

VITILIGO LESION ASSESSMENT TOOL ON SMARTPHONE

By

VIKTORIYA BORETSKAYA

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Program in Partial
Fulfillment of the Requirements for the Degree Bachelor of Engineering
(Hons)

(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Sri Iskandar, 31750 Tronoh,
Perak Darul Ridzuan

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CERTIFICATION OF APPROVAL

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Viktoriya Boretskaya

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Universiti Teknologi Petronas
in Partial Fulfillment of the Requirements for the Degree Bachelor of Engineering
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December 2013

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in 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.

Viktoriya Boretskaya

ABSTRACT

In some European countries skin diseases affect around 60 percent of the population [15]. For example in England, there are eight million people having skin disorder problems [16]. The effectiveness of a treatment depends on the type of the skin disorder, as some disorders can be easily managed by creams and ointments and some need long-term treatments. Melasma, melanoma, eczema and Vitiligo are common types of the skin disorders [16]. Vitiligo can occur at any age and is manifested by the appearance of white spots on the skin, that is, area lack of pigment - melanin. The therapeutic response analysis of the Vitiligo treatment is assessed by PGA method which gives undesired results due to visual assessments by dermatologist [1]. However, pigment distribution analysis can be done by using digital image analysis algorithm. The independent component analysis algorithm enables accurate objective measurement of repigmentation and measurements can be made in a short period of time [1]. The complete system requires a camera and a computer to run the analysis software on PCs. Thus, to make Vitiligo analysis system available to unspecialized users, the android based system using smartphone is envisaged. The algorithm therefore needs to be rewritten for smartphone. However, ICA algorithm is not an easy task for any hardware platform, especially for portable devices, mobiles [17]. ICA algorithm does vast computations thus; ICA algorithm is used to improve segmentation performance. In this project Vitiligo skin lesion assessment system is implemented and optimized on smartphone running Android OS. Android is OS system, designed for touch screen mobiles. It creates easy way of writing applications by providing platforms for implementation.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Skin diseases can have different visibility. Therefore the importance of dermatologists' accuracy in recognition and analysis of the pattern is highly important. The presence of the experience in the dermatology field is the key for making it much easier to recognize and differentiate the skin lesions. However even the most experienced doctor might face the problem in assessing the treatment efficacy as the treatment itself might take long time to be visually recognizable. In general, a systematic examination of the whole skin is considered as the best practice but not always warranted. Dermatologists up to now keep using visual assessment method with the low degree of patience's confidence. Even though dermatologists' investigations may be helpful same as the therapeutic trials, but not for the patience's confident. And again the reason to patience's doubt is time taken for doctor to see difference if that medical treatment is really beneficial. Thus, there is a need of better alternatives such as using digital image processing methods. The reason is humans have visual limitations unlike imaging machines which cover entire electromagnetic spectrum.

1.2 Development digital image processing into medical field

These imaging machines operate on computer generated images that humans are not able to associate with images. Thus, digital image processing has wide and varied field of applications. The process of acquiring an image of the area containing the text, preprocessing that image, extracting (segmenting) the individual characters, describing the characters in a form suitable for computer processing, and recognizing those individual characters, are in the scope of digital image processing. Digital Image Processing is a vast field and examples are ranging from medicine and industrial inspection to remote sensing and astronomy. Especially in medicine Digital Imaging covers a wide spectrum of activities. There are applications of use Digital Imaging in medicine like domestic or mobile support of patients, for monitoring persons in rescue

missions and disaster control [16]. There are researches on segmentation by using samples of Vitiligo and tumor diagnoses have been conducted [1-5]. The results of these researches prove that computer based image analysis improves medical diagnostic and therapy with high accuracy in a shorter period of time. On the one hand, image analysis methods are used to perform medical diagnostics for detection disease as well as follow-up control of therapy. On the other hand, some used methods for analysis are not reliable. One of the medical imaging issues is applying Physician's Global Assessment method by dermatologists besides this assessment is often used in medical clinics to assess Vitiligo lesion. This method causes some disadvantages in validity and reliability [3].



Figure 1: Dermatologist visually assessing the patient's face skin lesion

1.3 Problem Statement

Vitiligo is treatable skin disease but due to repigmentation it is slow process. It can occur at any age and it appears as white spots on the skin, that is, area lack of pigment - melanin. Melanin is produced by melanocytes located at the lower part of the epidermis skin layer where can notice the high absorption of the sun light. Melanin protects the skin from sun burn; if the amount of the melanin is high the skin gets darker and vice

versa. This pigment is responsible for color of skin or hair and deficiency of pigment is leading to Albinism or Vitiligo diseases. Melanocytes are present in both disease cases with different amount, however in Albinism melanocytes are not able to function at all while Vitiligo can be treated.

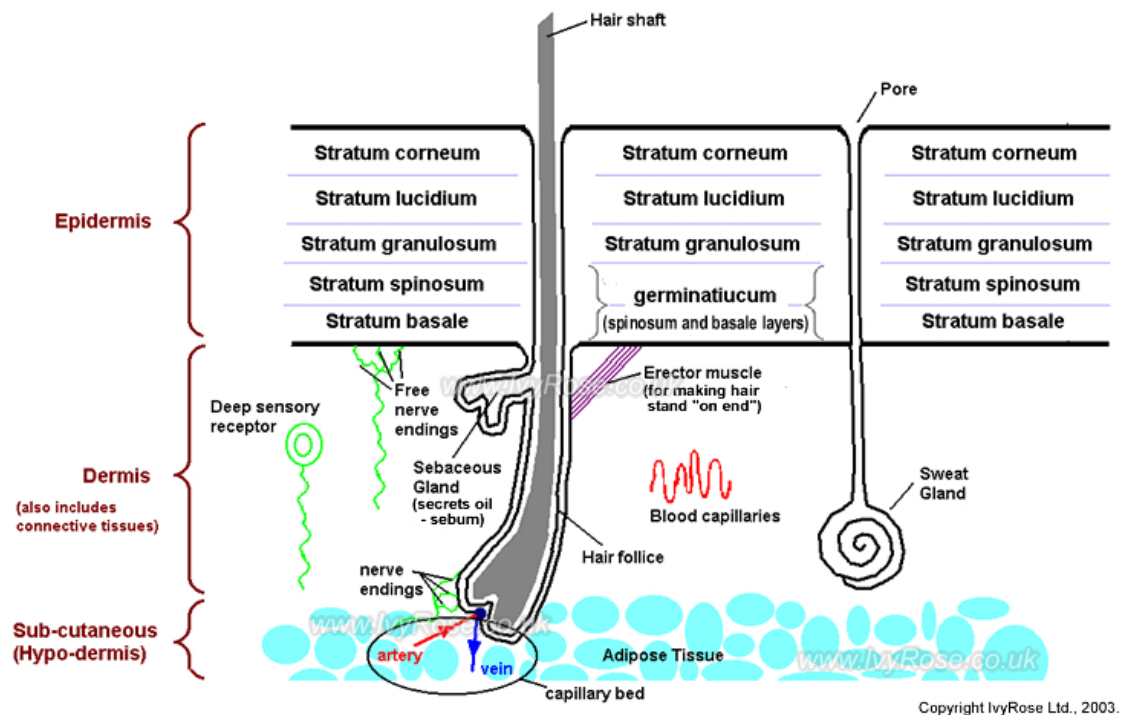


Figure 2: Skin structure

Vitiligo is a disease when human's immune system reacts against the body's own organs or tissues; or melanocytes destroy themselves [15]. However Vitiligo is not painful and does not have significant problems with health, but it may be cause discomfort for the patient to appear in a public with white spots on the skin. This discomfort may lead to some critical mental disease. Therefore, treatment of Vitiligo is highly appreciated.

The most used systems for assessing therapeutic response are Physician's Global Assessment (PGA), Psoriasis Area and Severity Index (PASI) and Lattice System Physician's Global Assessment (LS-PGA). However all three of them have some disadvantages in terms of reliability [3]. Currently, dermatologists rely on PGA assessment method to assess the therapeutic response to Vitiligo treatment. The PGA method is doctor's scoring system based on an ordinary scale of repigmentation within lesion over time [1]. The intra-rater reliability of the PGA is found as 'moderate' (ICC 75%); it was determined by interclass correlation coefficients (ICCs) [3]. Thus, it is a highly subjective method of assessment as intra-rate and inter-rate variation. Moreover the determination treatment efficacy is slow as it takes months for human eye to observe repigmentation within the lesions.

So the challenge is to develop an accurate and fast assessment by choosing proper methods and algorithms. The solution for the current problem is the use of digital imaging which can acquire important data that will be useful in analysis depigmentation due to Vitiligo and repigmentation during the treatment. The use of digital images is valued as the distribution of melanin in these images can be easily analyzed by proper selected algorithm which provides foundation for implementing image processing using modern software tool.

Thus, digital imaging can acquire important data that will be useful in analysis depigmentation due to Vitiligo and repigmentation during the treatment. However, this approach of analysis needs some improvement in order to make it easy available for dermatologists and patients. The use of the current approach requires the basic knowledge on using Matlab program and need for PC and camera. These difficulties can be overcome by making it available on our daily used smartphone. The engineering problem in implementing on smartphone is conversion from Matlab source code to C/C++ source code in Android OS. UTP-MATLAB like Framework (UMF) is an environment to ease the problem of the conversion which is based on IT++, LAPACK and BLAS library, which are mathematic and signal processing libraries. The user can easily use matrix calculation and MATLAB-like notation when installing the framework

in the application. Thus, it provides many useful functions for image or signal processing algorithms, which are written in MATLAB [17].

