Face Detection and Recognition for Android Smart Phone

by

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17745

Dissertation submitted in partial fulfilment
of the requirements for the
Degree of Study (Hons)
(Electrical)

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CERTIFICATION OF APPROVAL

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Approved by,

_____

(Dr. Aamir Saeed Malik)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2015

CERTIFICATION OF ORIGINALITY

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

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Awari-Yusuf Moshood Olawale

ABSTRACT

The level of processing power of mobile phones have been steadily increasing over the past few years and it has now reached an extent at which there are mobile phones that could run big applications with relative success. Applications with facial detention and recognition capabilities has also been advancing over the same period of time to a point where successful facial recognition could be implemented with considerable less amount processing power.

Due to these two advancement it has now become possible to run facial recognition application on mobile phones. Facial recognition which is the process of identifying specific people in a digital image by comparing and analyzing patterns [6] is now possible on mobile phones. This project would be developing a mobile application capable of performing facial detection and recognition.

ACKNOWLEDGEMENT

A lot of effort has been put into compiling this report from myself however the completion of this report would not have been possible without the help of various individual both in my university and beyond. I would like to extend my sincere gratitude to them all.

I would like to express my gratitude towards my parents and supervisor “Dr Aamir Saeed Malilk” for their kind cooperation and encouragement which help me during the course of my Projects

Most importantly my gratitude goes to Allah for giving the strength, wisdom and ability to complete this project.

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CHAPTER 1

INTRODUCTION

The field of face detection and recognition has attracted a lot of attention in recent times[1], this can be attributed to the large range of applications that it could be used for varying from access control, surveillance and security, personnel profiling and biometrics. But even though considerable amount of man hours as well as resources have already been devoted to the field, it is still a very attractive field to venture into since most of the work done are computer based application while this project would be implement on a mobile phone which has much has resource available to it as compared to conventional computers.

1.1 Background

Face detection is a crucial barrier that one encounters on the path to face recognition as it provides a backbone to be used for automatic face recognition. However face detection is not as facile as one might imagine, there are various challenges that arises since no two picture are ever the same, variations appear in image appearance such as pose front-facing (in which as part of the face appears undisturbed) or non-front facing(where partial face only exist) [2]. Other variation that might exist could be as a result of facial expression, occlusion, lighting condition and image orientation.

Due to the relative successes achieve by the computer based application for face detection and recognition in their field of operation and mobile phones being an integral part of daily life, it has become imperative to have such application developed and designed for the mobile platform.

According to Boren(2014), “There are officially more mobile devices than people in the world” [3] this provides an opportunity to even further increase the successes achieved by the computer programs since the mobile phone has such a large outreach.

Mobile platforms as well as its users are also well known for innovation thereby creating a chance for the limits of the use for such applications to stretched further from the conventional use it being developed for today (where mostly institutions and governments forms the greatest group of users) to a culture where private citizens and individuals can enjoy this technological marvel.

1.2 PROBLEM STATEMENT

Face detection and recognition are part of a broader field of image processing. Application normally used to carry out this processes are characterized with requiring a large amount of processing powerful since as images contain a lot of data for which signal processing must be done to extract information.

However mobile phones have much less processing power as compared to conventional computers where face detention and recognition have been implement with a considerable amount of success. The technology also used to develop the small camera fitted into mobile phones also limits the quality of images that could be captured as compared to larger hi-tech cameras used data acquisition being feed to computers.

The above mentioned points of limited processing power as well as reduces image quality makes it difficult if not impossible to use established techniques such as template-match usually used for image localization, candy edge method used for collecting edge map image from a face image [4], Gabor wavelets for extraction texture feature or feature invariant method for locating the eyes, nose, ears and mouth [4].

This methods has to be modified if they are to be variable for use on mobile phones has most of the above methods rely mostly on the ability of the computer to run ultra-fast processes which is not the case when performed on mobile platforms.

1.3 OBJECTIVE

The aim of this project is to develop an android mobile application with the following capabilities.

- Face detection
- Face recognition

The world we live in today is much different from that of every just a decade ago, one change that is much more profoundly noticeable is need for security. Security is now top is every company or institution that hopes to survive in this increasingly hostile environment. In previous days the classical way to ensure security is the use of human personnel as security guards but the use of human results in a lot of mistakes occurring and could also be very expensive.

So how does one implement a security system that would be relatively cheap and still have very error rate, this can be implement by using software programmed to perform various function. But classical way to do this would require a lot of capital investments in a computer that also consumes a lot of space as well as power so we propose replacing the human personnel with a mobile phone. The mobile phone would be loaded with a facial detection and recognition application that is capable of differentiation between authorized employees and non-employee while giving out varying instruction to peripheral devices connected to it.

1.4 SCOPE OF STUDY

This project involves the creation of a mobile android application which implements face detection as well as recognition. The project begins with the development of a background application on android's development platform (android studio). The application would include foreground android features such as Layout, text-views, image-view, surface-view as well as buttons. This is written in xml to represent the GUI (Graphic User Interface) which is what the user of the application sees and can communicate with.

With the completion of the background and foreground, one can move on the development of function which are implement in the java class file of the android project. The java class file would also contain the codes that perform various tasks that are displayed to the user via the GUI. Various API classes would also be implemented during the course of this project but the highest level of API involved would be class 21. This allows for the application to be available to use on more devices and also having enough advancement to implement complex algorithm as well as perform advanced functions thereby reducing the amount of programing lines required to complete the project.

The application would also contain a database that is capable of storing detail of various people, each entry into the database who contain a unique face graph describing the details of the face in question and could be retrieve for verification later on when recognition is perform. The database should also have the capability to find faces within the database when given specific description about the face required.

For effective use of this application, the mobile phone used should have an minimal power of 4MP, a power greater than this is also application as the greater the power the more detailed the captured image would be therefore requiring relatively less preprocessing to get the image ready for face detection.

The phone of use should also have a CPU that is powerful enough, a CPU with very low power low result in the process that too long to complete, a phone with at least 1.5 GHz would be advisable to use for the running of this application.

