NEAR INFRARED IMAGING FOR SUBCUTANEOUS VEINS LOCALIZATION USING WEARABLE OPTICAL IMAGING DEVICE

BY

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FINAL PROJECT REPORT

Submitted to Department of Electrical & Electronic Engineering in Partial Fulfilment of the Requirements for the Degree Bachelor of Engineering (Hons) (Electrical & Electronic Engineering)

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CERTIFICATION OF APPROVAL

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In partial fulfilment of the requirement for the Bachelor of Engineering (Hons)
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Approved:

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(Dr. Mohamad Naufal Bin Mohamad Saad)
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

September 2013

CERTIFICATION OF ORGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Mohd Khairul Bin Mohd Azam

ABSTRACT

Intravenous (IV) catheterization is a basic need for medical treatment. Skilled trained medical practices such as doctor, nurse or even paramedic need to learn as this their basic knowledge. To perform this treatment, they need to locate veins they can get by visual or feel it with their fingers. This technique has its own downside as sometimes different patient have differ skin tone and deepness of their veins. Sometimes patients also get scars or even some of them have thick hair. To attempt venipuncture, sometimes they need to repeat it two or three times if it does not succeed. This is due to non-visibility to locate patient's veins. This may result severe pain to the patient and leave a bigger impact to their health. These inaccurate catheter insertions need to be overcome with a device that can help medical practitioners to locate veins from patients easily and fast for venipuncture process. Today's technology give human to look through human's body but non of them have a capability to locate and display subcutaneous veins structure right in front of their eyes for a user to perform iv catheterization process. In this project, near infrared (NIR) imaging technique will be choose as it has several advantages in compared to the other technique.

ACKNOWLEDGEMENTS

First of all, I would like to give my gratitude to my creator, Allah S.W.T for His blessings and guidance to and inspire me on completing my final year project. Not to miss, I would like to give my gratitude to whom that has support and assist me on completing this project.

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On my journey becoming well-rounded student, I have been taught well on theories, sharpen my skills with hands on with well equip laboratory with expertise lecturers and lab assistant. All this complete set of educational input output based Universiti Teknologi Petronas especially Electrical and Electronic Engineering Department had been taught me to become a competent engineer.

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CHAPTER 1

INTRODUCTION

Background

Today's medical technique uses an invasive medication to take a blood sample or inject drugs through vein using venipuncture and IV catheterization technique. This entire task had to be done by a skilled trained who is qualified using naked eye or feel trough their finger to locate the veins. Human varies in different skin colour, depth of veins, hair and much more due to genetics and geological. Due to these factors, it will cause complication to the medical in charge and increase chances in bursting or veins damage resulting from increasing number of attempts. Studies show that patients that required IV medication receive 2.18 venipuncture on average [1]. This is a serious matter as patients come from various backgrounds. This might cause to needle phobia to the patient and some of the cases harm to the patient such as infant. Non-successful venipuncture may lead to swelling tissue around IV catheter. There is a need for a new technology that integrates with a device that can allocate veins for medical staff. A device that is built to snap an image for veins, reconstruct it and display to the user with high contrast will serve the purpose. Science had put a few steps forward towards medical world. Some examples device that has been capability to visualize internal organs such as in table 1 below:

Ultrasound	Ultra-sonic based technology to visualize internal organ of a human body. This medical imaging technique use echoes same as bats and dolphin to gain information.
Magnetic resonance imaging (MRI)	By combination of magnetic field and pulses of radio waves, MRI can generate diagram of internal structure of a human body in detail. Images are much more precise than a possible x-ray can do.
Positron emission tomography (PET)	Using nuclear medicine imaging techniques, it create 3D image inside body.
Computed tomography (CT Scan)	It uses x-ray to produce images inside human body

Table 1 Different type of Devices to locate human's internal organ

Device shown are used to analyse deep vascular system and internal human organs. In addition, it is bulky, expensive and time consuming which is not suitable for simple venipuncture or IV cauterization process.

Objectives

There have been some studies to locate user's subcutaneous veins. A development of NIR range imaging by Vincent Paquit et al, and suggest an idea for automatic catheter insertion by computing 3D path for needle [2]. The experiment that they have done in [3] to localize the best NIR wavelength as optimization for physiological differences such as skin tone, hair and skin properties. In this project, author use previous research as a base to improve the system to make it portable, user friendly and efficient for a medical practice to trace subcutaneous veins localization. It is a need to implement in medical sector. Author will focus on develop a portable automatic detection for the best veins selection using optimum NIR illumination to overcome various skin tone problem from a patient using wearable optical device. Specifically this study aims to:

- To design and develop optical system for subcutaneous veins imaging.
- To develop the efficient algorithms for veins and skin contrast enhancement.
- Collecting samples and testing algorithms.
- Implement display on wearable optical system.

The significant of this project is to facilitate medical practitioners finding veins in IV catheterization process for further medical treatment.

Problem Statement

Medical is important in daily life. It has improved from time to time. In medical sector, venipuncture and IV catheterization technique is a fundamental to a medical staff. As population grows, the needs for better medical practices highly demand. Studies have shows that there is always room for human error in venipuncture [1]. Injuries should be kept to minimize as possible in treat patient.

Genetics and their way of life has made human variety in color, skin thickness, hair and some of them might have scars due to accident. Due to these factors, it is hard for venipuncture and IV catheterization to be done. It is highly needed for a new device that can mount on user head as an optical device and display to a user subcutaneous major veins in front of the user that undergo IV catheterization process.

It is a major success in medical world if we can implement this technology to minimize human mistake and ease them during IV catheterization process.

Significant of Project

The aim of this project are to built a bench-top optical system for us to collect samples from a variety of candidates as their skin tone varies from one and another. Samples can be used for further studies and been analysed on their skin colour, thickness of hairs and some of them might have a scars. From there, algorithm can be created to enhance the image and produce the consistent outcome. Thus this will give a solution to the problem that had been faced by medical practitioners on performing manual venipuncture and IV catheterization technique.

The algorithm will give a solution to the medical world, as it does a real-time image processing and give output to the user. At the same time, this will reduce accident that might occur during venipuncture. Indirectly, this will reduce time consumption for paramedics to perform IV catheterization technique and save a cost for a patent to undergo further treatment if accidents occur.

Scope of Study

The main objective to archive in this project is:

i. Built up a bench-top for optical system for subcutaneous veins imaging in collecting samples.

ii. Understanding a Matlab algorithm for image processing for veins localization.

iii. Implementation new algorithm for wearable optical system

Relevancy of the Project

My studies in Universiti Teknologi Petronas had given me enough knowledge in dealing with image processing. A lot had been taught for four years including image processing that include in my syllabus of learning outcome. Knowledge in Matlab can be implemented in this project and sharpen my skill and knowledge in this software. Besides that, to tackle in real word situation need me to understand on time management, cost that need to take count of to accomplish this project. All this had been taught during my studies. This project taught me on how to be critical and creative thinking that can be applied in real world engineering solving problem.

Feasibility of the Project

This project can be divided into three aspects on feasibility, which are technical aspects, time and economic. Technical aspect of feasibility is to define the workability by considering the knowledge that can be applied throughout the learning process in accomplishing the project. As for example, literature review was conduct to ensure that the best approach to be used in solving and creating algorithm in veins for Matlab. For the software that had been used, it can be copied and install from Universiti Teknologi Petronas library. Hence, it is considered as feasible in technical, time and economic aspects.

CHAPTER 2

Literature Review

Gaining intravenous IV access required experience by professional such as paramedics, doctor, and nurses. It is an essential technique in medical world. Indeed the procedure looks simple, but it requires experience and a lot of hours in practices to perfect. According to Hershey et al in [4], this practice had been taught since 1628. Traditionally this process use naked eye and bare hand to feel the subject's vein.

Nowadays, a lot of research had been done regarding this problem. Options for localization for subcutaneous veins had been narrow specifically into three techniques that are NIR imaging, Transillumination and Photoacoustic technique [5]. All this methods have its own pro and cons.

Transillumination is a technique that uses a visible light to illuminate target's sample. In this method, it requires a user to apply the device directly on the patient's skin. It becomes a major drawback in this method because germs can be transmitted through a direct contact between patient and device to another patient. This require user to clean the device thoroughly every time it need to be used. Not only time consuming, it is costly as well. According to [5,6,7] single visible wavelength are not enough to penetrate deep skin tissue in localization vein process.

In obtaining an image for vein vessels, Photoacoustic use ultrasonic wave and non-ionizing laser pulses. This technique has its own limitation that is, unable to provide orientation of the object as stated in [8,9,10] and only provide limited imaging depth and diameter. This technique is really sensitive to chaos wave and tends to generate noise in terms of echo signal. This problem significantly reduce signal to noise ratio.

