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| University of reading |
| A Face Authentication System |
| Final Year Project |
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**Project Supervisor: Hong Wei**

**Project ID: A-FACE**

**Module Code: SE3IP11**

**Student Name: Tom Bedford**

**Student Number: xw009807**

**Submitted: TBD**

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**Abstract**

Computerised Face authentication is vastly being integrated into today’s technologies and systems. As an efficient and effortless method of character recognition this technology aspires to be prevalent in every-day activities in the aims of managing data and location access and delivering customized user experiences. This report illustrates the design, implementation and effectiveness of a proof of concept facial authentication system. The system utilises Viola-Jones methodology of feature extraction and PCA (Principal Component Analysis) to derive a fast and efficient means of digital face detection and verification. It features a configurable threshold acceptance value in order to handle a range of illumination levels which provide a challenging constraint in image analysis. The developed system can potentially complement an existing user authentication layer or operate as an independent authentication system. Its application can be easily extended to provide some form of greeting message or profile to future students attending a university open day

**Acknowledgments**

Hong Wei – project supervisor

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## Glossary of Terms and Abbreviations

OPENCV – Open computer vision

PCA – Principal Component Analysis

Eigen Faces – definition and ref

## 

## Introduction

Biometric analysis has been a focused area of research for many years due to its distinctive features, minimally invasive recognition methods and potential automation. Technological advancements have provided more powerful and affordable hardware and open sourced software libraries allowing the technology to be researched more openly. Although biometric evaluation such as finger print recognition has delivered more reliable results than face recognition it requires additional expensive hardware to install and requires focused interaction from its user. With the least overhead for system instalment, least invasive recognition technique and fastest functionality facial recognition has become the most popular choice of biometric analysis.

Facial recognition is the identification and verification of noticeable characteristics of a human face. In the field of image analysis it is leading the race in research as its speed and versatile application out weights previous methods. It is less invasive than other biometrical analysis methods like retinal and finger print recognition with less hardware requirements. Human to computer authentication is an integral functionality of many software systems as it manages data and/or location security. Facial recognition is a task performed effortlessly by humans on a daily basis. The sheer complexity of the human brain can truly be admired whilst replicating this complex functionality in machine software. Distinctive features of the human face such as the nose, mouth and eyes are algorithmically recognised by object detection and association to geometrical shapes.

This project explores the application of face detection and verification and its effectiveness as an authentication based system using the open vision library developed by IBM.

## Problem Articulation / Technical Specification

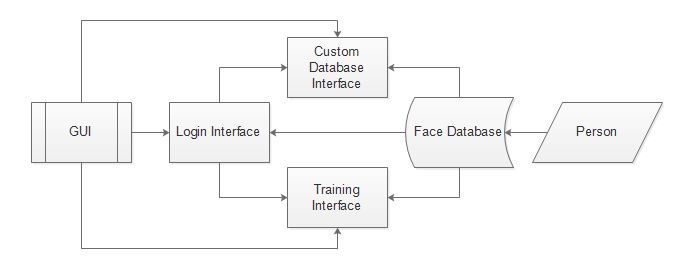
The fundamental goals of the developed system in this study is the successful detection of a user’s face and the association of the face image and the target databases facial images within a set threshold to grant a user access through a login interface. The threshold of acceptance can be adapted to suit the needs of the systems environment and substantially dictates acceptance rates in the recognition process. It is assumed that users will present there face at an offset no greater than 40 degrees and the camera will be of sufficient quality to capture images to an adequate resolution. The user will not be wearing items that obstruct large portions of the face. To provide a reliably secure authentication system recognition results must fall within a refined acceptance threshold that ensures access only to known users of the system. These assumptions and constraints where originally defined in the PID [] report referenced at the end of this document and submitted at the beginning of the project.

To satisfy the project deliverables derived in the PID each deliverable must meet its acceptance criteria.

The proposed solutions are based on addressing three main modules of the system’s functionality, the GUI (Graphical User Interface), face detection and verification functionality.

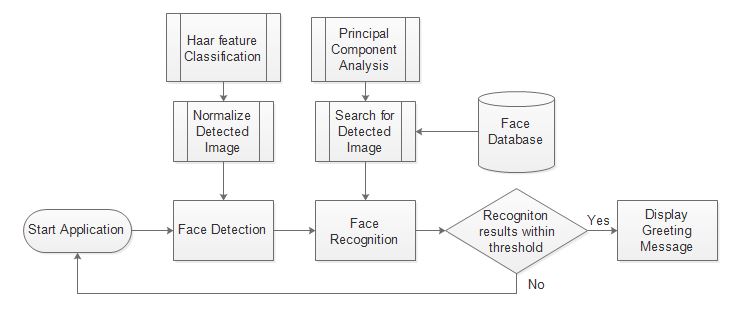
The GUI must be developed to provide a simple interface for the user to detect and capture an image of their face and submit it as part of the authentication process. The GUI will also need to host a training screen where the user can select, load and train a face database prior to face recognition.

**Figure. 1** face authentication graphical user Interface design.



All possible solutions must address and satisfy the functional demands of the systems three main modules, the GUI (Graphical User Interface), face detection and user verification. Figure 1 illustrates the work flow of the proposed GUI. It can be seen that the program interface is built up of three main displays, the login, training and custom database screens. The login and training screens are essential to the systems functionality and the custom database screen is to provide further customisation for creating and adapting databases for training.