1.5 Relevance of the Project

The main purpose of the project is to understand and study how image processing could be successfully done on mobile phones. The type of image processing done is this project could be described as one of the most relevant as it has to do with human and this kind of image processing exist everywhere around us today.

Face detection and recognition as become a necessity in system as the need for security increases. Due to the increasing amount of security threats and lapses that exist around us today, the need of devices capable of performing this function are more profound than ever. As mobile phone has become such an integral part of our lives nowadays, an application solely localized on the phone having such a capability would be of tremendous benefit to the user. The target user of this application could include small companies for attendance purpose, voting booths to verification of voter, normal cell phone user for access control, security firms for access control and government structures for verified bidding process.

CHAPTER 2

Literature Review

There currently exist an excess of 1,5 million mobile applications available on Google's online market (play store) for download [5] with various functions ranging from gaming, entertainment, media, sports, education and many more, but not many of them have much to offer the user in terms of user enhancement. One tends to find hundreds of application that basically perform the same function, the only difference between them are the designers and maybe the background. This helped to realize that to be able to compete in the mobile application development industry, one needs to have a product that stands out in major aspects such as functionality, design, method and innovation.

But of this 1.5 million mobile application available to download on Google's play store, running a simple search of "Face recognition" would give you hundreds of results. However a closer look at the result would show you that less than fifty of these mobile applications available for download have face recognition capability. An even closer look would revile to you that 80% of these application are designed only for user identification for the purpose of unlocking ones phone. That means they are less than ten application now available to download for free on the google play store that are capable of performing face recognition for non-access control purposes. This helps to ascertain that there is a good potential for an application capable of perform face recognition with an edge over other application by not only being able to be used for user identification but also in live scenarios for identify the multiple faces in images it view as well as extract feature to be collated with an existing data base for various purposes such as attendance notification, intruder alert, personnel tracking as well as others.

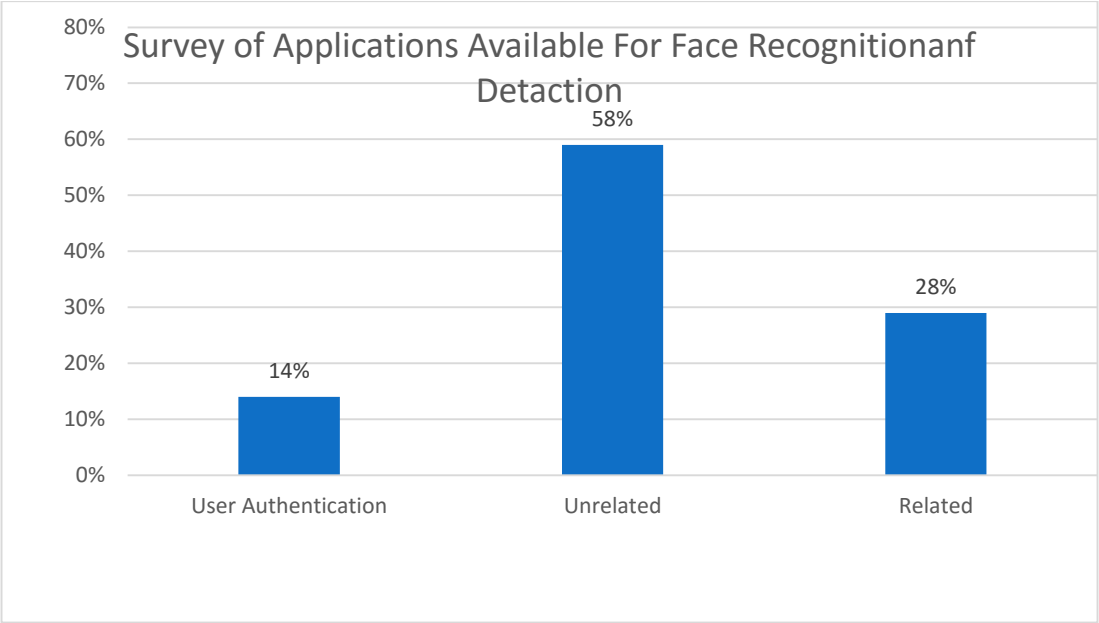

Figure 1:Survey Of Appplication For Face Recognition of Google Play store

There are a several methods that have been recognized to perform the task of automatic face detection with considerable success under various conditions. These techniques include feature-based methods, template-matching methods and appearance or image-based methods, but of the three methods Zhao & Chellapa, 2006 concluded that the Appearance or image-based methods achieved the best result. This could be attributed to the high level of similarities between faces and dissimilarity with non-face [6] but extensive training done by the computer could further help to increase rate of success. Edge detection is also a promising techniques now being used, its aim is to create cluster or segments within the image rather than directly identifying them, which is done by finding out the transitions between homogeneous regions [7].

After completing the task of face detection, then program performs feature extraction to initiate facial recognition. Face recognition (or facial recognition) application is a software application under the field of biometrics that is capable of identifying specific individual in a digital image by analyzing and comparing patterns [8], such as between an existing image on a data base and a new probe data [9].

Face recognition as an offshoot of visual object recognition can be a complicated task to achieve as one is trying to resent a 3D object which could result in a large number of images depending on the lighting condition, viewer's line of sight, distance from object and other conditions [10]. There exist numerous techniques that could be used for this purpose that can accounts for all these variation such as facial geometry, skin pattern recognition, facial thermogram, smile recognition, dynamic facial features and others [11] [12]. The application is able to do this by acquiring information about the distinct feature of the face such as length or width of the nose, the depth of the eye sockets, distance between eyes, and the shape of the cheekbones to come up with numeric codes called faceprints which usually contain (80 nodal points for a moderate size program with good success rate) [13].