VeinViewer is an example of some devices that had been around to be used for subcutaneous vein localization from Luminex Corp. It uses digital NIR with 740nm wavelength of electromagnetic spectrum. Green light had been used to project on the surface of the skin to approximate the location of veins using simple algorithm of image processing [11]. This device works perfectly on regular person but there is a lot of improvements have to be done due to lack of consideration on certain aspect such as characteristic on skin surface. VeinViewer assume that all the darker area that produce on the image are veins. Other physical aspect such as scars, hair can also generate darker image. Veins that displays on a person's skin are depend on calculated value of the depth of the veins [12]. This been disadvantage to a patient that has deeper veins as the algorithm for VeinViewer cannot detect it.

NIR imaging has more advantages than other technique such as radiological method that can be harmful to human body if it applied several times. NIR imaging did not use any ionize radiation and perfectly save to be use several time on our body. Light rays can be penetrated deeper in skin tissue due to low absorbent coefficient from water in the range (740nm - 940nm) [13].

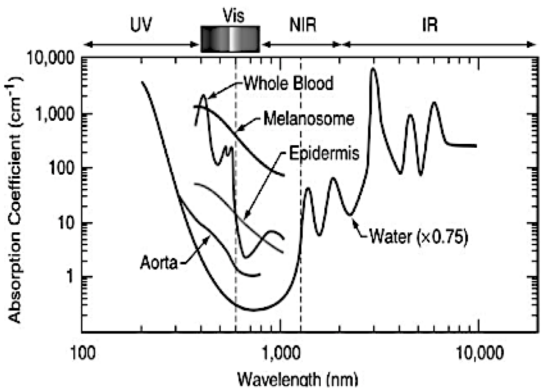


Figure 1 Absorbent Factors [13]

From all the data and comparisons that had been discuss, NIR imaging will be choose on developing subcutaneous veins localization. This project will be focus on developing efficient algorithm for NIR imaging technique and ultimately to produce a portable optical imaging device that can be allocate veins for IV cauterization process.

CHAPTER 3

Methodology

Flowchart

Flow diagram in Figure 2 shows on complete task for final year project (FYP) that will be conducted. The overall project can be divided into two sections that is job scope for FYP 1 and FYP 2.

For FYP 1, in-depth study had to be done on previous research in NIR imaging. Next, bench-top optical systems need to be design and develop as shown in Figure 2 to collect data from variety of samples gaining from all kind of subjects that having different kind of gender, physical and age.

In FYP 2 phase, we need to develop algorithms that can enhance contrast between veins and other biological disturbance such as skin colour and hair. The absorption coefficient of deoxygenated haemoglobin can cause veins appear darker in NIR imaging [14]. We can manipulate these properties to allocate veins and differentiate them from other properties such as scars, hair or skin colour.

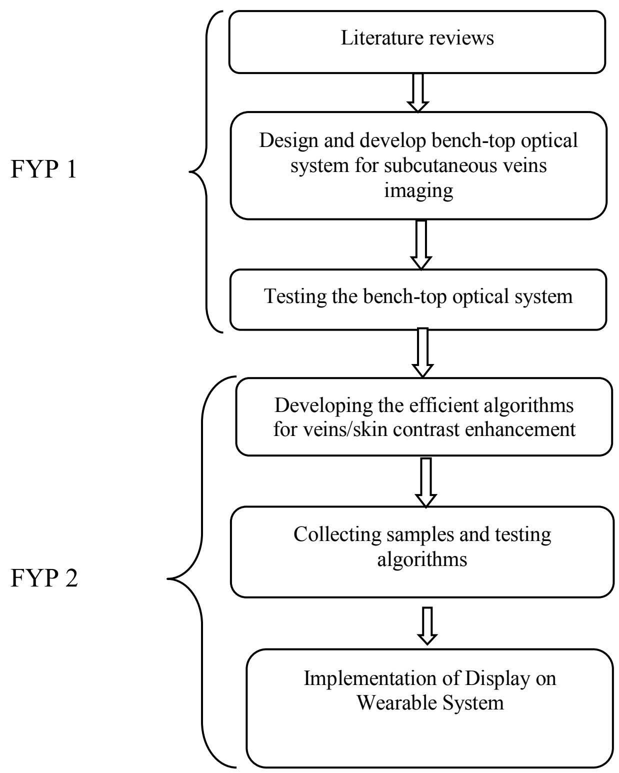


Figure 2: Overall final year project flow diagram (FYP 1 & FYP 2)

Project Tasks

Literature review:

- After the conformation on project title, literature reviews need to be done on giving deeper understanding on the project. This steps also give a brief idea on how was the project going to be conducted.

Understanding Matlab language:

- On learning process, Matlab environment of coding need to be familiarize by referring to a books and online sources.

Compiling code to M-file:

- After testing and debugging had been done, M-file need to be created for the code to be run into Matlab.

Running the code:

- Data sample that had been taken being implement into the algorithm and need to run into Matlab to get the desired output for further analysis.

Improving algorithm:

- After the algorithm had been done, it can be improve in the future for it to be robust

Research Methodology

Naoto Miura et al in [15] purpose a method to be used for personal identification using vein pattern detection on finger can be used for our base study on developing an efficient algorithm for image enhancement. Veins detection using NIR can be related in a research by Carsten Steger in [16], shows on algorithm that produce from curved line extraction can be use in bench-top acquisition system. We can test our algorithm once we had gain our sample space by taking pictures from variety of candidates using bench-top optical system.

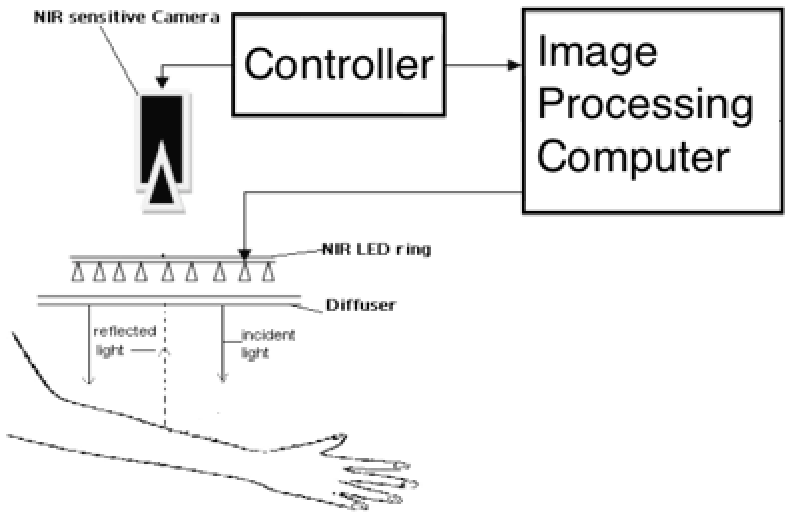


Figure 3 Bench-top optical system to collect samples

Next steps, we develop a portable optical system as shown in Figure 4 as a replacement from bench-top optical system to make it light and easy to be used.

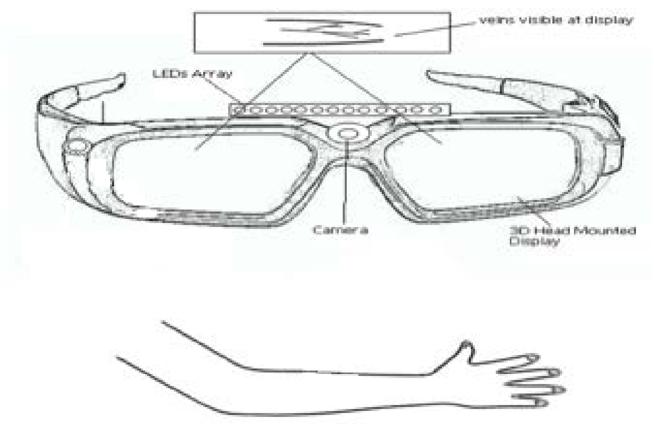


Figure 4 Wearable Optical System

The portable optical device also will be tested to capture NIR images from variety of candidates that have different kind of physical background.

In final stage, the algorithm that was originally used in bench-top optical system will be modified so that it consume less computational power, more efficient, can run on embedded platform and fit in for our new portable optical device.