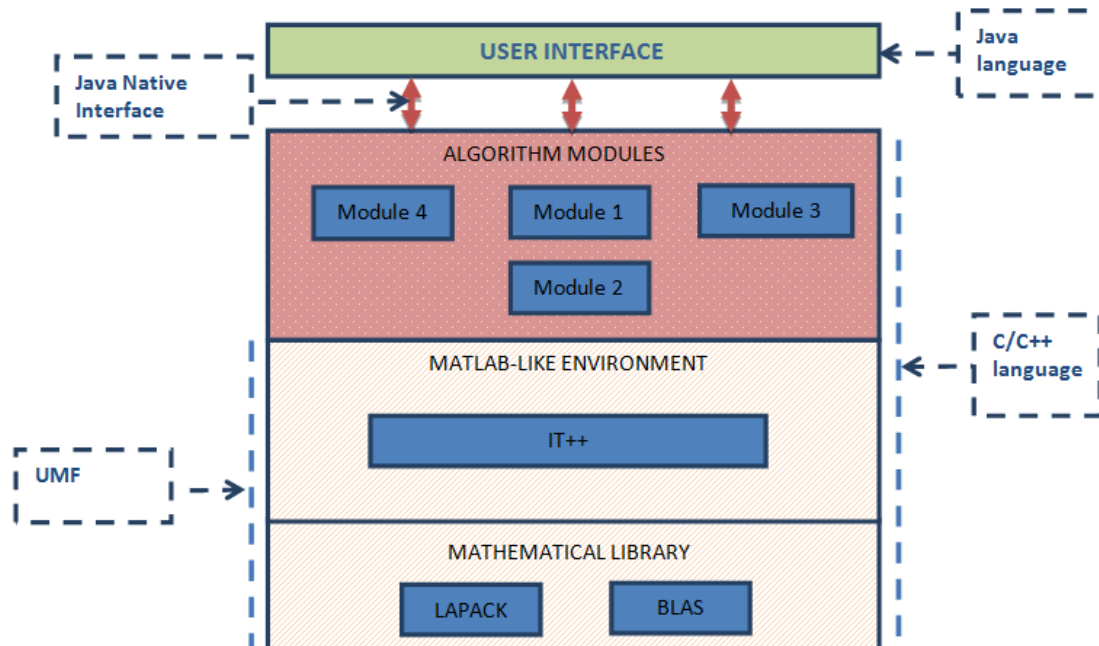


Figure 3: Framework design

1.4 Objectives and Scope of study

The main objective is to measure objectively skin repigmentation for the assessment of therapeutic response in Vitiligo treatments. The measurement is done by applying principal component analysis followed by independent component analysis in order to represent digital skin images in terms of melanin and hemoglobin composition respectively. Current image analysis technique is not reliable in terms of portability. Therefore by creating application of Vitiligo assessment tool on smartphone will ease the use of the assessment tool.

The project is based on collaborative work between Universiti Teknologi PETRONAS and Dermatology Department, Hospital Kuala Lumpur. The software codes are mainly

from the leading software package in the field: *The Matlab Image processing Toolbox* . The image Processing Toolbox is a collection of Matlab functions used for the solution of digital image processing problems. The importance of design image processing systems is the accurate and fast testing and experimentation before reaching desired solution. Particularly reducing the cost and time are major requirements to develop a viable system. Besides any system needs formulate approaches which will lead to an acceptable solution. Besides, apps tool can be made available to dermatologists for clinical use. The scope of the project is to assess the pigmentation of the skin surface by light reflectance. Skin, however does not only vary in structure and brightness but also in color. Some part of the light penetrates into the upper layers (epidermis, dermis) of the skin and gets reflected depending on the difference in the index of reaction between the air and skin surface [1].

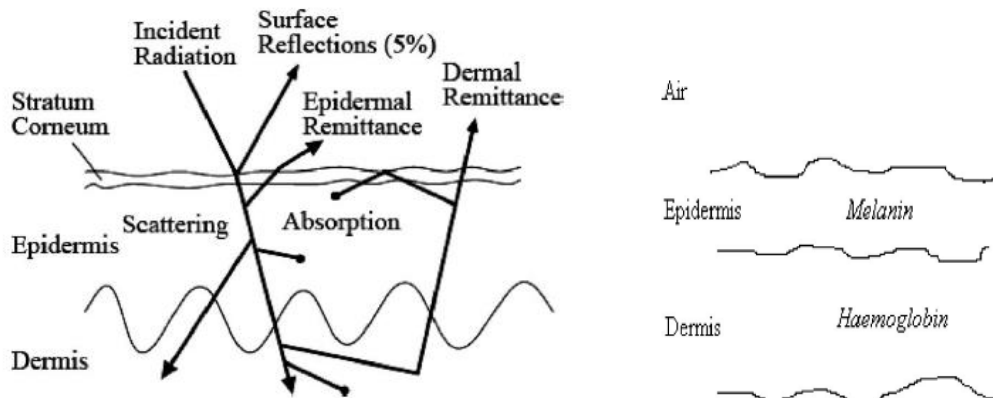
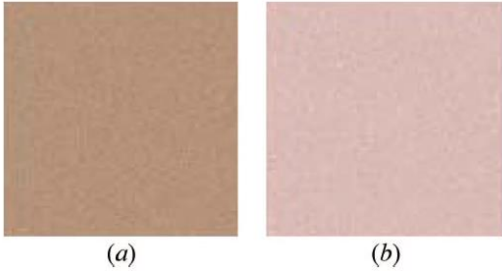


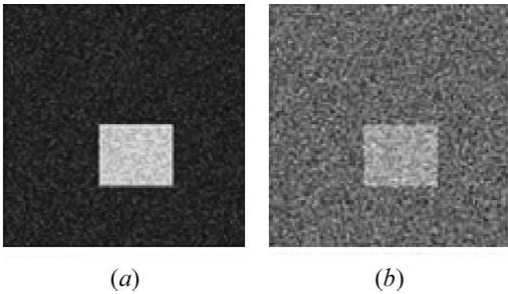
Figure 4: The light penetration into the skin

The light penetrates into the skin and exits back or gets attenuated by the skin chromophores (melanin and hemoglobin). The partial distribution of melanin and hemoglobin in digital images of the skin can be separated by employing independent component analysis of the skin color image [1]. Principle component analysis reduces RGB into two dimensions then with the help of ICA can represent vectors of melanin and hemoglobin. The dimensional reduction of RGB into two principal components is done by subtracting the mean value of image spectral bands from each spectral band

(RGB) [1]. The result of the subtraction is eigenvectors which are used as linear transform of original RGB values. By multiplying eigenvectors with RGB values can get vectors in new space. It proves that principal component analysis is representing RGB skin images by two principal components: principal component 1 and principal component 2 with high accuracy. Independent component analysis arranges PC1 and PC2 in terms of melanin and hemoglobin in order to express its' distribution as a function of pure density vectors. ICA analysis is a function of mixing matrix and independent components. The goal of the ICA analysis in the process is to get the skin area images due to melanin and hemoglobin. ICA is the most optimized process in segmenting an object from its background in a digital image [1]. It is a method of representing skin area due to melanin and hemoglobin. On these melanin or hemoglobin images can easily detect the lack of color pigment which is Vitiligo lesion.



a) Healthy skin b) Vitiligo skin lesion



a) Melanin image b) Hemoglobin image

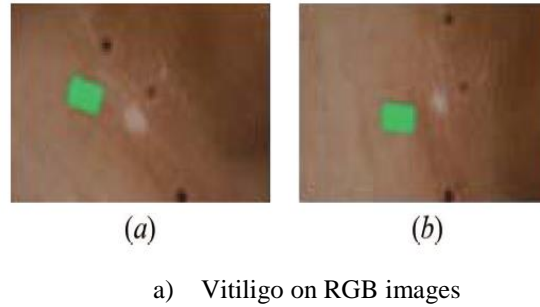


Figure 5: Simulated healthy skin and Vitiligo lesion images.

There are many available methods to segment: Heuristic method, using double threshold, fuzzy c-means based lesion, automatically extraction and many more. The current project is based on Euclidean distance thresholding and performed on the melanin of a skin color image to separate Vitiligo skin lesion from healthy skin [1]. Euclidean distance is performed on the melanin of a skin color image to separate Vitiligo skin lesion from healthy skin. In the technique, two samples of the pigment melanin, each representing the Vitiligo skin lesion and healthy skin segments are obtained. The Euclidean distance is used to map each pixel to its closest segments. The overall flow chat is shown in the figure below.



Figure 6: The overall flow chat

The implemented Vitiligo lesion detection algorithm is used for medical systems running on PCs that can only be used at one stable place. It is causing the reason for developing standalone medical device. Besides, it is beneficial to provide dermatologists with the reliable assessment tool installed on smartphone.

The implementation of Vitiligo assessment algorithm on smartphone includes conversion of designed ICA algorithm to Android by using Java and C programs. The purpose of using Java is to create User Interface as it standardized and platform

independent constructs for creating user interfaces. Java creates applications where user interfaces written in Java, by managing threads, networking and variety other tasks. The aim of the second part of the project is the process creating Java interface for a program written in C. Knowledge of using Java program is highly important, same as the language C/C++. The conversion is based on UMF framework which is based on putting all of the libraries source code and setting file and build with Android NDK in the destination application.

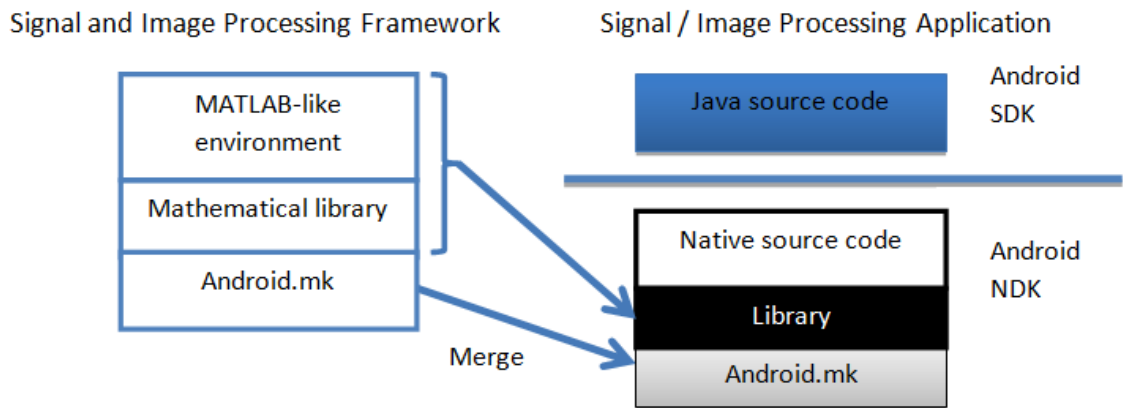


Figure 7: Using Signal and Image Processing Framework in Specific Application

The whole study gives opportunity to gain knowledge as well as practical experience in digital image processing. The ration between theory and experience can slightly vary depending on individual approaches.

However, implementation the whole Matlab source code to Android application from A to Z takes a lot of time therefore objective of Final Year Project 2 is implementing core parts of Matlab source code by investigating the source code, debugging, listing the functionalities which have to be implemented. Therefore in the second part of the final year project was developed android application.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of skin disorders

Perfect skin for most of the people is a dream. Many people suffer from some kind of skin disorders. There are huge variation in symptoms and severity. Besides, they can be permanent or temporary treatable or incurable, situational or genetic, painless or agonizing, minor inconveniences or life-threatening diagnoses.

