding frequency level.

The algorithm of image fusion using DWT described in the following steps
1. Size of inputs images:
Given a two dimensional images (example image 1, image 2) it is necessary to convert it into the same size a power of two square forms.
2. Computation of two dimensions DWT:
In this step, the two dimensional Discrete Wavelet Transform should be applied to the resized two dimensional images.
3. Fusion rule:
The most used of image fusion rule using wavelet transform is maximum selection, compare the two coefficients of DWT of the two images and select the maximum between them. While the lowpass sub band is an approximation of the input image, the three detail sub bands convey information about the detail parts in horizontal, vertical and diagonal directions. Different merging procedures will be applied to approximation and detail subbands. Lowpass subband will be merged using simple averaging operations since they both contain approximations of the source images.
4. Inverse discrete wavelet transforms:
After selected the fused low frequency and high frequency bands, fused coefficient is reobtained using the Inverse fast discrete wavelet transform (IDWT)to get the fused image which represent the new image.

2.2.1 Why DWT in Place of FFT?

Fourier Transmission (FFT) representations do not include local information about the actual signals. Although the DWTs can provide localization information, they do not provide flexible division of the time-frequency plane that can track slow changing phenomena while providing more details for higher Frequencies.

2.2.2 Theory and Mathematical Expression

There are two classifications of wavelets : (a) orthogonal (the low pass and high pass filters have same length) and (b) biorthogonal (the low pass and high pass filters do not have same length). Based on the application, either of them can be used.
Discrete Wavelet Transform (or DWT), is an orthogonal function which is applied to a finite data.The Discrete Wavelet Transform (DWT), which is based on sub-band coding is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required.

TWO DIMENSIONAL DISCRETE WAVELET TRANSFORM

$$\int_{-\infty}^{\infty} f(x) Z(\bar{a}, b)(x)\, dx$$

where the bar is the complex conjugate symbol and function Z is some function. The two dimensional discrete wavelet transform is essentially a one dimensional analysis of a two dimensional signal. It only operates on one dimension at a time, by analyzing the rows and columns of an image in a separable fashion. The first step applies the analysis filters to the rows of an image. This produces two new images, where one image is set or coarse row coefficients, and the other a set of detail row coefficients. Next analysis filters are applied to the columns of each new image, to produce four different images called sub bands. Rows and columns analyzed with a high pass filter are designated with an H. Likewise, rows and columns analyzed with a low pass filter are designated with an L. For example, if a subband image was produced using a high pass filter on the rows and a low pass filter on the columns, it is called the HL subband.

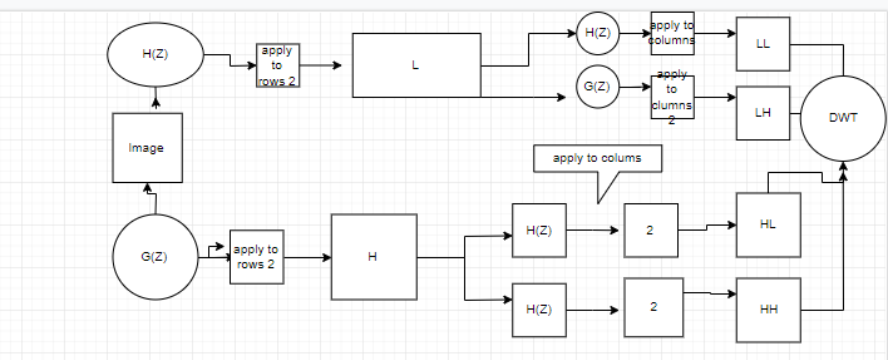

Figure 2.1: TWO DIMENSIONAL DISCRETE WAVELET TRANSFORM[1]

Each subband provides different information about the image. The LL subband is a coarse approximation of the image and removes all high frequency information. The LH subband removes high frequency information along the rows and emphasizes high frequency information along the columns. The result is an image in which vertical edges are emphasized. The HL subband emphasizes horizontal edges, and the HH subband emphasizes diagonal edges.

2.2.3 Why FPGA rather than Matlab Itself?

The hardware realization which is based on FPGA technology provides a fast, compact, and low power solution for image fusion.as we know in software we are using the floating point values suppose if we have to write 1 in two bit we can simply represent it as 01.if we want to implement in 8 bit we can simply represent

00000001. so in softwre we have to take floating point value which makes it slower as compared to FPGA. thats why we use FPGA for the image fusion rather than matlab.