Tools

As this research project being conducted, some of equipment that had been used listed as below:

Software:

i. Matlab
ii. DT-Acquire

Hardware:

i. Computer (running windows XP operating system)
ii. Power supply (modified from ATX power supply)
iii. Near Infrared LED ranging from (740nm – 940nm)
iv. CCD Camera to captured vein image
v. Tripod

Image Grabbing

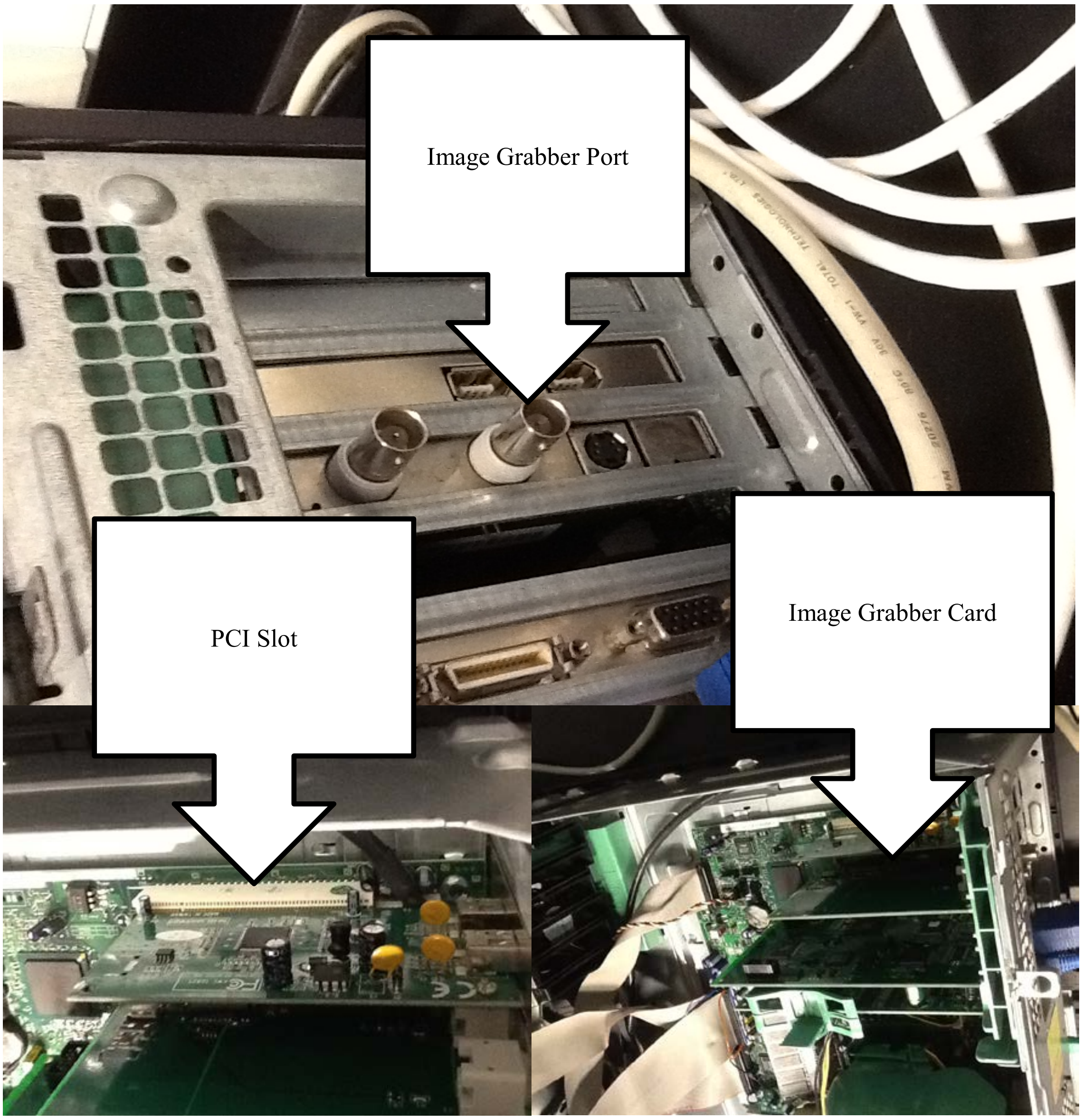


Figure 5 Image grabbing Card

CCD Camera

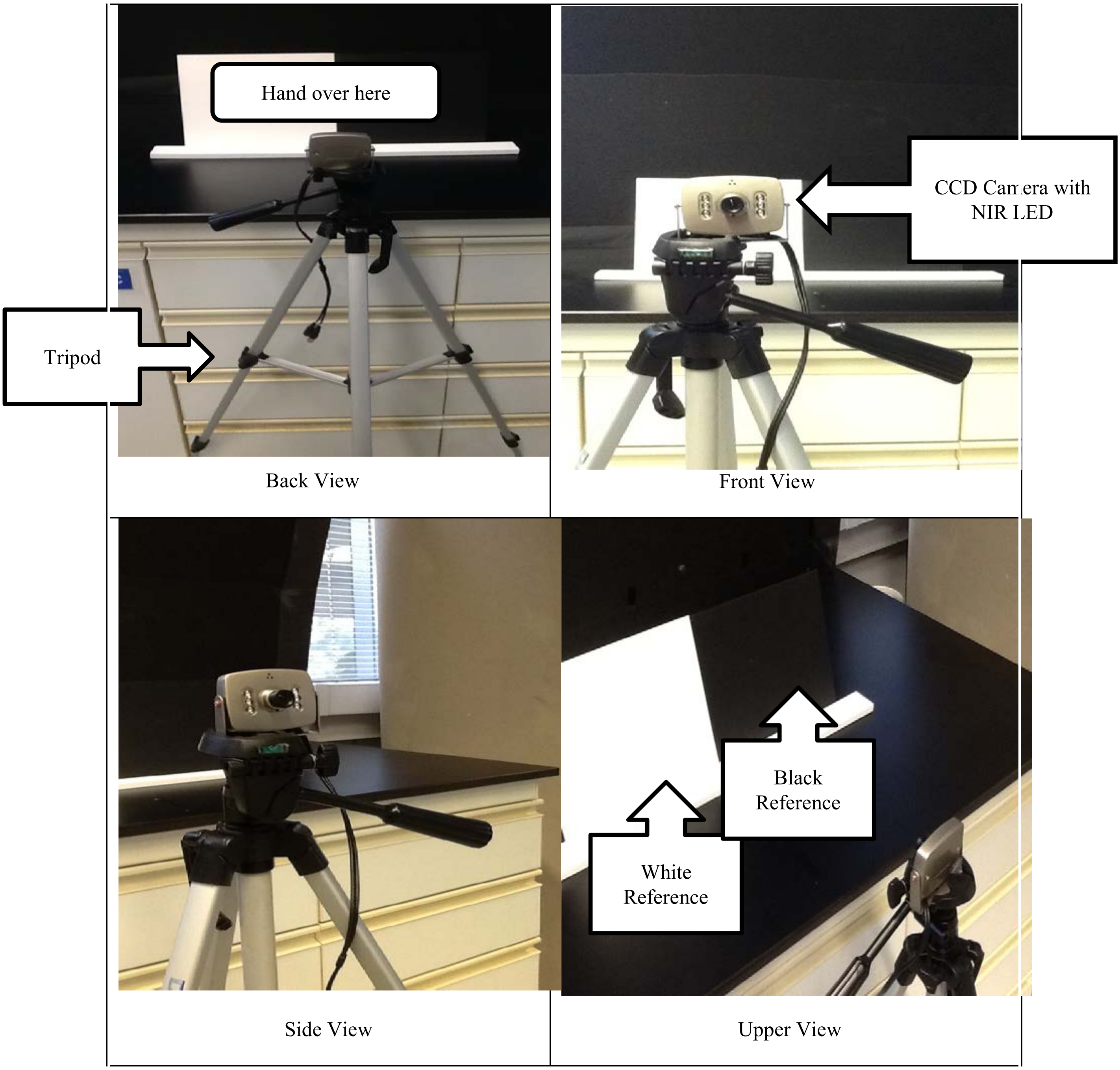
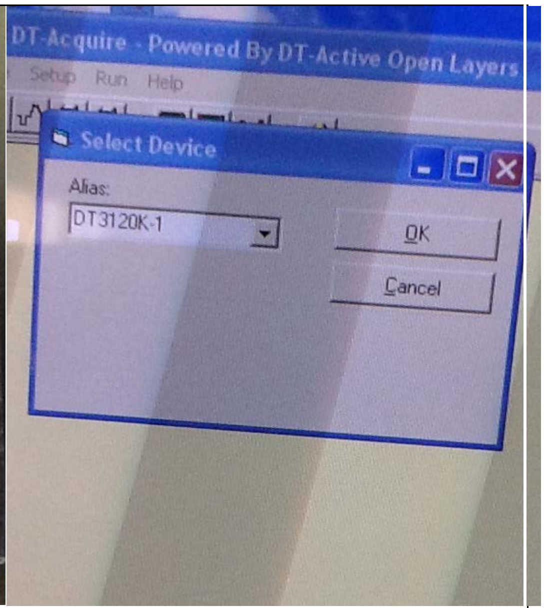