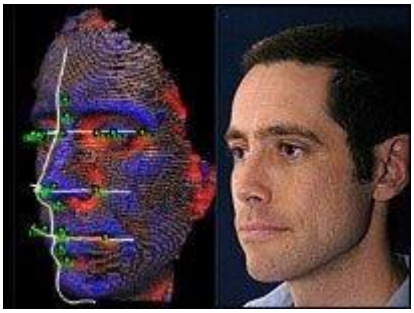

Figure 2: Facial Geometry

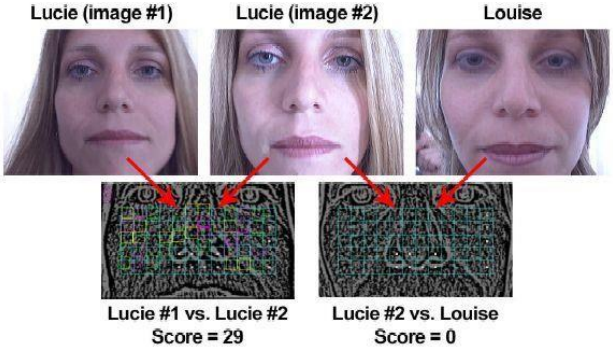

Figure 3: skin Patten Recognition

However there are challenges in the implementation of face recognition, when some certain condition changes or occurs, this could affect the success rate of the application. These conditions include partial faces occurring due to obstruction or orientation of face, changes in lighting, application of make-up, use of sunglasses, long hair and even changes in facial expression such as a big smile [8] [13].

The returns on the other hand could be enormous as there is a surge in the need of facial recognition application and with its introduction to the mobile platform thereby enhancing portability and convenience of use the market is bound to expand even further. The institutions or areas where facial recognition are currently being use vary from governmental to non-governmental or commercial use, a summary of the places of use as well as their functions are state below.

No	Institute (Place of use)	Function
1	Law enforcement	Speedy identification and verification of individuals for investigative and processing proposes
2	Immigration	Fast clearance through Customs
3	Legislature	Verification of lawmakers prior to vote
4	Election Commission	Verification of individual for processing on eligibility to vote
5	Prisons	Employee access and inmate monitoring

Table 3: Governmental Use of Facial Recognition Application

No	Institute (Place of use)	Function
1	Banking and finance	Identity Verification to minimize fraud
2	Healthcare	Insurance verification
3	Gaming Industry	User identification for verification purpose
4	Residential Security	Access control
5	School and daycare	Identify verification of individual coming to pick up children

Table 4: Non-Governmental Use of Facial Recognition Application

CHAPTRER 3
METHODOLOGY

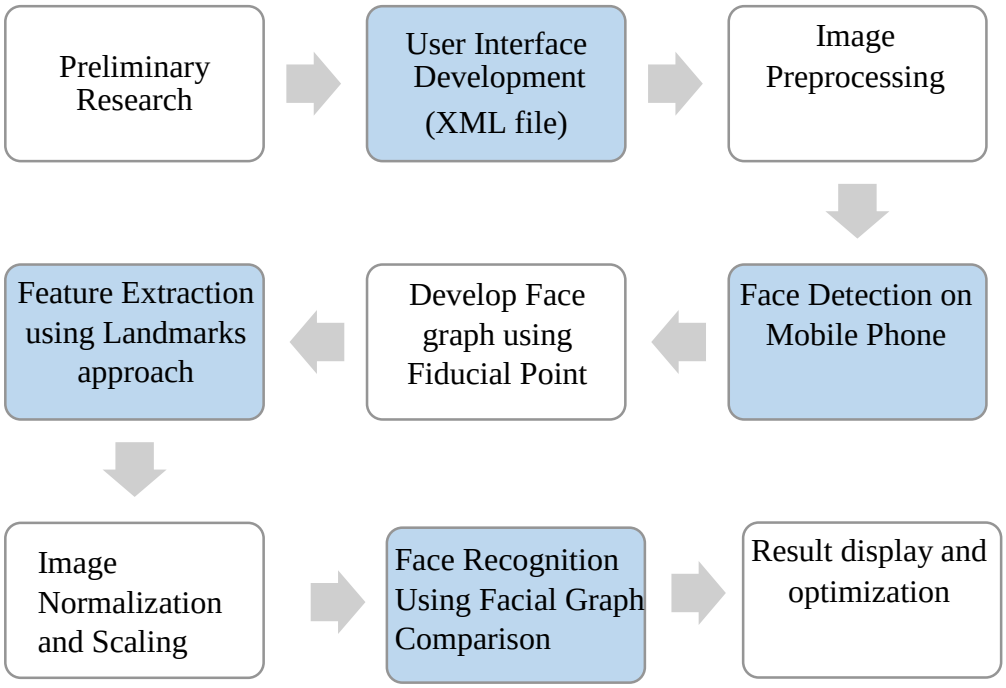

Figure 4: Methodology

This project contains several bottle necks, one of them being the development of the background application (Graphic User Interface) which is the platform that users would see and be able to communicate with the program. This would include android.layout, android.styles for simplification and standardization, surfaceView, imageView, buttons, editText, textView and D-pad. Upon developing an initial draft of what the application user interface looks like using an XML interface can then venture into the java class file to start the programming of what the elements of the Graphic user interface would do.

Another obstacle that is required to be overcame is that of the algorithm selection. Due to the face recognition being relatively new to the android platform. It is difficult to say which algorithm would perform best on it so the selection would be based on trial and error as well as modifying to fitted the new platform. In the development of the face detection and recognition segment of the program various API would be user so has to decrease the complexity of the program as well as improve the efficiency, the API would include android.harware, android.media, android.view, android.util and others.

3.1.0 Image Pre-processing

This is done upon acquisition of an image from the mobile phone camera, so as to make the task of face detection less tedious. This is a very crucial step as it adapts the image into a more usable form. The major objective of this stage is to reduce the amount of noise present in the image being processed from faces. There are several preprocessing methods available for using on the java platform but most would slow down your speed of processing so the methods stated below help with removing distinct noise while still achieving a decent speed of processing. The method of preprocessing used in this application is grayscale contrast enhancement, this help to improve the acquired image by brightening the dataset.

3.2.0 Face Detection

This is the process of identifying the region of the image which contains human faces. Two approaches were used in this project to detect faces and both gave varying levels of detecting after image characteristics were changed. Below is a description of the methods used for face detection.

