"I hereby declare that I have read through this report entitle "*Development Out-of-Plane of Face Detection Using SURF and Skin Color YCbCr Color Space Technique* " and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

Signature : ....

Supervisor's Name : En. Mohd Safirin Bin Karis

Date : 1st June 2015

DEVELOPMENT OUT-OF-PLANE OF FACE DETECTION USING SURF AND SKIN COLOR YCbCr COLOR SPACE TECHNIQUE

NAZURAH BINTI ISMAUN

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "*Development Out-of-Plane of Face Detection Using SURF and Skin Color YCbCr Color Space Technique*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Nazurah Binti Ismaun

Matrix No :

Date : 22nd May2015

Special for my beloved parents, lecturer and friends

ACKNOWLEDGEMENT

Assalamualaikum w.b.t.

All praises be to Allah, Lord of the Universe, the Merciful and Beneficent to Prophet Muhammad S.A.W, His Companion and the people who follow His path. First and foremost, I would like to thank Almighty Allah for allowing me to undergo finish partial of final year project 1 with a safe and blessed. Firstly, I would like to take this opportunity to express my sincerely gratitude and appreciation to my parents and my family for the support.

Great deals appreciated go to my beloved mom Pn. Timah Binti Latib and also all my family members to support and encouragement.

The special thanks goes to my helpful supervisor, Mr Mohd Safirin Bin Karis. The encouragement and support that he gave truly help the progression and smoothness of the final year project. The co-operation is very valuable.

Finally, I would like to thank again to the people above and everyone who are helping me to success. I very appreciate the opportunity for letting me gain invaluable knowledge and learn the valuable experiences. Thank you very much for the wonderful hands.

ABSTRACT

This report is presents investigations of development out-of-plane of face detection using Speeded-Up Robust Technique (SURF) and skin color of YCbCr color space technique. In this research, the method of SURF and the skin color of YCbCr color space are developed. SURF technique is a new technique that usually used in C++, OpenCV and MATLAB software. Both techniques are used in order to compare the performance in terms of time response. SURF technique possess an extraction of SURF feature point and matching the point while skin color of YCbCr color space extract the skin region. All the results are presented within MATLAB 2013a software. Out-of-plane image are manipulated input to determine whether it can detect face area. Images are captured from 0°, 45° and 90° to varying an out-of-plane images. It shows that SURF technique can detect the SURF feature point in different angles, but the matching point cannot detect if images in 45° and 90°. However, the skin color of YCbCr color space has given a better result to detect skin region of face in all angles. Besides that, the tone skin color of all respondents does not affect the result for both techniques.

ABSTRAK

Projek ini membentangkan siasatan mengenai *development out-of-plane of face detection using Speeded-Up Robust Technique (SURF) and skin color of YCbCr color space technique*. Dalam kajian ini, kaedah SURF dan warna kulit daripada YCbCr akan dibangunkan. Teknik SURF adalah teknik baru yang biasanya digunakan dalam C ++, OpenCV dan perisian MATLAB. Kedua-dua teknik digunakan untuk membandingkan prestasi dari segi tindak balas masa. Teknik SURF mempunyai satu titik pengekstrakan ciri SURF dan memadankan titik manakala warna kulit YCbCr ekstrak kawasan kulit. Semua keputusan dibentangkan dalam MATLAB perisian 2013a. *Out-of-plane* imej akan dimanipulasikan input untuk menentukan sama ada ia boleh mengesan kawasan muka. Imej-imej yang ditangkap dari 0 °, 45 ° dan 90 ° digunakan untuk mempelbagaikan kesan *out-of-plane*. Ia menunjukkan bahawa teknik SURF dapat mengesan titik ciri SURF dalam sudut yang berbeza, tetapi titik padanan tidak dapat mengesan jika imej dalam 45 ° dan 90 °. Walau bagaimanapun, warna kulit daripada YCbCr telah memberikan hasil yang lebih baik untuk mengesan kawasan kulit muka di semua sudut. Selain itu, warna kulit daripada semua responden tidak mempengaruhi hasil untuk kedua-dua teknik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABRREVIATIONS

SURF	-	Speeded-Up Robust Features
SIFT	-	Scale-Invariant Features
SVM	-	Support Vector
RGB	-	Red-Green-Blue
MLPs	-	Multilayer Perceptron
CBIR	-	Content-Based Image Retrieval
DoG	-	Difference of Gaussian
PCA	-	Principal Components Analysis
HSI	-	Hue Saturation Intensity
HSV	-	Hue Saturation Value
YIQ	-	Luminance In-phase Quadrature
CCTV	-	Closed-circuit Television

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss about the development out-of-plane of face detection using SURF and skin color YCbCr color space technique. The project objective, problem statement, scopes of work and motivation will be also presented.

1.1 Out-of-Plane

Nowadays, face movement position has become a popular research because it is difficult to determine the image movement. Many research were developed to find a way to solve this problem. The accurate algorithm is needed to determine and identify the position of an uncontrollable facial movement. Normally in-of-plane image are easier to distinguish compared to out-of-plane images. The Viola and Jones object algorithm is one of the most popular technique for object detection and also used for out-of-plane image detection. Beside that, the square patch feature is also being used for object detection and it gives a faster result. In previous works, the square patch feature is used for out-of-plane detection. For out-of-plane detection without any extra sample data is possible due to the point based representation of the patch feature [1]. Furthermore, In-of-Plane and Out-of-Plane are different and its involve in 2D or 3D images.

1.2 Speeded-Up Robust Features (SURF)

Nowadays skin detection is a most popular technique that has been used to detect and tracking human-body parts like a face detection. The role of face detection is to find the location and sizes of human faces by using computer software. In the other word, face detection technique is a universal range and involved with complicated algorithm. It it also difficult due to some limitation exists like uncontrolled lighting, complex background, and gender. Many techniques had developed to overcome this problem like traditional algorithm EigenFace and 2D-PCA until Scale-Invariant Feature Transform (SIFT) is proposed in 1999 by David G. Lowe. SIFT has been widely used for detection and recognition image because it can extract local personal specific feature and most important SIFT can perform well. Some methods are being proposed to speed it up like a kid-tree and PCA, although, SIFT is having show a better result and performance. Kd-tree is used in search k-nearest neighborhood and to reduce dimensions of SIFT features and then PCA is proposed. All the methods that have been proposed still cannot satisfy speed requirement of SIFT. So to provide a better way to solve the problems, Speeded-Up Robust Features (SURF) algorithm is proposed in 2006.

SURF (Speeded Up Robust Features) is a robust image detector and descriptor that can apply and used in computer vision task like 3D version. In 2006, SURF is first represented by Herbert Bay et. al it is developed based on SIFT technique and quietly similar [9, 10]. However, SURF is several times faster in real time and it more robust against different image transformation than SIFT.

However, SIFT used the difference of Gaussians (DoG) filter, whereas the Hessian Matrix is used in SURF for approximation operating on the integral image to locate the interest points and this will reduce the computation time drastically. Besides that, the special characteristic of a Hessian matrix is it has good performance and high accuracy. The First-order Haar wavelet that response in x and y direction is used as descriptor in SURF. SURF uses an efficient of integral images because it's based on the sum of 2D Haar wavelet response [9, 10]. SURF technique is not only providing a robust image descriptor, but it also can be used in computer vision like object recognition or 3D reconstruction.

Face detection has been the popular area of research nowadays due to the robust characteristic of SURF. SURF algorithm is still a new technique and almost similar to SIFT as more research has been developed to show the special characteristic and ability in SURF algorithm. Based on the previous research, development out-of-plane of face detection using SURF and skin color YCbCr color space technique has been proposed in this project due to the ability of SURF algorithm.

1.3 Skin Color of Face Detection

Face detection is universal area and many factors is affecting a detection. In recent years, face detection in color images has gained much attention. Color is the major feature of human face detection compared to other features. Color is a useful cue to extract skin regions, and it only performance in color images [14]. Besides that, color is providing a much faster result than processing other facial features. However, color also has a problem during a detection and this is caused by many different factors like a lighting, object movement and surrounding effect.

There are many different color algorithms proposed over the last 400 years such as RGB, YCbCr, HSV, HSI and YIQ. The most commonly employed color space is the RGB color space, which is based on the additive mixture of the three primary colors R, G and B. RGB is widely used for processing and storing the digital image [2, 3, 6, 14]. RGB color space is simplicity, but he problem of this color space is RGB does not separate luminance and chrominance and is a device dependent, so in different devices the image is looking different [14]. Next YCbCr is also one of color spaces that usually used. YCbCr color space has used in the area of digital video. However, it is contrast to RGB, YCbCr color space achieves better performance because it is luminance independent [13].

1.4 Problem Statement

Face detection is a universal and involved with a variety of techniques. It it difficult to detect the face due to some limitation exists like uncontrolled lighting, complex background, and gender. Besides that, to detect out-of-plane face detection is more complicated compared to in-of-plane (frontal images) face detection. So to detect a skin color of out-of plane is difficult and there is no conclusion about which technique is the most suitable. The execution out-of-plane face detection based on skin color detection is very limited and not widely been explored yet especially for CCTV. The aim of out-of-plane face detection is to easily detect the face of the person from the CCTV with different angles. Beside that, the variety of human tone skin color in face detection has been a normally problem in order to detect face detection. So, a new technique of out-of-plane face detection using skin color is developed to overcome this problem. The existing research has been explored image of an out-of-plane detection, but mostly the existing technique is not achieved the high accuracy of the result. So to provide a high of accuracy of the image, SURF technique is used to analyze due to its ability in real time taken. Real-time is applied to the system which can help faster results.

1.5 Objectives of Project

The objectives of this project are:

1. To identify the mathematical algorithm of speeded-up robust features (SURF) and skin color of YCbCr color space technique using Matlab software.
2. To develop the method of out-of-plane face detection using SURF technique.
3. To develop the method of out-of-plane face detection using skin color of YCbCr color space technique.
4. To compare performance in term of time response between SURF and the skin color YCbCr color space technique.

1.6 Scopes of Project

In order to ensure this project is conducted within the boundary, five scopes are listed:

1. Develop the SURF and skin color of YCbCR color space technique using MATLAB 2013a.
2. This research is carried out by nine respondents from fourth year Bachelor of Electrical Engineering students.

3. This research required various skin tone colors while all the respondent's attire and background image remain fixed.
4. The image of the total respondents is captured from three different angles which are $0°, 45°$ and $90°$.

1.7 Motivation

The criminal case is rapidly increasing in the most cities in the world including Malaysia. The increasing number of criminal cases will rise if the government did not take action towards it. In 2014**,** the criminal case of ATM in Johor, Selangor and Malacca are happening where a Latin America gang flaw within the authentication method to hack into a minimum of fourteen cash machines (ATM) and got away with virtually RM 3 Million. This case became a major title in media social. In order to prevent these cases, the development of protection system such a CCTV are highly important as the function in monitoring the critical places such as banks or shopping complex (where the places are fully crowded with citizen) will give advantages to everyone. For this purpose, this project will explore more about the out-of-plane image. Many researchers have found that there are still some problems exists in matching speed and accuracy of the images. Due to this problem, a new method of out-of-plane face detection using SURF technique and skin color will be developed.

1.8 Project Report Outline

In this section, the outline of the project report is presented. This report is including of six chapters and each chapter is explained generally.

Chapter 1 generally discusses about background research of Out-of-plane, Speeded-Up Robust Features (SURF), skin color of face detection and also stated clearly about problem statement and objectives.

Chapter 2 is more focus on literature review about the skin color of face detection and Speeded-Up Robust Features (SURF) technique. The improvement of SURF technique and skin color face detection are reviewed based on previous researcher from 2001-2014.

Chapter 3 is discussed about the methodology of this project. Besides that, flow charts of project and flow of SURF and YCbCr color space technique are also discussed in this chapter. The algorithm that related to this project is discussed in this part.

Chapter 4 is explained more about the result of SURF and skin color YCbCr color space. An analysis and discussion will explain based on the result.

Chapter 5 will consist of conclusion of the overall work and recommendation of future works.

CHAPTER 2

LITERATURE REVIEW

This chapter will explain the review of previous research which is related to out-of-plane of face detection using SURF and skin color YCbCr Color Space Technique. The SURF technique algorithm is one of a new technique that had been developed after Scale-Invariant Features Transform (SIFT). The advantage of SURF is several times faster than SIFT technique and also more robust against different image transform. While YCbCr is color space technique that chose in this research to distinguish skin color region.

2.1 Previous Research of Out-of-Plane

Object detection is an incredibly vital stage for several applications like recognition and tracking. The increasing importance of image analysis of autonomous system as well as on automation platform means that there's a requirement for strong formula for detection of object interest. Researches Yasir Mohd proposed a method to extend the weak classifiers for an out-of-plane rotated object detection [1]. The Square Patch feature is weak classifier that is used in this research. Out-of-plane detection with none further sample information assuming because of the purpose primarily based illustration of the patch feature. The feature points within the classified information trained from a frontal face will be turned by assuming that it mapped on the surface of the thing of interest. For the simplication object of interest like the face will be assumed to be flat.

2.2 Previous Research of Speeded-Up Robust Features (SURF) Technique

Recently most previous research has been conducted to show the different between SURF and another technique for face detection like a SIFT technique. In research [9], it is a difficult to analysis an image. This research comes out the idea to see the difference from two methods that exactly show the similarity of SURF and SIFT. The objective of this research is to present SIFT and SURF methods for scale and rotation invariant interest point and also feature detector and descriptor. Besides that, it shows the way to extract distinctive invariant features from images before used it to match between different views of an object/scene. SIFT has four step and use DoG (Difference-of-Gaussian) function while SURF algorithm is based on the Hessian matrix equation.

On the other way, SIFT is already known to show a good performance in face recognition and object detection, so this research is proposing research on face recognition exploit with SURF features due to lack of investigating of an application of SURF on face recognition. Two steps are used in this research which are SURF feature extraction and SURF feature matching for recognition. SURF uses Hessian-matrix which reduces an the time faster on the integral image before interest points are located [10]. At the matching step, the results shown that SURF is much faster than 128-dimensional SIFT. But obviously SURF features are performing better at matching speed compared to SIFT and conclude that SURF feature is also suitable for face recognition.

Furthermore, the researcher from China develop new technique for face recognition system to overcome light changes, expression changes and head movements. SURF algorithm, PCA and K-means algorithm is applied to find a new better result than SURF and SIFT algorithms. This simulation shows that this new propose methods are better and PCA-SURF feature is more robust than others [11]. The dimension of the feature space is reducing with PCA and fast indexing methods is added in matching state while lowering the computation time of features matching.

In addition, to find similarity between two images of the same scene is difficult, so researchers [12] summaries two algorithms of Scale-Invariant Feature Transform (SIFT) and Speeded-Up Robust Features (SURF) and proposed three shorter SIFT descriptor to find the SIFT and SURF performance evaluation against various image deformations on Benchmark dataset. SIFT detector, propose changes in existing SIFT and SURF detector are three methods that used in this journal. The 64D and 96D SIFT descriptor perform to matching at a reduced a cost and then it is compared with a traditional 128D SIFT descriptor. This result shows that 32D SIFT is not performing well compared to others because it is very small and difficult to capture sufficient pattern information and this affluent to larger wrong matches during classification.

2.3 Previous Research of Skin Color of Face Detection

The wide selection of applications and therefore the issue of face detection have created it a stimulating drawback for the researchers in recent years. Face detection is tough in the main due to a large part of non-rigid and textual difference between the faces [3,4]. The great challenge for the face detection is the large number of factors that govern the problem space.

In order to optimize the growth and the function of skin color of face detection several methods had been used in previous research. The research written by Sanjay Kr. et al they have develop and analysis the performance of the skin color detection based on three different algorithms. It used RGB, YCbCr and HSI as the main concern of the algorithm to make comparisons and it combined three of different algorithms to develop new skin color [2]. The purpose of the study is to develop a new skin color based on face detection algorithm. However the combination of their algorithm does not give 100% of accuracy, slightly better than RGB, YCbCr and HSI algorithms.

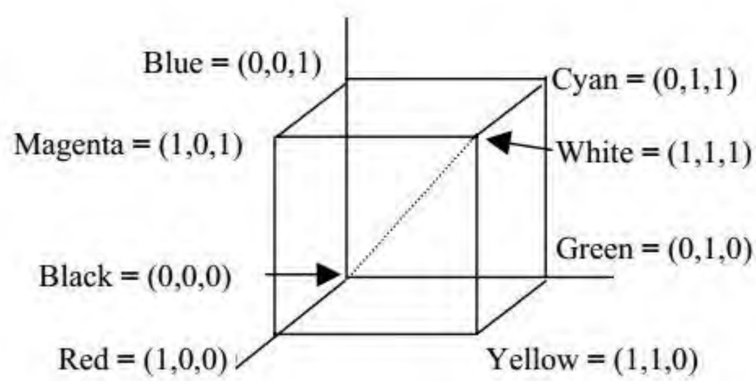


Figure 2.1: RGB Color Cube [2]

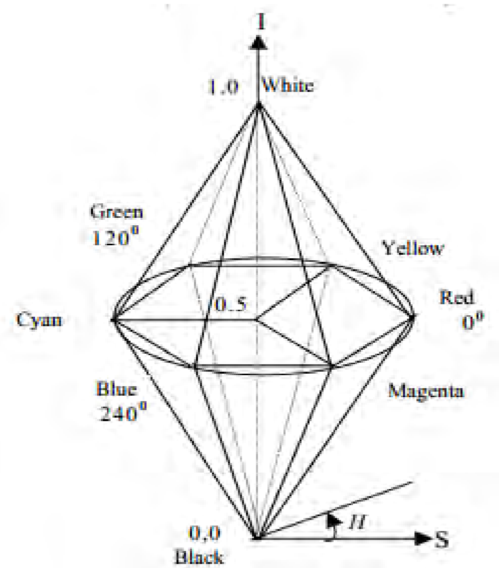


Figure 2.2: Double Cone Model of HIS Color Space [2]

Furthermore, Tarek M. Mahmoud tries to develop new fast techniques for skin detection to overcome time consuming for a skin color detection algorithm that cannot be used in real time system. YCrCb color space, image resizing technique and sipping technique are applied in this research. YCrCb is an encoded nonlinear RGB signal and it choose to use because its effectiveness in skin detection [3]. In this technique, rather than testing every image pixel to label it as skin or non-skin (classic techniques), a collection of pixel is skipping. The reason of the skipping method is the high likelihood that neighbors of the skin color pixels are also skin pixels, particularly in adult pictures and vice versa. The proposed methodology will quickly observe skin and non-skin color pixels, which successively dramatically scale back the computer hardware time required for the protection method. Accordingly, the aimed hybrid technique may be utilized in any filtering system supported color detection to forbid adult pictures from display. The proposed of skipping with hybrid technique eventually show a better result than the classic method.

Other than that, the variation range of human facial pattern is a big problem in face detection that may influence by lighting, face sizing and also facial expression. So, Son L. P. proposes a new approach of face detection. A colour input image is initially processed apply Neural Networks to look at the skin region at intervals the image and also the skin-colour classifier employs the committee machine technique, that improves colour detection by combining the classification results of a group of multilayer perceptrons (MLPs) [4]. The major advantages of Neural Network are speed and shape invariance. Skin colour classifier achieves a better result from the individual MLPs classifier. Then, the result of skin detection then is applied with a post - processing technique. The post - processing is an improve technique, which will reduce the number of false detections, while luminance and shape features is important to distinguish between face and non-face.

Researches from India, present a segmentation and edge detection as a basic method in this research. The objective of this research is to improved segmentation algorithm for face detection in color images with multiple faces and skin tone region. H. C. Vijay Lakshmi and S. PatilKulakarni stated that HSV and YCbCr colour space help to a greater extent in handling intensity variations [5]. In this research, Canny and Prewit edge detection algorithm is combined with color spaces to propose a new algorithm. This combination shows that it is improved the performance, from the previous combination of YCbCr color space with Robert Cross edge.

In addition, the researcher from Qatar and Egypt is proposed an algorithm for faces and facial feature detection in color images. Although RGB color space is one of the most popular color spaces for processing and storing digital images, but it is not widely used in skin detection algorithms because the chrominance and luminance components are mixed. However, RGB and YCbCr are often used for skin color detection techniques [6]. A skin detection algorithm is used to determine skin location in images, then face detection extract eyes, mouth or nose before verification step is applied to that image. The result achieves a high rate of accuracy and the algorithms used succeed detect front face but cannot detect overlapped faces.

Besides that, SURF Descriptor with SVM classifier and color histogram is combined to solve the problem related to Content-Based Image Retrieval (CBIR). CBIR is a database where large images and similar query images are taken from it. Shape, intensity, and color are used in CBIR systems to extract the same images from same database images [7]. The result shows that each methods has their own advantages and to get a better result the three methods needed to be combined.

Next, the main problem to record skin detection it to have the best color space to select and algorithm involve in it. A pixel-based skin color detection technique is proposed. For color space algorithm, a large set of XM2VTS face database is used to test whether the color space are able to enhance the compactness of the skin color [8]. Bayesian Classifier, Gaussian

Classifiers and Multi-layer Perceptrons are a method for skin detection. Bayesian classifier shows a good performance among the others. The piecewise linear classifiers is higher classification when combine with HSV and RGB compared to others classifiers image with a good illumination conditions. Post-processing is needed for object in similar background color because the skin will invariably lead false detection.

The color space of RGB, YCbCr and CIELab are used in this paper to detect skin color. Firstly, the RGB image is converted into YCbCr color space in order to obtain a binary image. Then morphological operation and median is applied before noise is removed and refined from the image. Next, CIELab color space is applied with the same process to detect the skin color as YCbCr. CIELab color space is showed a better result compared to YCrCb because it can improve the performance of face segmentation under poor or strong lighting conditions [13].

Next, K.C Wei et. al purpose combination of three colour model of RGB, HSV and YCbCR. In HSV and YCbCr colour space, the hue (H) and chrominance (CbCr) is additional combined with RGB properties to improve the differential between skin pixels and non-skin pixels [14]. Then, morphological operation is used for segmentation of face region to refine the skin regions. The results shows that the skin color model that purpose in this journal is able to deal with various brightness and illumination condition. So, from the result, AdaBoost face classifier is choose to make a differential.

Skin color segmentation is a technique to distinguish between skin and non-skin pixels of an image [15]. In this journal, researcher is used RGB, YCbCr, HSV, HIS and nRGB color models with a threshold for a skin color segmentation. The function thresholds is to remove non skin of an image. Then, automated system is presented for switching of color models. HSV color space give a better results among other color space.

2.4 Summary and Discussion of The Review

Speeded-Up Robust Features (SURF) is a new technique that develops by Herbert Bay in 2006 to overcome the problem of Scale-Invariant Feature Transform (SIFT) that related to speed in real system. SURF is not widely used in face detection, but from a previous research show that SURF is performing better than SIFT in real time system. SURF technique is used in C++, open CV and also MATLAB software.