Figure 6 CCD Camera

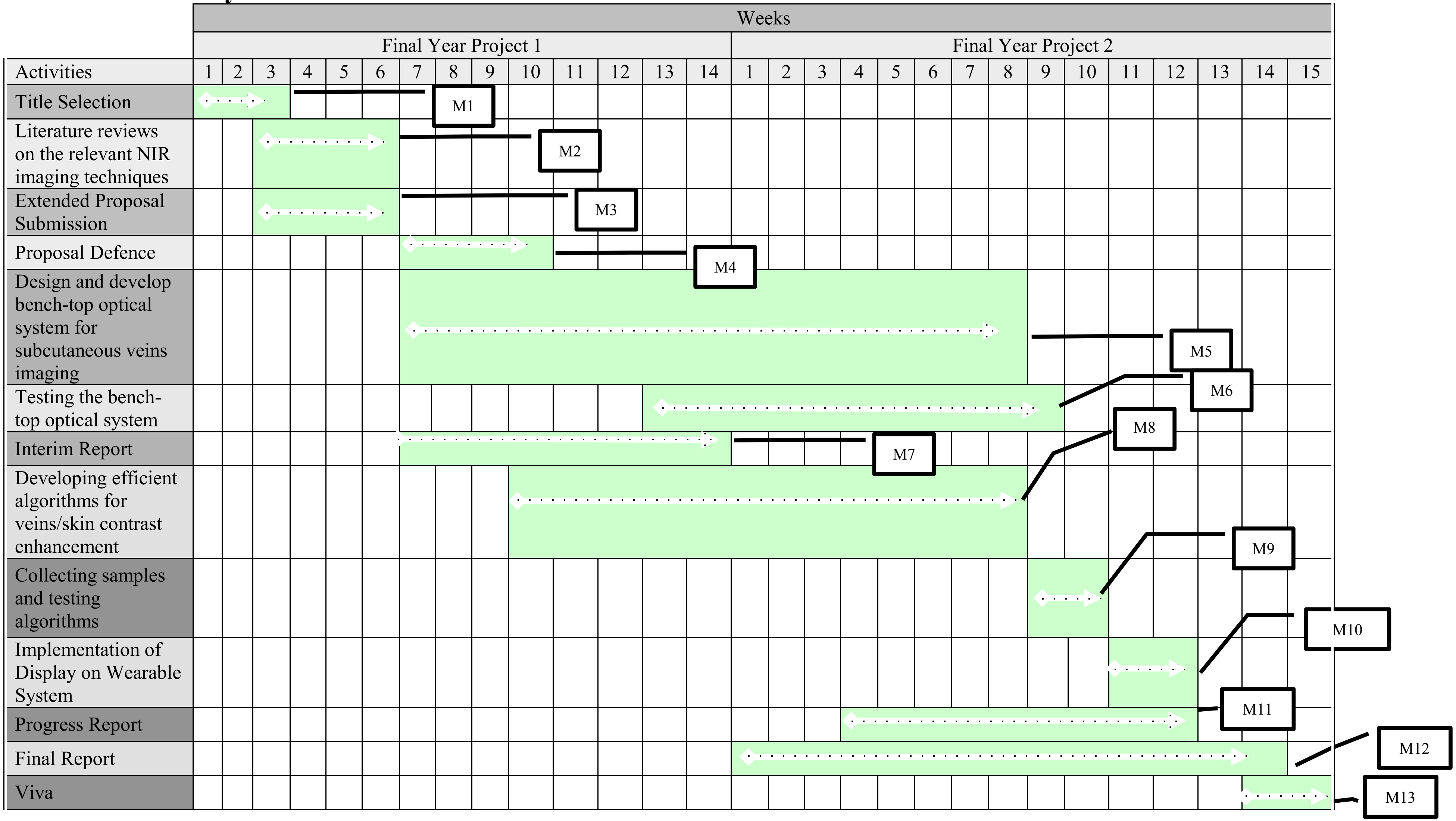
CD Software



User Interface

Figure 7 Software and User Interface

Gant Chart & Key Milestone



Finished Task	On Going Task	Future Task

FYP 1	FYP 2
Milestone 1 – Completion on choosing title (week 3)	Milestone 8 – Completion for developing algorithm (week 8)
Milestone 2 – Completion writing literature review (week 6)	Milestone 9 – Completion on collecting samples and testing (week 10)
Milestone 3 – Submission for extended proposal (week 6)	Milestone 10 – Completion implementation for portable optical (week 12)
Milestone 4 – Proposal defence (week 10)	Milestone 11 – Completion on progress report (week 12)
Milestone 5 – Completion of designing bench-top optical system (week 12 until week 8 –FYP 2)	Milestone 12 – Completion on final report (week 14)
Milestone 6 – Completion on testing bench-top optical system (week 14 until week 9 –FYP 2)	Milestone 13 – Viva (week 15)
Milestone 7 – Submission of interim report (week 14)	

Table 2 Key Milestones

CHAPTER 4

Results and Discussion

<u>Developing Hardware (bench-top optical system)</u>

Power Supply

Bench-top optical system has its own power supply. To give NIR LED its own power, portable power supply needs to be design. ATX T-450 switching power supply had been altered to fit NIR LED supply needed.

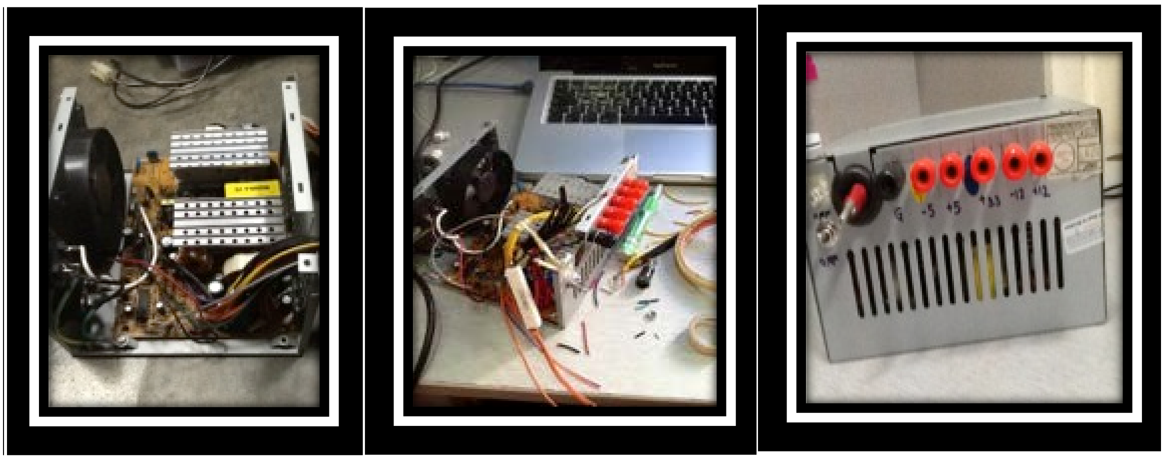


Figure 8 Modified power supply

NIR LED

To create NIR ring as in figure 2, different type of wavelength NIR LED had been choose. Table shown different type of NIR LED wavelength that will be used in bench-top.

Source	Brand / Part No	Package Size	Number of LEDs	Radiant Intensity	Peak Wavelength
RS components	VishayTSAL7600	5mm	1	200mW/sr	640nm
RS components	Vishay TSHG8200	5mm	1	1600mW/sr	830nm
RS components	Vishay TSHG5210	5mm	1	2300mW/sr	850nm
RS components	Vishay TSHG6200	5mm	1	1800mW/sr	850nm

RS components	Vishay TSFF5210	5mm	1	1800mW/sr	870nm
RS components	Vishay TSHF6210	5mm	1	1800mW/sr	890nm
RS components	OSRAM Opto Semiconductors SFH 4511	5.1mm	1	1200mW/sr	950nm
RS components	Vishay TSAL6100	5mm	1	1000mW/sr	940nm

Table 3 Different type of NIR LED wavelength

High power LED been used to give better penetration at different wavelength. Different type of wavelength will penetrates skin into veins to give a reflection towards AD 080CL - 2 CCD Multispectral camera. 2CCD Multispectral camera can capture images that has wavelength exceed human vision wavelength. Type of wavelength that AD 080CL can be summarize as in figure 11.

NIR LED does not visible to human's eye. It needs to perform simple experiment (figure 9) under a camera to check whether it is working using 3V lithium battery.

Breadboard need to be use as a place to hold NIR LED. Normal LEDs had been placed as in the diagram to show how NIR LEDs will be placed later.