3.2.1 Method 1

In this method, we are using color information as a tools in the process of detecting faces, as it simplifies the task of face localization in complex environments [21]. Therefore the primary method used for detection in this project is skin color and based on the area of the picture where skin is detected, face localization is then performed by using model based face tracking.

Several models of human face is compared with the area of the picture where skin is detected to find out exactly which part of the image contains the face based on geometric features.

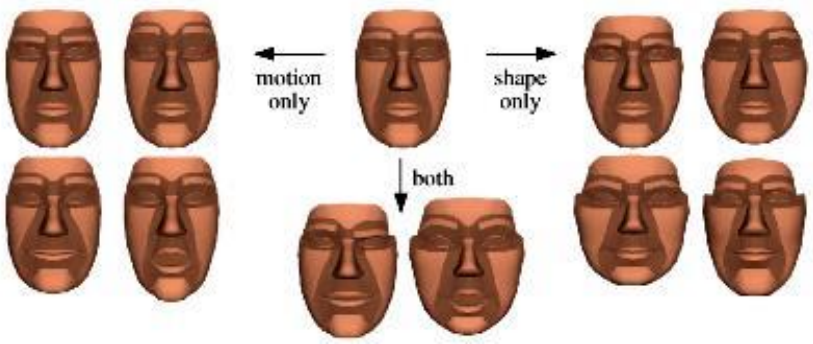

Figure 5: Face Model

3.2.2 Method 2

This method also uses the skin color as a primary method of detection but is complimented by another method of face localization which searches for areas within the picture that contains facial features such has the eyes and nose. The color as the basic of detection has been found to be not only computationally efficient but also very effective with great performance even with inclined face (rotation) and faces where partial occlusions occurs [23]. Since Human skin is known to form a considerably close cluster in color space even when considering different races, face color distribution can be modelled using the Gaussian mixtures [23]. The below equation is then used to derived an H-S model which could be used for faces from various races.

$$p(\mathbf{x}|C) = \sum_{j=1}^{M} p(\mathbf{x}|j)P(j) \qquad (1)$$

$$P(j)^{new} = \frac{S_j}{n} \qquad \mu_j^{new} = \frac{1}{S_j}\sum_{i=1}^{n} \mathbf{x}_i P(j|\mathbf{x}_i) \qquad (2)$$

$$\Sigma_j^{new} = \frac{1}{S_j}\sum_{i=1}^{n} [\mathbf{x}_i - \mu_j^{new}] \cdot [\mathbf{x}_i - \mu_j^{new}]^T P(j|\mathbf{x}_i) \qquad (3)$$

x = data n = Number of face i= Pixel no j = component

P (j) = mixing parameter $p(x|j) =$ Gaussian with mean μ_j

S_i = Sum of probabilities P (j | x_i) $p(x|C) =$ Covariance

Face localization is done is this method by searching for the location of the eyes. This is modelled as two white regions separated by a dark region which exist in close proximity to each other depending on the size of the bigger area of skin detected.

3.3.0 Image Normalization and Scaling

This section of the projects helps with using creation of a database. This is a necessary step as several image recognition techniques can be very fragile and require proper structuring of dataset to function properly. Once a face is detected in an image the way the section of the image is saved in the database should be uniform for every face in the image as well as every image included in the database.

The way image normalization and scaling is performed in this project is by first making sure every fiducial point used for feature extraction are contained in the image and then identifying a constant which is equal to the distance between the two eyes to surround all the bounder fiducial point. With respect to the left eye, right eye and mouth bottom distance from boundary is equal to constant but for the fiducial point with the lowest y-coordinate value, the distance from the boundary is twice the distance between the two eyes.

Figure 6: Image Normalization

3.4.0 Feature Extraction

After image normalization and scaling the image is now ready to be processed to extract more detailed information about the face detected. In this project the feature based approach is used to perform feature extraction. Based on an initial face model consisting of eyes, nose base, and 3 tips of the mouth, one can effectively map the face. Facial feature are extracted using spatial filters that search within specified regions for each feature of interest. The image below show a brief description of variation in the image that are recognized as which feature.

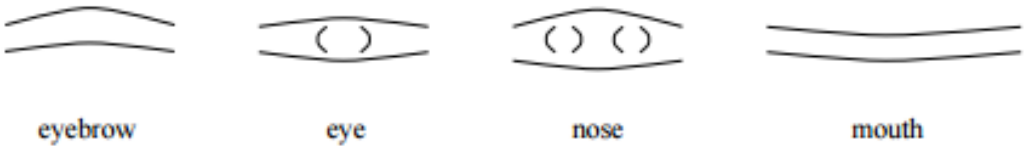

Figure 7:Examples of Feature

The image is processing using image segmentation method and then searching it for contours before each segment is correlated with existing face model to identifying specific coordinated where the feature exists. The image below give an example of templates used to generate face models that is then used of feature extraction.

Figure 8: Face Model Templates

3.5.0 Facial Recognition using Face graphs

Upon successful identification of face of interest and processing it to extract coordinates of specific features of interest, one now has to make calculations of displacement of these points from one another to develop face graph for the face in question.

To perform the task of face recognition the detect face first has to complete the process of feature extraction. Using landmarks approach one is limited to a maximum of twelve mention fiducial point:

- Left Eye
- Right Eye
- Nose Base
- Left Cheek
- Right Cheek
- Left Mouth
- Bottom Mouth
- Right Mouth
- Left Ear
- Left Ear Tip
- Right Ear
- Right Tip

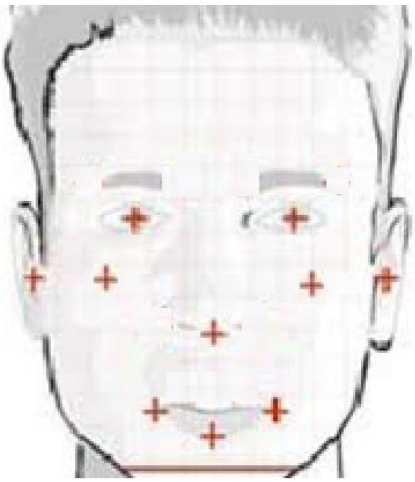

Figure 9: All Features

These fiducial Points would return a particular point on the image which contain both an “X” as well “Y” value. These values could be used to identify where each feature is on the image.