The definition of the term skin disorder or lesion is a superficial growth or patch of the skin that does not resemble the area surrounding it. Skin lesion consists of two categories: primary and secondary. Primary skin lesions are mostly present at birth while secondary are those changes in the skin which result from the primary skin lesion. It can be as a natural progression or as a result of scratching, picking at a primary lesion. The major classes of skin lesion, based on primary and secondary categories, are Squamous Cell Carcinoma, Seborrhoeic Keratosis, Melanocytic Nevus, Melanoma and Actinic Keratosis [12].



(a) Seborrhoeic Keratosis



(b) Melanocytic Nevus



(c) Actinic Keratosis

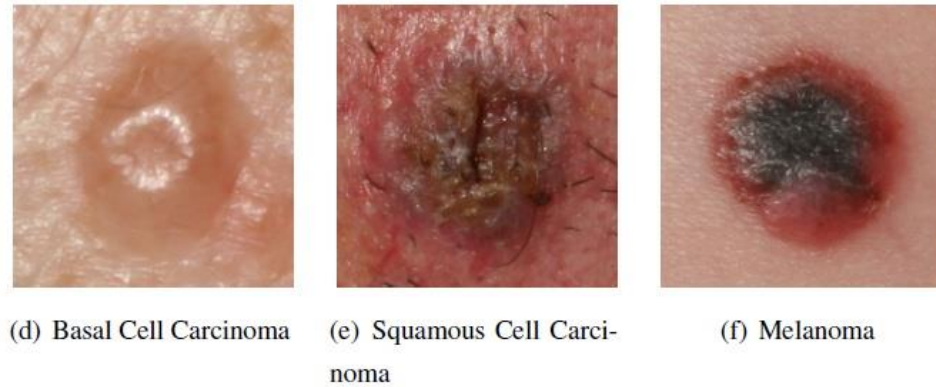


Figure 8: Picture of skin lesion types*

**Reproduced from Ahmad Fadzil and Hermawan N. (2009)*

2.2 Melasma

The current project will be considered on most common skin lesion types which is Melasma and Vitiligo. Melasma is common skin problem; it has brown to gray-brown patches on skin. Melasma is particularly common in women, especially pregnant women and those who are taking oral or patch contraceptives or hormone replacement therapy (HRT) medications. Most people get it on their cheeks, bridge of their nose, forehead, chin, and above their upper lip. It also can appear on other parts of the body that get lots of sun, such as the forearms and neck.

2.2.1 Melasma signs and symptoms

Signs of Melasma are dark patches on skin and they usually appear on the cheeks, forehead, bridge of nose and chin. Regarding the symptoms, Melasma does not have any however; people do not like the appearance of Melasma on their skin.

2.2.2 Melasma diagnosis, treatment, and outcome

Diagnosis of this kind skin disorder is done by dermatologists visually. In order to see penetration of melisma dermatologist use Wood's light device. The procedures are

usually done by using biopsy method which based on removing a small bit of skin. There are melisma treatments are available such as hydroquinone, tretinoin and corticosteroids. This medicine usually comes as creams, gels or lotions. After the treating melisma comes treating therapy called maintenance therapy which prevents melisma from returning.

2.2.3 Melasma causes

Pale patches appear on the human skin cause of skin pigment disorders. People with skin of color are more prone to Melasma because they have more active melanocytes than those with light skin.



Figure 9: Melasma, type of skin disorder

2.3 Vitiligo skin lesion

Vitiligo is another skin disorder where patches have light skin color. Mostly Vitiligo affects the skin but it can develop where ever pigment exist. As an example hair may turn to white color as well even the mouth from inside may lose the color same as eyes.

2.3.1 Vitiligo signs and symptoms

Dermatologist these skin disorders call as loss of pigment or depigmentation. Depigmentation appears on skin, hair, eyelash, inside mouth and even genitals. The effect of depigmentation is lighting skin, other than that people who has Vitiligo feel healthy. Living with Vitiligo can cause other symptoms such as low self-esteem and depression that is hard to beat. This can happen regardless of the amount of color loss or type of Vitiligo.

2.3.2 Vitiligo diagnosis, treatment, and outcome

Diagnosis is usually done by giving to patient the questions such as whether anyone in the family has Vitiligo. Besides dermatologist does review medical history or perform a physical exam visually. As for treatment the goal is to restore lost skin color.

2.3.3 Vitiligo causes

Vitiligo occurs about equally in people of all skin colors and races. Vitiligo happens when melanocytes die. There is no specific reason is discovered till now.



Figure 10: Vitiligo type of skin disorder.

2.4 Current methods of assessments – strengths and drawbacks

2.4.1 Nursing assessment

This type of assessment includes detailed dermatological history which should cover starting from history of the patient's skin condition, general assessment, and specific

skin assessment, consideration of the skin as a sensory organ and assessment of the patient's knowledge about his skin condition. All information listed above need for diagnosis, management and nursing care of the existing skin disorder [11].

2.4.2 Physical assessment

This assessment considers such factors as religion, culture. Besides, assessment procedures should be done in a warm environment with privacy as doctor must check whether the skin disorders are only on one part of the body like arms and legs or there is lesion on the private parts of the body as well. Dermatologists carefully examine the distribution, shape and character of skin patches. It is important to have good conditions for assessment such as warm environment, good lights and time. In conclusion can say that this assessment method is very subjective and leads to inter-rate and intra-rate variability.

Listed above types of assessing the skin disorder are basically done visually where power of observation is high. It is vital to not only look but also listen to patient. This will bring benefits for visual assessment, prevention and cure of disease. In current case education of dermatologist is very important, however, some or new dermatologists will have no experience of patience with skin conditions. Therefore they must be aware of wide-range effects of skin disease and understand the basic principles of skin disease and care. In conclusion can say that diagnosis of dermatologists have limitations, seeking further advice as necessary.

2.5 Developing Android apps

Nowadays there are number of telecom offers and options. In addition, they are becoming more and more widespread. For example can notice how capacity of digital switches and transmission structures are increased same goes to enabling companies to optimize the use of shared public networks. Here it comes to the mobile applications as well, where the benefit of using it for current experiment is the strategy of obtaining resources, shared among a large number of users. The next part of the project is converting results from Matlab into Android Tablet. Some authors [2] claimed that the best choice is Java Platform Micro Edition, due to its simplicity. As for our opinion we are going to use Android application. Mobile applications or software are having the same meaning and they exist for the smart phones. In general these applications are interconnected with websites for the new updates or sharing files, documents also have included emails, calendar, contacts, weather information, GPS, location based services and etc [5]. Sometimes to have them on the phone need to buy from the owner however nowadays phones already have installed. The installation is usually done from the mobile software distribution platforms. So far one of the leading platforms is Google's Android [6]. Android is a free source Operation System used for the smartphone where modification and distribution is done by the device manufacturers, besides Android has high development and productivity from famous vendors such as Samsung, Acer and HTC [6].

2.5.1 Techniques of conversation

Created Independent Component analysis algorithm in Matlab using Image Processing Tool Box can be used on Android Tablet. There are available few options:

- a. Manually porting Matlab code to native C using Matlab functions in C (requires significant and time consuming programming efforts).

b. Automatically porting Matlab code using Matlab Coder (requires purchase of the very expensive Matlab Coder; in addition, not sure if it covers everything what needed for the project).

c. Installing Matlab Run-Time on Android (too heavy for Android Tablet and not sure if it is possible)

d. Running Matlab algorithm externally on some server (Android app is stand-alone, so may not be able to use this option).

2.5.1 MathWorks

With the access to Matlab coder the conversion could be done easier because it can generate C code or build a library and add that to project for android. From algorithms written in Matlab can be generated readable source code, or a standalone compiled executable or a library that can be shared. MathWorks engineers also explore how can automatically generate MEX functions that can be used to verify the behavior of the generated code back in Matlab or to accelerate computationally intensive portions of Matlab code by running it at compiled speed. However, this code will not be as fast as the Matlab version, since the Matlab code is highly optimized especially for matrix operations.

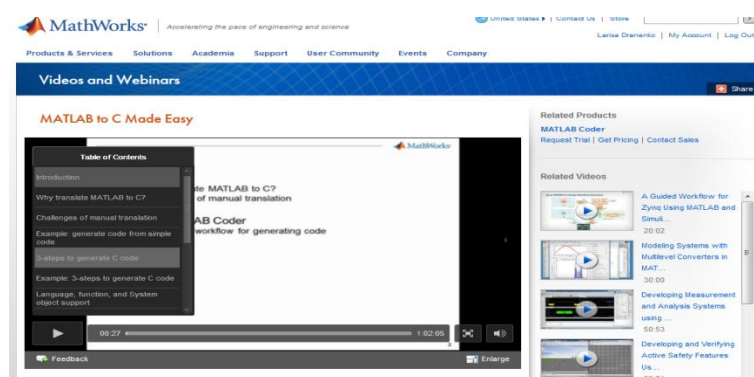


Figure 11 MathWorks webpage

2.5.2 Octave

Octave is another option which is highly recommended as well. It can full fill the necessary needs for the conversion Matlab code to Android. Octave is a different sort of app, it is like Matlab (trademark of MathWorks), but free (as in freedom) software. Not some similar program, but really Octave running natively. Unpacking the executable and other files necessary for Octave to run will take a while to install or upgrade it.

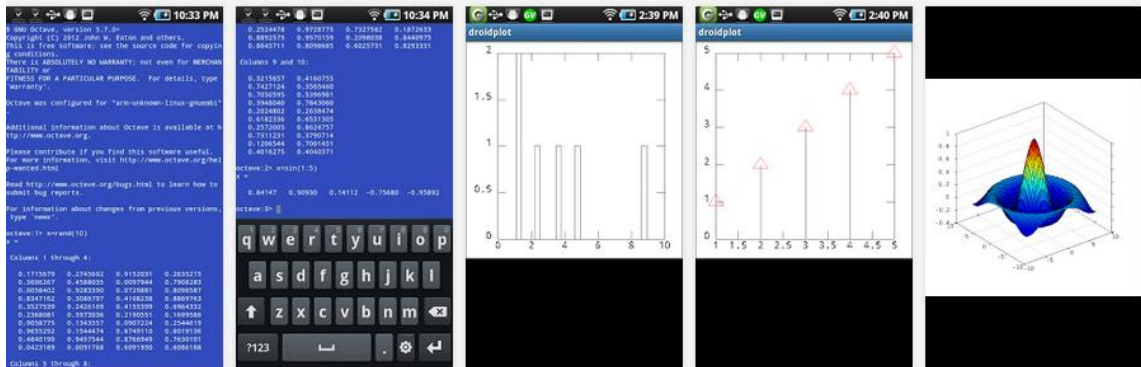


Figure 12 GNU Octave for Android

2.5.3 Android SDK

The best way to make conversion is to reprogram algorithm with available libraries for android in this case openCV can help since it has several functions to do image processing. OpenCV4Android SDK package enables development of Android applications with use of OpenCV library.