2.2.4 Software Requirements

following are the softwares required for the testing and deployment of this project.

1:-MATLAB-Simulink Simulation

2:-Xilinx ISE Design Suite

3:-Cloud application model

CHAPTER 3

Problem Formulation

”In this chapter we express the working of our model and what previously researchers present their model and how my model is different from others.”

3.1 Past Models of Image Fusion

3.1.1 Image Fusion using Matlab

In this model of image fusion technique is implemented on the Matlab software.the idea is quite same the fusion of image takes lot of time as we have taken the example of floating point in software.
we know in software we are using the floating point values suppose if we have to write 1 in two bit we can simply represent it as 01.if we want to implement in 8 bit we can simply represent 00000001. so in softwre we have to take floating point value which makes it slower as compared to FPGA. thats why we use FPGA for the image fusion rather than matlab.

Drawbacks

1:- it is approx 10 times slower as comapred to FPGA based image fusion.
2:- Low power will also play a vital role in this model.

3.1.2 Image Fusion using FPGA

Now the researchers come with a idea of using FPGA rather than software(MATLAB). The resultant image is more reliable, clear and more realistic. Image fusion is giving a new image that retains the most accurate information and originality each input image. The fused image is generated to improve the image content and to make it better for the user to detect, recognize and identify targets.hence we can conclude that image fusion fpga is an good initiative by the researchers in the field image processing.

3.2 Proposed Model of Image Fusion on FPGA for Telemedicine Application

Now a days if we use Image Fusion technology in terms of telemedicine for healthcare system then it can be quite beneficial for society and livings of people .

=:-There has been a lot of development in dedicated real time imaging systems with the high spatial, spectral resolution as well as faster sensor technology.my idea is quite different in terms of implementation on FPGA as well as showing the output of images or in medical terms we can reduce the cost of printing of Xray and MRI,CT scan,ultrasound of pregnent women. this technology helps people both in terms of cost and easyness. on the other hand in current scenario of covid we don't have to go to hospital again and again.

3.2.1 Block Diagram

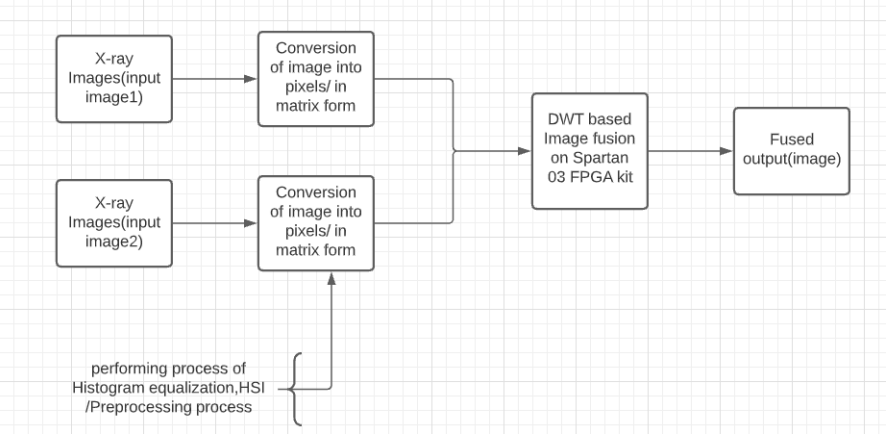

Figure 3.1: Stage-1 of system[1]

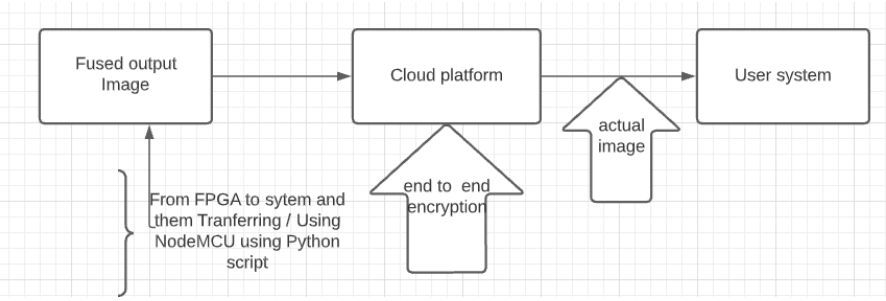

Figure 3.2: Stage-2 of system[1]

hence in this way there is quite good application of image fusion in field of telemedicine application.