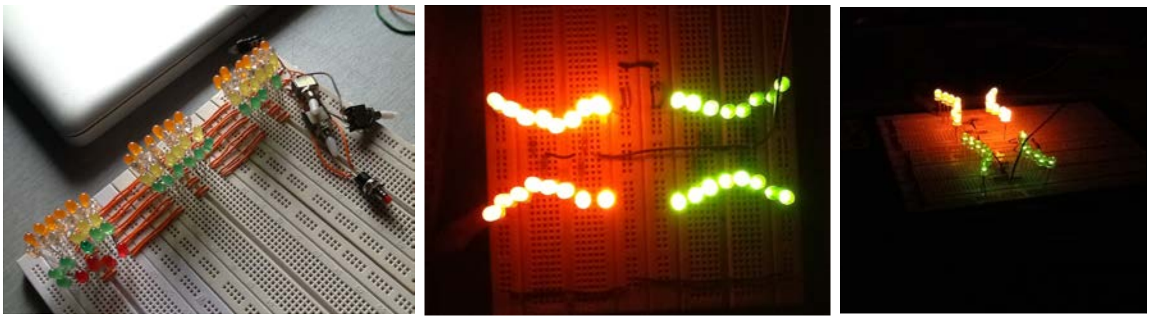


Figure 9 Breadboard to hold LEDs

Figure 10 NIR LED (OFF-Left) and (ON-Right). Only visible under camera.

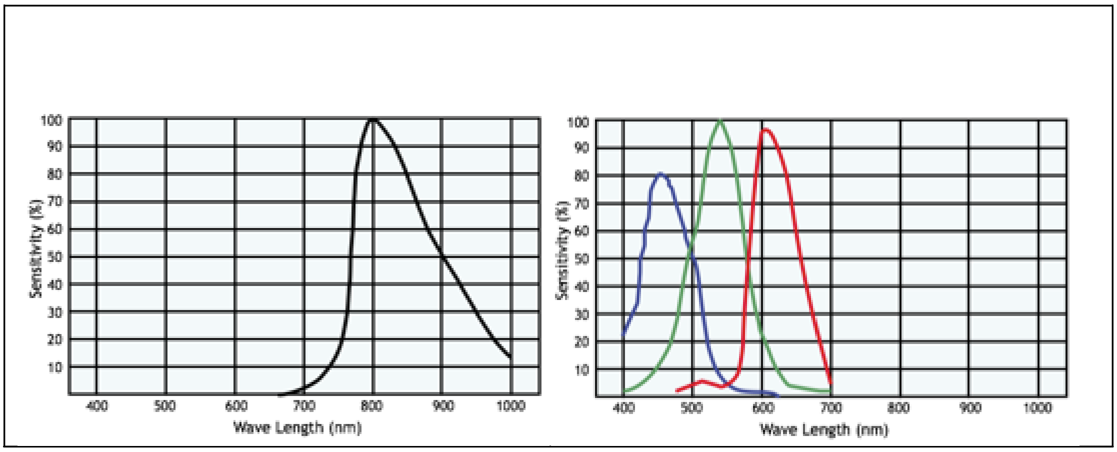


Figure 11 NIR and visible response AD 080 CL[17]

Figure 12 AD 080CL Multispectral camera

Developing Algorithm

In developing efficient algorithms for veins/skin contrast enhancement, it is a necessity to take step-by-step in understanding on image processing using Matlab. One of the key points is to understand how to extract image and video and process it.

Video

In the experiment, video that had taken from a bench-top or wearable optical system need to be extracted for further analysis and will be kept in image processing computer. Data from a video can be altered for our references and study. It is easier to detect video image of a vein in grey scale. To perform that, motion video in Matlab using webcam camera that built in into the laptop had been captured as testing purpose.

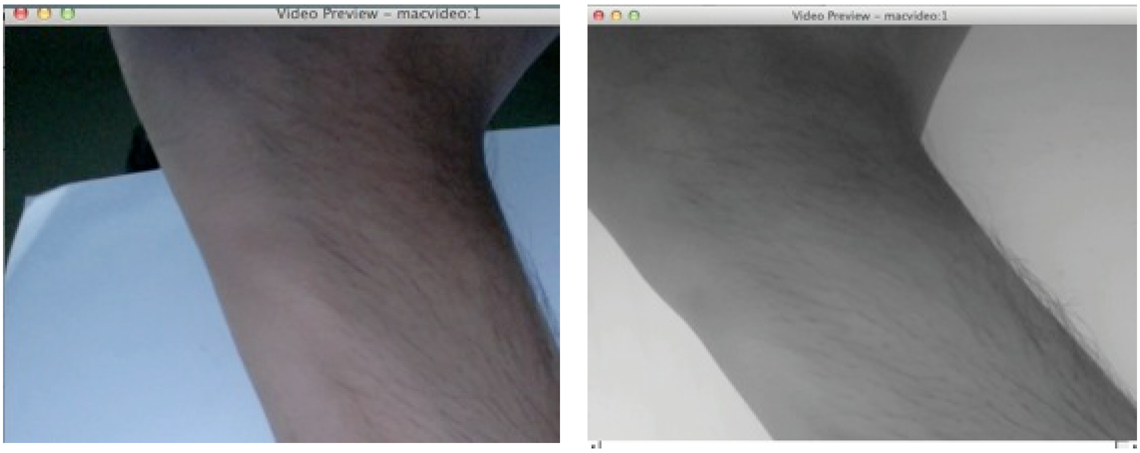


Figure 13 Input video image (Right) and filtered grey scale video image (Left)

In this process, video had been captured using Matlab and filter the data to get grey scale images. Grey scale displays intensity information of the image. Image of the veins are also sharpen for human eye to grab the image.

Image Processing

In basic colour representation, colour can be divided into three channels, which is red (R), green (G) and blue (B). RGB can produce primary colour that our vision can see. To summarize, using RGB channel can form almost all primary colour. Next, to experiment on changes images data, we extract R, G, and B channels, as this is important for us to analyse the sample of images. For the data collection in terms of images, image that had been captured and read using Matlab as below:

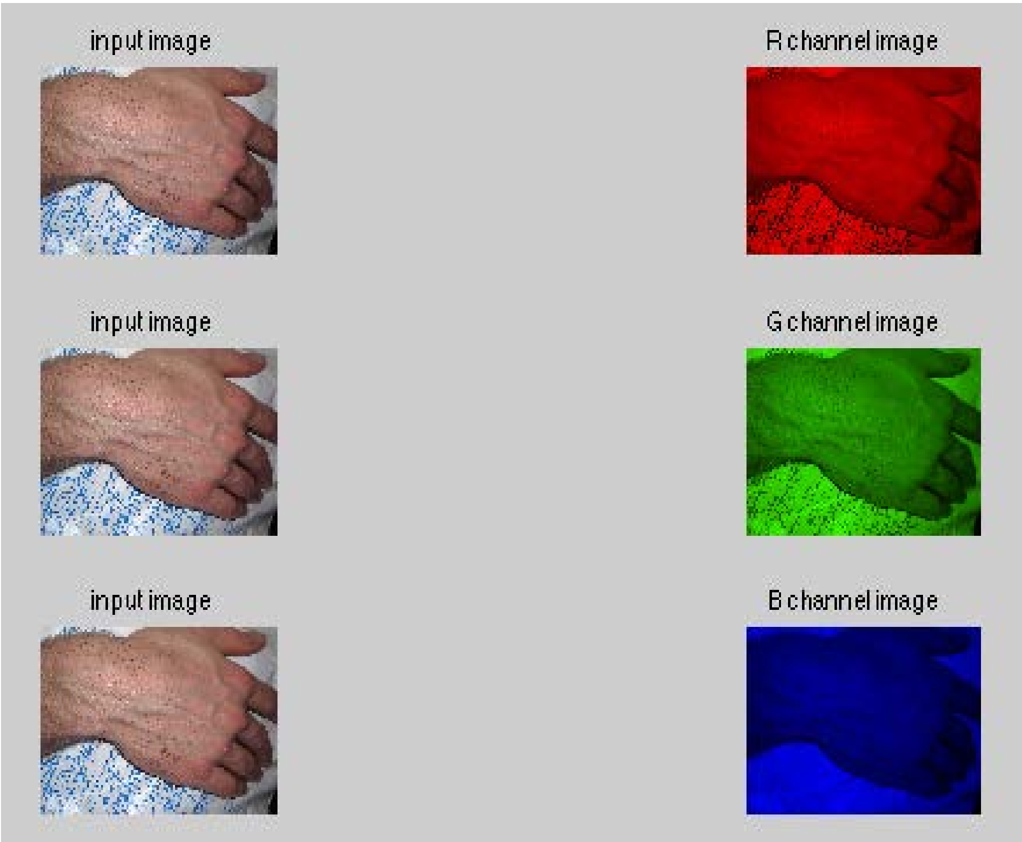


Figure 14 Extract input image to RGB channel using Matlab

From the result, the display Red region will only display red channel and black shows a zero value in the image. It applied to other two colours, which is green and blue.

To further analyse data, image also can be filer in such way that the original image can be "motion blurred, blurred and even sharpen" it.