The values do not reveal the full picture and subsequent use for face recognition. The values have to be compared with each other to tell the displacement of each to one another.

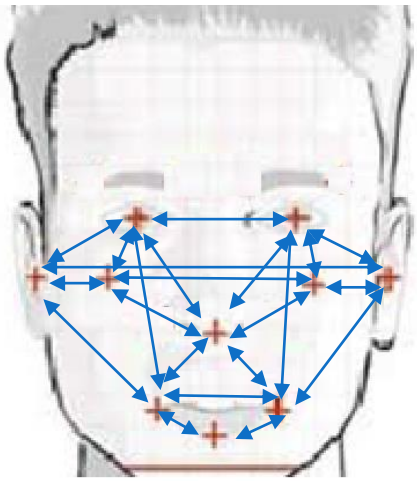

Figure 10:Features with displacements

3.6.0 Project Activities

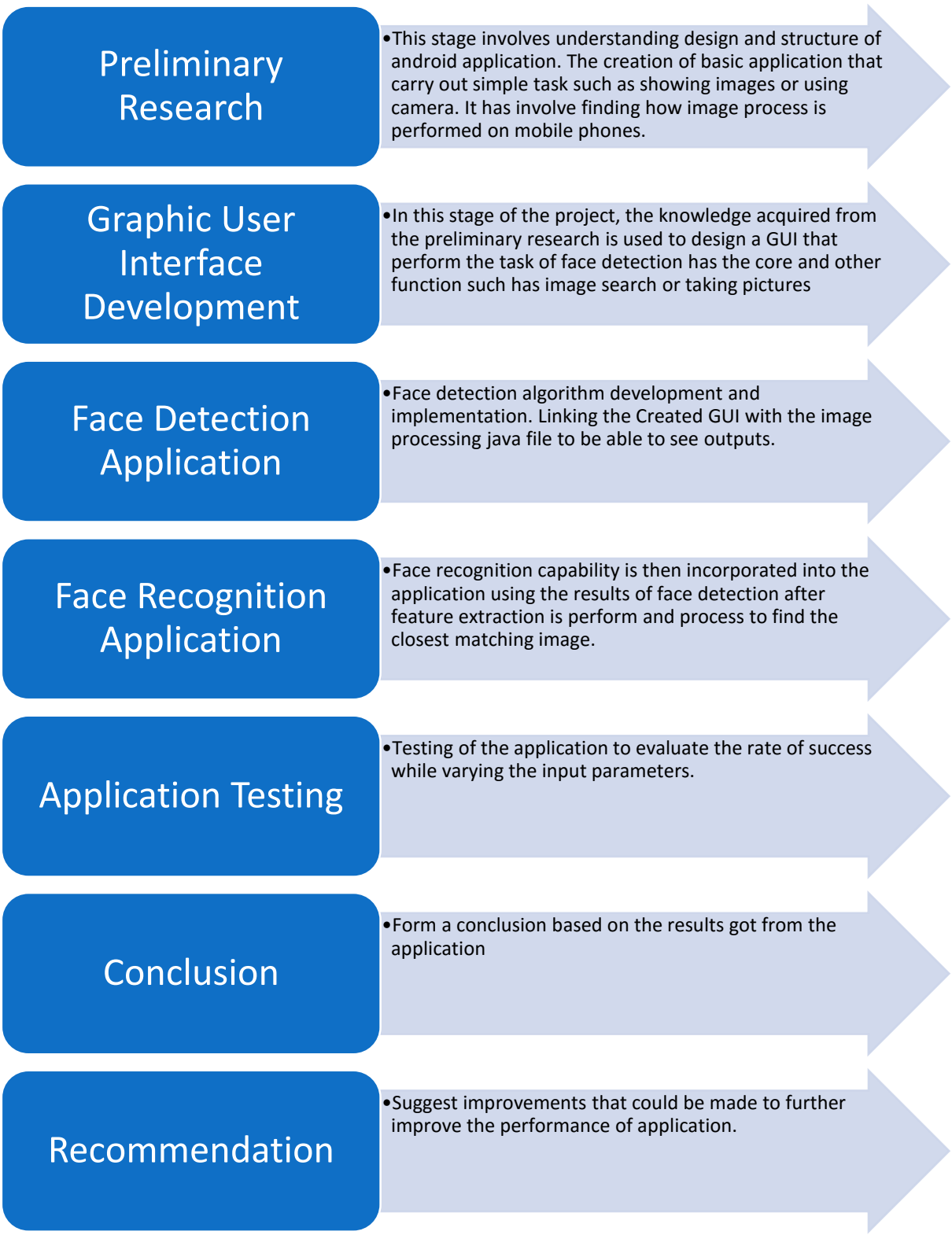

Figure 11: Project Activities

3.7.0 KEY MILESTONE

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Submission of final year project title selection form														
2	Layout and background set up														
3	Submission of extended proposal														
4	Application with image processing capability														
5	Proposal defense														
6	Application with face detection capability														
7	Submission of interim draft report														
8	Submission of interim final report														

Figure 12: Key Milestone of Project

3.8.0 GANTT CHART FYP 1

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Select & confirmation of project title														
2	Early research on the proposed topic: hello world based apps														
3	GUI development: layout and background set up														
4	Main application development														
5	Proposal defense														
6	Preparing interim draft report														
7	Preparing interim final report														

Figure 13: Gantt chart for FYP I

3.9.0 GANTT CHART FYP 2

No.	Item/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Incorporating automatic detection															
2	Enhancing Face detection mechanism															
3	Begin research on Cloud Processing															
4	Progress Report Compilation															
5	Research on Face Recognition Algorithm															
6	Develop Face Cloud based Face Recognition															
7	Electrex / Presedex															
8	Draft Report															
9	Final report															
10	Viva															

Figure 14 Gantt Chart for FYP II

3.10.0 TOOL & SOFTWARE REQUIRED

Tools & software that will be used throughout the project are:

- Laptop
- Android Supporting Mobile Phone (Developer Capable)
- OpenCV
- Matlab
- Android Studio
- Eclipse
- Genymotion
- Oracle Vm VirtualBox

CHAPTER 4

RESULTS AND DISCUSSION

4.0.0 Results

The first objective of the project is to implement face detection on android smart phone. This part of the project has been successfully concluded with results shown in the images below.