Besides that, skin color is a widely used in face detection. Many algorithms based on color space are used to detect face detection. RGB, YCbCr and HSV is an example of a method that most have in color space. However RGB is the mostly used in the previous research. Although RGB color space is one of the most popular color spaces for processing and storing digital images, but it is not widely used in skin detection algorithms because the chrominance and luminance components are mixed [5]. In this research, YCbCr color space will be applied in order to detect skin color of face detection. YCbCr is commonly used in the area of digital video, representation, transmission and processing. It was originally developed for the color representation of digital television.[14]. However, it is contrast to RGB, YCbCr color space achieves better performance because it is luminance independent [13]. Based on Table 2.1, out-of-plane, SURF technique and skin color of face detection are combined in one table and listed according to the year the journal are published.

Table 2.1: Summary of Literature Review

Ref.	Years	Title/Page	Method	Description
1	2012	Out-of-Plane Rotated Object Detection using Patch Feature based Classifier.	1. Patch Feature	1. The square patch feature is as discriminating as the suitable Viola-Jones Haar-like classifier and is faster. 2. The feature points in the classifier data prepared for a frontal face can be rotated by assuming that they are mapped on a surface of the object of interest.
10	2009	Face recognition using SURF features (2009)	1. SURF 2. SURF for Face Recognition • SURF feature extraction • SURF feature matching	1. The function of SURF is a scale and in-plane rotation invariant detector and descriptor. 2. SURF has a great performance compared to SIFT. 3. SURF uses Hessian-matrix approximation in the operation of the integral image to find the interest points, which to eliminate the computation time drastically. 4. SURF is much faster than the 128-dimensional SIFT at the matching step. 5. The SURF features perform only better in recognition compared to SIFT, but it shows an improvement on matching speed.

12	2011	SIFT and SURF Performance Evaluation Against Various Image Deformations on Benchmark Dataset	1. SIFT Detector 2. Propose Changes in existing SIFT 3. SURF Detector	1. Most descriptors performed reasonably well aside the 32D SIFT that has shown underperformed. 2. The reason is that 32D SIFT descriptors are very limited and therefore fail to capture sufficient pattern data. 3. This end up in larger wrong matches throughout classification.
11	2012	Combining Speeded-Up Robust Features With Principle Component Analysis In Face Recognition System (Volume 8, Number 12, December 2012)	1. Proposed PCA-based SURF descriptor. 2. Feature Clustering. 3. Classification Stage	1. The performance of the proposed method is better than other alternative methods. 2. PCA-based SURF local descriptors are more robust than authentic SURF and SIFT local descriptors.

9	2013	A Comparison of SIFT and SURF (Vol. 1, Issue 2, April 2013)	1. SIFT Algorithm Overview • Scale Space Extrema Detection. • Key point Localization. • Orientation Assignment. • Description Generation. 2. SURF Algorithm Overview	1. SIFT is to determine the image rotation, scaling change, noise, illumination changes, and also has strong robustness. 2. SURF is based on multi-scale space theory and therefore the feature detector is based on Hessian matrix. 3. SIFT has detected a lot of features compared to SURF but it is good in real-time speed. 4. The SURF is fast and has shown a great performance compared to SIFT.
4	2001	Skin Colour Based Face Detection (November)	1. Neural-Network Based Skin Colour Model 2. Heuristic Post-Processing Technique for Face Detection.	1. Speed and shape-invariance. 2. Colour-based segmentation is unaffected by changes in size and orientation of faces. 3. Post-processing techniques. • Decrease the number of inaccurate detections in the previous stages by eliminating background of skin color appearance, and adding facial pixels that do not have a skin color. 4. Luminance and shape features.

				• Used to analyze between face and non-face patterns
2	2003	A Robust Skin Color Based Face Detection Algorithm (Vol. 6, No. 4, pp. 227-234 ,2003)	1. RGB Color Space 2. YCbCr Color Space 3. HSI Color Space	1. The red, green and blue color components are highly correlated. This makes it hard to perform some image processing algorithms. 2. Not very much friendly with force detection based on skin color classification.
6	2006	Faces and Facial Features Detection in Color Images	1. Skin Colors Detection • Pixels-based Skin detector • Images Segmentation • Edge detection • Optimizaion 2. Features Detection 3. Verification of eyes, mouth and nose detection.	1. RGB components may affect to the lighting conditions which make the face detection may fail when the lighting conditions change. 2. RGB color space is one of the most color spaces that usually used for processing and storing digital images, it is not widely used in skin detection algorithms because the chrominance and luminance components are mixed.
14	2006	RGB-H-CbCr Skin Colour Model for Human Face Detection	1. RGB, HSV and YCbCr 2. Morphological operations	1. RGB-H-CbCr skin color model is able to deal with various brightness and illumination conditions. 2. Using a test data set of 100 images, containing a total of 600 unique faces.

				3. H (Hue) channel shows significant discrimination of skin colour regions, 4. Cb-Cr subspace offers the best discrimination between skin and non-skin regions.
8	2007	Skin Detection using Color Pixel Classification with Application to Face Detection: A Comparative Study	1. Skin segmentation 2. Bayesian Classifier with the Histogram Technique 3. Gaussian Classifiers 4. Multi-layer Perceptrons	1. XM2VTS face database is used to check or try out the color space. 2. Bayesian classifier shows a great performance among the others. 3. When HSV and RGB is combined, the piecewise linear classifiers are show higher classification compared to others classifiers image with a good illumination conditions. 4. Post-processing is required for object in same background color as a result of the skin will greater lead false detection.
3	2008)	A New Fast Skin Color Detection Technique (Vol:2 ,2008)	1. YCbCr Color Space 2. Image Resizing Technique 3. Skipping Technique	1. YCrCb is an encoded nonlinear RGB signal. 2. Proposed skipping and hybrid techniques in terms of the measured CPU time. • The proposed methods achieve excellent results than the classic method.

5	2010	Segmentation Algorithm for Multiple Face Detection in Color Images with Skin Tone Regions using Color Spaces and Edge Detection Techniques (Vol. 2, No. 4, August, 2010)	1. Segmentation 2. Edge Detection • Robert's Cross Edge Detection • Canny Edge Detection • Prewitt Edge	1. The combination of color spaces is to analyze the skin pixels combined with Canny and Prewitt edge detection algorithm for acceptable segmentation are proposed. 2. The segmentation using a combination of color spaces combined with Canny and Prewitt edge detection for obtaining the region boundaries segment better when compared with the combination of YCbCr colour space and Robert Cross edge.
13	2012	Comparison between YCbCr Color Space and CIELab Color Space for Skin Color Segmentation (Volume 3,No.4, July 2012)	1. RGB color space 2. YCbCr color space 3. CIELab color space	1. Analyze the efficient method for skin color segmentation under varying lighting conditions. 2. RGB image is converted into YCbCr color space and binary image is obtained, by applying the morphological operation and median filter, noise is removed and refined image is obtained. After skin color segmentation with CIELab color space in real time. 3. CIELab color space is an absolute color space, it defines colors exactly.

				4. CIELab color space is better than YCbCr because it gives more information than the other color space model.
15	2013	Skin Segmentation Using RGB Color Model and Implementation of Switching Conditions (Vol. 3, Issue 1, January -February 2013, pp.1781-1787)	1. Skin segmentation (RGB, YCbCr, HSV, HSV, HIS, and nRGB color models) 2. Switching condition (automated system)	1. Skin segmentation to extract skin-pixels from an image. 2. Color models with thresholds, help to remove non skin like pixels from an image. 3. Combination of these color models overcomes all varying lighting conditions and changes in illumination
7	2014	Content Based Image Retrival Using SURF, SVM and Color Histogram – A Review (Volume 4, Issue 6, June 2014)	1. SURF Descriptor 2. SVM Classifier 3. Color Histogram	1. Content-Based Image Retrieval (CBIR) is an operation in which recall similar query images from the large database of images. 2. CBIR system uses the features (example: shape, intensity, color) to extract the same image from the database of images. 3. SURF is a fast image point descriptor and SVM is best classifier.

CHAPTER 3

METHODOLOGY

In this chapter, the main topics that will discuss is the methodology and approach used to complete this project. Flow Chart of the project and the technique used are explained in this chapter. This chapter is basically the plan or the action that will do to complete the works in right time.

3.1 Project Flow Chart

The flow chart for the overall project is shown in Figure 3.1. The flow chart consists of two stages which stage 1 and stage 2. Stage 1 will be done on Final Year Project 1 (FYP 1) and stage 2 will be conducted on the Final Year Project 2 (FYP 2). The flow chart will be carried out and the process will end until the full report is submitted.

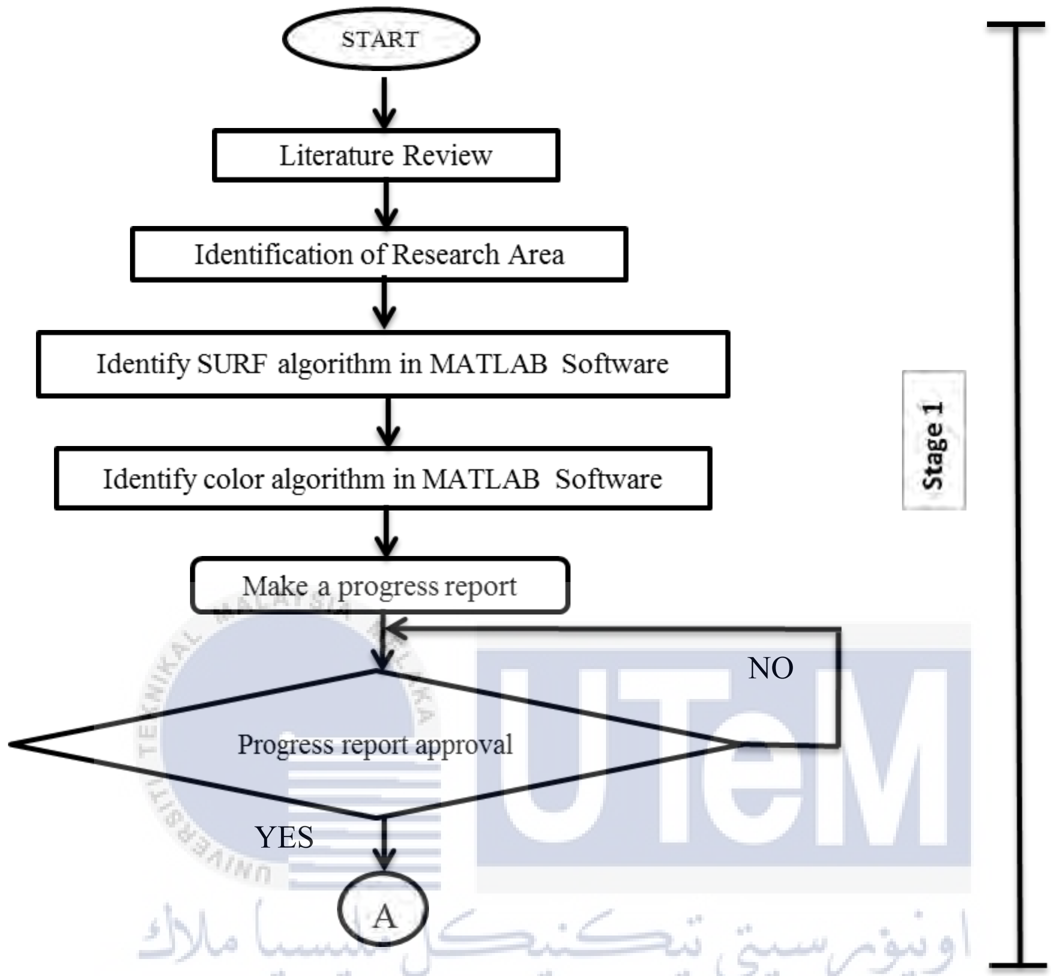


Figure 3.1: Flow Chart for the Methodology of FYP 1

As stated in the flow chart in Figure 3.1, only stage 1 will be conducted for FYP1 This project starts with a Literature Review. The literature review is some sort of review discusses on information in a specified area and sometimes a detail on a particular topic. Basically the objective is to know more about the project is going to conduct and to know the problem of previous research.

Next, is identification of research area. After done with a literature review, so more information about this project is finding out based on the previous research that have been read. Then, the SURF Algorithm is identified and find out based on the previous research. The Hessian Matrix is used in SURF for approximation operating on the integral image to locate the interest points and this will reduce the computation time drastically [9, 10].

After identifying about SURF algorithm, the color space is identified by MATLAB Software. Skin color is a good feature for detection the human face [13]. However, in PSM 1 the color space is only covered through analysis with examples of coding in MATLAB software. After finding all algorithm then the algorithm will be applied on Matlab. When the algorithm is succeed, thids project continue by proceeding to a progress report.

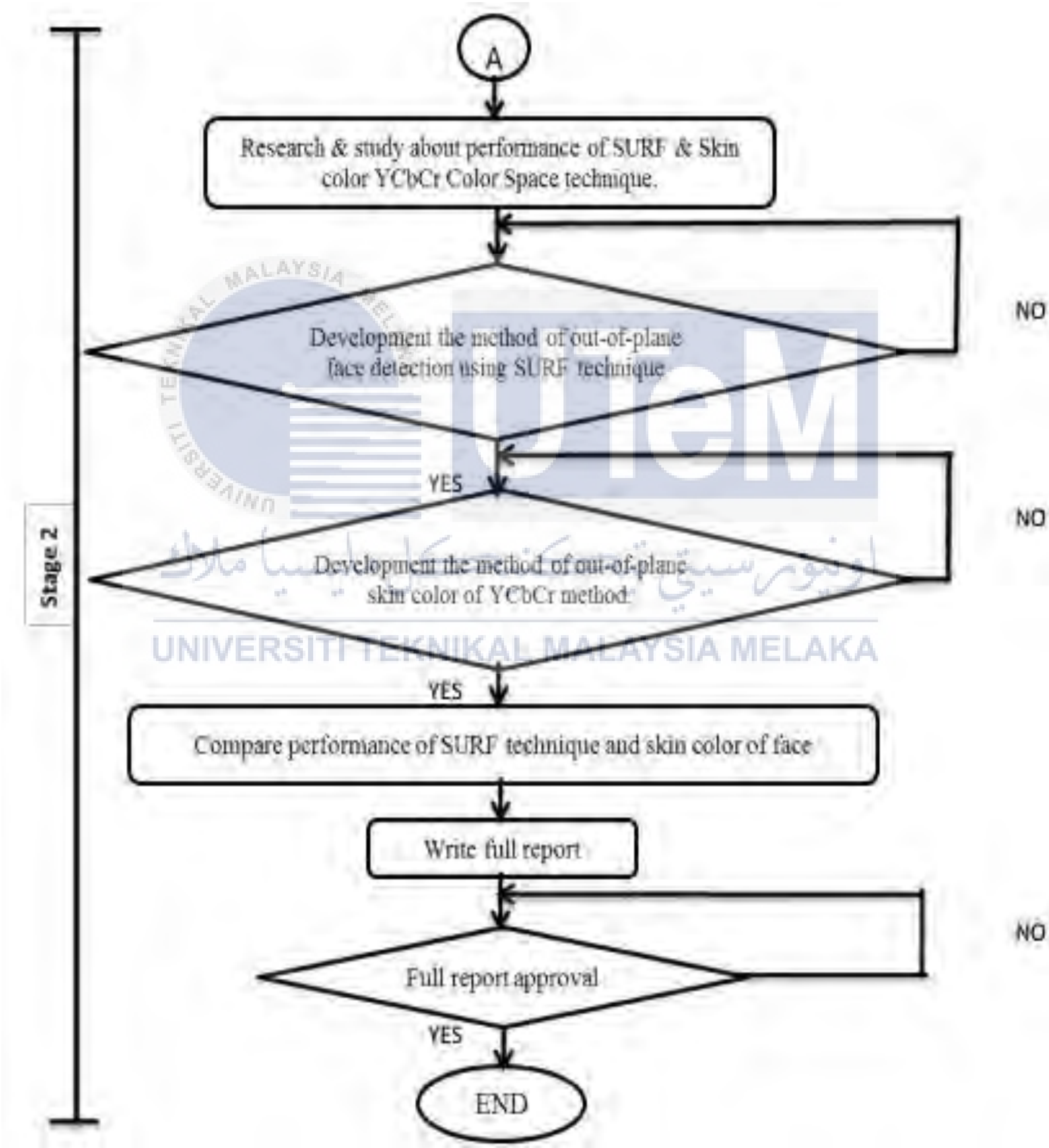


Figure 3.2: Flow Chart for the Methodology of FYP 2

From the flow chart shown above, the stage 2 is conducted for FYP 2. The FYP 2 is continued after the progress report is approved by the supervisor and panel. Firstly, FYP 2 started with make a research and study about the SURF technique and skin color of YCbCr method. Then, this project is proceed with develop the method of out-of-plane face detection using SURF technique. After the development using SURF technique is successful, then the project is continuing with development the method of out-of-plane skin color of YCbCr method. The efficiently skin color space method detects the skin color is depends on color space that will choose [13].

Based on the method that have been developed, so the next step is making a comparison between SURF technique and skin color detection based on the time response. Finally, the project is done and the next step is make a full report. Furthermore, the project will end if the full report is approved by the supervisor and panel.

3.2 Speeded-up Robust Features (SURF)

Speeded-Up Robust Features (SURF) are similar with Scale-Invariant Features Transforms (SIFT) but different of the algorithm. SURF is a scale and in plane rotation invariant features. SURF employs integral images and efficient scale space in order to generate interest point detector and descriptor. The function of the detector is to locate an interesting point in the images and the description explains the features of the interest point and build the feature vectors of the interest point.

3.2.1 Interest Point Detection

SURF (Speed- Up Robust Features) is different with SIFT (Scale- Invariant Features Transform) algorithm. SIFT is used DoG (Difference-of-Gaussian) while SURF is based on multi-scale space theory, but determinant of the approximate Hessian Matrix is only based on feature detector. Blob-like structure is detected first at the location where the maximum determinant before the interest point is located. SURF is developed because of the problem faced by SIFT algorithm that is in real time. So, to reduce time drastically, the integral image is used the Hessian Matrix approximation. Hessian Matrix is also has high accuracy and a good performance. Given a point x = (x,y) in a image I, the Hessian Matrix H (x,σ) in x at scale σ is defined as:

$$H(\mathrm{x},\sigma) = \begin{bmatrix} \mathrm{L_{xx}}(\mathrm{x},\sigma) & \mathrm{L_{xy}}(\mathrm{x},\sigma) \\ \mathrm{L_{xy}}(\mathrm{x},\sigma) & \mathrm{L_{yy}}(\mathrm{x},\sigma) \end{bmatrix} \tag{3.1}$$

Where $\mathrm{L_{xx}}(\mathrm{x},\sigma)$, $\mathrm{L_{xy}}(\mathrm{x},\sigma)$, $\mathrm{L_{xy}}(\mathrm{x},\sigma)$ and $\mathrm{L_{yy}}(\mathrm{x},\sigma)$ are the convolation of the Gaussian second order partial derivatives[9][10]. Box filters of 9x9 are used to reduce computation time. Estimation of Gaussian with $\sigma = 1.2$ is used and it represents the minimum scale for compute blob response maps. The weights applied to the rectangular region.

$$\det\ (H_{approx}) = D_{xx}D_{yy} - (wD_{xy})^2 \tag{3.2}$$

Where w is a weigh of the energy conversation between Gaussian Kernels. The Gaussian Kernels are:

$$w = \frac{|\mathrm{L_{xy}}(1.2)|_F |\mathrm{D_{yy}}(9)|_F}{|\mathrm{L_{yy}}(1.2)|_F |\mathrm{D_{xy}}(9)|_F} = 0.912 \ \approx 0.9 \tag{3.3}$$

3.2.2 Interest Point Description

The proposed of SURF descriptor is based on SIFT theorem. SIFT is a very good in descriptor compared to others. The sums of the Haar-wavelet is used to describe the feature of an interest point.

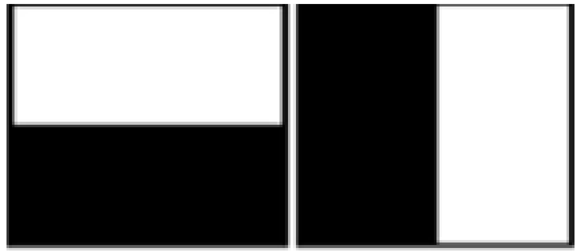


Figure 3.3: Haar-wavelet used in SURF [9,10]

3.3 YCbCr Color Space

Figure 3.4: YCbCr color space in CbCr plane where Y = 0.5

The YCbCr is commonly used in the area of digital video, representation, transmission and processing. It was originally developed for the color representation of digital television [14]. YIQ and YUV color space is exactly same with YCbCr because it also developed to work with digital television format. Basically, luminance information is stored as a single component (Y channels) and chrominance information is stored as two color-difference components (Cb and Cr channels). Cb is represents the difference between blue and luma component while Cr represents the difference between red and luma compenants [14]. However, it is contrast to RGB, YCbCr color space achieves better performance because it is luminance independent [13]. This color space is related to RGB color space:

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 16 \\ 128 \\ 128 \end{pmatrix} + \frac{1}{256}\begin{pmatrix} 65.738 & 129.057 & 25.064 \\ -37.945 & -74.494 & 112.439 \\ 112.439 & -94.154 & -18.285 \end{pmatrix} \times \begin{pmatrix} R_N \\ G_N \\ B_N \end{pmatrix} \quad (3.4)$$

The R, G, B takes a typical value from 0 to 255 and Y channels is take a same value with RGB of 0 to 255 while Cb and Cr channels are placed in the range of 16 to 240.

3.4 Basic flow of Speeded-Up Robust Features (SURF) Technique and YCbCr Color Space Method

In this research, the face detection method is developed using Speeded-up Robust Features (SURF) and YCbCr color space method. Both techniques are used to compare the performance of face detection in term of time response.

3.4.1 Speeded-Up Robust Features (SURF) Technique

In 2006, SURF is first represented by Herbert Bay et. al it is developed based on SIFT technique and quietly similar[9, 10]. SIFT has been widely used for detection and recognition image because it can extract local personal specific feature and most important SIFT can perform well but SIFT cannot give a faster performance. So, SURF is proposed to overcome the problem of speed.