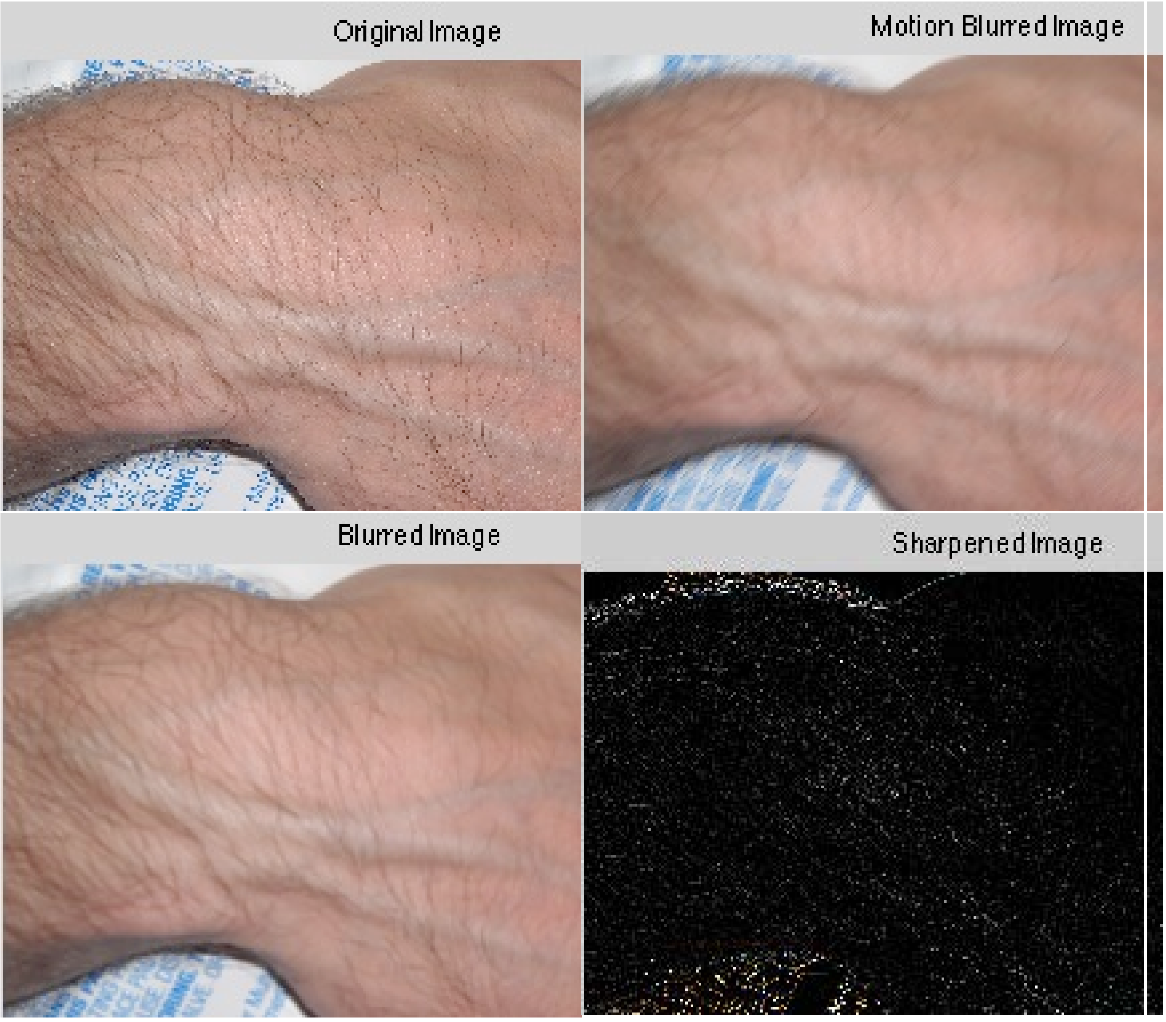
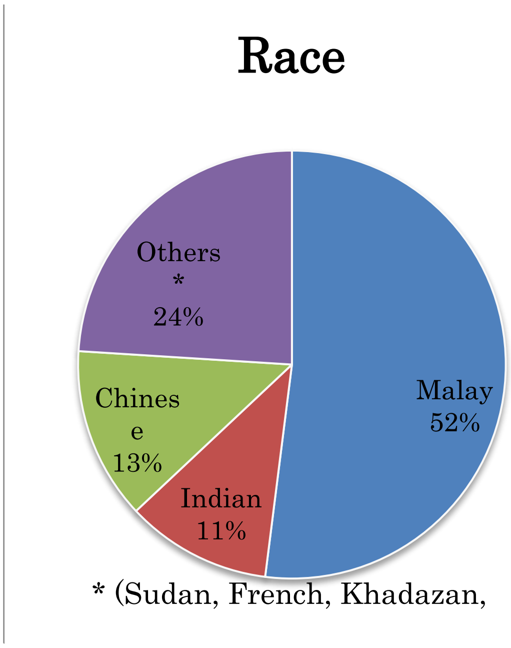


Figure 15 Filtered image using Matlab

The experiment had been launched with 100 candidates (details candidates as attached in appendix) as participant to get a veins sample. The sample can be use as database and had been tested for algorithm. The candidates had been classified into three categories, which are fair, brown and dark skin.



The images that we get from CCD camera produce output vein images that is dull which contain a lot of noise. To get a better result from veins data, images need to be enhanced by smooth the image and enhance the contras out of it.

To get started, large images need to be *cropped*. This can be accomplished by using a simple command in Matlab as shown below:

```
Cropped_im = im(50:145,:,1) %sample data vein image obtain = im
```

Sample image that had been cropped using Matlab as shown in Figure 17

Figure 16 Before Cropped

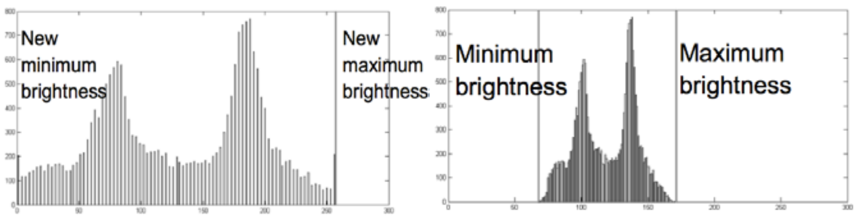
Figure 17 After Cropped using Matlab

Cropped image being converted to grey scale as in Figure 19 (a). The grey scale image give only one channel information and make it simpler to handle the code. The following step is using *auto-contrast* function in Matlab to get optimal image. This will give a better view of veins and background. Image that had been produce for auto-contrast function can be seen in Figure 18.

Figure 18 Image after using auto-contrast function

Better distribution value can be seen in histogram graph. In comparison with two-histogram graph for auto-contrast and grey scaled, the histogram graph for auto contrast give better distribution value.

(a)



(b) (c)

Figure 19 (a) Original image that had been Auto Contrast (Left), Grey Scale (Right), (b) histogram for auto-contrast image, (c) histogram for grey scale image

As we can see, *auto-contrast* and *histogram equalization* enhance the image and at the same time increase noise in the image. Sample image that had been processed already contain a lot of noise due to poor quality camera. *Auto-contrast* and histogram equalization enhance the noise. The noises become clearer. High amount of noise can affect quality veins image that need to be harvest.

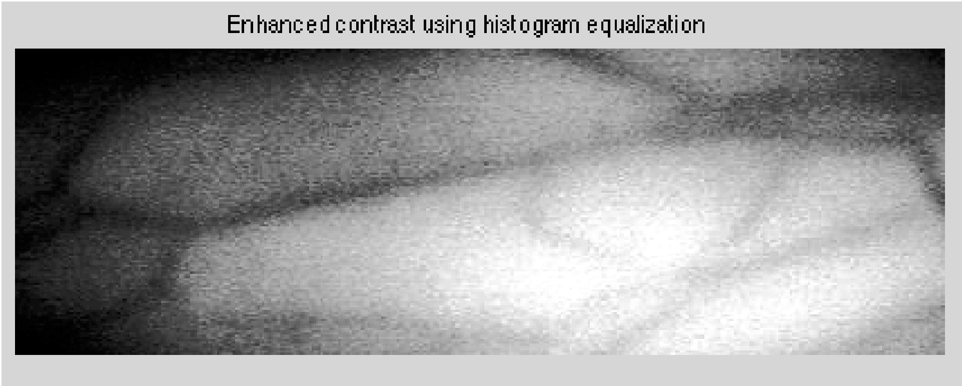


Figure 20 Enhanced image using histogram equalization from grey scale

Therefore, additional step to reduce the noise in image is necessary. *Smoothing* algorithm need to be implement. This can be done with Matlab function as below:

```
h=fspecial('average', [3 3]);
g= imfilter(im3, h); %im3 is the image that had been enhanced contrast
using histogram equalization
imshow(g);title('Mean filter for smoothing image');
```