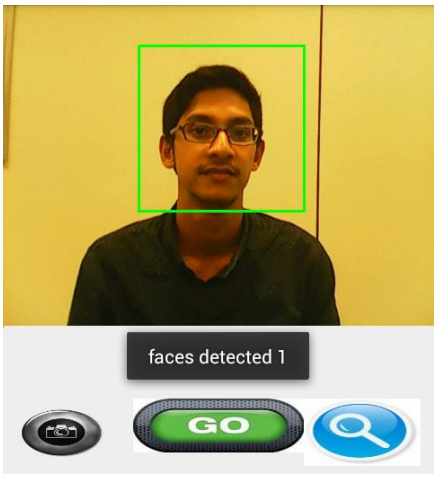

Figure 15: Method 1 - Results for Single face

The application is now capable of performing two main tasks which are explained below.

- Capturing Images using the camera able on the smart phone

  By clicking on the camera button on the screen of the phone, the camera capture interface of the phone is shown through which one can capture an image that is stored in the gallery of the phone.

- Searching and selecting images from the gallery of the smart phone

  The captured image or any image of choice could then be selected using the search button on the screen of the application. By selecting the search button a separate window is trigger which allows you to select an image from the gallery of phone.

- Detecting the location and number of faces in the selected image

  Face detection is performed on the selected image by pressing the “GO” button. Upon pressing the button the application searches for faces on the image present on the screen

of the phone. After identifying the faces presenting the image it then draws a green rectangle on the area of the image that contains the face.

After identifying all the images present in the image, it then counts the total number of faces present and displays the result to the users as shown in the images below.

The application is not only capable of detecting single faces as shown in the previous image but could also detect multiple faces as shown in the figures below.

4.0.1 Results from Method 1

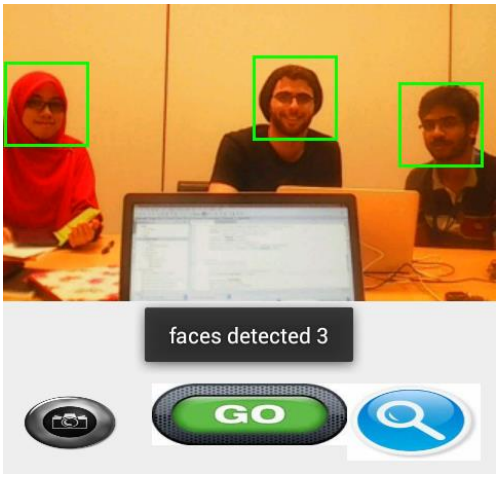

Figure 16: Method 1 - Results for Multiple Faces (3)

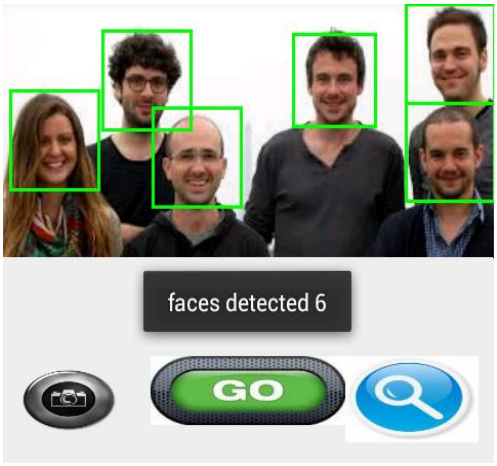

Figure 17: Method 1 - Results for Multiple Faces (3)

Figure 18: Method 1 - Results for Multiple faces (6)

Figure 19: Method 1 - Results for Multiple Faces (7)

4.0.2 Results from Method II

Figure 20: Method 2 - Results for Multiple Faces (5) (very close faces)

Figure 21: Method 2 - Results for Multiple Faces (3) (faces further apart)

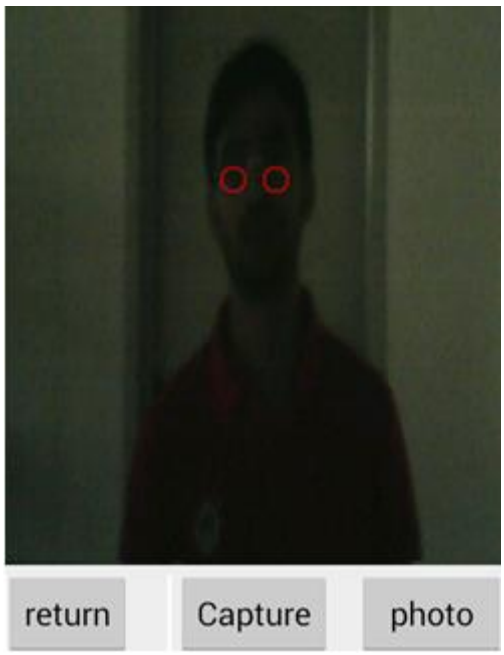

Figure 22: Method 2 - Results for Single Face (low light)

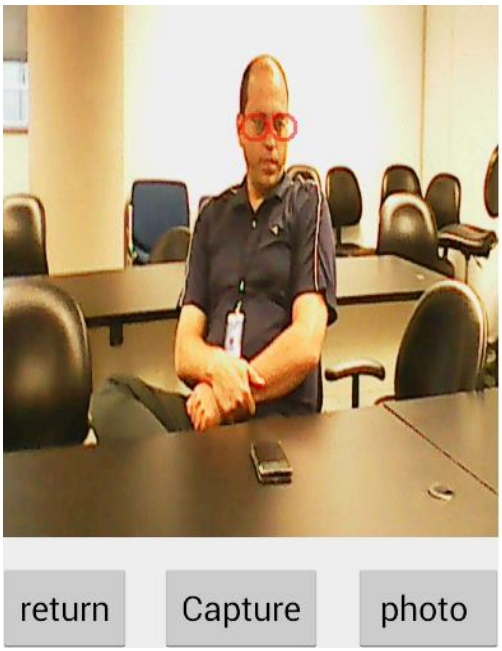

Figure 23: Method 2 - Results for Single Face (bright light)