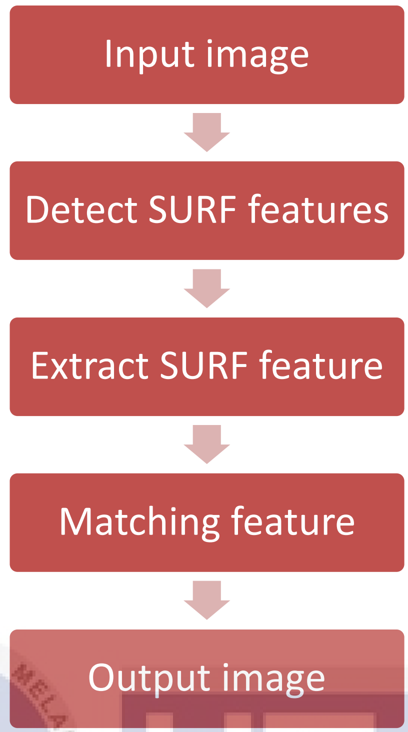


Figure 3.5: Flow of Face Detection using SURF Technique

Figure 3.4 shows the flow of face detection using Speeded-Up Robust Features technique. The main advantages of SURF are able to compute distinctive descriptors quickly. SURF is invariant to common image such as image rotation, scale changes and illumination changes. The input image of nine respondents with different skin color and angles which are $0°, 45°$ and $90°$ are used. This technique will read the input image before extract SURF features. Then, two images are used to detect the crosspoint matching in the images. The first matching is display as outliers and the matching is detect matching point of feature outside the desired image (image 1). Next, the second matching is display as inliers which all the ouliers is removed. Finally, output image is display in yellow box.

3.4.2 YCbCr Color Space Method

Skin color detection is the most important work in face detection. In this research YCbCr color space is used to detect the skin portion of an image. Nine respondents with different angle of the image is used as an input image. The face detection using YCbCr color space process is broadly classified into six parts. The process is shown below:

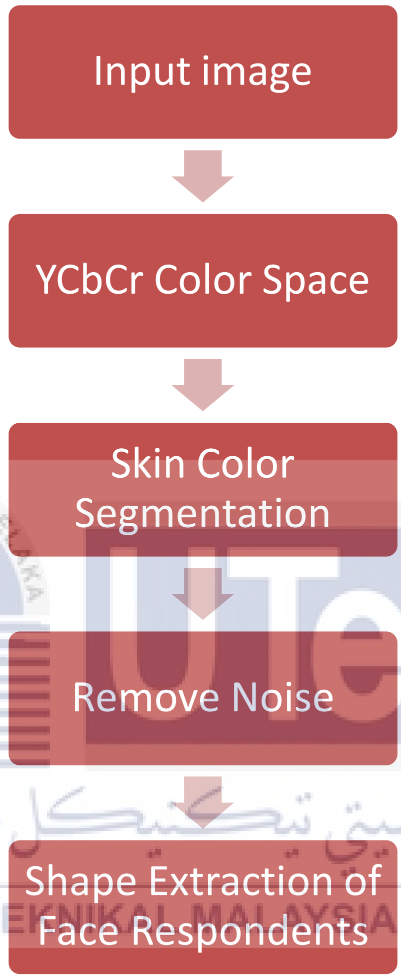


Figure 3.6: Flow of Face Detection Using YCbCr Color Space

Figure 3.5 shows the flow of face detection using the YCbCr color space which consists six parts. In the first part of detection stage, the input image of nine respondents with different skin color and angles which are 0°, 45° and 90° is used. Once an image is loaded, it is stored as a three primary colors red (R), green (G) and blue (B) before it converts the image to others color space such YCbCr and HSV color space. Then, the YCbCr color space is used in this research to detect skin color. After that, the skin color segmentation is used to extract a skin region and eliminate non-skin region. Next, is removing noise and refined image before the system shown the face respondent in the image.

CHAPTER 4

RESULT AND DISCUSSION

This chapter will discuss about the result that related to this project. The analysis of this chapter is represented into two parts which are SURF technique and skin color YCbCr color space technique.

4.1 Introduction

Nine respondents from fourth year Bachelor of Electrical Control students, which have different skin color are selected in order to conduct this research. The background image and the attire's are remaining same with all respondents. To verify out-of-plane face detection, image of all respondent are captured from three different angles which are 0°, 45° and 90°.

The entire sample is listed accordingly on color of their skin. Sample A is categorized as the respondent which has the lighter skin color and Sample I is categorized as the respondent which has a darker skin color. Sixth column in the table represents the time taken for skin color detection.

(a) **(b)** **(c)**

Figure 4.1: Three Different Angles of Face Detection

Figure 4.1 shows a three different angle of face detection. In this Figure 4.1 (a) represents 0°, Figure 4.1 (b) represents 45° and Figure 4.1 (c) represents 90°.

4.2 Face Detection using SURF Technique

SURF (Speeded Up Robust Features) is a robust image detector and descriptor that can applied and used in computer vision task like 3D version [9, 10]. SURF is normally used to detect feature point and matching point.

(a) (b) (c) (d)

Figure 4.2: Feature Point and Matching Point of SURF Technique

Figure 4.2 shows the result of feature point and matching point by using the SURF technique at 0°. Seven images are stated as Figure 4.2 (a), Figure 4.2 (b), Figure 4.2 (c), Figure 4.2 (d), Figure 4.2 (e), Figure 4.2 (f) and Figure 4.2 (g). All the figures are representing as the step to detect face using SURF technique. Firstly, two images are applied in this technique. Image Figure 4.2 (a) are called as desired image. The angle of the image Figure 4.2 (a) is fixed as 0° while the angle of the image Figure 4.2 (b) will be changed to 0°, 45° and 90°. Secondly, image Figure 4.2 (c) and Figure 4.2 (d) is detected the SURF feature. Next, Figure 4.2 (e) and Figure 4.2 (f) show matching point and display as outliers and inliers. Basically, outliers defined as the point that match outer point outside the desired image while inliers defined as the point that match inside the desired image. Lastly, the system shows the final image (yellow box) in Figure 4.2 (g). If the angles of image Figure 4.2 (b) are varied with 45° and 90°, the number of matching point displayed cannot detect. Table 4.1, Table 4.2 and Table 4.3 show the result of feature point and matching point by using three different angles.

Table 4.1: Table of Feature Point and Matching Point Using the SURF Technique at 0°

Class / Sample	Feature Point (Image 1)	Feature Point (Image 2)	Matching Point (Outliers)	Matching Point (Inliers)
A	15	74	5	4
B	14	28	8	3
C	16	25	9	5
D	9	39	5	5
E	15	61	11	6
F	20	65	11	8
G	19	30	10	7
H	26	30	12	10
I	14	52	6	5

Table 4.1 shows the table of feature point and matching point using the SURF technique at 0°. The table has four classes which are feature point of image 1 and image 2 together with matching point of outliers and inliers. All the data are recorded based on the following samples.

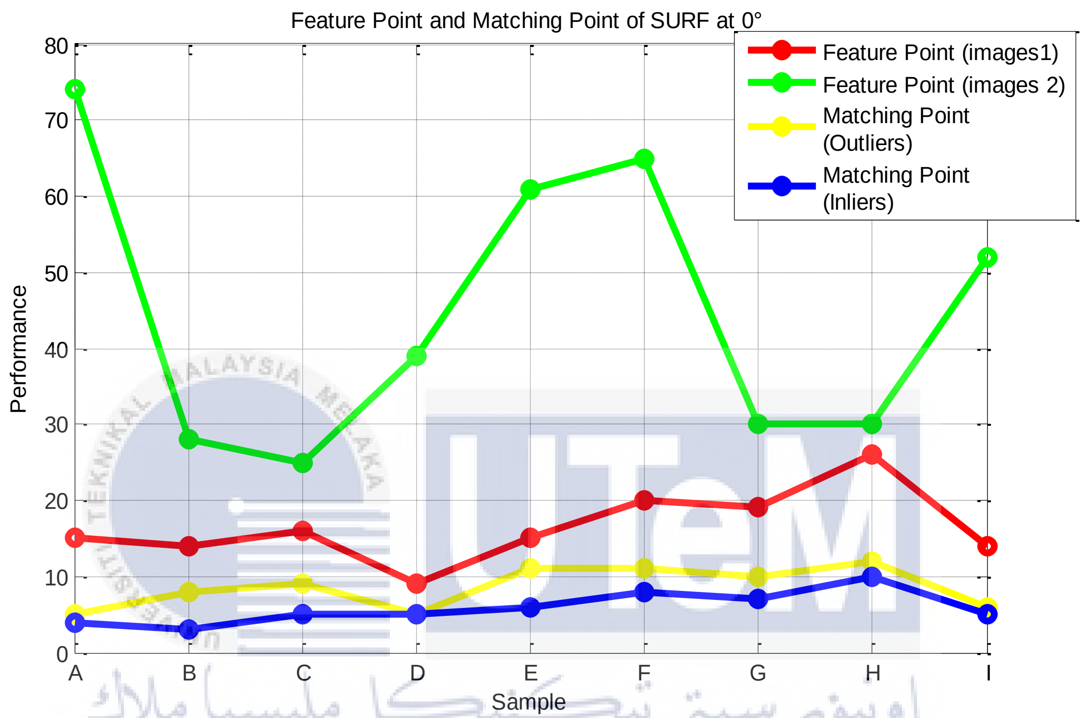


Figure 4.3: Graph of Performance Using the SURF at 0°

Figure 4.3 shows the graph of performance using the SURF at 0°. Four different color lines in the graph are displayed to show different performances. The red line represents a feature point of image 1 or desired image, the green line represents a feature point of image 2, the yellow line represents matching points of outliers and the blue line represents matching points of inliers. Based on the graph of Figure 4.3, sample H and D shows a the highest and lowest number of feature point at image 1 while sample A shows the highest number of feature points at image 2 compared to sample C that have lowest number of feature point. The number of feature point of image 2 is higher than image 1 (desired image) due to the size of the image used. Then, the number of outliers and inliers are shown constantly between both of matching point. By referring from the graph, the number of matching points for outliers are higher than inliers because outliers can detect matching points outside the desired images instead of the inliers that only detects a matching point inside desired image. So, it clearly shows that all samples at 0° can detect the matching point due to similarity of angles.

Table 4.2: Table of Feature Point and Matching Point Using the SURF Technique at 45°

Class / Sample	Feature Point (Image 1)	Feature Point (Image 2)	Matching Point (Outliers)	Matching Point (Inliers)
A	15	48	0	0
B	14	22	0	0
C	16	89	1	0
D	9	60	1	0
E	15	127	0	0
F	20	52	0	0
G	19	41	0	0
H	26	53	0	0
I	14	30	0	0

Table 4.2 shows the table of feature point and matching point using the SURF Technique at 45°. The angles of image 1 is fixed, whereas angle of image 2 is changed to 45°. The feature point of image 1 and image 2 is recorded with matching point of outliers and inliers. Based on Table 4.2, it is shown the sample C and D have a number of matching point for outliers.

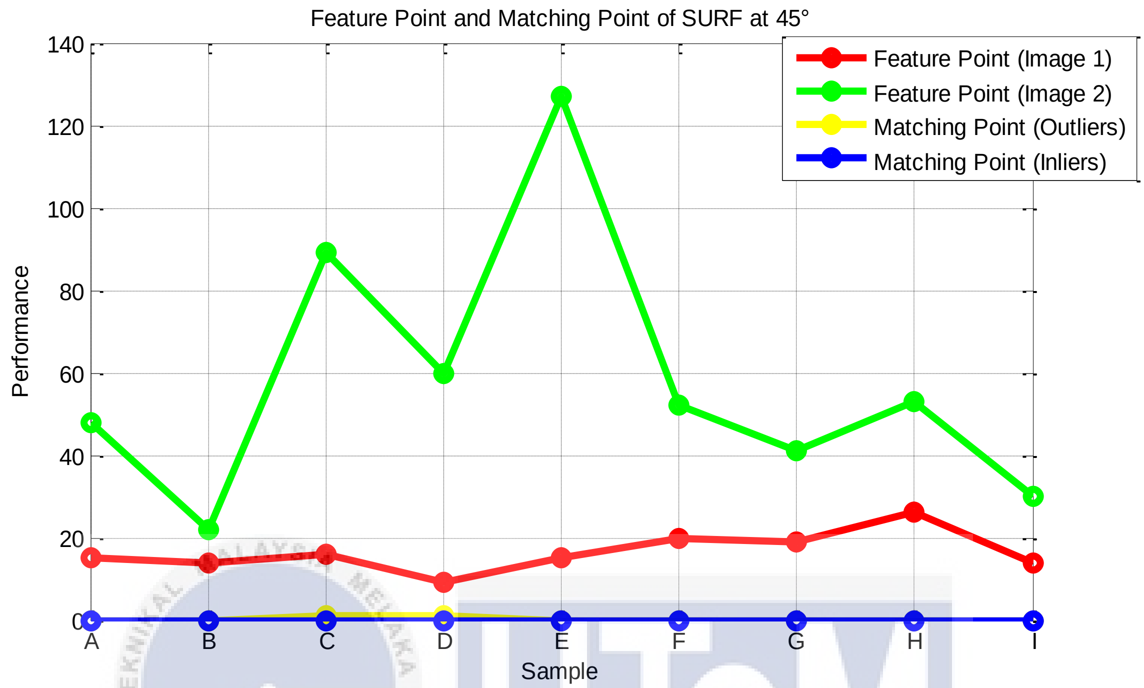


Figure 4.4: Graph of Performance Using the SURF Technique at 45°

Figure 4.4 shows the graph of performance using the SURF technique at 45°. Four performances are shown in the graph with different color. The red line, green line, yellow line and blue line represent a feature point of image 1, feature point of image 2, matching point of outliers and matching point of inliers. From the graph of Figure 4.4, the red line shows sample H has the highest number of feature point for image 1 compared to others sample. Then, the graph shows feature point for image 2 is shown higher than image 1. The sample E shows the highest peak point and followed by sample D for feature point of image 2. However, the graph for matching point of outliers and inliers shows moderate between both lines. The matching point cannot detect due to the different angles of the images used between image 1 and image 2.

Table 4.3: Table of Feature Point and Matching Point Using the SURF Technique at 90°

Class / Sample	Feature Point (Image 1)	Feature Point (Image 2)	Matching Point (Outliers)	Matching Point (Inliers)
A	15	34	0	0
B	14	24	0	0
C	16	314	0	0
D	9	129	0	0
E	15	248	0	0
F	20	58	0	0
G	19	74	0	0
H	26	49	0	0
I	14	30	0	0

Table 4.3 shows the table feature point and matching point using the SURF technique at 90°. The result of the performance of nine samples is recorded. The angles of image 2 are changed to 90° while the angles for image 1 (desired image) is unchanged.

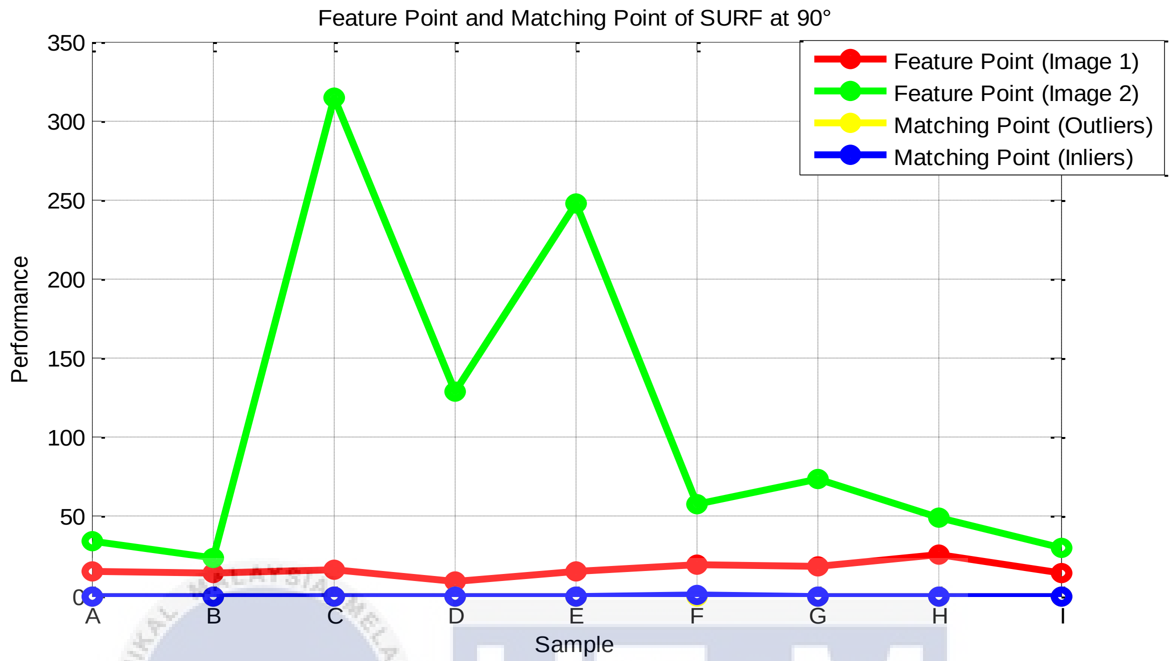


Figure 4.5: Graph of Performance Using the SURF Technique at 90°

Figure 4.5 shows the graph of performance using the SURF technique at 90°. Based on the graph of Figure 4.3, green line shows a higher value compared to other line. The green line represents a feature point of image 2. Sample C shows a highest number of feature point of image 2 and the lowest number shows by sample B. However, as can see from the graph, the red line represents the point of feature point are shown constantly same with all samples. The number of feature point of image 1 (desired image) is same as in Figure 4.3 and Figure 4.4. Then, from the graph, the matching point of outliers and inliers represent in a straight line. The number of matching point could not detect for both outliers and inliers due to angles of images 2.

Overall, the angle of the images affects the performance of feature point and matching point by using SURF technique. Different angles are applied in this technique in order to vary the result of out-of-plane. The number of feature point for image 2 are increasing due to change in angles and shows higher values at 90° follow by 45°and 0°.

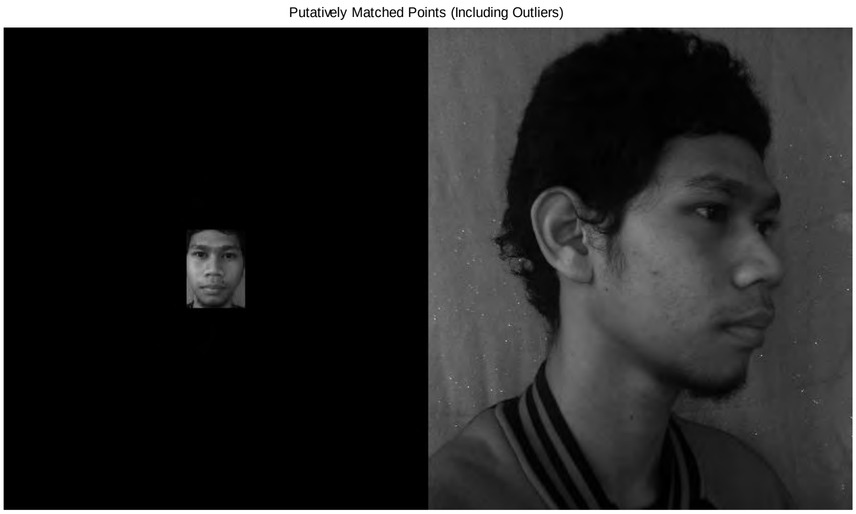


Figure 4.6: No Matching Point Detected

Figure 4.6 shows the matching point that cannot detect if the angles of image 2 are set at 45°and 90°. However, based on Table 4.2, samples C and D able to detect number of matching point of outliers at 45°.

Error using
coder.internal.errorIf
(line 9)
MATCHED_POINTS1 and
MATCHED_POINTS2 do not
have enough points.

Error in SURF_Match_amir
(line 84)
[tform, inlierBoxPoints,
inlierScenePoints] = ...

Figure 4.7: Error in Matching Point

This error is displayed in the ***command window*** by using MATLAB 2013a. So, out-of-plane images cannot detect a face detection and are not able to give a good result. However, using in-of-plane image, the system will give a good result.

4.3 Face Detection using Skin Color YCbCr Color Space Technique

In this research, YCbCr color space is used to detect the skin color of the image. The YCbCr is commonly used in the area of digital video, representation, transmission and processing. It was originally developed for the color representation of digital television [14]. From previous research shows that YCbCr provides a better result.

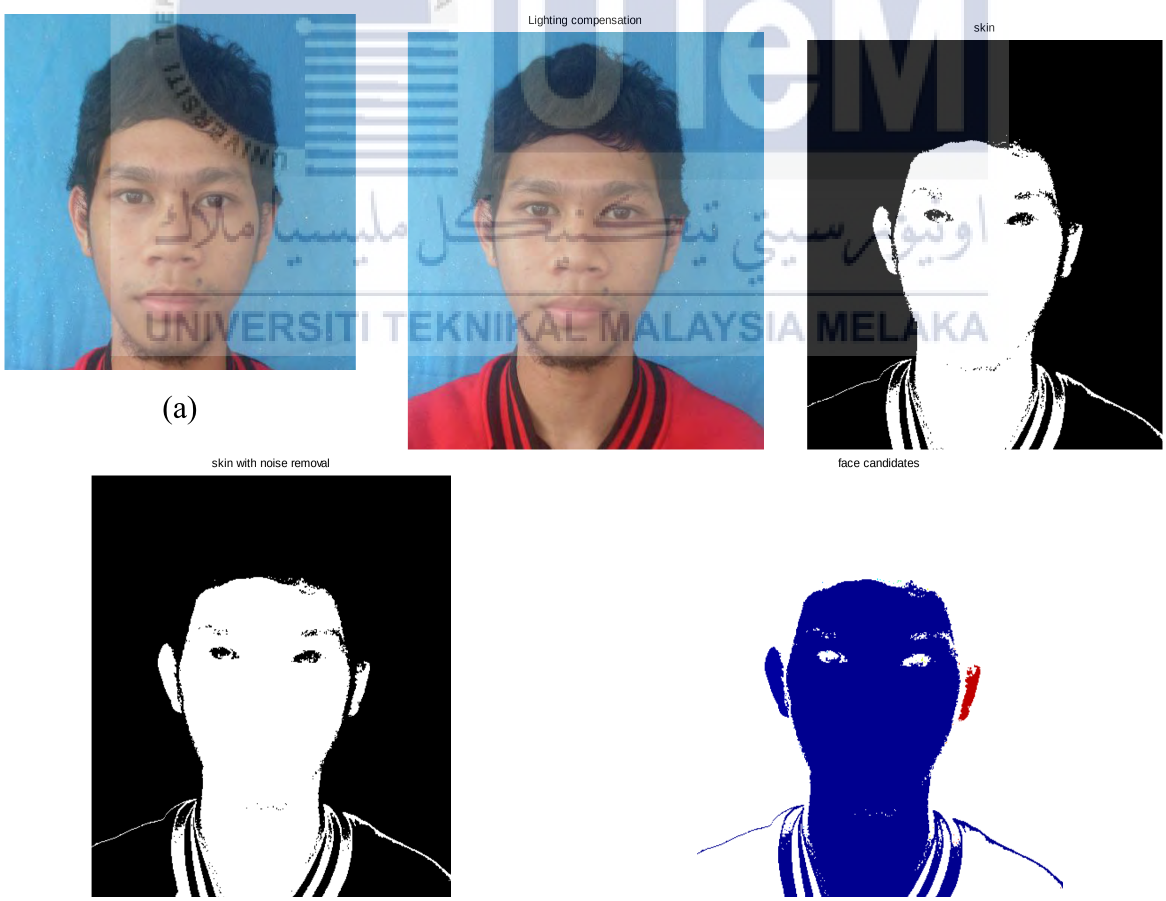


Figure 4.8: The result of Skin Color of Face Detection at 0°

Figure 4.8 shows a result of the skin color of YCbCr at 0°. The five images of Figure 4.8 (a), Figure 4.8 (b), Figure 4.8 (c), Figure 4.8 (d) and Figure 4.8 (e) represent the step to detect the skin region of face detection by using the YCbCr color space. Firstly, the input image has detected at Figure 4.8 (a) and the RGB color space is converted to YCbCr color space at Figure 4.8 (b). Once an image is loaded, it is stored as a three primary colors red (R), green (G) and blue (B) before it convert the image to others color space such YCbCr and HSV. Then, Figure 4.8 (c) represents the skin of the image. Skin color segmentation is used to extract a skin region and eliminate non-skin region. Next, noise is removed previously from the image before the system shown the face samples in Figure 4.8 (d). Finally, blue color in Figure (e) shows the shape of the sample after extracted.