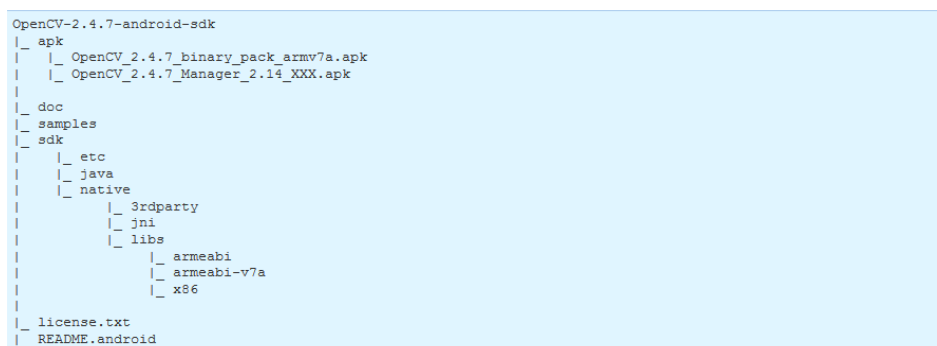


Figure 13 The look of the package contents structure

2.6 Related works

2.6.1 ICA for assessing Vitiligo therapeutic response

There are already implemented algorithms, which are quite important for the current project. There has been proposed a new and accurate image analysis technique for skin repigmentation [1]. The proposed method is based on use principal component analysis followed by independent component analysis to represent digital skin images in terms of melanin and hemoglobin composition. The representation skin area due to melanin and hemoglobin is done by use of principal component analysis which converts RGB image to two principal components PC1 and PC2. To find these principal components of an image the mean value image spectral bands subtracted from each RGB spectral bands. The resulting covariance matrix is used to calculate the eigenvectors then can obtain that these eigenvectors are linear transform of original RGB values. Next, independent component analysis will align skin color distribution as a function of pure density vectors of PC1 and PC2 on independent image coordinates x and y [1]. PCA of and image is found by initially subtracting the mean value from each of image spectral bands (RGB) to obtain zero mean variable.

$$R = R_0 - \mu_{R_0}, \quad G = G_0 - \mu_{G_0}, \quad B = B_0 - \mu_{B_0}, \quad (1)$$

Covariance matrix of RGB is calculated by using following equations:

$$COV = \begin{bmatrix} C_{RR} & C_{GR} & C_{BR} \\ C_{RG} & C_{GG} & C_{BG} \\ C_{RB} & C_{GB} & C_{BB} \end{bmatrix}, \quad (2)$$

where

$$C_{XX} = \frac{1}{N} \sum_{i=1}^N (X_i - \mu_i)^2 \quad (3)$$

$$C_{XY} = C_{YX} = \frac{1}{N} \left(\sum_{i=1}^N X_i Y_i \right) - \mu_X \mu_Y \quad (4)$$

$$\mu_X = \frac{1}{N} \sum_{i=1}^N X_i \quad (5)$$

$$COV = \gamma \lambda \gamma^T, \quad (6)$$

Equation (6) is used to find eigenvectors which is linear transform of original RGB vectors. Resulting matrix has uncorrelated components; primary axis of the data has been aligned.

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (7)$$

After finding COV matrix $[X_1; X_2; X_3]$ can obtain that

$$\begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix}$$

is eigenvectors of COV matrix; it proves that RGB image can be represented by using PCA [1]. The color distribution can be represented in terms of melanin and hemoglobin s_1 and s_2 , with image coordinates (x,y) which are independent variables. The color vectors of the two pigments per unit quantity are denoted a_1 and a_2 , respectively. It is also assumed that the compound color vector $v(x,y)$ can be calculated using linear combination of the color vectors as shown in the equation (8).

$$v(x,y) = a_1 s_1(x,y) + a_2 s_2(x,y). \quad (8)$$

This equation is known as ICA equation; it gives stronger independence condition. This equation is used to find new matrix and the output is images that represent area due to melanin or hemoglobin [1]. The author of this paper compares the skin repigmentation assessment by physician's global assessment and the developed algorithm to ensure the accuracy of the proposed algorithm. Doctors compare the digital images of Vitiligo lesion before and after six weeks of treatment. The changes in Vitiligo area on digital images can be easily and fast determined repigmentation process. Therefore the conversion of RGB images to melanin skin images is very essential for the current project. The use of principal component analysis and independent component analysis method is able determine repigmentation due to treatment and depigmentation due to Vitiligo skin disease in a shorter period of time. Therefore, proposed algorithm eliminates intra-rate and inter-rate variability in the skin disorder assessment process.

2.6.2 ICA for melanoma screening

Moreover, dermatologists use ABCD rule for melanoma screening as a guideline to make visual assessment [12]. The author describes that the most of the techniques focus on recognizing melanoma instead of classifying the types of lesion. As a solution to this problem was developed a system based on ICA algorithm and color features for melanoma detection through the use of a Support Vector Machine. The process of using ICA is to optimize segmentation process to separate the lesion region from normal skin. The use of a single set of filters from a mixed collection of images is highly beneficial in segmenting the skin lesion from healthy skin because filter can deal with the lesion located at the borders.

2.6.3 ICA for assessing Ulcer therapeutic response

ICA is used to extract grey level hemoglobin images from RGB color images of Ulcer lesion. Extracted hemoglobin images indicate areas of hemoglobin distribution reflecting detected regions of repigmentation. Data clustering technique was used to segment detected regions of healing from the extracted images. Based on the results obtained indicate that developed ICA algorithm is accurate and precise with sensitivity

of 88.2% and 98.82% and specificity of 98.82% when compared to the dermatologist's assessment [18]. The study in this paper is concentrated on utilizing optical characteristics of pigment hemoglobin to detect regions of granulation tissue as a measure healing process. ICA algorithm employed to extract grey-level images that show the distribution of hemoglobin from RGB image of Ulcer.

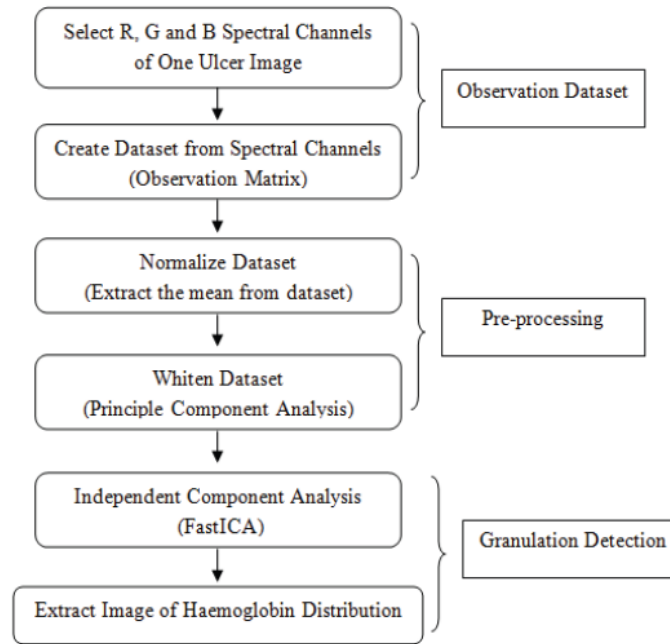


Figure 14 Flow chart of hemoglobin distribution Detection ICA algorithm*

**Reproduced from Ahmad Fadzil and Leena Arshad (2012)*

In conclusion can say that digital skin image analysis gives us two advantages: it can find out where non-melanin areas on human's body and repigmenting it in a short time. Knowledge regarding image morphology, full color image processing, image data compressing is getting more useful in medicine. All this can be done by properly selected algorithms, which can deal with segmentation and registration of digital images.

CHAPTER 3 METHODOLOGY

3.1 Digital image processing technique

The skin disorders can be analyzed by using digital image analysis. Responsibility of pigmentation and registration for the isolation of pathological findings highly appreciated as matching of sequential images in computer systems. In medicine, diagnostic evaluation and verification of Vitiligo or any other type of skin disease is done visually [2]. Skin images are highly important in determining repigmentation progress cause of connection of RGB images and melanin. This connection can be done by reducing 3D RGB images into 2D data. This reduction is made by using ICA which gives ability to arrange 2D data into melanin and hemoglobin therefore can be easily determined Vitiligo lesion (non-melanin area) and progress of repigmentation. The reason of choosing ICA over PCA is that the PCA is a transformation procedure to convert a set of observations into a set of variables called principal components though ICA is extended approach of PCA it can provide sources and separate signals into independent subcomponent [7]. So the meaning is that ICA will separate melanin spectrum from the noisy spectrum and this is what we are looking for.