CHAPTER 4

Progress work

4.1 Preprocessing of Image

Histogram Equalization

firstly the preprocessing of image is takes place.so here the first step i have done is Adjusting Intensity Values Using Histogram Equalization. here i have taken my own image which have some loss of information and i have applied the histogram equalization which is shown in the figure attached-

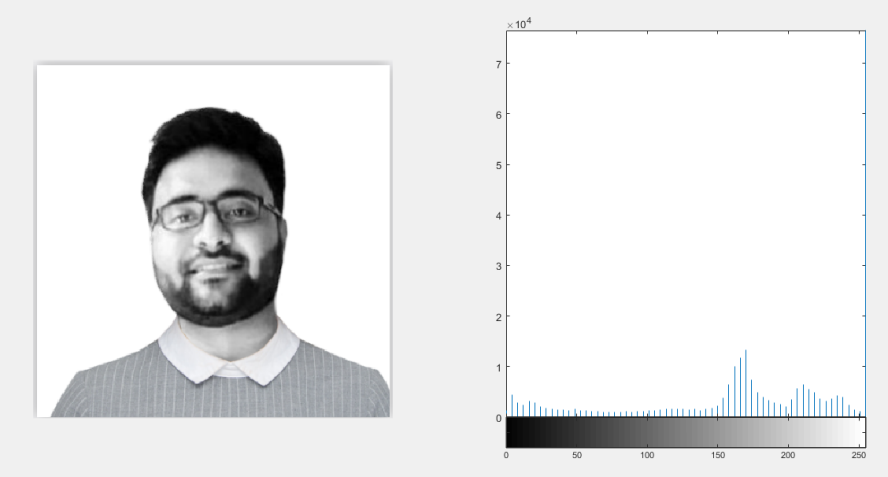

Figure 4.1: Histogram Equalization[1]

now In this example, the histogram equalization function, histeq, tries to match a flat histogram with 64 bins, which is the default behavior. You can specify a different histogram instead.
now here i am Displaying the contrast-adjusted image and its new histogram

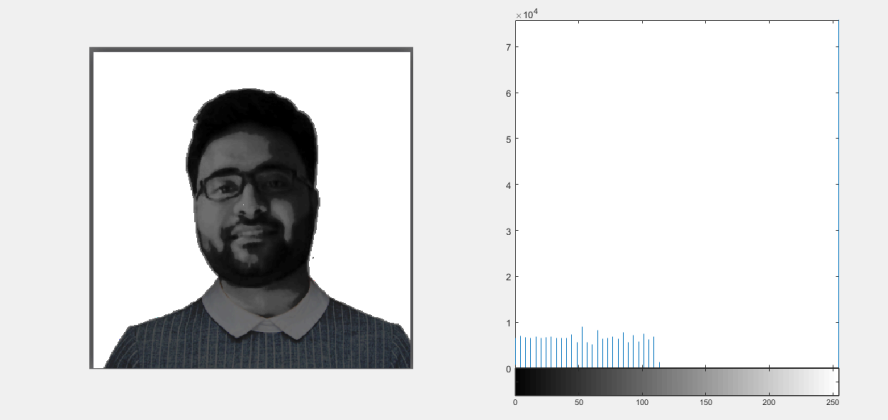

Figure 4.2: contrast version of Histogram Equalization[1]

so what is the exact path trace?

now here is the plot transformation curve of histogram equalization-

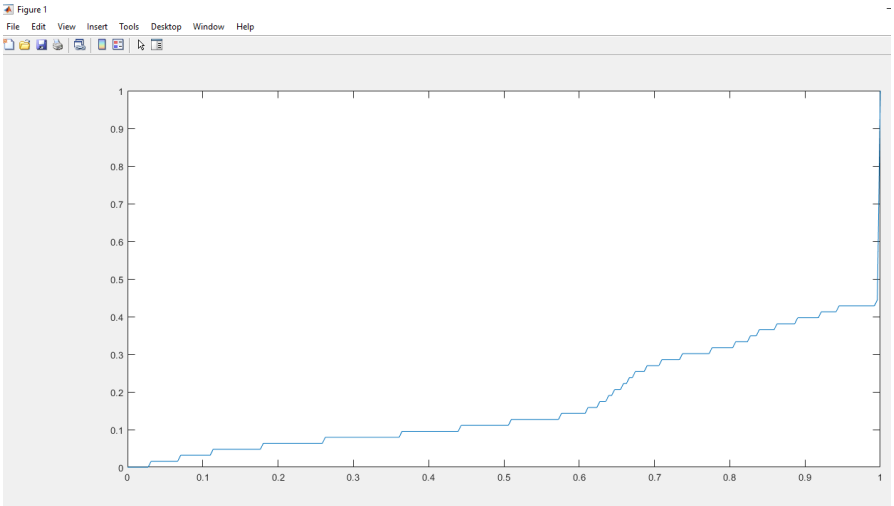

Figure 4.3: plot transformation curve[1]