Table 4.4: Table of Skin Color Detection at 0°

Class / Sample	Face,I (s)	Color, T (s)	Skin, S (s)	Skin with Noise Removal, SN (s)	Face Sample, L (s)
A	0.000005	0.000001	0.000002	0.000003	0.000002
B	0.000031	0.000001	0.000003	0.000006	0.000006
C	0.000017	0.000002	0.000004	0.000006	0.000006
D	0.000012	0.000002	0.000017	0.000005	0.000006
E	0.000014	0.000001	0.000003	0.000002	0.000016
F	0.000022	0.000001	0.000002	0.000004	0.000003
G	0.000017	0.000001	0.000003	0.000003	0.000002
H	0.000011	0.000001	0.000003	0.000003	0.000002
I	0.000030	0.000005	0.000003	0.000005	0.000002

Table 4.4 shows the table of skin color detection at 0°. The table has five classes which have face (I), color (T), skin (S), skin with noise removal (SN), and face sample (L). All the data are recorded based on the following samples.

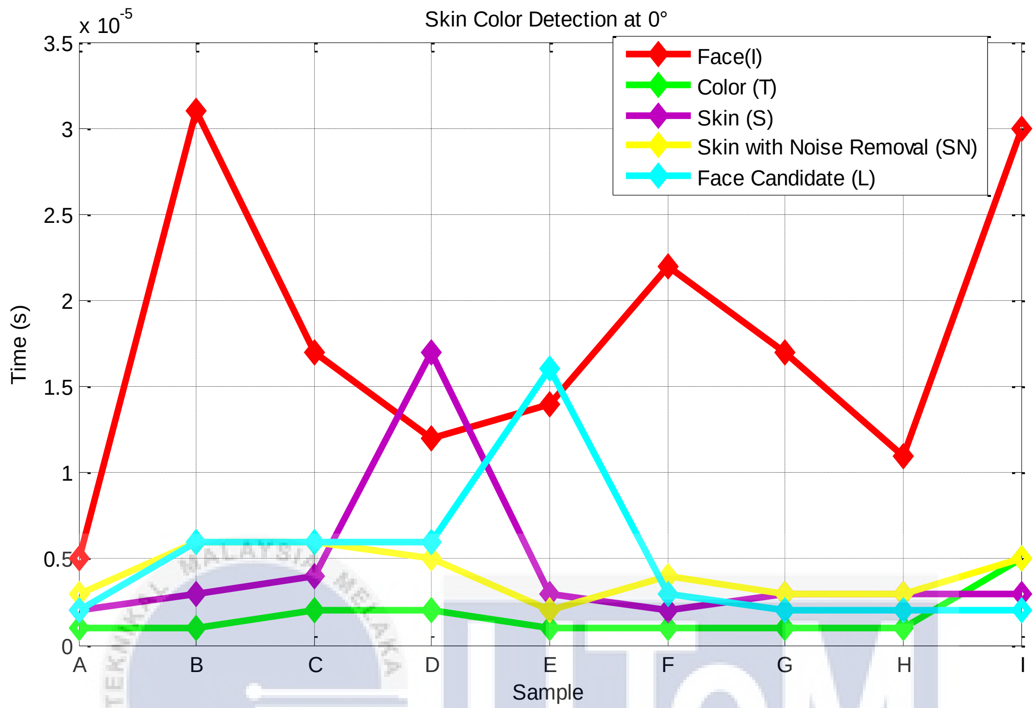


Figure 4.9: Graph of Skin Color Using YCbCr Color Space 0°

Figure 4.9 shows the graph of the skin color using YCbCr Color Space at 0°. The graph shows a time taken to run the step of detecting a skin region of face detection by using the YCbCr color space. The red line represents face, the green line represents a color, the purple line represents skin, the yellow line represents skin with noise removal and the blue line represents face samples. Based on the graph of Figure 4.9, sample B shows the highest time and sample A shows the lowest time to detect the input images of faces. For the color classes, sample I show the highest time while the others sample shows a moderate time to convert the color from RGB to YCbCr color space. Other than that, the line purple shows sample D has the highest time to detect skin compared to others sample. From the graph, clearly shows the process to detect skin with noise removal will take a moderate time. Lastly, sample E shows the highest time among all while sample A, G, H and I show the lowest time to detect the faces for all respondent face.

Table 4.5: Table of Skin Color detection at 45°

Class / Sample	Face, I (s)	Color, T (s)	Skin, S (s)	Skin with Noise Removal, SN (s)	Face Sample, L (s)
A	0.000028	0.000001	0.000002	0.000003	0.000002
B	0.000029	0.000001	0.000004	0.000002	0.000003
C	0.000017	0.000002	0.000003	0.000008	0.000003
D	0.000016	0.000001	0.000003	0.000006	0.000016
E	0.000013	0.000004	0.000008	0.000006	0.000008
F	0.000033	0.000002	0.000004	0.000003	0.000002
G	0.000014	0.000001	0.000004	0.000002	0.000002
H	0.000028	0.000001	0.000003	0.000003	0.000012
I	0.000023	0.000003	0.000002	0.000017	0.000002

Table 4.5 shows result of skin color detection at 45°. The time taken are used to detect the skin color YCbCr color space for face detection.

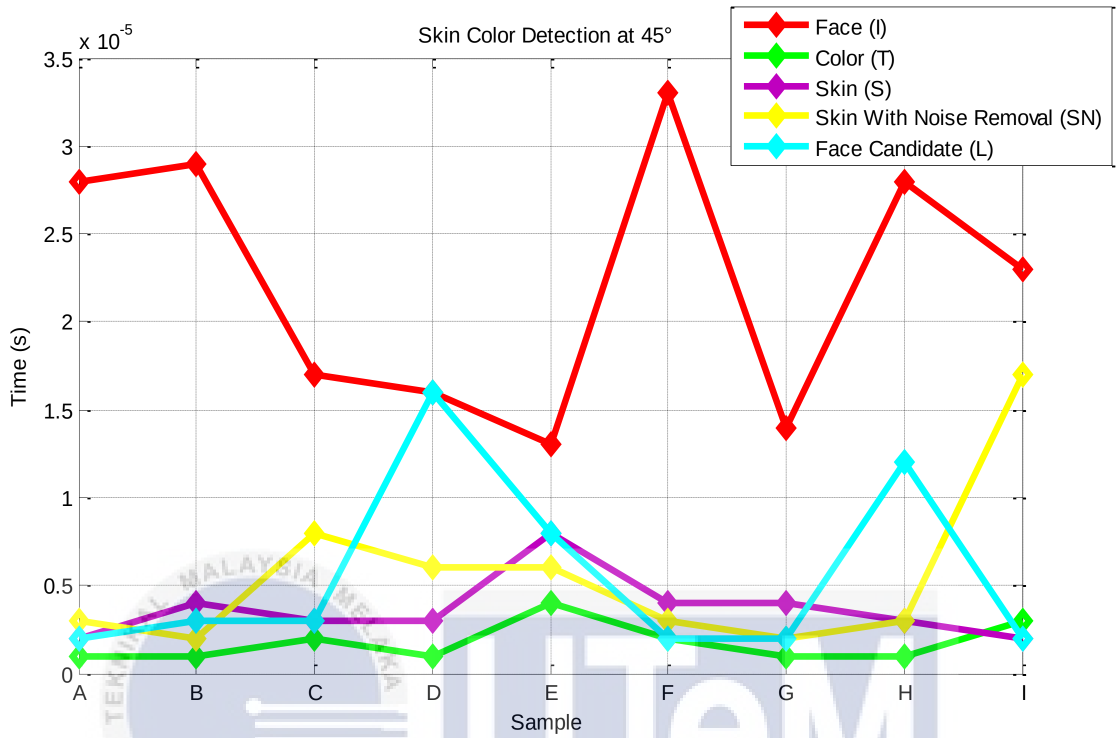


Figure 4.10: Graph of Skin Color Using YCbCr Color Space at 45°

Figure 4.10 shows the result of the skin color using YCbCr Color Space at 45°. The graph shows a time taken to run the five steps in order to detect a skin region of face detection by using the YCbCr color space. Five different colors are used to represent the step. The red line, the green line, the purple line, the yellow line, and the blue line representing the face (I), color (T), skin (S), skin with noise removal (SN), and face sample (L). Based on the graph of Figure 4.10, sample F shows a higher time while sample E shows a lower time to detect an input image of faces. Next, as can be seen from the graph, all the samples take a moderate time to detect the color. Then to detect a skin, sample E shows a higher time while others sample actually shows a constant time. As shown in graph, sample I show a highest time to detect skin with noise removal compared to others. Finally, sample D and H show a higher time to display a face candidates compared to others. So, the tone color of the face has not affected the result.

Table 4.6: Table of Skin Color at 90°

Class / Sample	Face, I (s)	Color, T (s)	Skin, S (s)	Skin with Noise Removal, SN (s)	Face Sample, L (s)
A	0.000011	0.000002	0.000002	0.000002	0.000002
B	0.000010	0.000002	0.000003	0.000002	0.000004
C	0.000021	0.000003	0.000026	0.000007	0.000004
D	0.000020	0.000001	0.000005	0.000005	0.000006
E	0.000024	0.000004	0.000006	0.000009	0.000003
F	0.000042	0.000003	0.000002	0.000003	0.000004
G	0.000028	0.000001	0.000003	0.000004	0.000002
H	0.000025	0.000001	0.000002	0.000003	0.000002
I	0.000030	0.000001	0.000002	0.000002	0.000002

Table 4.6 shows the table of skin color at 90°. The result of the time taken of five steps to detect a skin region of nine samples is recorded. The angles of image are changed to 90° in order to vary the result for out-of-plane image.

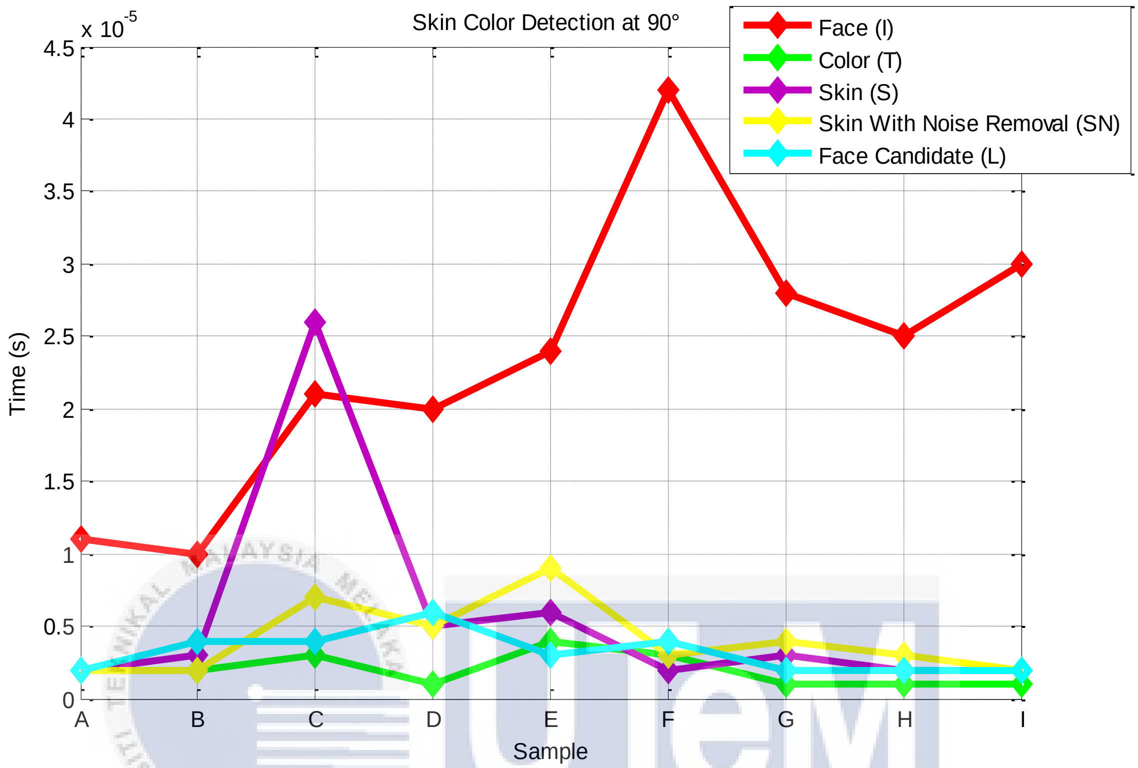


Figure 4.11: Graph of Skin Color Using YCbCr Color Space at 90°

Figure 4.11 shows the graph of skin color at 90°. The red line represents face, the green line represents a color, the purple line represents skin, the yellow line represents skin with noise removal and the blue line represents face samples. From the graph it clearly shows that, sample F shows a greatest time and sample B is shows a lowest time to detect an input image of face detection. Sample C shows a highest time compared to others sample that have lower time to detect a skin region. However, as can be seen from the graph, all the samples show mostly moderate time to detect color, skin with a noise removal and face sample. The difference in tone skin color has not affected with the result.

4.4 Comparison Between SURF and Skin Color YCbCr Color Space Technique

SURF and skin color YCbCr color space technique are compared based on time response for both techniques. The angles for three different angles are applied.

Table 4.7: Table of SURF Technique vs Skin Color YCbCr Color Space Technique

Sample	Degree (°)	Time of SURF Technique (s)	Time of Skin Color YCbCr Color Space Technique (s)
A	0	5.798294	0.000319
	45	5.473473	0.000324
	90	1.918251	0.000311
B	0	2.039660	0.001244
	45	1.046966	0.000620
	90	1.856675	0.001099
C	0	2.492458	0.001146
	45	1.964905	0.001077
	90	2.444938	0.000730
D	0	2.873807	0.001352
	45	1.838776	0.002600
	90	2.203809	0.000866
E	0	2.851303	0.001752
	45	2.004990	0.001850
	90	2.484854	0.001530
F	0	2.957548	0.001218
	45	1.860188	0.000321
	90	2.198428	0.000742
G	0	1.735289	0.000345
	45	4.394834	0.000306
	90	4.428879	0.000554

H	0	1.878517	0.000434
	45	1.245741	0.001039
	90	1.552288	0.000100
I	0	1.791225	0.000487
	45	1.423833	0.000457
	90	1.43542	0.000299

Table 4.7 shows table of SURF Technique vs skin colors YCbCr color space technique. The total time of two techniques is recorded at three different angles which are 0°, 45° and 90°.

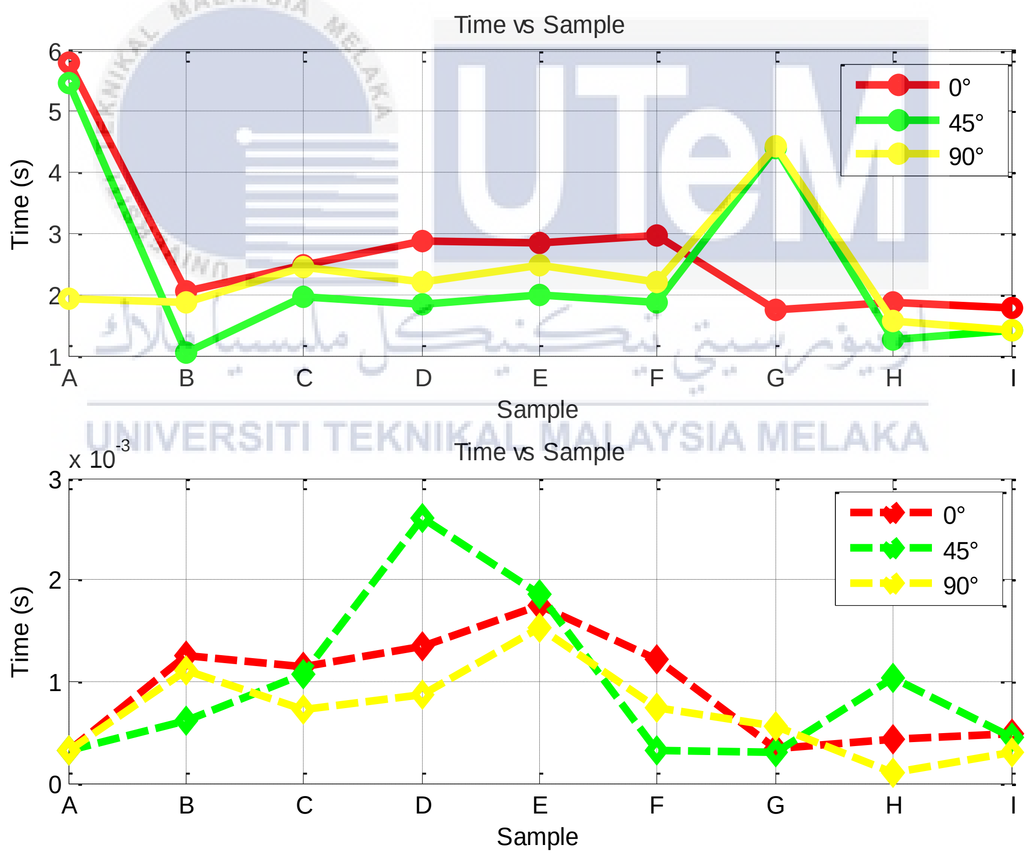


Figure 4.12: Graph of SURF and Skin Color of YCbCr Color Space Technique

Figure 4.12 shows the results of SURF and the skin color of YCbCr color space techniques. The total time of SURF and the skin color of YCbCr color space technique at three different angles are used to make a comparison between both techniques. Based on the graph, Figure 4.12, the red line represents a total time taken at 0°, the green line represents a time taken at 45° and the yellow line represents a time taken at 90°. Two different types of lines are used where the solid line represents SURF technique and the dotted line represent a skin color of the YCbCr color space. Using SURF technique, sample A gives a highest time to detect a feature point and matching point due to lighter skin color. However, skin color detection shows a higher time taken by sample D. So, a lighter and darker skin color take a lower time to detect the skin region of the face.

In conclusion, different tone color of all samples has not affected the result between both techniques. From the result, skin color provides faster result compared to SURF technique. The average times between the both techniques are slightly different. Color can detect a region of face at different angles meanwhile by using the SURF technique only SURF feature point that can detect at three different angles and not available for matching point. Matching point could give best result if image 2 at 0°. Therefore, from this research, the skin color of YCbCr color space technique able to give a good result due performance that functioning detects a region of skin color at 0°, 45° and 90° with the lowest time taken compared to SURF technique.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, the objective of the Final Year Project (FYP) is achieved. The objective to develop the method of out-of-plane face detection using SURF and the skin color of YCbCr color space technique are successful with MATLAB 2013a. The performance in term of time response between both techniques is compared. Both techniques are slightly different in order to detect a face. SURF technique used SURF feature point and matching point while skin color of YCbCr are using extraction the skin region using color space. Besides that, the accuracy between both techniques cannot be calculated or display other than compared by using the time response. The response time for both techniques varied with the differences in skin color of all respondents.

In order to complete this research, nine respondents which have different skin color are selected. Other than that, the image of the all respondents is captured from three different angles which are 0°, 45° and 90°. By using SURF and the skin color YCbCr color space technique, the results show that skin color gives more lowest time compared to SURF. The skin color of all respondents does not affect the result, however, different angles are effected results obtained from SURF technique. SURF cannot detect the matching point of the image if different angle is used between image 1 (desired image) and image 2 while color can detect the skin region in all angles.

5.2 Recommendation

For future works, many improvements can be suggested to continue this project. One suggestion is using variations of face shape for face detection. The shape of a human face is different from one and others. However, to classify the human face shape are difficult. Oval, rectangular, round, heart and square are some example human face shape. So, the next research can be developed by varying the skin tone color and human face shape by applying the SURF and skin color of the YCbCr color space techniques. Besides that, increase the numbers of database in future works are highly recommended in order to find the accuracy by using both techniques.

REFERENCES

[1] Y. M. Mustafah and A. W. Azman, "Out-of-Plane Rotated Object Detection using Patch Feature based Classifier," *Procedia Engineering*, vol. 41, pp. 170–174, 2012.

[2] S. K. Singh, D. S. Chauhan, M. Vatsa, and R. Singh, "A Robust Skin Color Based Face Detection Algorithm," *Tamkang Journal of Science and Engineering*, vol. 6, no. 4, pp. 227–234 ,2003.

[3] T. M. Mahmoud, "A New Fast Skin Color Detection Technique," *World Academy of Science*, *Engineering and Technology*,pp. 447–451, 2008.

[4] S. L. Phung and D. K. Chai, "Skin colour based face detection," *Seventh Australian and New Zealand Intelligent Information Systems Conference* ,2011.

[5] H. C. V. Lakshmi and S. PatilKulakarni, "Segmentation Algorithm for Multiple Face Detection in Color Images with Skin Tone Regions using Color Spaces and Edge Detection Techniques," *International Journal of Computer Theory and Engineering*, vol. 2, no. 4, pp. 552–558, 2010.

[6] M. a. Berbar, H. M. Kelash, and a. a. Kandeel, "Faces and Facial Features Detection in Color Images," *Geom. Model. Imaging--New Trends*, pp. 209–214, 2006.

[7] K. Singh, "Content Based Image Retrival Using SURF , SVM and Color Histogram – A Review," *International Journal of Emerging Technology and Advanced Engineering,* vol. 4, no. 6, pp. 293–295, 2014.