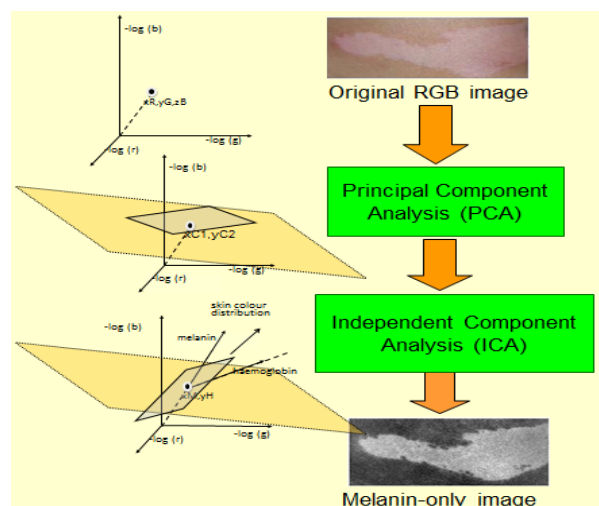


Figure 15: ICA working principle *Reproduced from Ahmad Fadzil & Hermawan N. (2009)

3.2 Gantt Chart

3.2.1 First semester

No	Activities/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	<i>Selection of Project topic</i>														
2	<i>Research</i> <ul style="list-style-type: none"> • <i>Understanding Vitiligo, causes, treatment, symptoms</i> • <i>Research on Vitiligo assessment</i> 														
3	<i>Learn ICA and practice</i>														
4	<i>Implement ICA on the project</i>														
5	<i>Matlab practice</i>														

3.2.2 Second semester

No	Activities/Weeks	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Learn Basic Android <ul style="list-style-type: none"> Learn Android SDK 															
2	Learn Android developer <ul style="list-style-type: none"> Java language Interfaces 															
3	Implement Algorithm to Android platform															
4	Create UI															
5	Testing															
6	Debug															
7	Viva															

3.3 Android Application Development

So far one of the leading platforms is Google's Android [6]. Android is a free source Operation System used for the smartphone where modification and distribution is done by the device manufacturers, besides Android has high development and productivity from famous vendors such as Samsung, Acer and HTC [6]. Android is built on top of a solid and proven foundation: the Linux kernel. The program cannot call the Linux directly instead there have a helper which is Dalvik Virtual Machine. The next layers above the kernel contain the Android native libraries. Dalvik virtual machine is located on the Android Runtime sitting also on the above the kernel layer. One of the Google's implementation of Java is on Dalvik VM, which was optimized for mobile devices. All code will be written in Java and run within the VM. Above the libraries and runtime layer, there is Application Framework layer. It's provides the high-level building blocks. And the topmost layer is Application and Widget layer. End users can only see this type of layer.

In this part was developed useful Android application by starting with the basics of the Android tools and into developing the screens and home screen widgets that user will interact with.

- Creating new blank project in Eclipse
- Understanding errors
- Creating an emulator (AVD)
- Setting up and copying lunch configurations
- Running first application
- Studying the anatomy of the project

In the second part of the project is implementing the digital image processing technique on the android based application. The basic of Java language has been studied in order to proceed as android developer because android application mostly on Java language. Basically, the process of android application development can be seen in figure below.

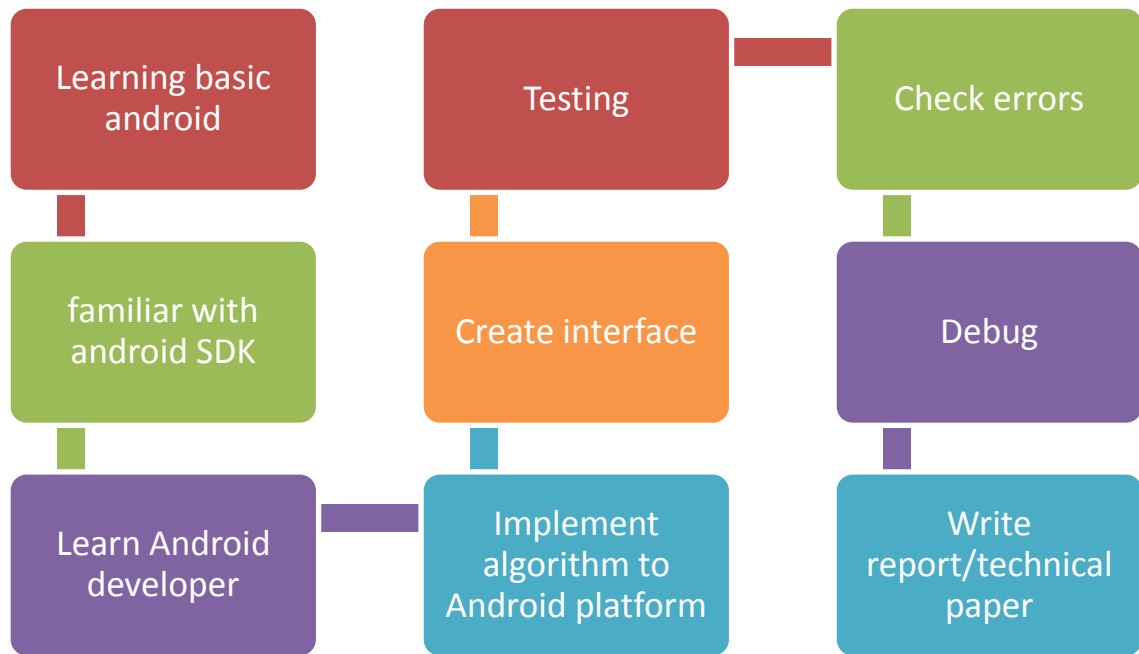


Figure 16: Project flow

3.4 Software and tools

The software tools selected are from the MATLAB Image Processing Toolbox. Image Processing Toolbox offers some significant advantages, not only by its computational tools, but also because it is supported under most operating systems in use today. During the current Final Year Project I main objectives are learning the fundamentals of MATLAB functions and programming in image processing. The second part of the project will be done with the help of Android, developed by Google is an operating system. The reason for choosing Android is due to its efficiency status among the other operating systems. Android provides convenient platform for implementation [17]. Android is good to build User Interface and utilize Android APIs from Google's support like touch screen and graphic display. The most important part in the project flow is Vitiligo skin lesion assessment system which includes ICA algorithm, which will be written in C code through Android Native Development Kit.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

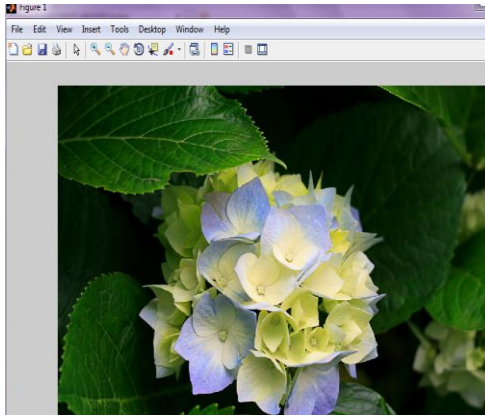
As it was said above work of FYP1 was considered on learning some basics such as reading images, displaying images, writing images, image types, converting between data classes and image types, function `imadjust`, spatial filtering, color image representation in Matlab, converting to other color spaces, RGB vector spaces.

4.1.1 Read Image

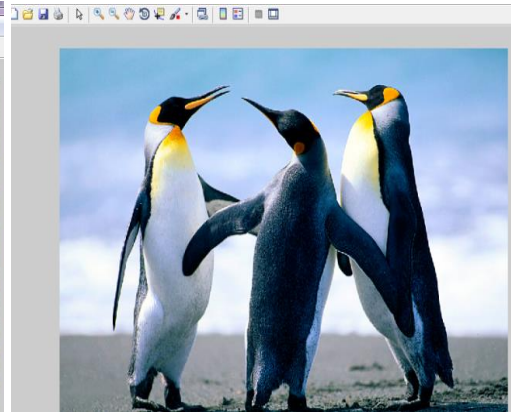
Images are read into Matlab using function `imread` ('filename'), the filename is the complete name of the image file (including any extensions). For example command line reads jpg image into image array `f`. The semicolon at the end of the command is used for suppressing and `imread` reads from directory. The most common way to read image on Matlab is to use full path in that directory in filename place, meaning that `Users\user\Desktop\` is the place where the image is located and Matlab reads directly from desktop. In the right side of the command window of Matlab can see the size of image for example for my used image size is (720*960) in case for better illustration of image size can use the command.

4.1.2 Image display

In order to display the image need to use following command `imshow` (`f`). When new image is used to display Matlab automatically replaces old image with new one. Next function is `imwrite` function which is used to write the images to graphic file. This command used to compress as much as possible while not degrading beyond a reasonable level. `imwrite(A,filename,fmt)` writes the image `A` to the file specified by filename in the format specified by `fmt`. `A` can be an M-by-N (grayscale image) or M-



a) Imread function



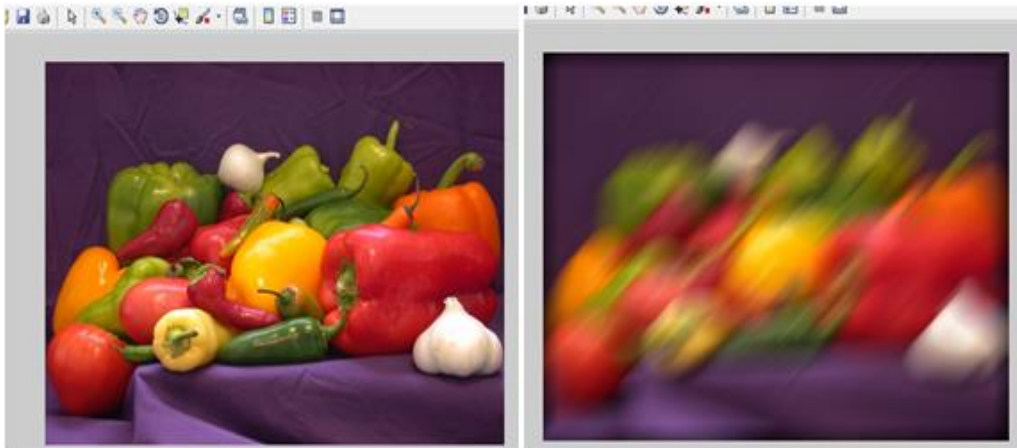
b) Imshow function



b) Im2bw function



d) fspecial('gaussian') function



e) RGB image smoothing

Figure 17: Examples of using image display functions

by-N-by-3 (true color image) array, but it cannot be an empty array. *filename* is a string that specifies the name of the output file. *fmt* can be any of the text strings listed in the table in Supported Image Types. This list of supported formats is determined by the MATLAB image file format registry. The table below summarizes the types of images that `imwrite` can write. The MATLAB file format registry determines which file formats are supported. However, for certain formats, `imwrite` may take additional parameters. In current project will be discussed more about Binary and RGB images. Digital images or binary images have logical array of 0s or 1s. In case if image is `uint8` which has the range from 0 to 255 is not a binary image. So to display `uint8` as binary need use the command `B=logical(A)` this logical function converts all nonzero values to 1s and values 0 to 0s. The most important part in image processing is color image processing using Image Processing Toolbox which easily handles RGB (red, green, blue) images. Matlab handles 24-bit RGB images in much the same way as grayscale.