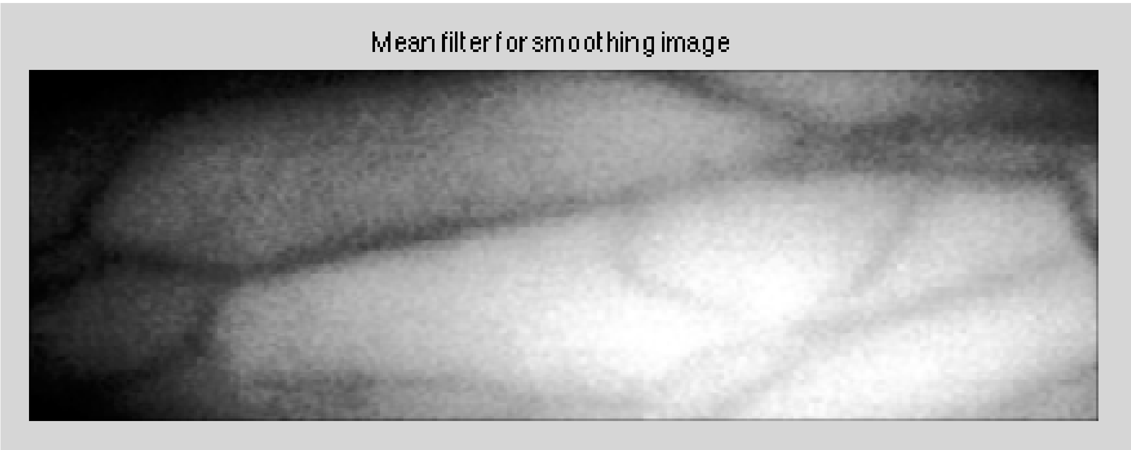


Figure 21 Smoothing the histogram equalization image

Image that had been smooth shows better result with less noise. This image can be used to analyse veins for further research.

CHAPTER 5

Conclusion and Recommendation

Conclusion

There are a lot of cases happened around the world every day that cause injury to veins during venipuncture process. New design, prototype and research had been done to reduce the chances of accident to be happened. Scientist, doctors and engineers are working together on solving and improving technologies for a better world to live in.

This project has implement previous research and adds improvement for developing near infrared imaging for subcutaneous veins localization using wearable optical imaging device.

In the market, there are already a technology that implement same concept (VeinViewer) but it is large and bulky, make it hard to handle on a single user. It is expensive and makes it rare to find in hospitals or clinic. This project aims to improve better algorithm in image processing to trace veins and make it portable and cheap for almost of the hospitals or clinic to use as medical facilities that every medical practitioner can use it to apply venipuncture and IV catheterization technique.

As for prototype, author had start with bench-top to collect data from variety of samples that has a lot of variety types of skin such as dark, brown, yellowish or even white colour. As for consideration, the algorithm must be able to detect veins under of a person that have thick hair on their arm. In contrast with this project, VeinViewer can only detect veins for a person that has fair skin and thin layer of hairs.

This entire improvement can significantly help to improve medical world.

Recommendation and Future Improvement

There are some of the problems that need to be encounter for future work as improvement in this system. The images that we get from bench-top NIR camera has too much illuminates in the subject. A better LEDs and a filter need to be develop to reduce high illumination and a better camera need to be used. Images that we get with high degree of illumination cause veins images that produce less visible than it should.

Figure 22 RAW data with high degree of illumination and noise

Noise in images gives big impact on output result. By getting poor quality images that obtain at the beginning of the stage in acquiring data, it is almost impossible to reduce all these noise. By applying a lot of filtering using algorithm, it will cause losses in such big amount of data. The images become deterioration and further step on harvesting data cannot be done.

Recommendations for a better camera also need to be considered. As an output image contains noise, a better camera can produce sharp images with less noise. This will help on veins detection and images that need to be processed later on.

The CCD camera that had been used to take sample can be replaced with a CCD camera that is sensitive to infrared. A better quality of image is a necessity to obtain a desirable result. One must be careful in a step of acquiring data, as it is one of the crucial steps.

Algorithm that had been produce could be improves for future study.

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APPENDICES

Appendix A List of candidates to participate in vein database

UNIVERSITI TEKNOLOGI PETRONAS

Name :   Student's No :

Course :   Test :

estion umber	Name	Race	(M/F) Gender	Student ID.	Do not write in this column
1.	Mohd Khairul Mohd Azam	malay	M	15213	
2	Nayib Hatim Bin Kamarudin	Javanese	M	15137	
3.	Alfred Arvind Raj	Indian	M	14589	
4.	SADIQ HUSAYNI BIN SAHARUDDIN	MALAY	M	15179	
5	MOHD KHAIRUL ARIFFIN BIN SERUJI	MALAY	M	15153.	
6	Ahmad Shahir Saffuan bin Zainal Abidin	MALAY	M	13010	
7	Abdul Rashid B. Mohamed Mydin	MALAY [illegible]	M	14681	
8	ABDILLAH BIN NASIB	MALAYSIAN	M	15198	
9	ZUL HAZMI B MOHD ZULKIFLI	"	M	1519[illegible]	
10	AMIR ZAHRAN BIN AZHAR	"	M	15235	
11	MOHAMAD HAIQAL BIN MAZLAN	"	M	13126	
12	USAMAH AZMAN	"	M	13413	
13	Kanwisa Siriphruek	Thai	F	12932.	
14	Sariyah Hajiberahing.	Thai	F.	12934	
15	Tay Mei Chen	Lain?	F	13406.	
16	Haziq Iqram B- Mohammed Shafri	Malay	M	SPM	
17	Nasiruddin Zhariff b. Rasip	Malay	M	13276	
18	Mohd Zulkifly Abu Hamin	Malay	M	14602	
19	Nik Mohd Al Qayyum B. Nik Ab. Rahman	Malay	M	13283	
20	Muhamad Saffi Bin Hassan	Malay	M	13190	
21	mohamad Hasan Bin Ismail	Malay	M	13128	
22	Muhammad Syafiq bin Samsuddin.	Malay.	M	13256.	
23	TRAN DUC CHUNG	Vietnam	M	14157	
24	Zulyadain Ishak	Malay	M	12915	
25	NUR THANIA AWATIF MOHAMAD ROSDI	MALAY	F	13326	
26	ERMALIZA SUZANA ULUL AZMI	MALAY	F	13055	
~~27~~	~~NOR AMALIA BT HUSSIN~~	~~MALAY~~	~~F~~	~~13291~~	
27	CHEAM SHEH REN	CHINESE	F	13044	
28	NOR LIYANA BT MEHFAR	MALAY	F	15170	

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UNIVERSITI TEKNOLOGI PETRONAS

Name :
Course :

Student's No :
Test :

Question Number	Name	Race	(M/F) Gender	Student ID	Do not write in this column
29	Prasanth Raj Baskaran	INDIAN	M	18876	
30	Nurul Syamimi A. Aziz	Malay	F	15761	
31	Yeap Jia Ming	Chinese	M	16108	
32	Muhammad Zulhilmi Adnan	Malay	M	13271	
33	MOHAMAD AFIQ B. AZMAN	MALAY	M	13116	
34	AMIN FAHIM	MALAY	M	13026	
35	Gilbert Johnson	Bidayuh	M	13071	
36	JAYVARMAA A/L RAJARAM	INDIAN	M	15325	
37	P. Panjaabegesan	INDIAN	M	13355	
38	ABDULLAH RASHED	ARAB	M	14977	
39	AHMAD HAZIQ BIN AZMI	MALAY	M	18338	
40	M. SYARAHBIL B. SALLEHUDDIN	MALAY	M	Non-utp student (working)	
41	MAJID ILIM	Pakistan	M	PhD Student (un-registered)	
42	MOHD ASNAWI B. MOHD YUSOF	MALAY	M	13153	
43	HAMDAN BIN PATTHI	MALAY	M	14007	
44	NORAZIF ANUAR BIN HASNI	MALAY	M	19375	
45	MOHAMMAD NAUFAL AKMAL BIN JUMAAT	MALAY	M	19443	
46	MASRIHAN BIN ABU HASAN	MALAY	M	19454	
47	Mustamin Bin Mustaffa	Malay	M	13480	
48	Badiuzaman Bin Bahand	Malay	M	15165	
49	KARINE LOMBARD	FRENCH	F	20565	
50	LAURA MARX	AUSTRIAN	F	20563	
51	David Ladu	South Sudan	M	20529	
52	Miguel Venâncio Nhassavele	Mozambican	M	20557	
53	Melania Lapate	Mozambican	F	20533	
54	Luciano Julio Mangue	Mozambican	M	20532	
55	Amirul Ashrof b. Othman	Malay	M	18824	
56	Nurul Asyiqin Bt Mokhtar	Malay	F	18804	
57	MUHAMMAD HANIF B. ZAKARIA	Malay	M.	18333	

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UNIVERSITI TEKNOLOGI PETRONAS

Name :　　　　　　　　　　　　Student's No :

Course :　　　　　　　　　　　Test :