4.1.0 Detection Rates

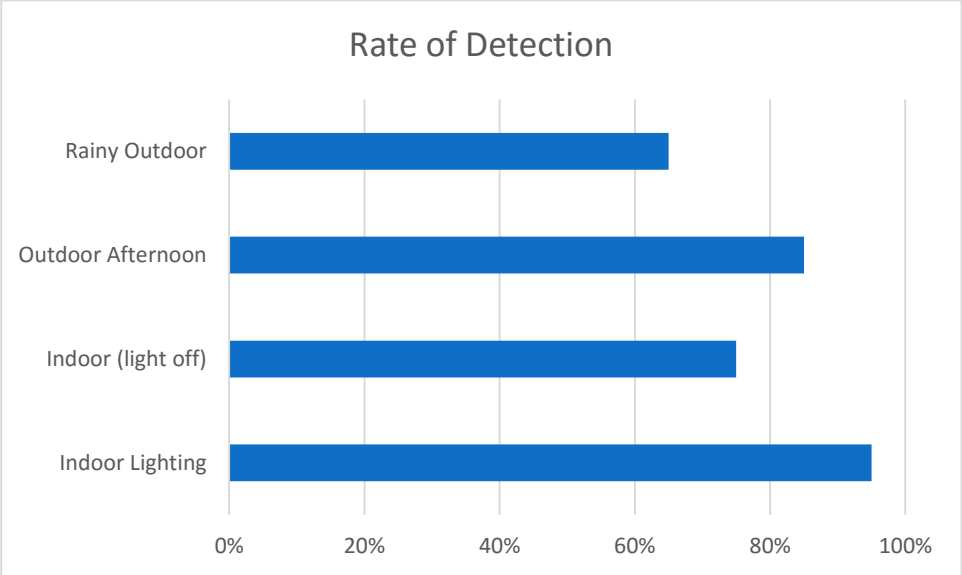

Figure 24: Graph of detection based on Environmental Condition

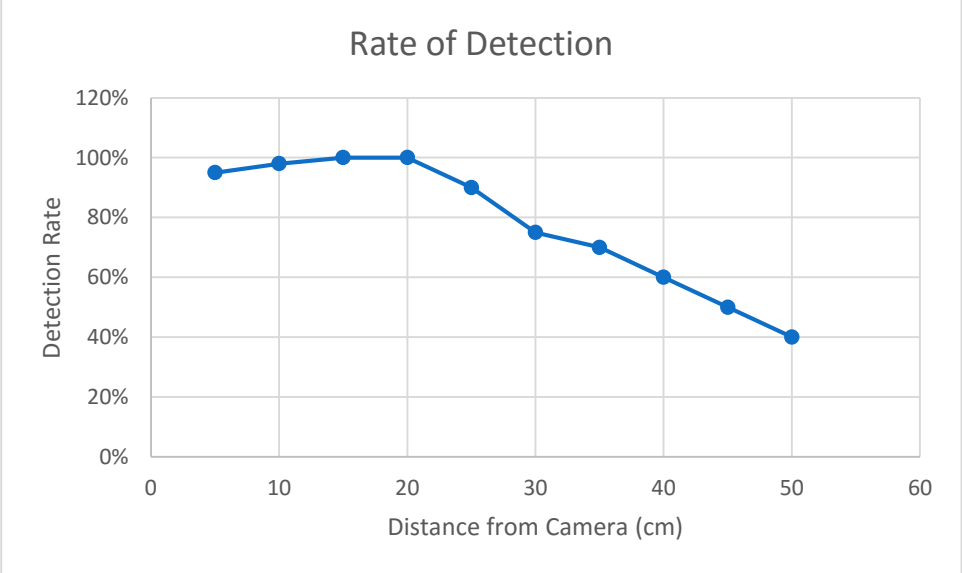

Figure 25: Graph of Detection rate versus Distance from Camera

4.2.0 Face Recognition results

Upon the acquisition of individual faces using the results from the face detection process, the view is then switched the face recognition platform to start the process of face recognition.