[8] K. Nallaperumal, S. Ravi, C. N. K. Babu, R. K. Selvakumar, A. L. Fred, S. Christopher, and S. S. Vinsley, "Skin Detection Using Color Pixel Classification with Application to Face Detection: A Comparative Study," in *International Conference on Computational Intelligence and Multimedia Applications (ICCIMA 2007)*, 2007, pp. 436–441.

[9] P. M. Panchal, S. R. Panchal, and S. K. Shah, "A Comparison of SIFT and SURF," *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 1, no. 2, pp. 323–327, 2013.

[10] G. Du, F. Su, and A. Cai, "Face recognition using SURF features" vol. 7496, pp. 749628–749628–7, Oct. 2009.

[11] S. D. Lin, B. Liu, and J. Lin, "Combining Speeded-Up Robust Features with Principal Component Analysis in Face Recognition System," *International Journal of Innovative Computing, Information and Control,* vol. 8, no. 12, pp. 8545–8556, 2012.

[12] N. Y. Khan, B. McCane, and G. Wyvill, "SIFT and SURF Performance Evaluation against Various Image Deformations on Benchmark Dataset," *International Conference on Digital Image Computing: Techniques and Applications* pp. 501–506, Dec. 2011.

[13] N. a bin Abdul Rahman, K. C. Wei, and J. See, "RGB-H-CbCr Skin Colour Model for Human Face Detection," *Proc. MMU Int. Symp. Inf. Commun. Technol.*, 2006.

[14] A. Kaur and B. V Kranthi, "Comparison between YCbCr Color Space and CIELab Color Space for Skin Color Segmentation," *Int. J. Appl. Inf. Syst.*, vol. 3, no. 4, pp. 30–33, 2012.

[15] H. K. Saini and O. Chand, "Skin Segmentation Using RGB Color Model and Implementation of Switching Conditions," vol. 3, no. 1, pp. 1781–1786, 2013.

APPENDIX A: Gantt Chart For Final Year Project 1 (BEKU 4792)

	SEPTEMBER				OCTOBER				NOVEMBER				DISEMBER			
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16
CHAPTER 1- INTRODUCTION																
Research Background																
Problem Statement																
Objective of Project																
Scopes of Project																
CHAPTER 2 – LITERATURE REVIEW																
Analysis of Information																
Synthesis of Information																
Evaluation of Information																
CHAPTER 3 – METHODOLOGY																
Project Flow Chart																
Validity and Reliability of Data																
CHAPTER 4 – PRELIMINARY RESULTS																
Mathematical Algorithm																
Simulation of Algorithm																
Analysis of Algorithm																
CHAPTER 5 – CONCLUSION																
Conclusion																
Recommendation																

Presentation Week

Task Done

APPENDIX B: Gantt Chart For Final Year Project 2 (BEKU 4894)

TASK	FEBRUARY	MARCH				APRIL				MAY				JUNE			
	W1	W3	W4	W5	W6	W7	W 8	W9	W1 0	W1 1	W1 2	W1 3	W1 4	W1 5	W1 6	W1 7	W1 8
CHAPTER 4 – DEVELOPMENT, RESULT AND DISCUSSION																	
Development Method of Out-of-plane using SURF Technique.																	
Development Method of Out-of-plane using skin color YCbCr method.																	
Compare accuracy of SURF technique and skin color YCbCr method.																	
Make a analysis																	
CHAPTER 5 – CONCLUSION																	
Conclusion																	

Final Year Project 2 Presentation

Making Improvements the Final Report

Task Done

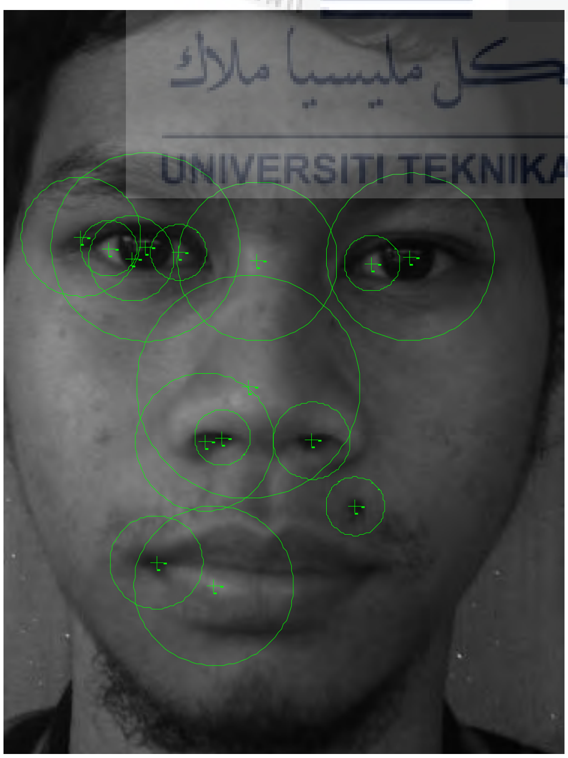
APPENDIX C: Project Milestones for Final Year Project 1

TASK	DATE
Deal with Supervisor and Confirmation Project Title	08/09/2014
Literature review	24/09/2014
Development of algorithm	22/10/2014
Seminar and Presentation Project Proposal	17/11/2014
Making Improvements the Proposal Report	22/12/14

APPENDIX D: Project Milestones for Final Year Project 2

TASK	DATE
Continue project from FYP1	23/02/15
Development Method of Out-of-plane using SURF Technique.	23/02/15-15/05/15
Development Method of Out-of-plane using the skin color YCbCr method.	23/02/15-15/05/15
Complete Develop and Analysis the Result From the Project	16/05/15
Submit Draft of Final Report to Supervisor	22/05/15
Making Correction of Final Report	25/05/15-29/05/15
Submit Final Report to Panel and Supervisor	01/06/15
FYP 2 Seminar and Demonstration	08/05/15-12/05/15
Making Improvement of Final Report based on feedback during the seminar	15/05/15-19/05/15
The deadline to submit Final Report	19/06/15

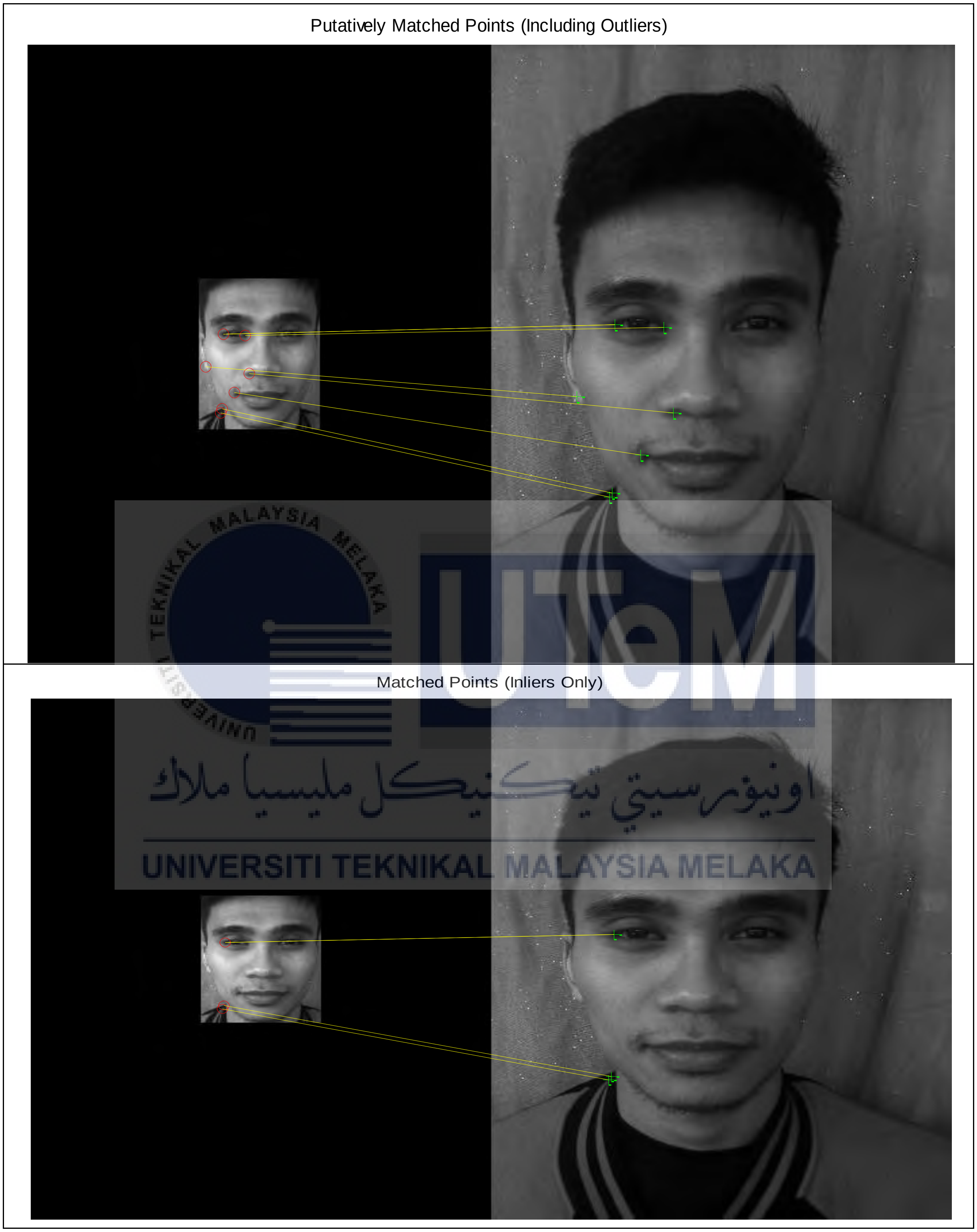
APPENDIX E: Face Detection Using SURF Technique at 0°

Sample A	Image Sample A
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

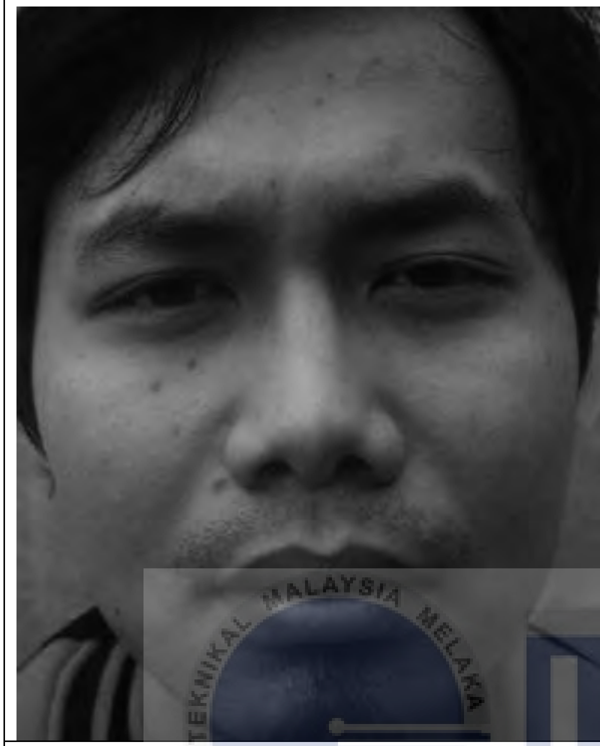

Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

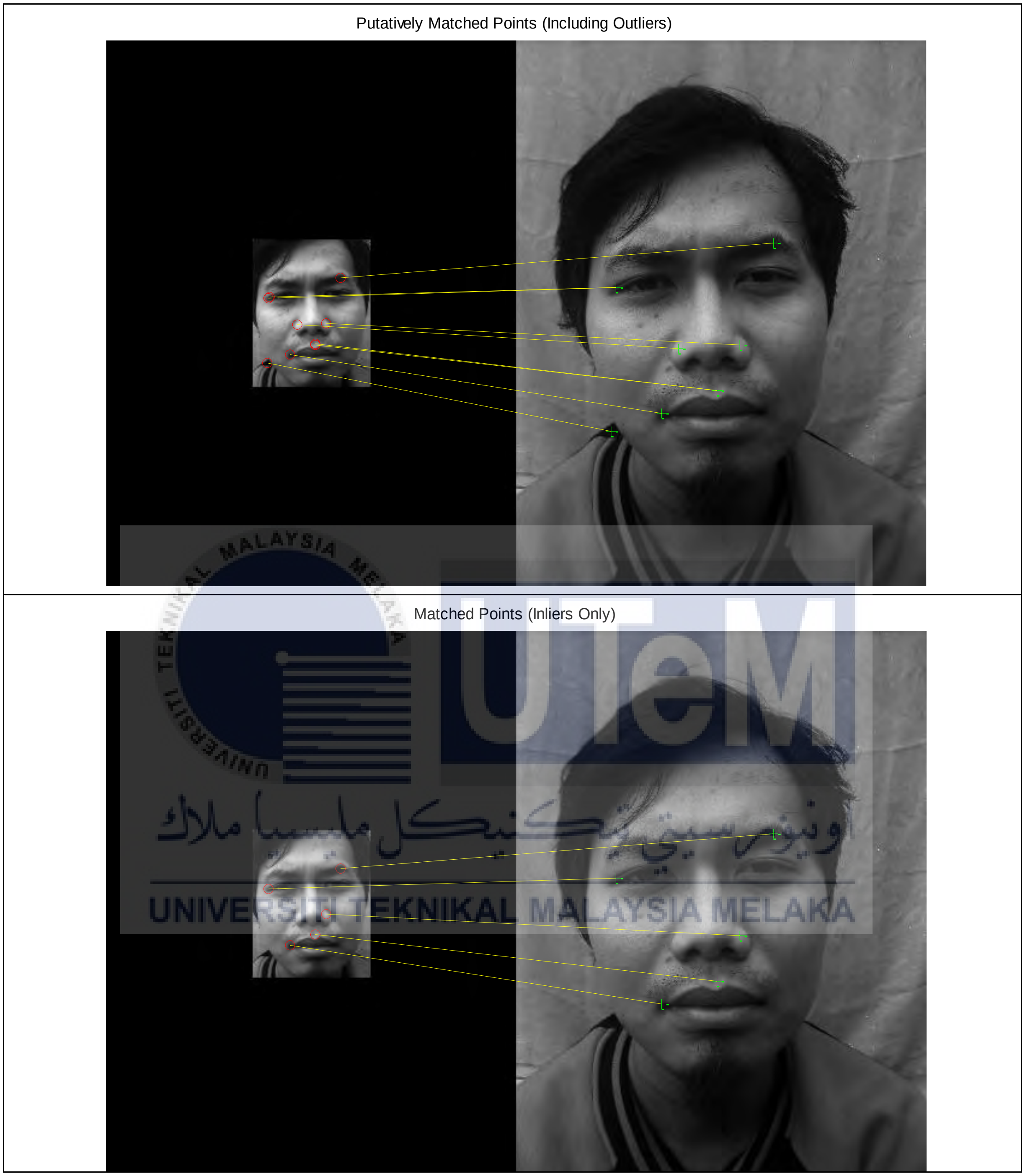

Detected Box

Sample B	Image Sample B
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

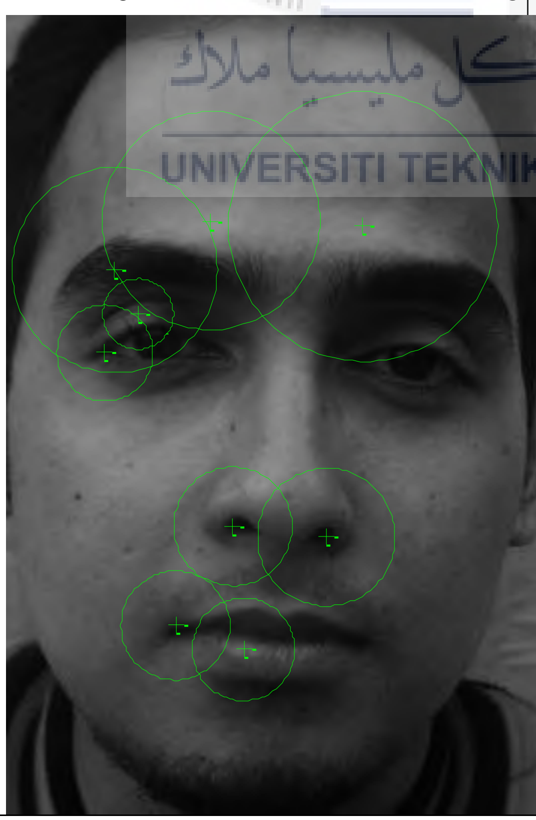

Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

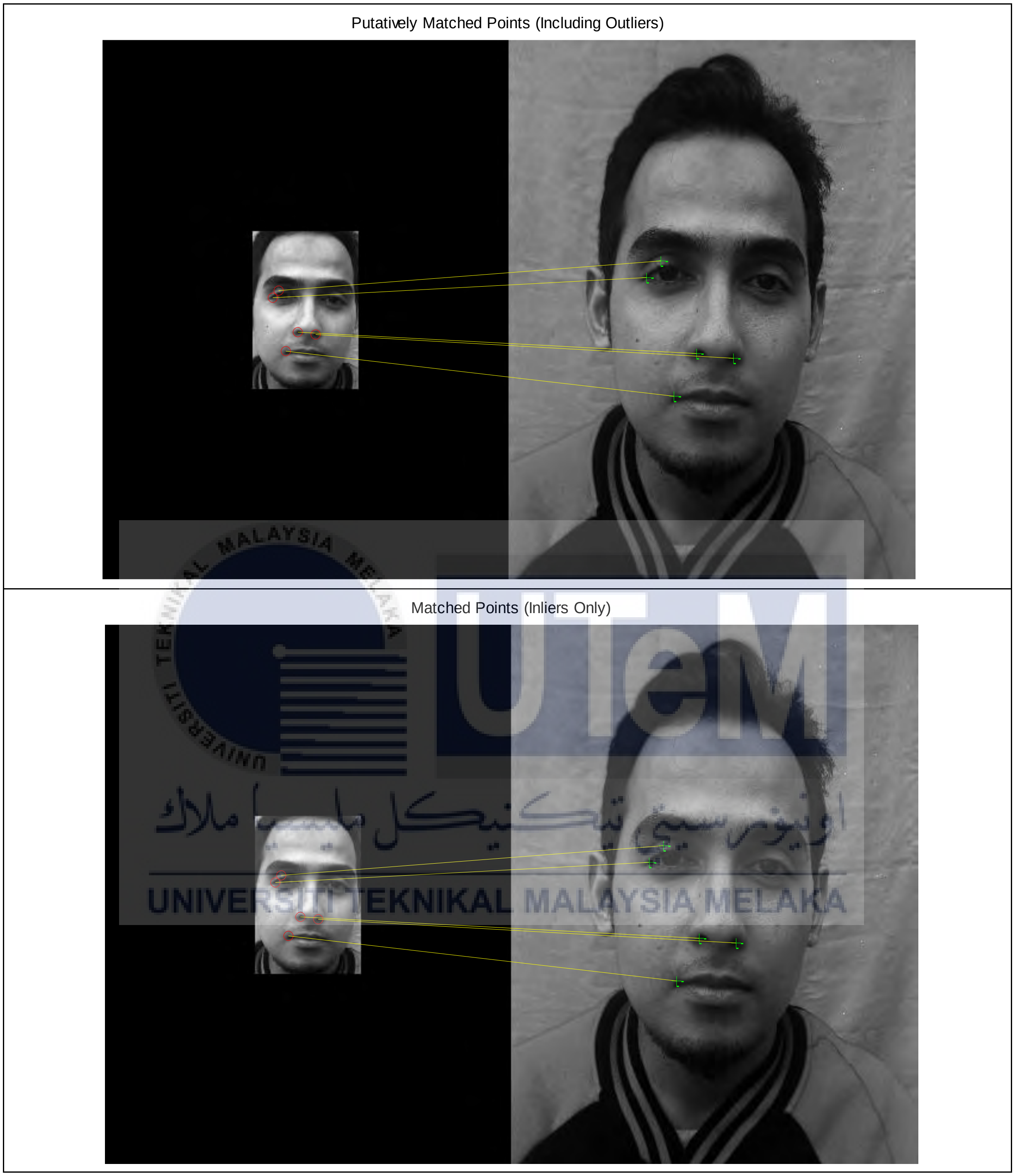

Detected Box

Sample C	Image Sample C
	
100 Strongest Feature Points from Box Image	300 Strongest Feature Points from Scene Image
	

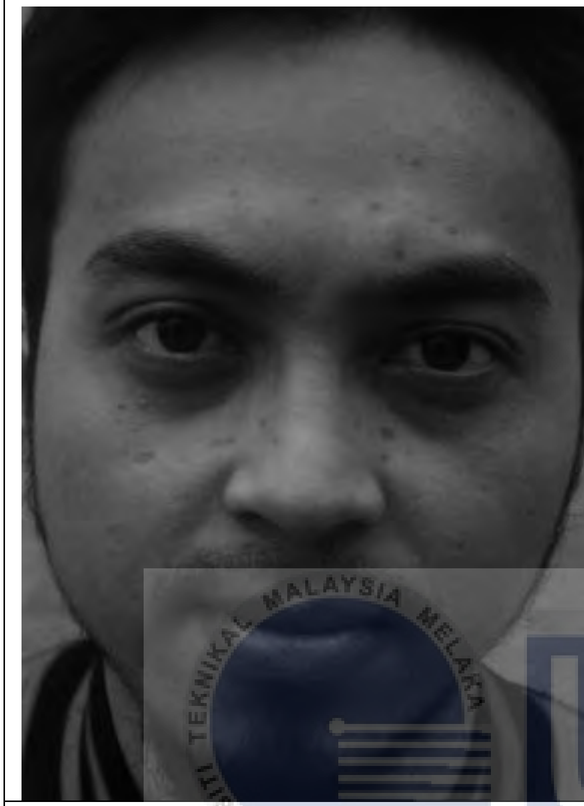
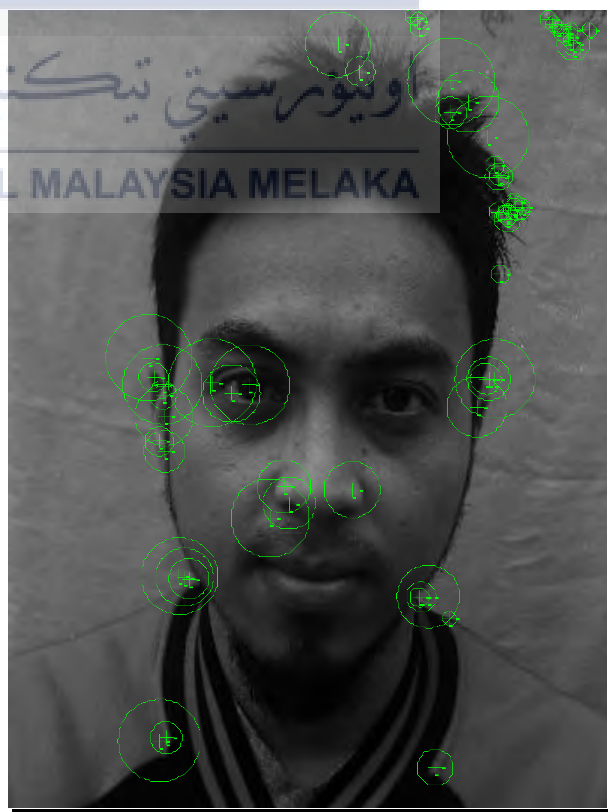

Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

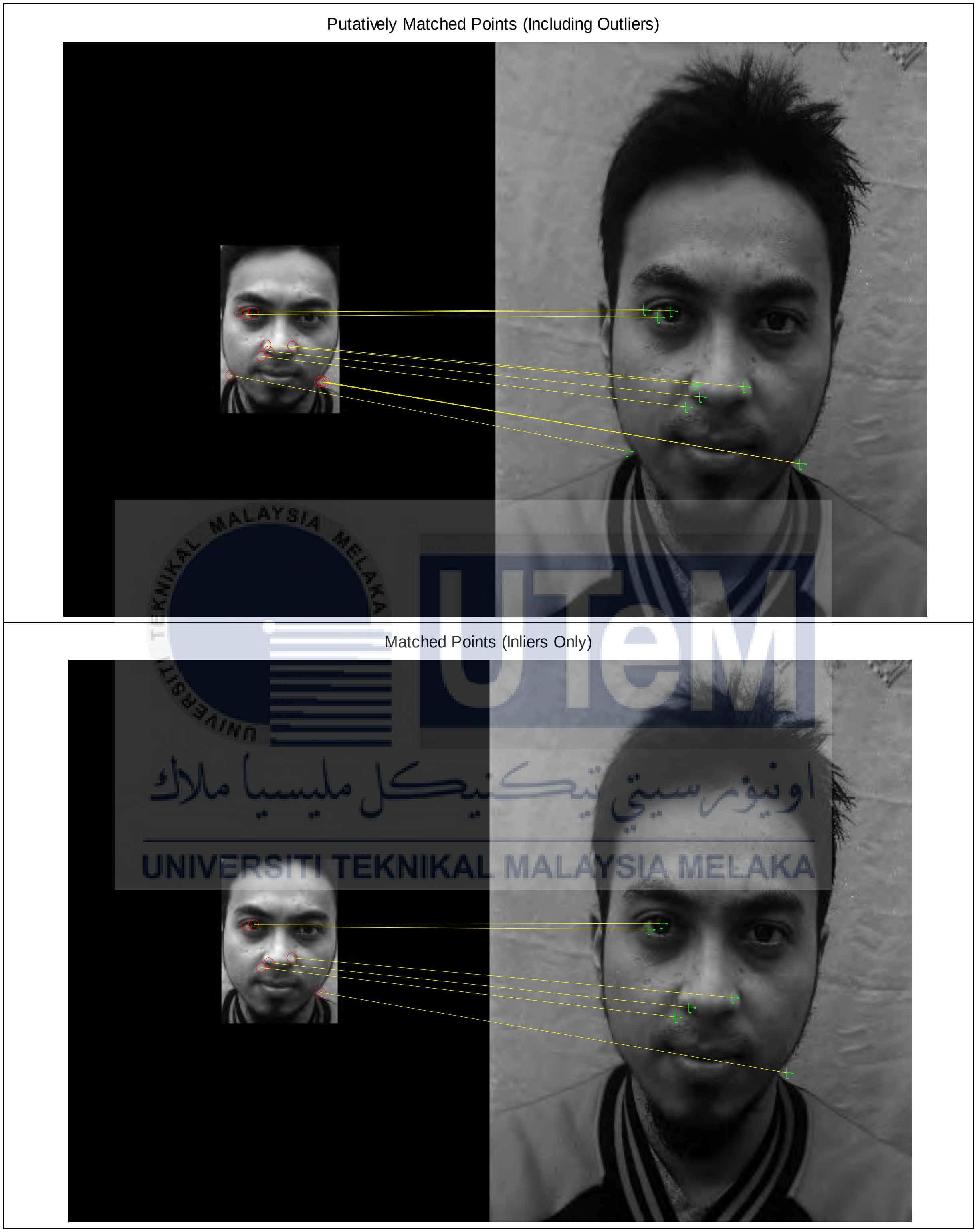

Detected Box

Sample D	Image Sample D
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

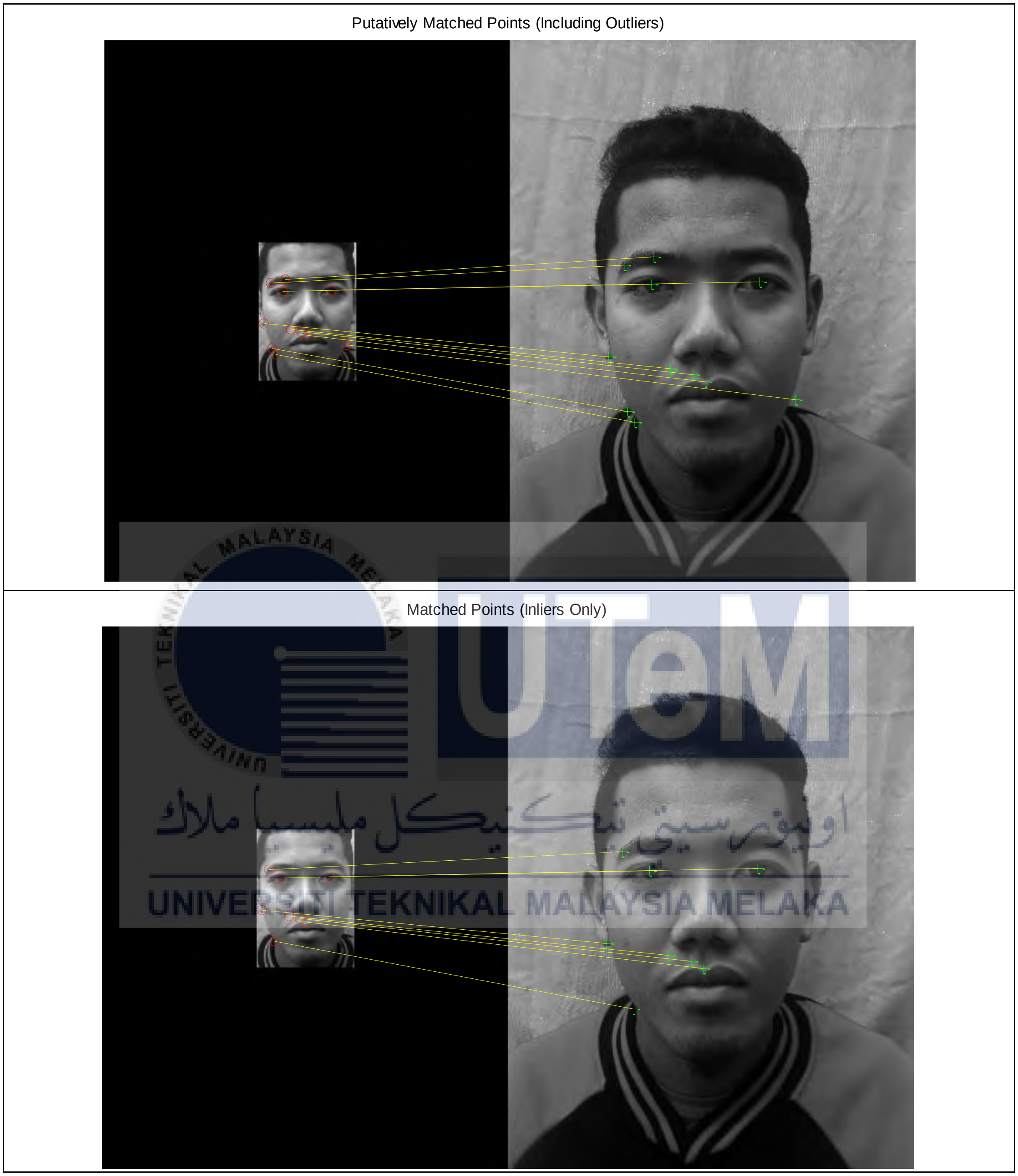

Detected Box

Sample E	Image Sample E
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

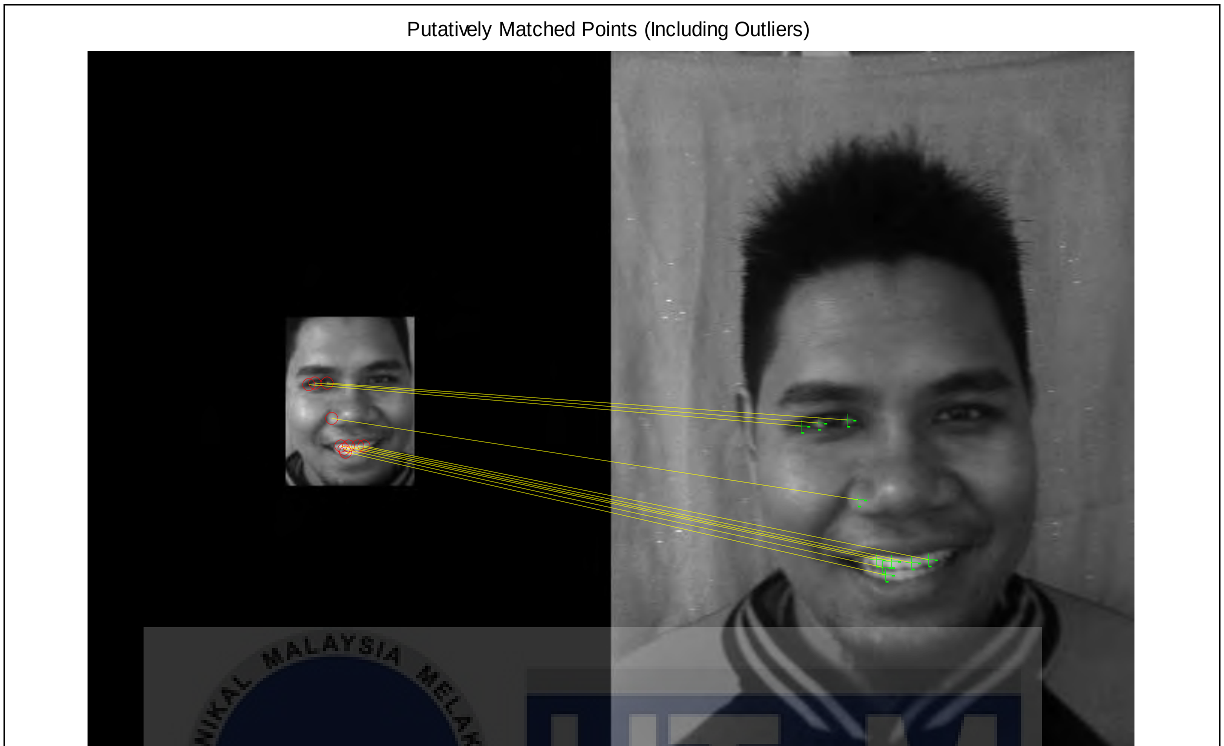

Detected Box

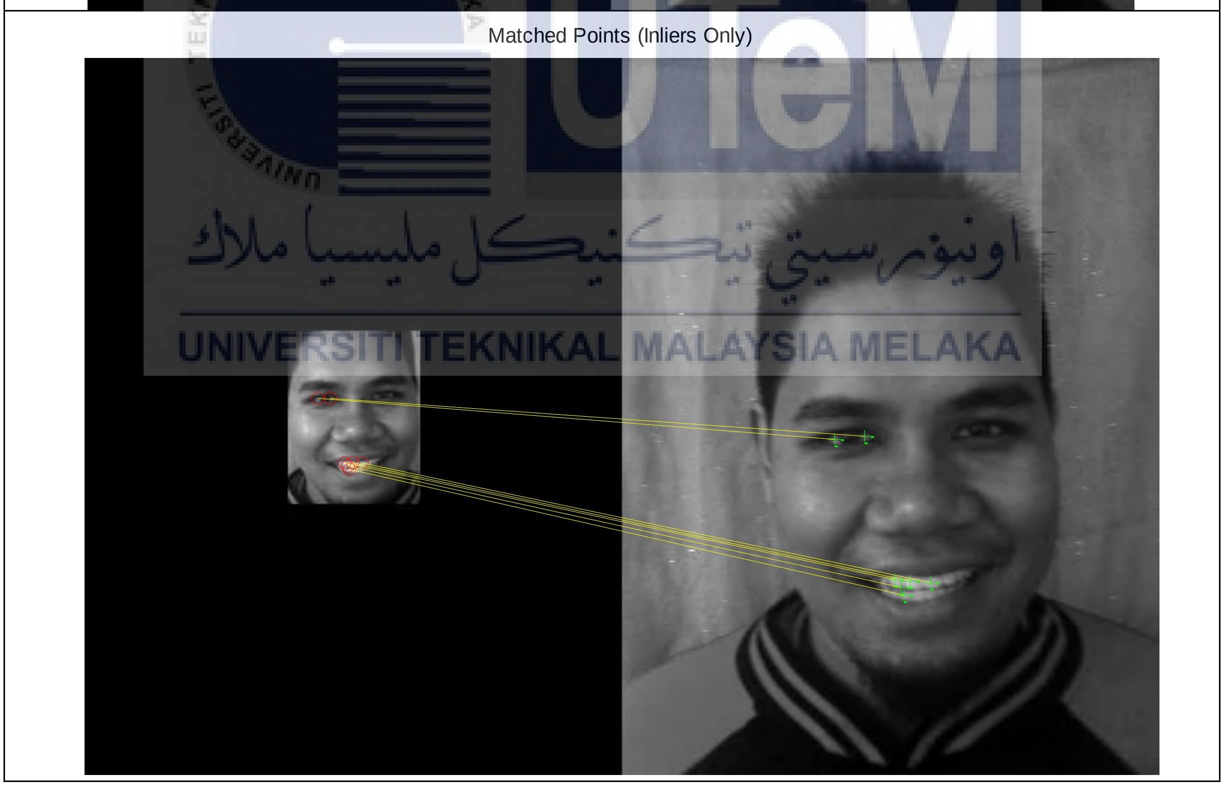
Sample F	Image Sample F
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)

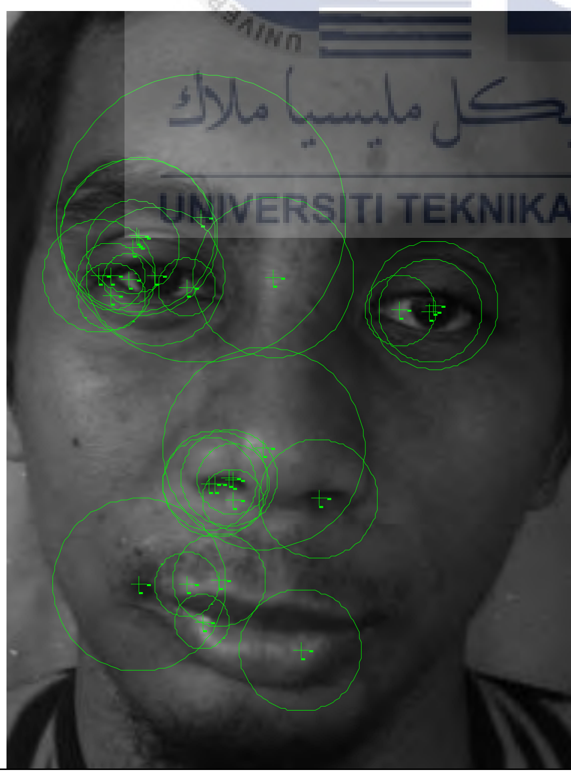

Detected Box

Sample G	Image Sample G
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)


Matched Points (Inliers Only)


Detected Box

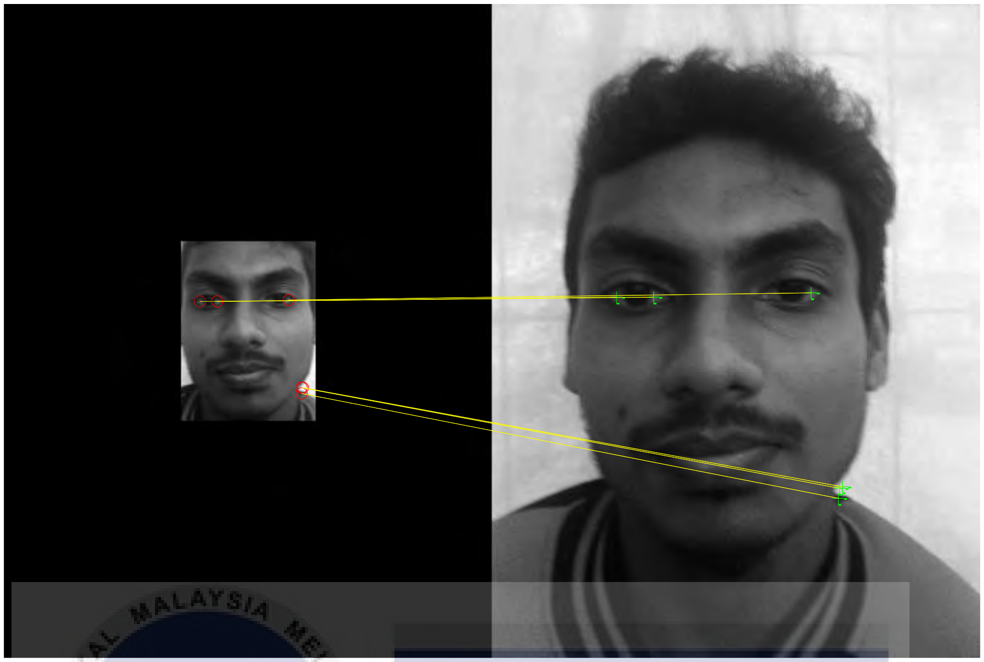
Sample H	Image Sample H
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)
Matched Points (Inliers Only)


Detected Box

Sample H	Image Sample H
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

Matched Points (Inliers Only)

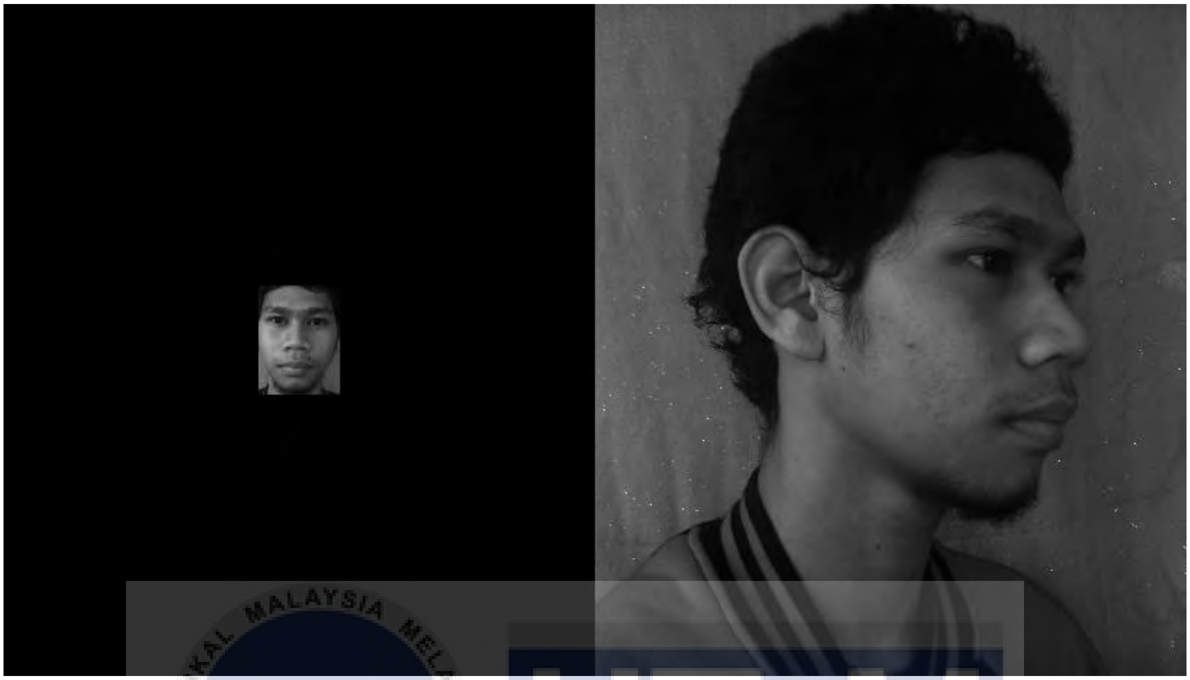


Matched Points (Inliers Only)


Detected Box

APPENDIX F: Face Detection Using SURF Technique at 45°

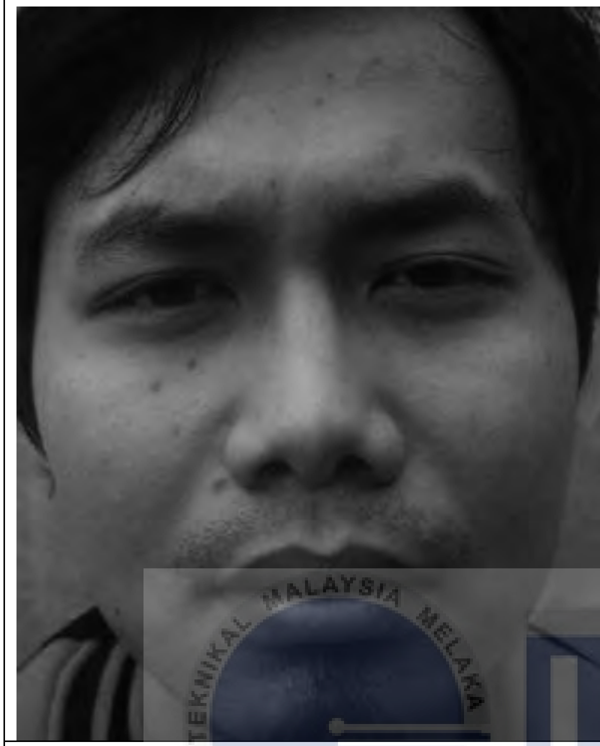
Putatively Matched Points (Including Outliers)