Adjust Contrast of Grayscale Image Specifying Contrast Limits

Figure 4.4: plot transformation curve[1]

4.2 DWT Technique for Fusion

here i have formulate the algorithm in few steps which are as follows:-

1. Size of inputs images:

Given a two dimensional images (example image 1, image 2) it is necessary to convert it into the same size a power of two square forms.

2. Computation of two dimensions DWT:

In this step, the two dimensional Discrete Wavelet Transform should be applied to the resized two dimensional images.

3. Fusion rule:

The most used of image fusion rule using wavelet transform is maximum selection, compare the two coefficients of DWT of the two images and select the maximum between them. While the lowpass sub band is an approximation of the input image, the three detail sub bands convey information about the detail parts in horizontal, vertical and diagonal directions. Different merging procedures will be applied to approximation and detail subbands. Lowpass subband will be merged using simple averaging operations since they both contain approximations of the source images.

4. Inverse discrete wavelet transforms:

After selected the fused low frequency and high frequency bands, fused coefficient is reobtained using the Inverse fast discrete wavelet transform (IDWT)to get the fused image which represent the new image.

4.3 Transferring of Fused Image

after the Fusion on FPGA we have option of tranfer the images back to the sytem but the problem here arises only user in system can access the image.however i have proposed an idea to save this picture as library using cloud apllication this can be done using simple python script of transferring of images.there is security encription is there through which the person on the other system all over the globe(doctor in my case) can access the actual report.

CHAPTER 5

Future Work and Conclusion

Currently the researchers works in the field of application of image fusion on FPGA.however in the application of telemedicine we can expect the begining of virtual reality and extended reality.through these technology we are trying to give patient a feel that he is sitting next to the Doctor.however it will done with the help of parallel computing which is also a difficult task to manage.
sometimes telemedicine principally focuses on transmitting medical information, VR has the potential to enhance this function. Particularly, VR can be used in telemedicine as an advanced communication interface, which enables a more intuitive mode of interacting with information, and as a flexible environment that enhances the feeling of physical presence during the interaction.

5.1 Conclusion

through this technique the resultant image is quite accurate and more reliable,having the critical information can be analysed which is the main objective of telemedicine that is convenient and more accurate.through this the cost of printing of images can be reduced 20-25 percent.the application in the field of telemedicine is quite a novality of this project and it can be benefitted both the patient and doctor both in terms safety and convenience.
at last we can conclude that in todays time of covid this project has a very good scope in terms of deployment or for generalising it for defence activity in hill regions.

APPENDIX A

Code Attachments Of basic Functios

A.1 Adjust Intensity Values Using Histogram Equalization

```
clc;
clear all;
close all;
I = imread('Screenshot (279).png');
subplot(1,2,1)
imshow(I)
subplot(1,2,2)
imhist(I,64)
```

A.2 Matlab code for Morphological reconstruction

```
clc;
clear all;
close all;
I = imread('Screenshot (279).png');
imshow(I)
mask = adapthisteq(I);%contrast of the image to create the mask image
imshow(mask)
```

Bibliography

[1] Karishma C Bhataria, Bhumika K Shah, "A Review of Image Fusion Techniques", Proceedings of the Second International Conference on Computing Methodologies and Communication (ICCMC 2018) IEEE Conference Record 42656; IEEE Xplore ISBN:978-1-5386-3452-3.

[2] Smt G. Mamatha, Dr V. Sumalatha, Dr. M.V. Lakshmaiah, "FPGA Implementation of Satellite Image Fusion Using Wavelet Substitution Method", Science and Information Conference 2015 July 28-30, 2015 — London, UK.

[3] Manasa Pemmaraju, Sai ChandMashetty,SrinivasAruva,MohanshankarSaduvelly,Bharat BabuEdara, "Implementation of Image Fusion based on Wavelet Domain using FPGA", International Conference on Trends in Electronics and Informatics, ICEI 2017.

[4] KiranParmar,Rahul K Kher,Falgun N Thakkar, "Analysis of CT and MRI Image Fusion using Wavelet Transform",2012 International Conference on Communication Systems and Network Technologies.