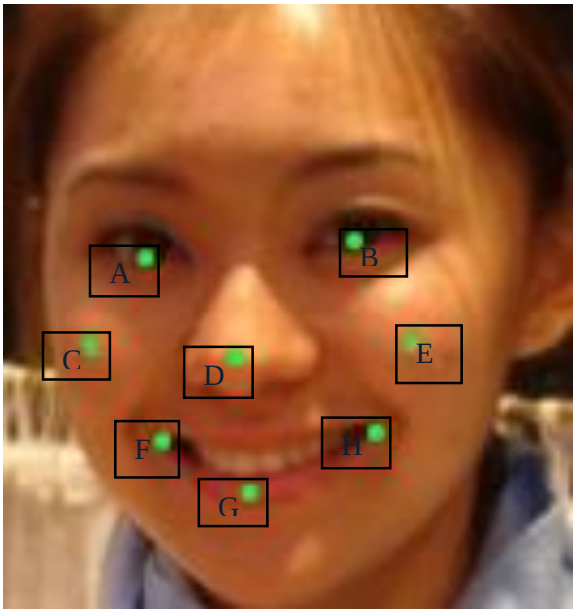

Figure 26: Feature Identification

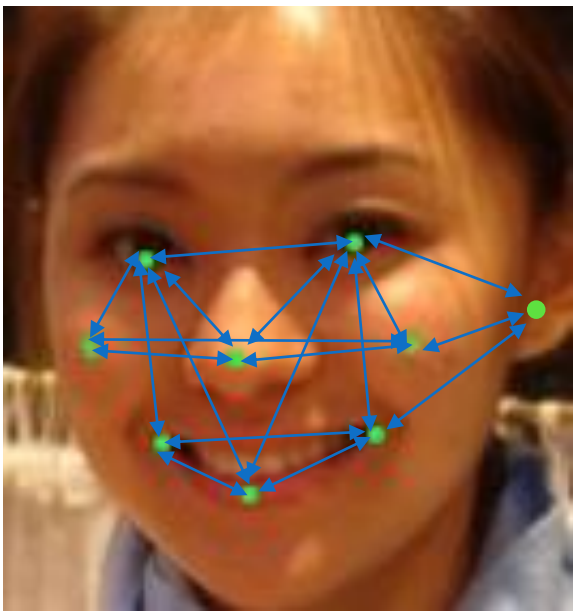

Figure 27:Coordinate displacement

4.2.1 Graphs of Results of Recognition

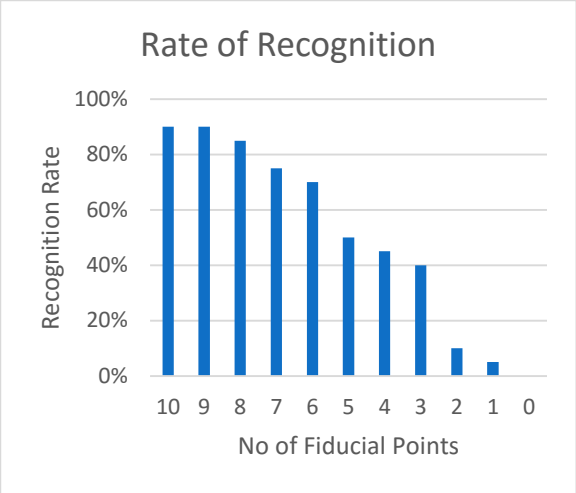

Figure 28:Graph of Recognition Results (1)

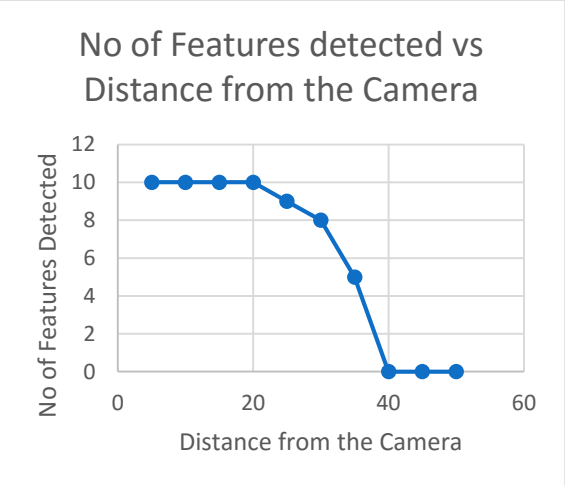

Figure 29:Graph of Recognition Results (2)

The above graphs shows the results derived from the Recogntion Platform. The First graph depicts the success rate of detection vs the no of fiducial point available to it to be used for detection. It shows that the Maximum Success rate of recognition of 90% is achieved when ten to Nine fiducial points are available for comparison. But when the face returns fisucial points of less than nine the success rate begins to drop until when the results are not dependable any longer, this happenes when 5 fiducial points are detected. This corresponds to 50% success rate for detection.

The second graph on the otherhand shows the relationship between the distance of camera from the person the No of Fiducial features detected. One can derived from the graph the pictures needed for recogntion has to be captured from a minimum distance of about 20cm to get the best success rate of recogntion. Moving further away from the camera would result in lesser fiducial features being detected and resulting in reduced success rate of recognition.

4.3.0 Discussion

4.3.1 Constrains

This model of face detection resulted in a significant amount of false negatives (the picture contains faces but the program does not detect any face.

4.3.2 Improvements

By increasing the amount of face models used for detection.

- This helped to slightly improve the rate of detection derived from the program.

By adding face model with varying degrees of orientations and angles of inclination.

- This help solved the problem of not detecting faces because they happen to be slighted or not all parts of face shown in the image (eg partial obstructed face, side of faces and faces covered by hair)

Figure 30: Face Model (Robust)

Improvement has also being made to this method

- Upon capture the user doesn't need to press the detect button for detection to occur, it is programmed to run automatically
- Upon selecting a photo using the search option previously a bug was noticed which is when the new picture is display the canvas which display the previous results still exist on screen thereby providing a false result until the detect button is pressed. The bug was fixed by also incorporating the detect function unto the photo search button so results are automatically displayed by creating a new canvas and highlighting the regions where faces exist.
- Enhance are also added to the detect button upon in which once a user presses this button the application detects area of the picture that contains faces add automatic saves the detected faces in a new location.

- The results of capture is now also being saved on the smart not only being cached as previously done so that previous results could be retrieved.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

The application is now capable of performing face detection with varying number of faces in the image. The first method of face detection perform when image is capture with optimum condition i.e. good lighting, distance of camera to face small, face properly aligned, full face exist clear in image, but when image capture with non-optimal condition the rate of false negative increases rapidly.

Method 2 on the other hand seems to perform well even under non-ideal condition and can detect faces even with very low light. But the rate of false positives detected using this method is greater than that of the Method 1.

But Method 2 still gives the best results has the false positive detection could be eliminate by specifying an higher threshold for the probability of face in other to reduce the rate of false positive thereby making it the better method.

The application presently uses Facedetector.Face API class present for android platform to enable the application to perform better in varying environment, the class should be incorporated with a face training capability. This would help the application to perform better with increasing number of faces and varying background.

The application also extract features from the images detected for further processing to be performed to get the identity of the person in the image. The features are then corollated with the exixtening features in database to findout if recognition is succesful.

Optimum conditions of capturing image with indoor lighting 500 lumen/m^2 , distance less than 20cm from face and frontial facing face would result in the best rate of successful recognition.

5.1 Future Work

Improvements could be made to the application to be able to detect faces in moving images. By extending this principle to moving image I could improve the rate of recogntion has several frames can be captured that is then used for feature extraction and comparison.

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