4.1.3 RGB image

The pixels values now consist of 3 values representing red, green and blue color unlike to grayscale images. The difference between these two types of images is RGB images are not two-dimensional but three-dimensional matrix which also known as multidimensional array. One of the useful commands is `pixel` command. Which returns the red, green, and blue values of the pixel at column 200, row 100. If RGB image is class of `uint8` then the range is from 0 to 255 and if `uint16` then the range is from 0 to 65535. The possible colors in RGB for 8 bits is $(2^8)^3$ is 16777216 colors. `BW = im2bw (I, level)` converts the grayscale image `I` to a binary image. The output image `BW` replaces all pixels in the input image with luminance greater than `level` with the value 1 (white) and replaces all other pixels with the value 0 (black). Specify `level` in the range `[0, 1]`. This range is relative to the signal levels possible for the image's class. Therefore, a `level` value of 0.5 is midway between black and white, regardless of class. To compute the `level` argument, can use the function `graythresh`. If you do not specify `level`, `im2bw` uses the value 0.5. Histogram used for grayscale images, to point out its gray levels. The idea of histogram is to enhance the poorly contrasted image by spreading out its

histogram (H. Papasaika-Hanusch). One of the ways to do it is thresholding where grayscale image is turned into a binary image by first choosing a gray level T in the original image, and then turning every pixel black or white according to whether its gray value is greater than or less than T. Here the data class is uint8 where the filter filters the image cameraman by using Gaussian method and result is clearer image from original one.

4.1.4 Spatial filtering

Spatial filtering of color images by concentrating mostly on RGB images can be done by 2 types of filtering: image smoothing and image filtering. To make filtering processing faster can be used another way to filter which is using following function. Example of using `imfilter` function. In order to use `imfilter` function need to create filter that can be used to approximate linear camera motion, `h = fspecial('motion', 50, 45)`.

Linear spatial filters for image smoothing are generated with function `fspecial` with one of three options: 'average', 'disk', 'gaussian'. Filtering is performed by using function `imfilter`. Generally linear spatial filtering is performed by convolution or correlation. Correlation is the processing passing the mask `w` by the image array `f`. Convolution is the same process except that `w` is rotated by 180 degree.

Image smoothing or spatial averaging can be accomplished by multiplying all pixel values by all elements which are 1s and dividing by the total number of these elements. The process of smoothing RGB images is same as in grey scale. The difference is that in grey scale the process involves single pixels while in RGB vector values. The average of RGB vectors is gives as:

$$\bar{\mathbf{c}}(x, y) = \frac{1}{K} \sum_{(s, t) \in S_{xy}} \mathbf{c}(s, t) \quad (1)$$

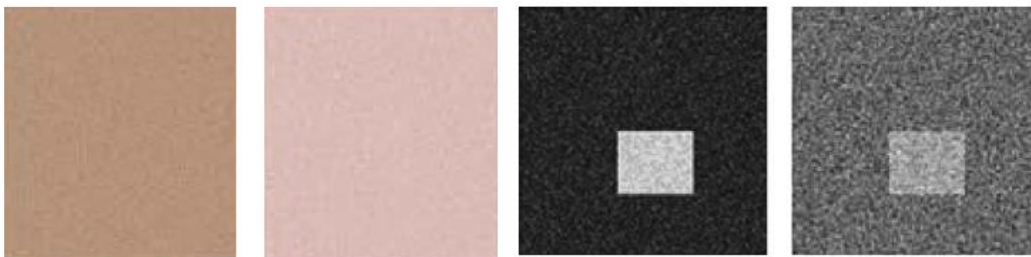
where K is number of pixels, so the properties for vectors is:

$$\bar{c}(x, y) = \begin{bmatrix} \frac{1}{K} \sum_{(s, t) \in S_{xy}} R(s, t) \\ \frac{1}{K} \sum_{(s, t) \in S_{xy}} G(s, t) \\ \frac{1}{K} \sum_{(s, t) \in S_{xy}} B(s, t) \end{bmatrix} \quad (2)$$

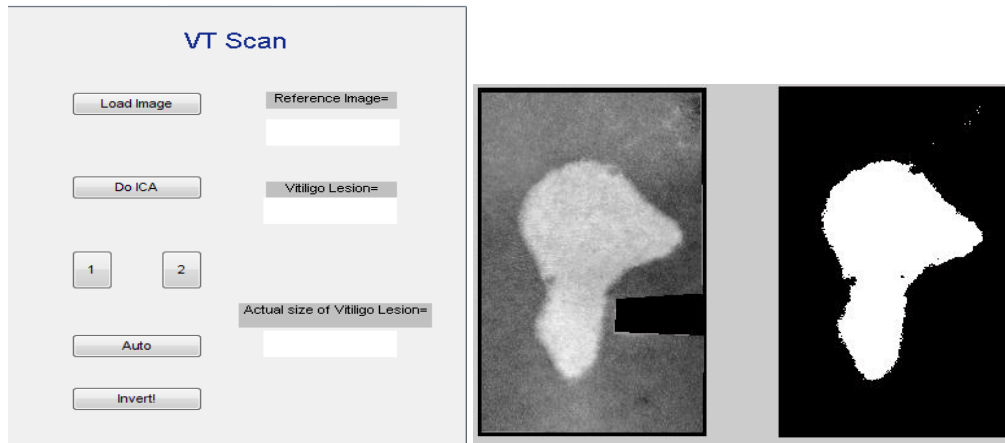
The formula above represents average on each individual component image. In conclusion from the formula above can say that smoothing by neighborhood averaging can be carried out on independent component basis. Now let's see how can be generated smoothing images in Matlab.

4.1.5 Measured performance

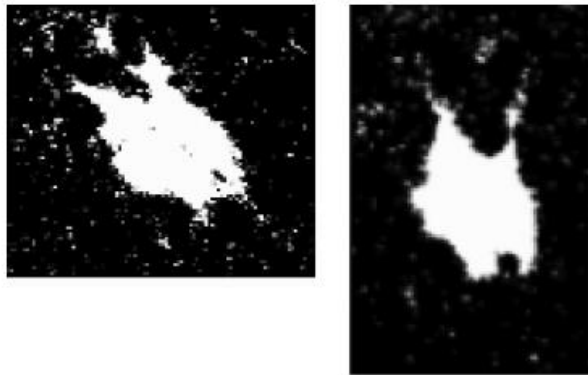
The chosen ICA algorithm does calculations based on reference image model. These images are divided into two types: healthy skin and Vitiligo skin lesion. Basically this model is based on distribution of color in three spectral bands RGB. In order to use these samples as a reference they need to be chosen by dermatologists. The best way to model the skin color distribution is using Gaussian distribution [1]. The use of these reference models to check the ability of the algorithm. The size of the reference image is 200×200 pixels and constructed based on the size of Vitiligo lesion found on the data [1]. As it was discussed in the previous chapters, Vitiligo occurs due to the lack of melanin, therefore from melanin component image healthy and Vitiligo areas can be seen on the images. Based on the results from the images, the previous and current repigmentation process can be easily analyzed.



a) Simulated healthy and Vitiligo skin



b) Reference model: melanin and hemoglobin



c) Results after 6 weeks

Figure 18: Segmented melanin image and segmented melanin image after 6 weeks

The comparison between PGA and the proposed algorithm will ensure the accuracy of the actual size of the pixel in each image which was calibrated using the reference image. Based on the comparison results the measurement of the proposed system is accurate with the less time spend for the assessment. The change in Vitiligo areas will help to dermatologist easily and fast to determine the repigmentation of the skin disease. However to make is more available we propose the progress to the current project which is making the system available on our smartphone. The repigmentation analysis is written in the Matlab software which can be converted into Java language in order to make it run on smartphone.

4.2 Creating Android apps

4.2.1 Installing Android development environment (Windows)

There are several available tutorials designed to help with installation and configuration of OpenCV4Android SDK. Online tutorials guide to install needed software which are given in the figure below.

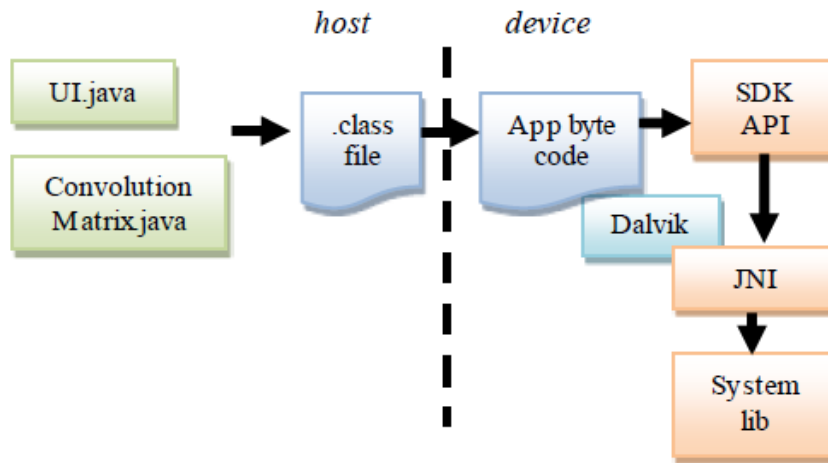
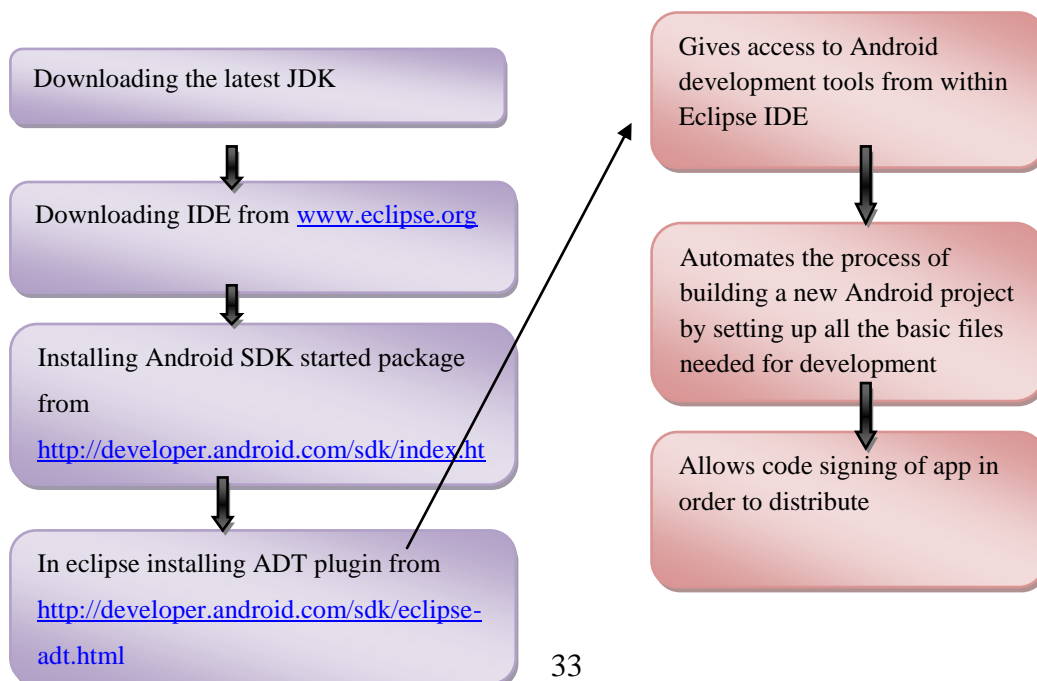


