"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   :   B011110158

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.
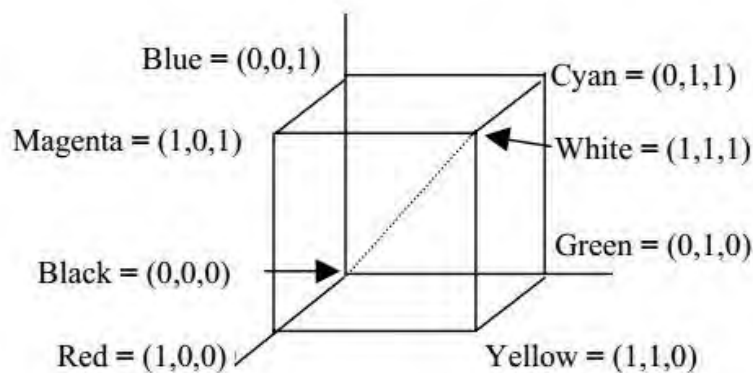
Figure 2.1: RGB Color Cube [2]
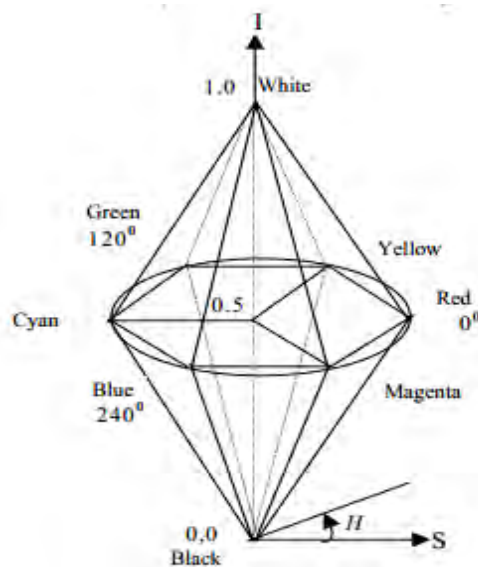
Figure 2.2: Double Cone Model of HIS Color Space [2]

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