Question Number	Name	Race	(M/F) Gender	Student ID	Do not write in this column
58	Nurul Bazlaa' Bt Aminudin	Malay	F	18095	
59	Syafiq bin Shaharizal	Malay	M	18168	
60	WAN NUR ALEEZ W. MOHD RIZAL	malay	F	17980	
61	AARON CHIA YUN ZHEN	Chinese	M	14945-	
62	Ahmad Nur Rifhan B. Supian	Malay	M	20056	
63	NUR NABIA HUDA ABD NASIR	Malay	F	19988	
64	Sum Yin Yan	Chinese	F	17928	
65	Ivan Gan Wei Ren	Chinese	M	16522	
66	MOHAMAD HAZIQ FAIZ BIN MOHD HASHIM	MALAY	M.	13129	
67	AARON SCOTT G. JUNSAI	KADAZAN	M	12996	
68	DEREK LAI CHAI ZERN	CHINESE	M	14233	
69	NATASHA BINTI IDRUS	BAJAU	F	16491	
70	SHAZWANI BINTI AZMI	MALAY	F	14919	
71	SARAH AMIRAH KAMARUDDIN	〃	F	14860	
72	M FARIS ASHRAF	MALAY	M	14974	
73	Uma Balasubramaniam	Indian	F	19648	
74	Kiranjeet Kaur	Sikh	F	20183.	
75	Koo Vui Fai Alwin	Sino Kadazan	M	17950	
76	Goh Juin Xien	Chinese	M	18151	
77	LYE HUI LI	Chinese	F	18481	
78	SEA YI THENG	Chinese	F	18481	
79	KIRUPHAKAREN NADESAN	Indian	M	18019	
80	NICKY TAY MUN YANG	Chinese	M	16502	
81	TAN JOK YI	Chinese	M	16552	
82	MA TARA TE AGOSTINHO BERNARDO	Indon	M	19494	
83	Kaeer aldin Mansoor Abdullah	Yemen	M	19596	
84	Ammar Faisal Abdalla	Sudanese	M	19498	
85	Nur Fathin Munirah bt Mohd Azman	Malay	F	13317.	
86	Che Zurida binti Che Lah	Malay	F	13043	

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Question Number	Name	Race	(M/F) Gender	Student ID	Do not write in this column
87	Yasaman Sadat Baekhlagh	Iranian	F	18467	
88	Nasser Sharifi	iranian	M	18504	
89	Islam Abdalla	Sudanese	M	17880	
90	Mario Henriques	[illegible]	M	18591	
91	NALINII A/P RAVICHANDRAN	INDIAN	F	16477	
92	HOJITA BT ITAM	SEMAI	F	16617	
93	KOSHALINI MUNIAN	INDIAN	F	15910	
94	Lachmi Sri A/P Manoharan	Indian	F	16454	
95	Ahmad Aiman Afif Bin Mohd Zamri	Malay	M	16428	
96	Nur Ashiqin Binti Suwarto	Malay	F	16319	
97	Mohd Syakirul Azat b. Ahmad Zahudi	Malay	M	16554	
98	Muhammad Shamir Abdul Rahim	Malay	M	14902	
99	Tong Kah Soon	Chinese	M	15942	
100	LIAN JIA-JIE	Chinese	M	16546	

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Appendix B Coding for Extract Input Image to RGB Channel

Preview for coding below as shown in Figure 14

```
% project clean up
clc
close all
clear all

% project location
driveLocation = '/Users/user/Documents/MATLAB/FYP/VeinRGB/';

% reads the input image
input = imread(strcat(driveLocation,'my-pics-024.jpg'));

% gets the size of the color image x - length, y - breadth & z -
RGBchannels
[x,y,z] = size(input);

% temporary storage created for RGB channels
red = input;
green = input;
blue = input;

% sets the complementary channels to 0 values
for k =1:z
    for i=1:x
        for j=1:y
            if k==1
                red(i,j,2:3) = 0; % sets k=2(green) & k=3(blue) to 0,
i.e k=1(red) is retained
            elseif k==2
                green(i,j,1:2:3) = 0; % sets k=3(blue) & k=1(red) to 0,
i.e k=2(green) is retained
            elseif k==3
                blue(i,j,1:2) = 0; % sets k=2(green) & k=1(red) to 0,
i.e k=3(blue) is retained
            end
        end
    end
end

% creates the RGB channel files
imwrite(red, strcat(driveLocation,'InputImageR.jpg'), 'jpg');
imwrite(green, strcat(driveLocation,'InputImageG.jpg'), 'jpg');
imwrite(blue, strcat(driveLocation,'InputImageB.jpg'), 'jpg');

% displaying results
% R Channel
figure('name','SplitColorImageToRChannel');
subplot(1,2,1), imshow(input,'Border','tight'), title('input image');
subplot(1,2,2), imshow(red,'Border','tight'), title('R channel
image');
% G Channel
figure('name','Summary SplitColorImageToGChannel');
subplot(1,2,1), imshow(input,'Border','tight'), title('input image');
```

```
subplot(1,2,2), imshow(green,'Border','tight'), title('G channel
image');
% B Channel
figure('name','Summary SplitColorImageToBChannel');
subplot(1,2,1), imshow(input,'Border','tight'), title('input image');
subplot(1,2,2), imshow(blue,'Border','tight'), title('B channel
image');
% Summary RGB Channel
figure('name','Summary VeinRGB');
subplot(3,2,1), imshow(input,'Border','tight'), title('input image');
subplot(3,2,2), imshow(red,'Border','tight'), title('R channel
image');
subplot(3,2,3), imshow(input,'Border','tight'), title('input image');
subplot(3,2,4), imshow(green,'Border','tight'), title('G channel
image');
subplot(3,2,5), imshow(input,'Border','tight'), title('input image');
subplot(3,2,6), imshow(blue,'Border','tight'), title('B channel
image');
```

Appendix C Filtered Image

Preview for coding below as shown in Figure 15

```
% Reading images
im =
imread('/Users/user/Documents/MATLAB/FYP/Filtering/filterVain.jpg');
imshow(im);
%we create special filters
subplot(2,2,1);
imshow(im); title('Original Image');


H1 = fspecial('motion',50,45);
MotionBlur = imfilter(im,H1,'replicate');
subplot(2,2,2);
imshow(MotionBlur);title('Motion Blurred Image');

H2 = fspecial('disk',10);
blurred = imfilter(im,H2,'replicate');
subplot(2,2,3);
imshow(blurred); title('Blurred Image');

H3 = fspecial('sobel');
sharpened = imfilter(im,H3,'replicate');
subplot(2,2,4);
imshow(sharpened); title('Sharpened Image');


figure, imy = rgb2gray(im);
imshow(imy)
figure, imshow(imy)
figure, imhist(imy)
imy2 = histeq(imy);
figure, imshow(imy2)
figure, imhist(imy2)
```

Appendix D Filtered Grey Scale Video Image

Preview for coding below as shown in Figure 13

```
%display hardware info
imaqhwinfo

imaqhwinfo('macvideo')

imaqhwinfo('macvideo',1)

vid = videoinput('macvideo',1,'YCbCr422_640x480');
set(vid,'ReturnedColorSpace','grayscale');
preview(vid)
```

Appendix E Image After Using Auto-contrast Function

Preview for coding below as shown in Figure 18

```
kLowContrastSteps = 5;
kHighContrastSteps = 5;
kChangePerStep = 0.05; %e.g. 0.1 will have contrast steps 0.4, 0.5,
0.6, 0.7...
%have user select files
[files,pth] = uigetfile({'*.bmp;*.jpg;*.png;*.tiff;';'*.*'},'Select
the Image[s]', 'MultiSelect', 'on');
files = cellstr(files); %make cellstr regardless of whether user
selects single or multiple images

for s = -kLowContrastSteps : kHighContrastSteps
    step = 0.5 + (kChangePerStep * s);
    label = ['g', int2str(round( step*100) )];
    for f=1:size(files,2)
        nam = fullfile(pth, strvcat(deblank(files(:,f))) );
        fprintf('file %s gain %.2f label %s\n',nam, step, label);
        if step < 0.5 %if reducing contrast, use linear transform
            bmp_contrast(nam,step,-0.5,true,label,false);
        else %if increasing contrast, use non-linear transform
            bmp_contrast(nam,step,-0.5,false,label, false);
        end;
    end;
end;
```

Appendix E Original image that had been Auto Contrast (Left), Grey Scale (Right)

Preview for coding below as shown in Figure 19 (a)

```
im=imread('/Users/user/Documents/MATLAB/FYP/experiment/g75small.jpg');

figure(3);
set(gcf, 'name', 'Overall Images')


subplot(3,2,1);
imshow(im); title('Original image that had been auto-contrast');

im2=rgb2gray(im);
subplot(3,2,2);
imshow(im2); title('Gray Scaled image');

im3=histeq(im2);
```

```
subplot(3,2,3);
imshow(im3); title('Enhanced contrast using histogram equalization');
```