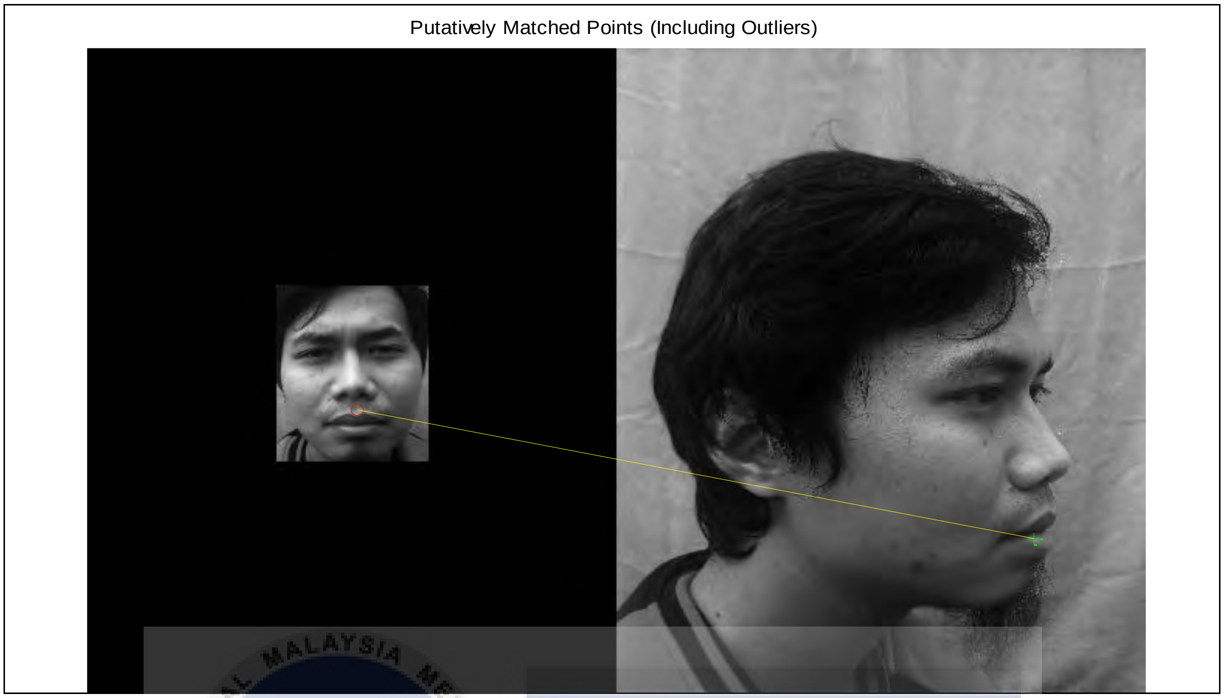


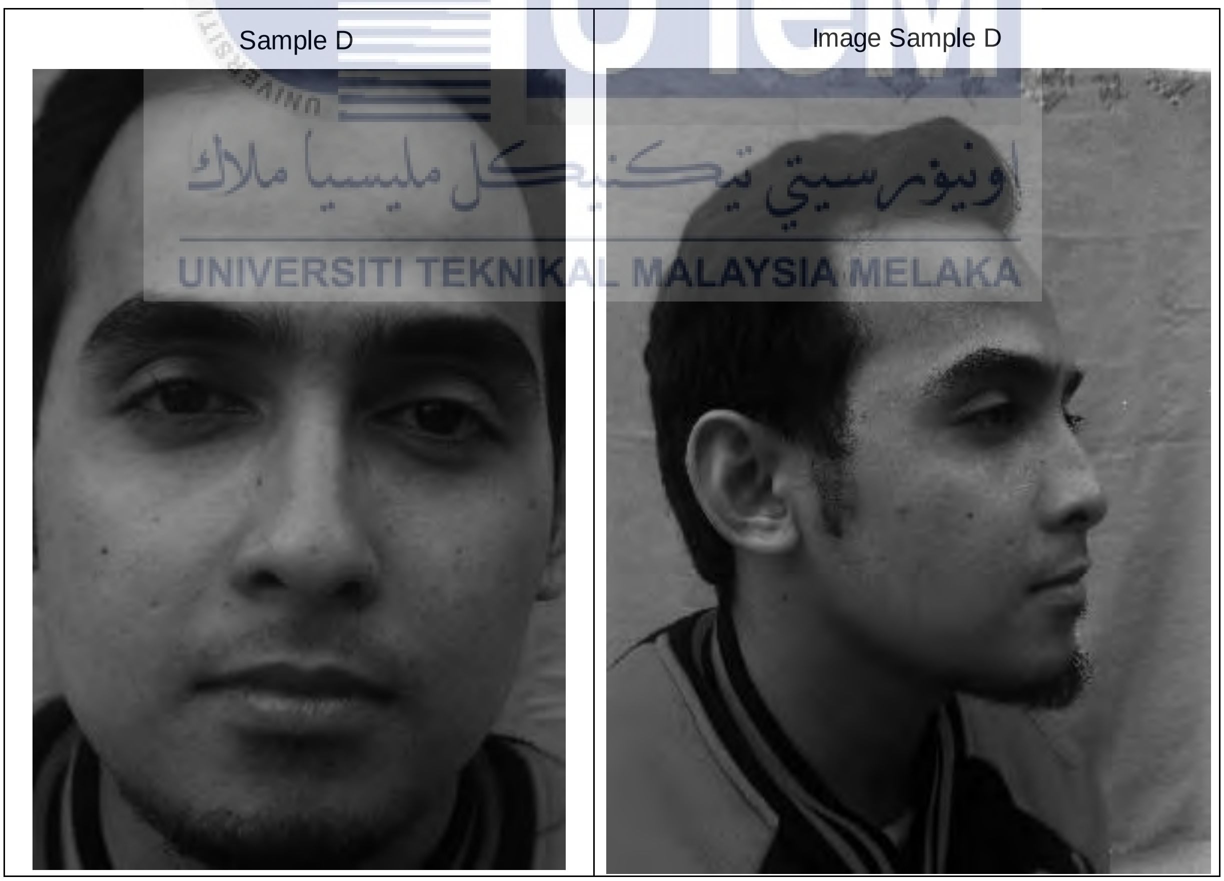
Sample B

Image Sample B


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

Sample C	Image Sample C
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)


Sample D
Image Sample D


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

Sample E	Image Sample E
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

Putatively Matched Points (Including Outliers)

Sample F	Image Sample F
	


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

Sample G	Image Sample G
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

Putatively Matched Points (Including Outliers)

Sample H

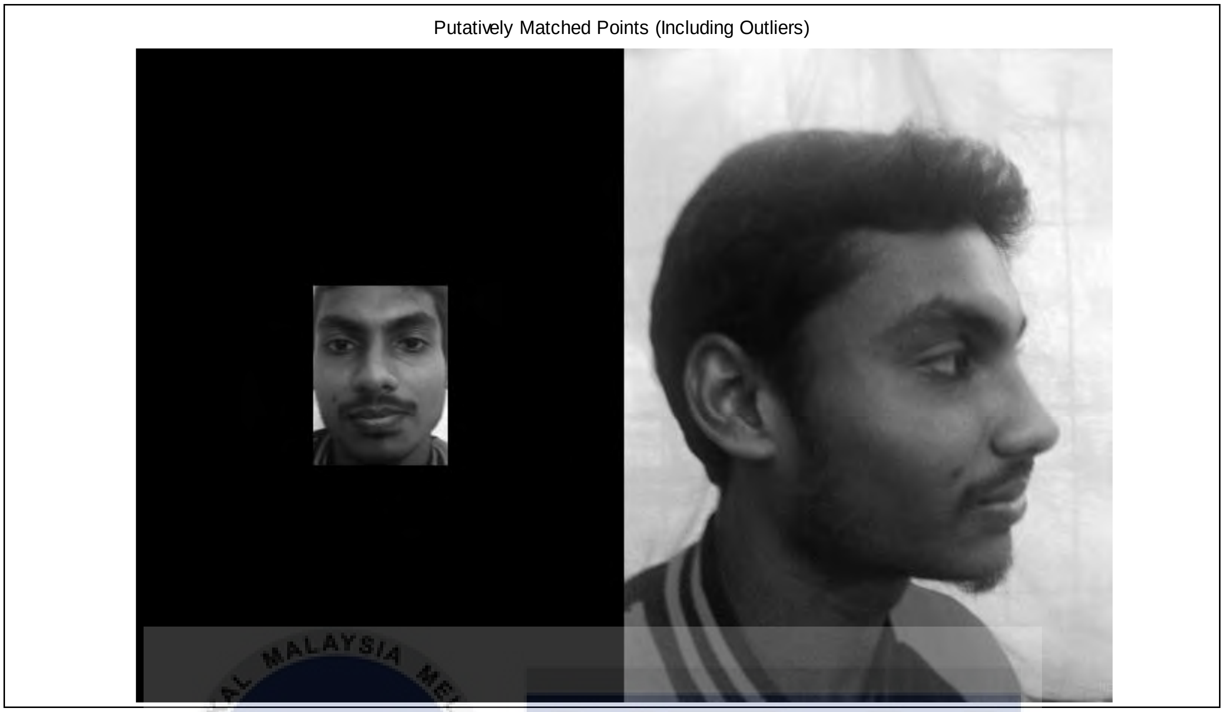
Image Sample H

100 Strongest Feature Points from Box Image

500 Strongest Feature Points from Scene Image

Putatively Matched Points (Including Outliers)

Sample H	Image Sample H
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)

APPENDIX G: Face Detection Using SURF Technique at 90°

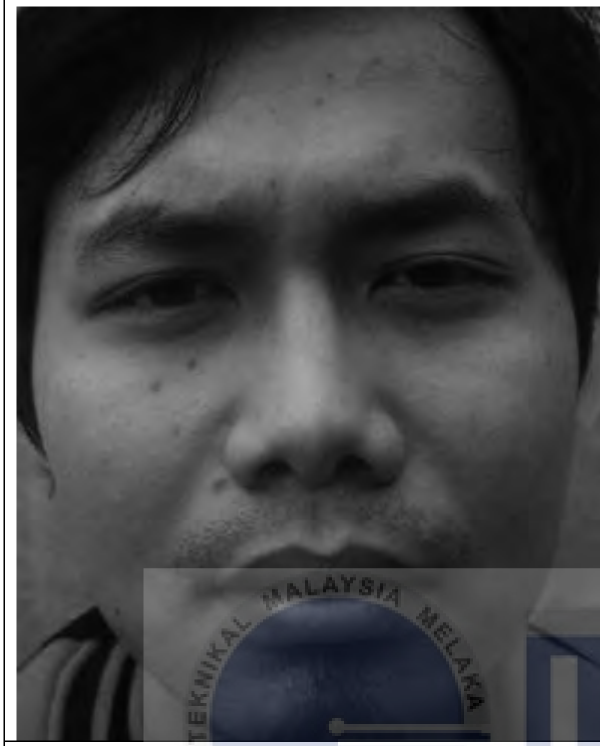
Sample A	Image Sample A
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

Putatively Matched Points (Including Outliers)

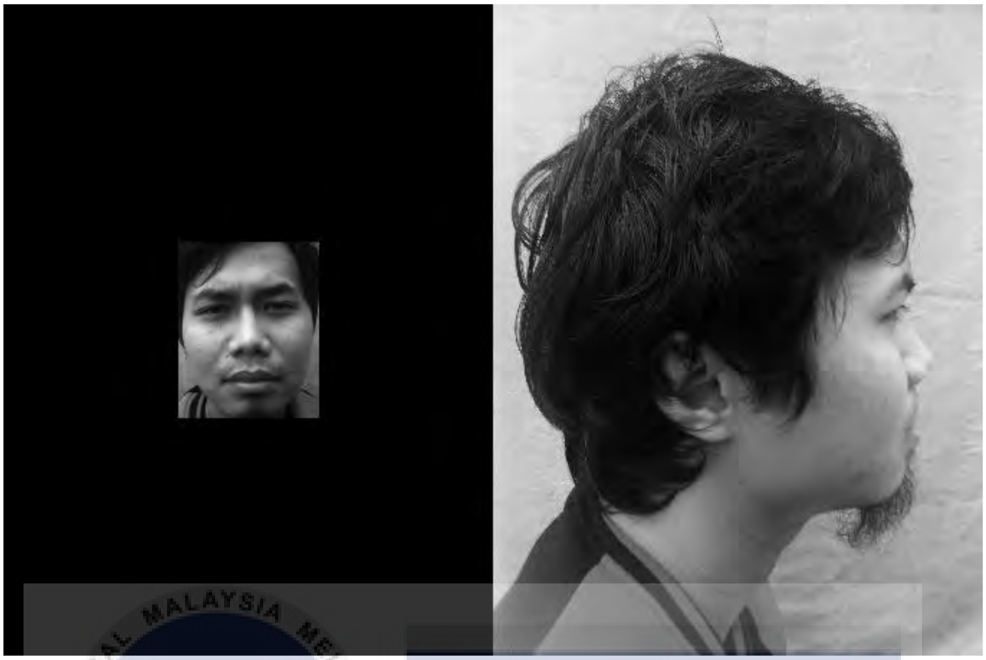
Sample B

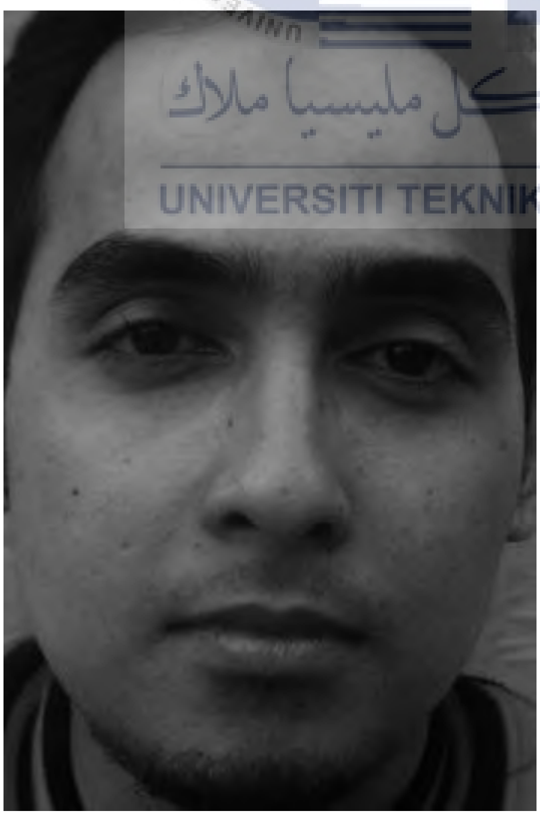
Image Sample B


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

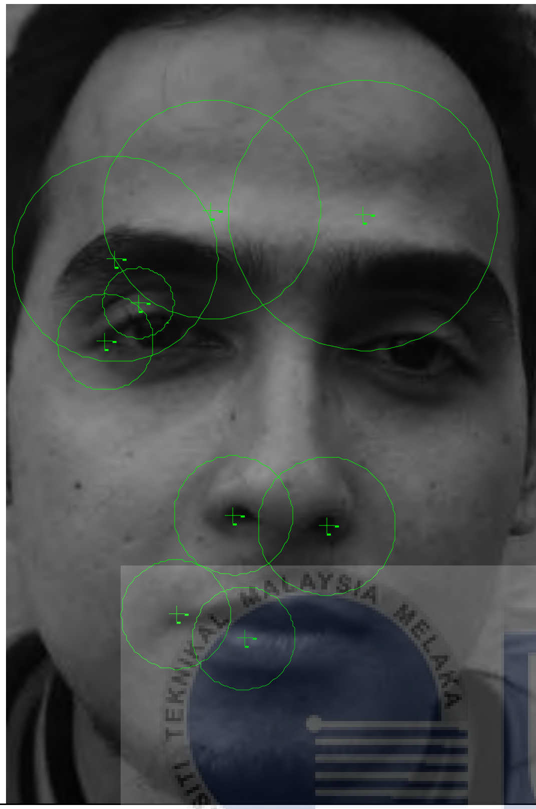
Sample C	Image Sample C
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

Putatively Matched Points (Including Outliers)



Sample D	Image Sample D
	

100 Strongest Feature Points from Box Image



500 Strongest Feature Points from Scene Image

Putatively Matched Points (Including Outliers)

Sample E	Image Sample E
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)


Sample F


Image Sample F


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

Sample G	Image Sample G
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	

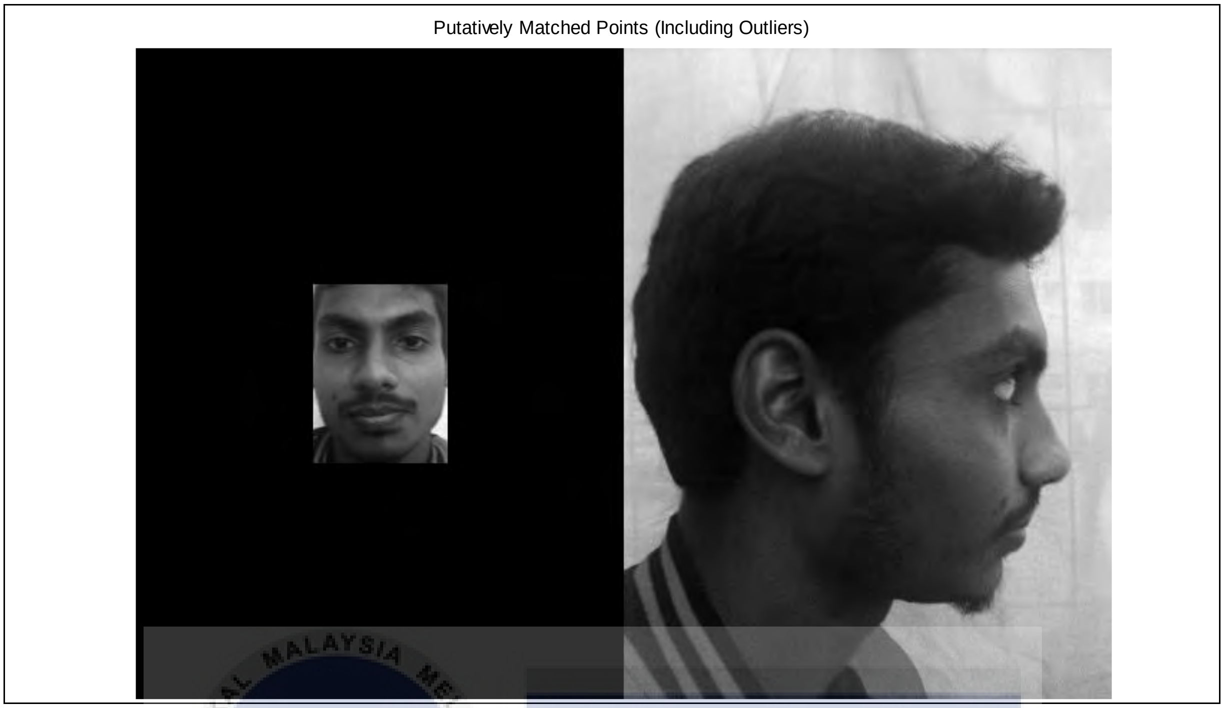
Putatively Matched Points (Including Outliers)

Sample H

Image Sample H


100 Strongest Feature Points from Box Image
500 Strongest Feature Points from Scene Image
Putatively Matched Points (Including Outliers)

Sample H	Image Sample H
	
100 Strongest Feature Points from Box Image	500 Strongest Feature Points from Scene Image
	


Putatively Matched Points (Including Outliers)