Figure 19: Java working flow*

**Reproduced from Duct ran & Azmadi Fawnizu*



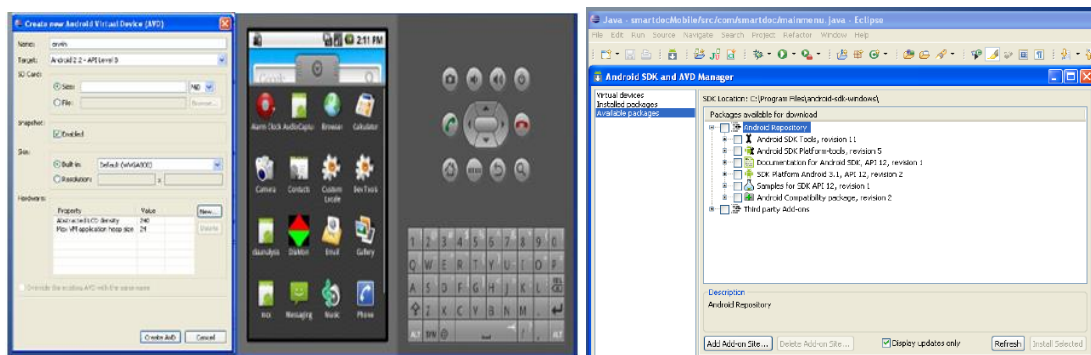
↓

Instructions on setting up SDK and development Environment can be found on <http://developer.android.com/sdk/installing.html>

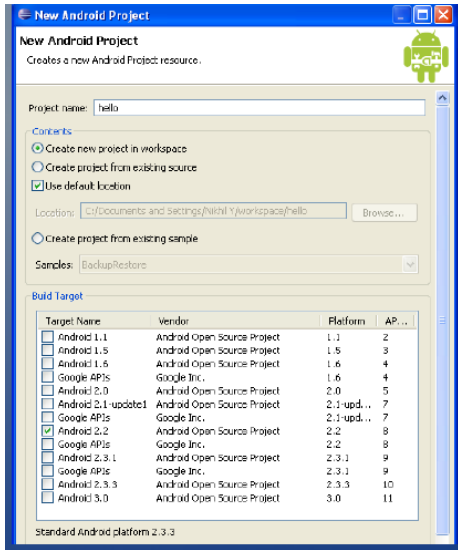
Figure 20: Android development environment

However, the full Android development does not always include the core SDK tools. It is requirement to keep track of downloads for the ADT plugin set-up C:\Program Files\android-sdk-windows\platformtools; Useful for “adb” commands. Android SDK has following components:

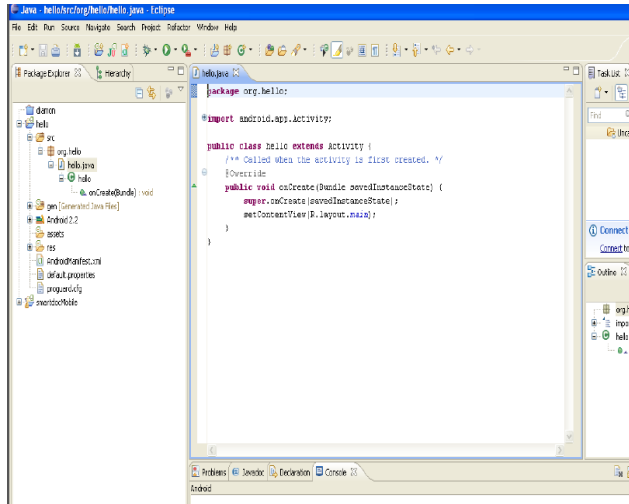
- src/ Includes your stub Activity Java file
- Gen/ This contains the Java files generated by ADT
- R.java file and interfaces created from AIDL files
- Assets/This is empty. You can use it to store raw asset files.
- Res/A folder for your application resources, such as drawable files, layout files, string values, etc.
- AndroidManifest.xml The Android Manifest
- Default/properties in this file contains project settings, such as the build target.



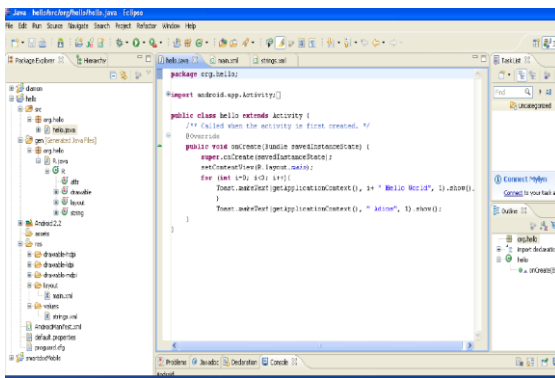
a) Virtual device



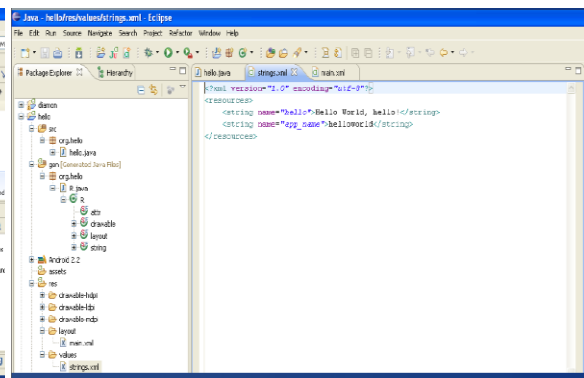
b) Android SDK and AVD Manager



c) "Hello world" empty project



d) "Hello World" project



a) "Hello.java" file

b) Strings.xml file C) main.xml file

Figure 21: Android apps

4.2.2 User Interface

UI is the first view of the application. The interface source file is inside the `res/layout/main.xml` of a project directory. The function `<button>` used to insert a button on the GUI. Every buttons was represented by an `id` each, which provided an identity to each button. The button id was used inside a java class file to execute a represented task when the button was pressed. The java code () shows a method how the button was represented into a different task. UI has four buttons with different functions. The first

button is “start” button which navigate user into 2 options either “capture a photo” or “choose image from SD card”.

```
package org.example.draftproject;

import java.io.File;

public class Start extends Activity {
    private Uri mImageCaptureUri;
    private ImageView mImageView;

    private static final int PICK_FROM_CAMERA = 1;
    private static final int CROP_FROM_CAMERA = 2;
    private static final int PICK_FROM_FILE = 3;

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        setContentView(R.layout.start_layout);

        final String [] items          = new String [] {"Take from camera", "Select from gallery"};
        ArrayAdapter<String> adapter    = new ArrayAdapter<String> (this, android.R.layout.select_dialog_item, items);
        AlertDialog.Builder builder    = new AlertDialog.Builder(this);

        builder.setTitle("Select Image");
        builder.setAdapter(adapter, new DialogInterface.OnClickListener() {
            public void onClick( DialogInterface dialog, int item ) { //pick from camera
                if (item == 0) {
                    Intent captureIntent = new Intent(MediaStore.ACTION_IMAGE_CAPTURE);

                    File imagesFolder = new File(Environment.getExternalStorageDirectory(), "MyImages");
                    imagesFolder.mkdirs(); // <----
                    File image = new File(imagesFolder, "image_001.jpg");

                    mImageCaptureUri = Uri.fromFile(image);

                    mImageCaptureUri = Uri.fromFile(new File(Environment.getExternalStorageDirectory(),
                                                                "tmp_avatar_" + String.valueOf(System.currentTimeMillis()) + ".jpg"));

                    captureIntent.putExtra(android.provider.MediaStore.EXTRA_OUTPUT, mImageCaptureUri);

                    try {
                        captureIntent.putExtra("return-data", true);

                        startActivityForResult(captureIntent, PICK_FROM_CAMERA);
                    } catch (ActivityNotFoundException e) {
                        e.printStackTrace();
                    }
                }
            }
        });

        } else { //pick from file
            Intent getPicIntent = new Intent();

            getPicIntent.setType("image/*");
            getPicIntent.setAction(Intent.ACTION_GET_CONTENT);

            startActivityForResult(Intent.createChooser(getPicIntent, "Complete action using"), PICK_FROM_FILE);
        }
    }
}
```

```

AlertDialog dialog = builder.create();

Button    = (Button) findViewById(R.id.btn_crop);
ImageView = (ImageView) findViewById(R.id.iv_photo);

setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View v) {
        dialog.show();
    }
})

@Override
public void onActivityResult(int requestCode, int resultCode, Intent data) {
    if (resultCode != RESULT_OK) return;

    switch (requestCode) {
        case PICK_FROM_CAMERA:
            doCrop();

            break;

        case PICK_FROM_FILE:
            mImageCaptureUri = data.getData();

            doCrop();

            break;

        case CROP_FROM_CAMERA:
            Bundle extras = data.getExtras();

            if (extras != null) {
                Bitmap photo = extras.getParcelable("data");

                mImageView.setImageBitmap(photo);
            }

            File f = new File(mImageCaptureUri.getPath());

            if (f.exists()) f.delete();

            break;
    }
}

private void doCrop() {
    final ArrayList<CropOption> cropOptions = new ArrayList<CropOption>();

    Intent intent = new Intent("com.android.camera.action.CROP");
    intent.setType("image/*");
}