APPENDIX H: Skin Color of Face Detection at at 0°

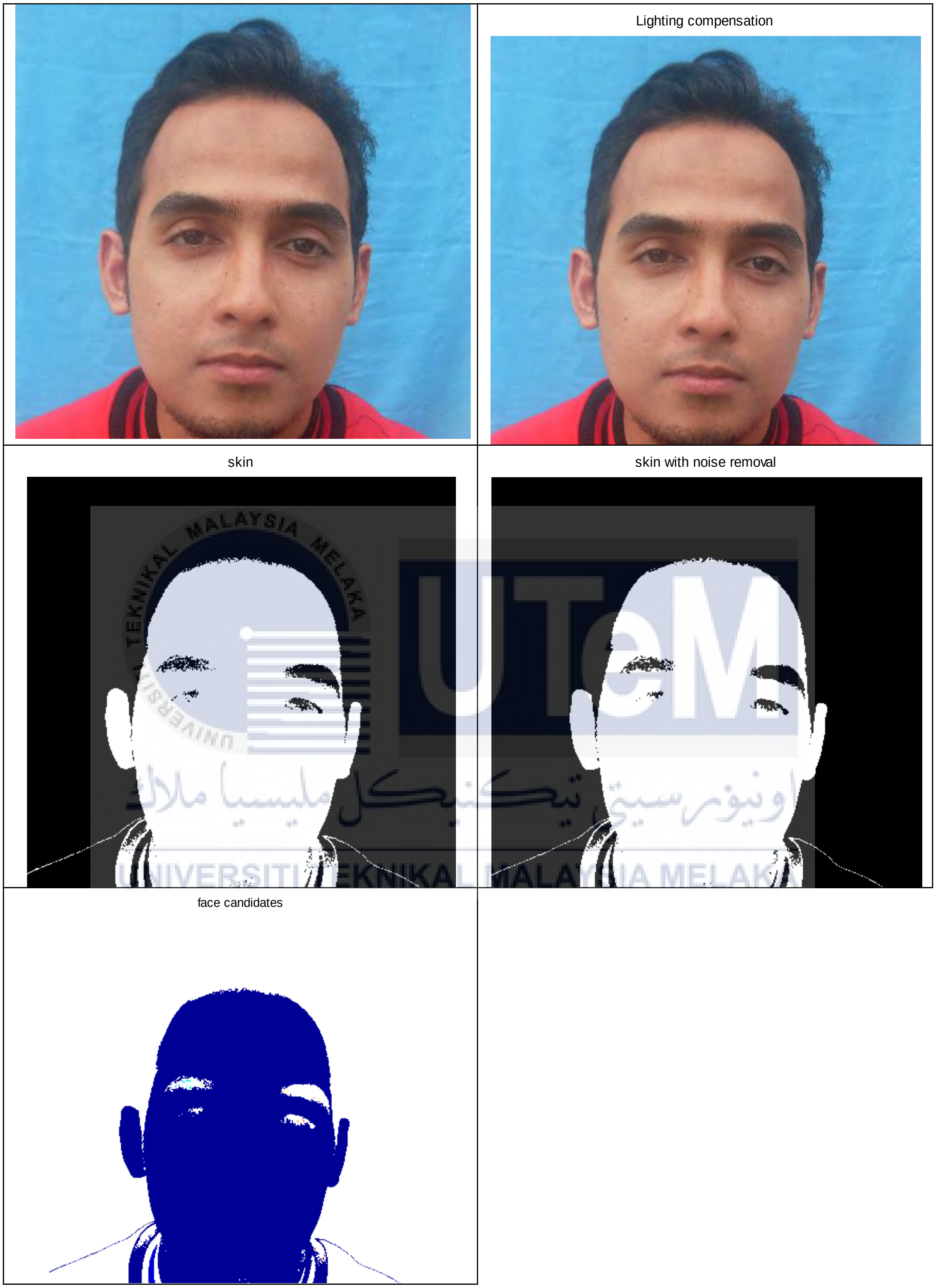
skin

skin with noise removal

face candidates


Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates

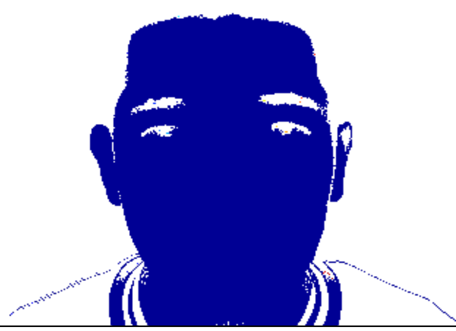

Lighting compensation
skin
skin with noise removal
face candidates

Lighting compensation

skin

skin with noise removal

face candidates



Lighting compensation

skin

skin with noise removal

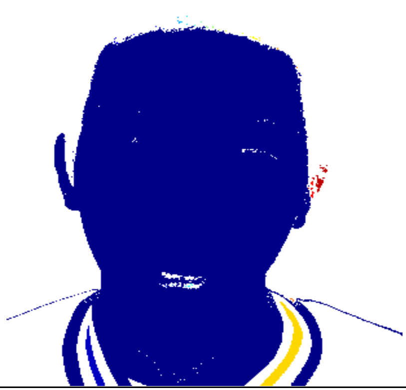
face candidates

Lighting compensation

skin

skin with noise removal

face candidates

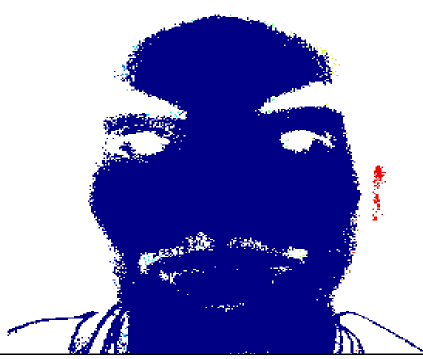


Lighting compensation

skin

skin with noise removal

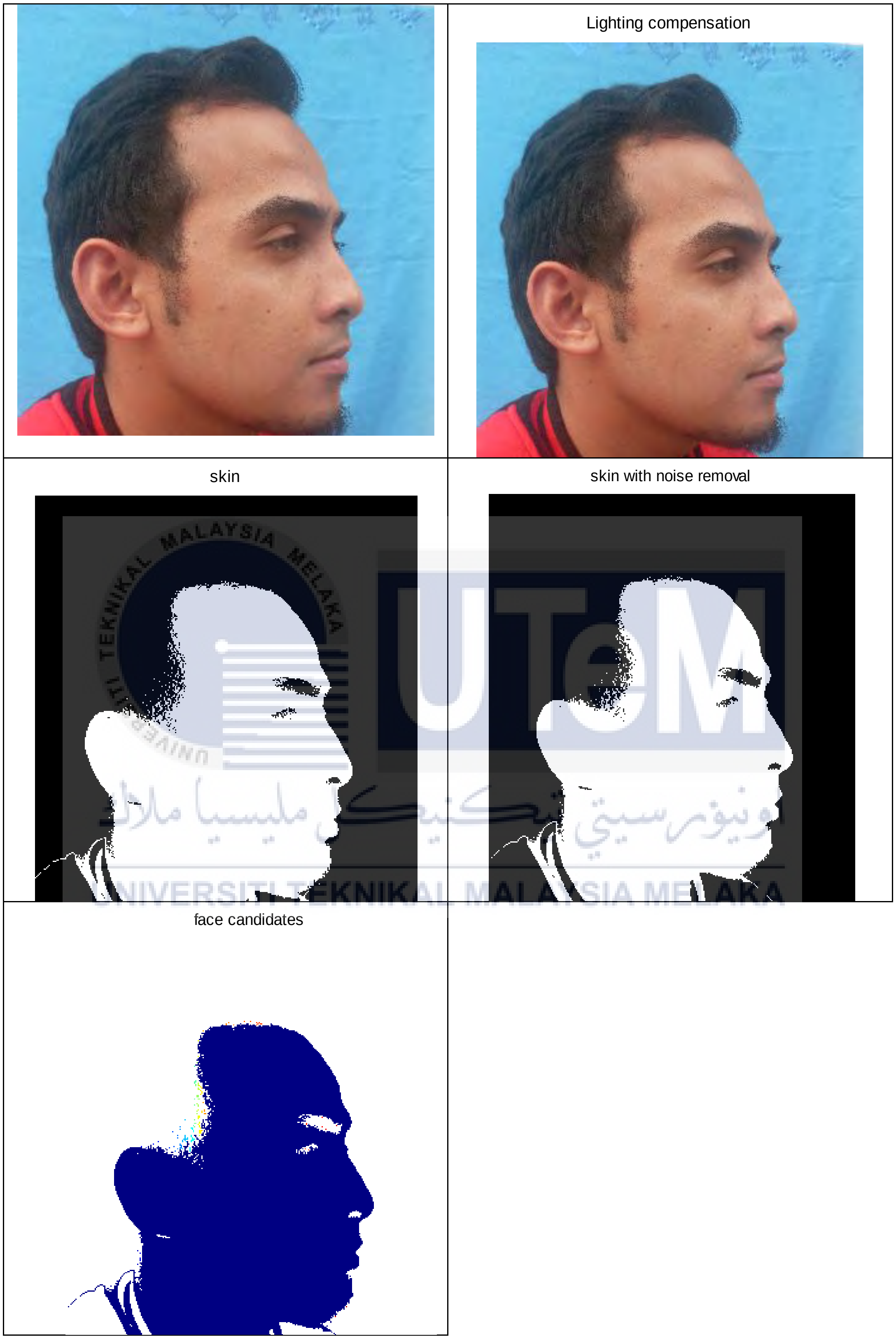
face candidates



APPENDIX I: Skin Color of Face Detection at at 45°


Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates

Lighting compensation

skin

skin with noise removal

face candidates

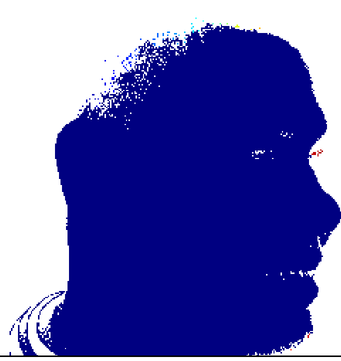

Lighting compensation
skin
skin with noise removal
face candidates

Lighting compensation

skin

skin with noise removal

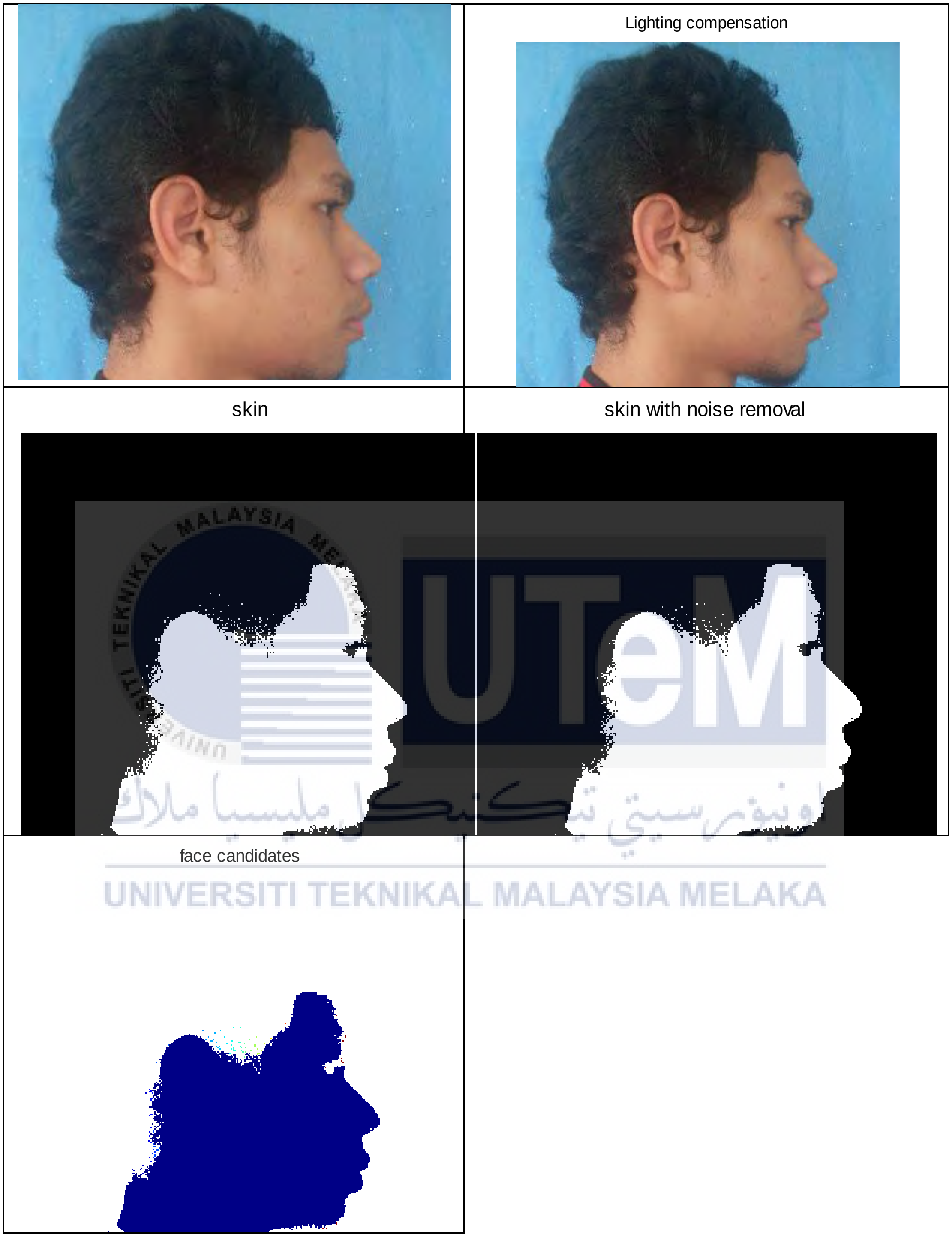
face candidates




Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates

APPENDIX J: Skin Color of Face Detection at at 90°

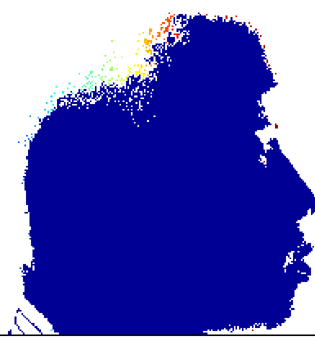


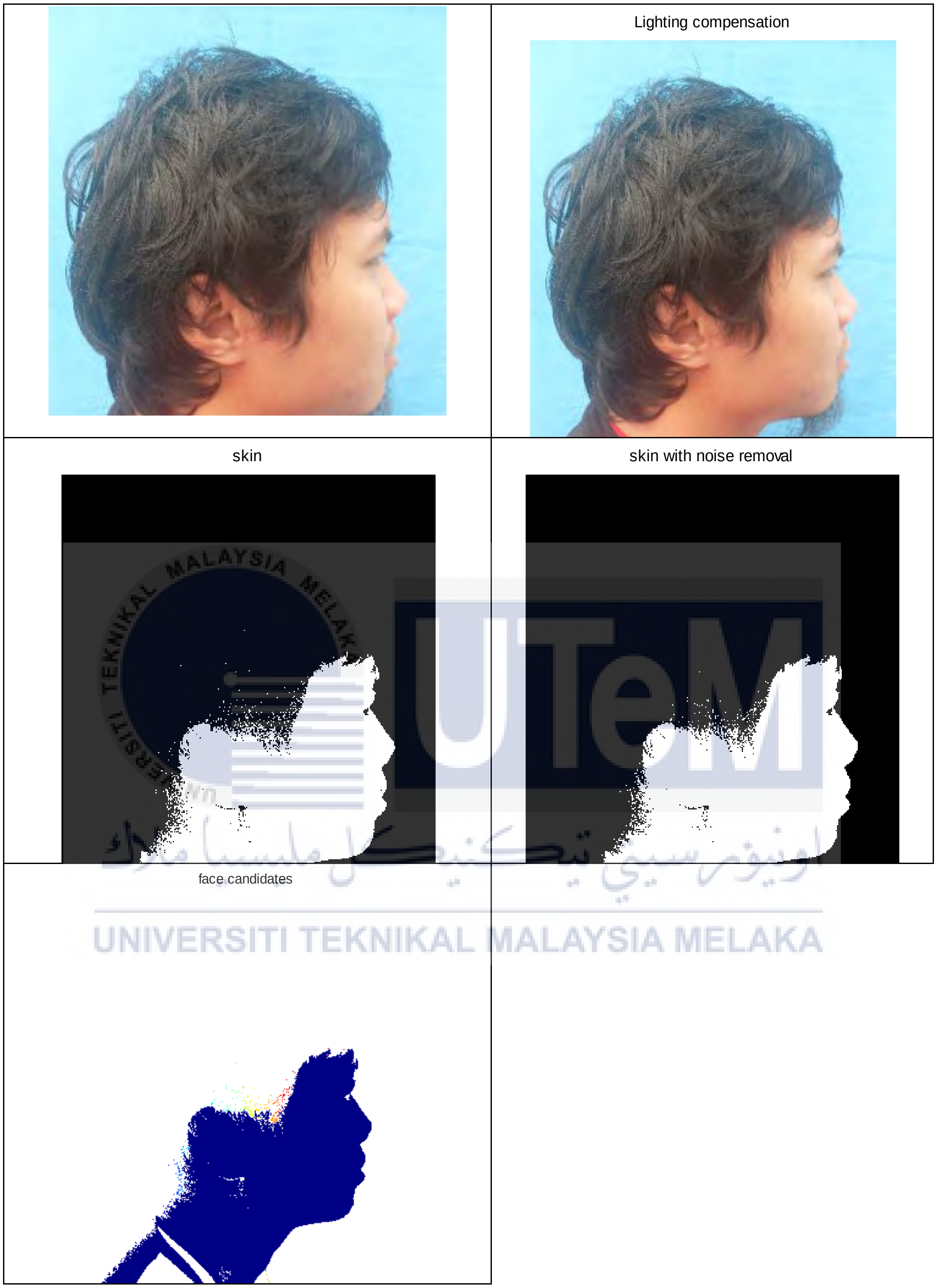
Lighting compensation

skin

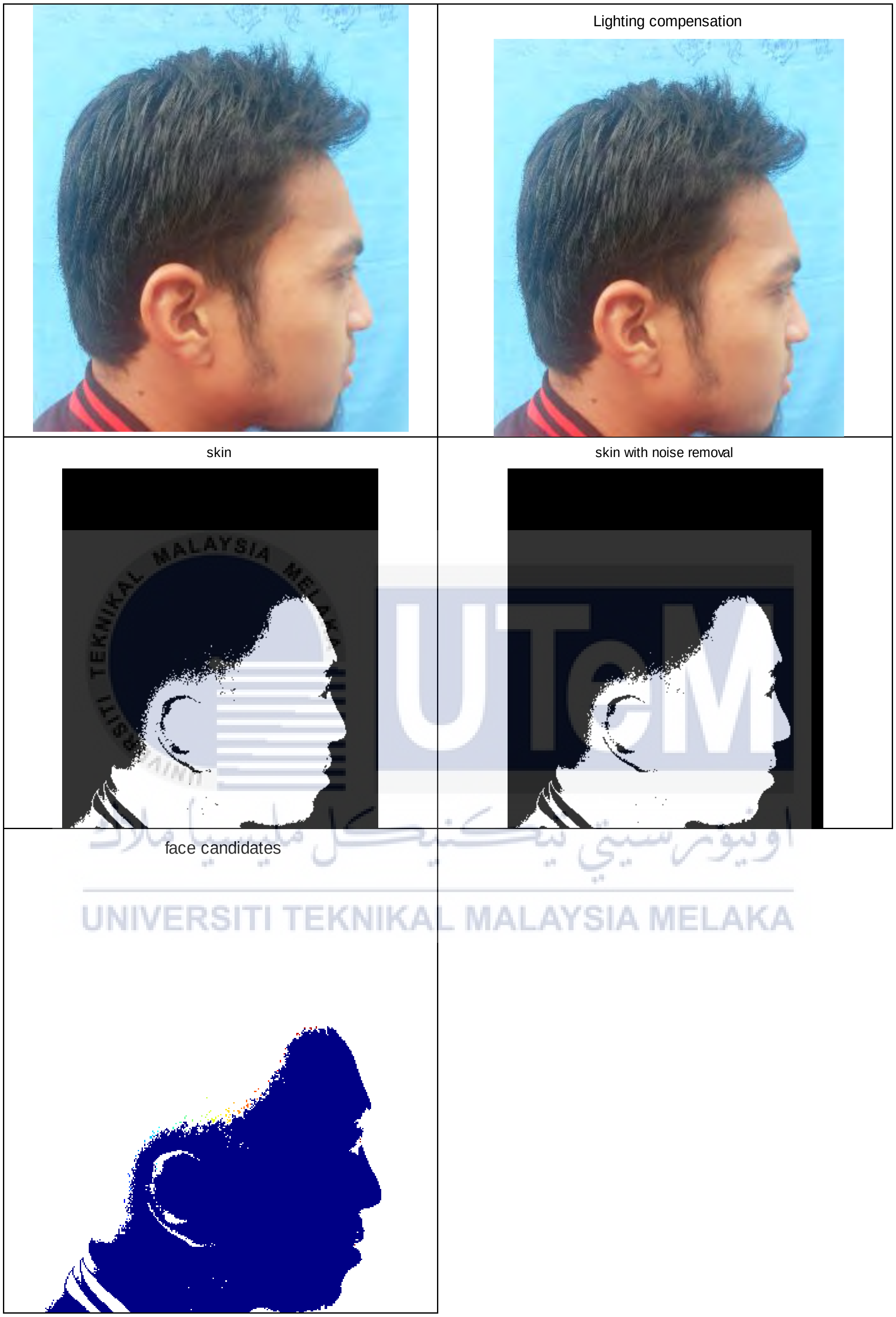
skin with noise removal

face candidates




Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates

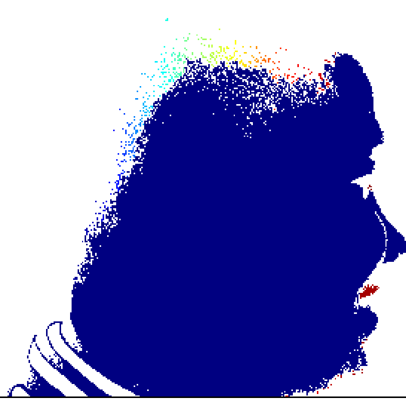

Lighting compensation
skin
skin with noise removal
face candidates

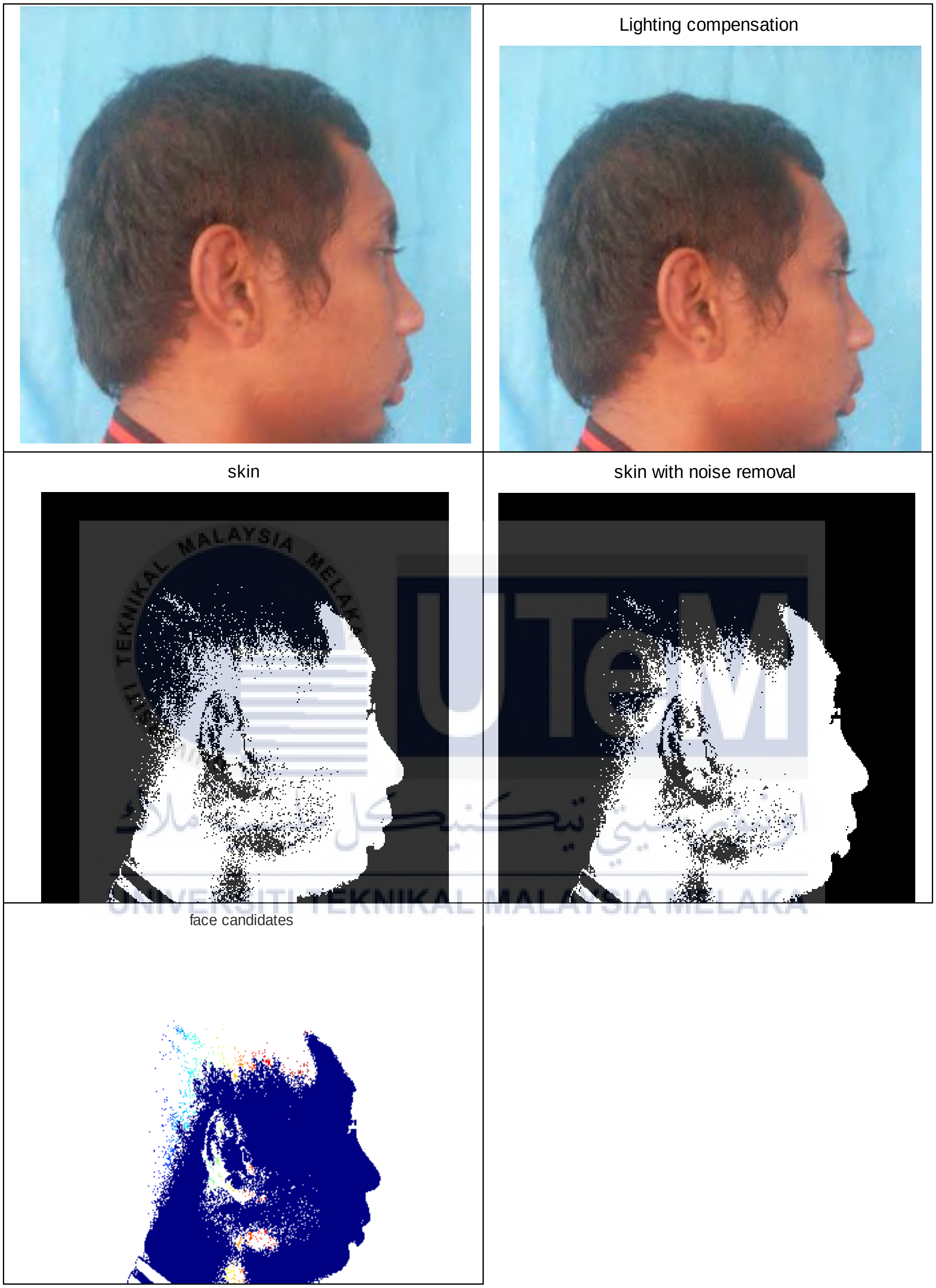
Lighting compensation

skin

skin with noise removal

face candidates




Lighting compensation
skin
skin with noise removal
face candidates


Lighting compensation
skin
skin with noise removal
face candidates