```

```

int size = list.size();

if (size == 0) {
    Toast.makeText(this, "Can not find image crop app", Toast.LENGTH_SHORT).show();

    return;
} else {
    intent.setData(mImageCaptureUri);

    intent.putExtra("outputX", 200);
    intent.putExtra("outputY", 200);
    intent.putExtra("aspectX", 1);
    intent.putExtra("aspectY", 1);
    intent.putExtra("scale", true);
    intent.putExtra("return-data", true);

    if (size == 1) {
        Intent i = new Intent(intent);
        ResolveInfo res = list.get(0);

        i.setComponent( new ComponentName(res.activityInfo.packageName, res.activityInfo

        startActivityForResult(i, CROP_FROM_CAMERA);
    } else {
        for (ResolveInfo res : list) {
            final CropOption co = new CropOption();

            co.title = getPackageManager().getApplicationLabel(res.activityInfo.applicationInfo);
            co.icon = getPackageManager().getApplicationIcon(res.activityInfo.applicationInfo);
            co.appIntent = new Intent(intent);

            co.appIntent.setComponent( new ComponentName(res.activityInfo.packageName, res.activityIn

            cropOptions.add(co);
        }

        CropOptionAdapter adapter = new CropOptionAdapter(getApplicationContext(), cropOptions);

        AlertDialog.Builder builder = new AlertDialog.Builder(this);
        builder.setTitle("Choose Crop App");
        builder.setAdapter( adapter, new DialogInterface.OnClickListener() {
            public void onClick( DialogInterface dialog, int item ) {
                startActivityForResult( cropOptions.get(item).appIntent, CROP_FROM_CAMERA);
            }
        });

        builder.setOnCancelListener( new DialogInterface.OnCancelListener() {
            @Override
            public void onCancel( DialogInterface dialog ) {

                if (mImageCaptureUri != null ) {
                    getContentResolver().delete(mImageCaptureUri, null, null );
                    mImageCaptureUri = null;
                }
            }
        });
    }
}

```



```

builder.setAdapter( adapter, new DialogInterface.OnClickListener() {
    public void onClick( DialogInterface dialog, int item ) {
        startActivityForResult( cropOptions.get(item).appIntent, CROP_FROM_CAMERA);
    }
});

builder.setOnCancelListener( new DialogInterface.OnCancelListener() {
    @Override
    public void onCancel( DialogInterface dialog ) {

        if (mImageCaptureUri != null ) {
            getContentResolver().delete(mImageCaptureUri, null, null );
            mImageCaptureUri = null;
        }
    }
});

AlertDialog alert = builder.create();

alert.show();

```

Figure 22: Start.java file

First, option - to capture the Vitiligo image of the patient, while the second option is to select the present Vitiligo image on the SD card. Second button in UI is Tutorial button for the tutorial to this application.

```

package org.example.draftproject;

import org.example.sudoku.R;

public class Tutorial extends Activity {

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.tutorial);
    }
}

```

Figure 23: Tutorial.java button

This button will navigate user to open a webpage, which is a tutorial webpage. In the tutorial webpage, there will be a video and step-by-step on how to operate the application. Third button is 'about' button, which tells the user all about the digital image assessment application on android, the developer and also an email of developer if there is any enquiries to ask.

```

+ * Excerpted from "Hello, Android",
package org.example.draftproject;

+ import org.example.sudoku.R;

public class About extends Activity {
- @Override
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.about);
}
}

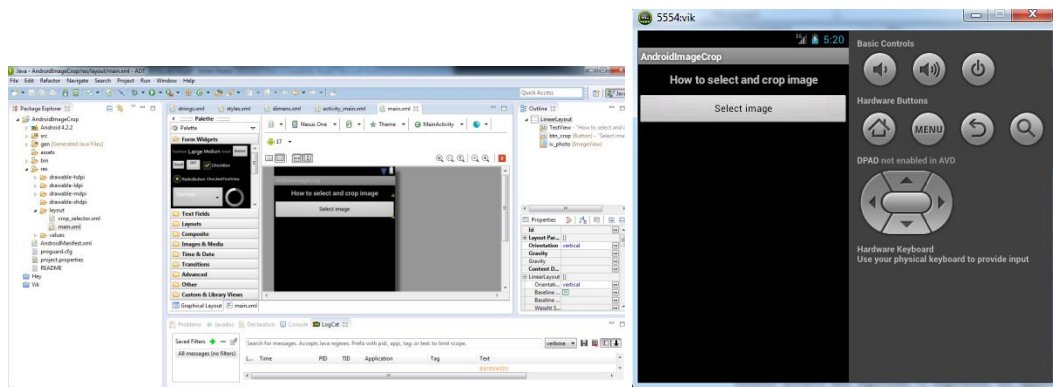
```

Figure 24: About.java file

And the last button is “exit” button it helps to exit the application when the user press the button. Before closing the button, it will automatically save all the important data.

4.2.3 How to select and crop image

Basically image crop is done when pressing the first start button of the UI where on UI appears camera with two options either captures or takes new picture of Vitiligo lesion. After selecting the image it will be copped based on your selection and new cropped image will be saved in the SD card memory for the next process.



```

package org.example.draftproject;

import org.example.sudoku.R;

public class LoadImage extends Activity {

    private static int RESULT_LOAD_IMAGE = 1;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.Loadimage);

        Button buttonLoadImage = (Button) findViewById(R.id.buttonLoadPicture); //click butt
        buttonLoadImage.setOnClickListener(new View.OnClickListener() {

            @Override
            public void onClick(View v) {

                Intent i = new Intent(
                    Intent.ACTION_PICK, android.provider.MediaStore.Images.Media.EXTERNAL_CC

                startActivityForResult(i, RESULT_LOAD_IMAGE);

            }
        });

    protected void onActivityResult(int requestCode, int resultCode, Intent data){

        if (requestCode == RESULT_LOAD_IMAGE && resultCode == RESULT_OK && null != data){
            Uri selectedImage = data.getData();
            String[] filePathColumn = { MediaStore.Images.Media.DATA };

            Cursor cursor = getContentResolver().query(selectedImage, filePathColumn, null, null
            cursor.moveToFirst());

            int columnIndex = cursor.getColumnIndex(filePathColumn[0]);
            String picturePath = cursor.getString(columnIndex);
            cursor.close();

            // String picturePath contains the path of selected Image

            ImageView imageView = (ImageView) findViewById(R.id.imageView);
            imageView.setImageBitmap(getScaledBitmap(picturePath, 800, 800)); //Scale picture to 8
        }
    }
}

```

Figure 25: Image crop.java

4.3 Discussion

For final year project, the task was mainly to do extensive research and come up with suitable method and algorithm to implement the application on smartphone. Also large amount of time was spent on studying digital image processing with Matlab codes through literature and online tutorials. In the digital image processing, several methods have been developed to classify images in order to know if there is exist some images

which are close to any arbitrary image previously encountered. This can be obtained by choosing the set of attributes, the texture features, which are also counted as spatial organization of the image. Basically, this approach is based on wavelets, adaptive segmentation, and genetic image analysis. In the current project skin image analysis is based on evaluation of the grey tone distribution of whole image frame and then on coherence length diagrams which able to estimate texture features. With these diagrams can easily describe the presence of white patches on the skin. The simple procedure can be used to see the grey tone distribution which can show the differences from the background. In order to segment need to normalize skin images to correlate it with skin repigmentation. In the case of processing images recorded by cameras. Consequently the objective to implementing Vitiligo assessment tool on Matlab tool has been achieved and results are included. The second objective is development of Vitiligo analysis algorithm on mobile device. This step took plenty of time, as creating Android application is very hard process; it requires long learning process; especially for the beginner in programming. The achievements are learning basics like building first application, environment setup, creating Android project, to be aware of directories and files in the Android projects, enable debugging and run application on a device. In order to start developing the system running on mobile devices need to get familiar with the tasks listed above. Overall, the project is beneficial for knowledge expansion in terms of engineering as well as programming skills. During the work on the project I inherently build tools to help myself to become more productive in the future. I have created various applications on Java in order to get more the concept of this language. I have divided Matlab code into several parts: load, crop image of healthy and Vitiligo lesion skin. I have tried to create applications independently for each step and at the end of the project to combine them into one Android application. Before writing any application I had to look on Internet for codes that already exist. I have compiled a list of apps that can make developing my app easier by increasing productivity and ensuring that my app is working well and has benefit for dermatologists use.

CHAPTER 5

CONCLUSION

Vitiligo is skin pigment disorder causes white patches on human skin. The disorder occurs due to lack of color pigment-melanin. It is found that the use of the proposed method is essential. The proposed digital analysis system helps to analyze repigmentation of skin disorders due to treatment. The accuracy of the system is proved by comparing the simulation results of proposed algorithm to Physician's Global Assessment results. The working principle of algorithm is based on conversion of RGB images to melanin related skin images. RGB (red, green, blue) is the standard for the display of colors: on computer monitors, on TV sets or images. The conversion is done by using PCA to dimensionally reduce RGB into 2D. Then, ICA aligns 2D data into melanin and hemoglobin skin images to determine Vitiligo lesion. Furthermore, results from 20 patients with different clinical features of Vitiligo such as generalized Vitiligo, acrofacial Vitiligo, segmental Vitiligo and universal Vitiligo were used in order to analyze and diagnostic performance of proposed ICA algorithm. Vitiligo lesion assessment tool is successively developed to identify skin repigmentation progress due to treatment. Segmentation technique used to isolate Vitiligo area in the melanin digital images from healthy skin area. In the current project images were segmented using thresholding method. The advantage of thresholding is ability to show hidden aspects of an image. Segmentation technique is widely used for medical purposes for example segmentation in melanoma is achieved by finding boundaries or by differentiating the pixels of the cell. While in the current project segmentation was done by use of independent component analysis which is good to align principal component axes in terms of melanin and hemoglobin. Melanin and hemoglobin are primary chromophores in skin and the relationship between light and skin enables to develop a new assessment system for skin disorders. The whole system is written in Java language including the User Interface (UI) and Independent Component Analysis algorithm. Android Software Development Kit for User Interface is used to utilize Android APIs from Google's support such as touch screen and graphic display. It is convenient to build a good user interface and easy to improve via the support of android development in the future. The

most important part of the Vitiligo Detection system, which has ICA algorithm, is written in C code through Android Native Development Kit to utilize the advantages of native code in terms of performance.

The development of the project takes more time to do research in order to improve the algorithm and can be used in purpose. The tasks and challenges in this project develop the skills in managing the time, how to solve the problems and get more independent and confident as the project is individual. Besides, the experiences in the lab and experiment will give me more skills to handle computer calculations properly and give me idea to do farther investigations. Overall project progress is according to the planned schedule. In conclusion can say that optimization of a computationally intensive algorithm such as this on a mobile platform is challenging due to the limited resources available.

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