**Figure 2.** Recognition process of the facial authentication system.



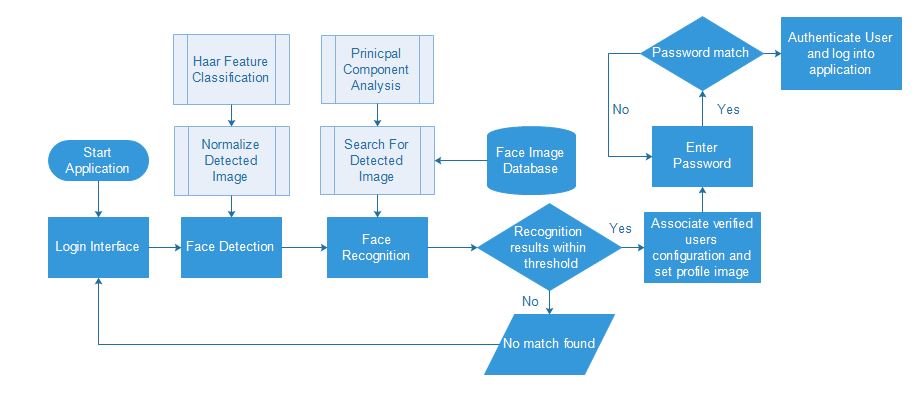
.

Here I need to discuss the proposed solutions to the task. What objectives need to be met to fulfil acceptance of system and the different methods of reaching the accepted solutions?

The face detection functionality will be capable of acknowledging a human face by recognising objective features that are incorporated in a human face with the use of trained classifiers provided by the Open CV library.

The strength of a stand-alone face recognition system used as a main authentication tool doesn’t appear to be the safest method of computer recognition.

## The Solution



**OpenCV(Open Vision Library). Using a java wrapper. JavaCV**

The OpenCV library is implemented in C++ programming language. Over the years wrappers and translated versions of the library have been developed to provide the ability for developers to utilise the libraries functionality from other programming languages such as Java.

**OPENCV Haar Classifier for face detection. Viola Jones methodology.**

The open vison library provides a variety of classifiers that have been developed and trained to detect objects and this instance facial features. The ‘haarClassifier\_frontalFace’ classifier use viola jones methodology to detect objects within an image or set of images.

**PCA (Principal Component Analysis) to refine relative data set**

Acceptance testing through thresholding comparison of trained data sets. The principal components represented as Eigen values and vectors are computed on the database image sets. The user image Is then captured using face detection and added to the relevant database image set. PCA analysis is then run on the updated image set which delivers a deviation percentage from the original analysis. The new image set is accepted if the value deviation is still in the given threshold of acceptance.

Recognition Acceptance:

Recognition acceptance is tested by performing PCA on the original database image set. The new user image is then added to the images set where PCA analysis is performed again. If the new image set PCA analysis falls within an acceptable threshold derived from the original PCA analysis the image is verified and validated. This image is then associated to the relevant user profile and image set.

Eigen Value Decomposition

## Literature Reviews

Methods of human authentication have previously and still are performed using unique credentials such as personal ID cards, passports, unique passwords and phrases. These methods of authentication often require some form of physical interaction or focus from its user.

All methods of computerised human identification operates on the basis that a set of uniquely identifiable data is submitted by a user to the system where it is compared and associated to the relevant stored data within a set threshold of acceptance. The form of this uniquely identifiable data has largely been an extension of a person such as a bank card or password. Biometrics offer the convenience of no extra materials, assets or memory cognition as they are physical features that individually identifies a person.

The face is the most exposed definitive characteristic of a human and therefore can be analysed with little demand of interaction from the person if any. A person need only look towards the scanning device which in this case is a camera for seconds and recognition can be successfully performed in real time or from a still image.

Face recognition is a popular method of identification in government surveillance systems []. It can be carried out on multiples entities simultaneously with speed which is extremely effective in crowds of people.

Only last year there was release of an advanced facial recognition system called DDFD (Deep ). The detection algorithm was extended from the foundations of Viola-Jones methodology of face detection [viola ref]

Moving towards fully automated authentication systems. Less invasive and applyabe to video stream and pictures.

In the earlier years of face recognition the face detection process of the recognition was carried out manually as there was no current automated process to extract recognisable features. With the advancements in processing power it is now much more affordable and

New technologies looking to automate sub processes to deliver a full application.

PCA is one of the most successful face detection algorithms to date. PCA is the method of reducing dimensionality of a data space (observed variables) and extracting data from the feature space (Independent Variables) which are needed to represent the data economically. The feature space in this case is the Eigen Space in which derived principal components are projected to deduce Eigen values.

* PCA is one of the most popular methods for face image analysis. It essentially optimizes the data needed to represent a defined set of data.

APPLICATIONS OF FACE RECOGNITION

Infrared technologies are currently being used in carparks to simulate a daytime like environment to extract car number plates in poor lighting conditions. This allows image recognition methods to extract the characters of the number plate. Infrared scanners used in this capacity are expensive to install and maintain but would provide more mobility of the system and more potential recognition environments.

As the environments lighting conditions are a CCP (Critical Control Point) of the systems functionality its placement must be considered careful to cater for its needs.

* Face recognition has been inherited by many high street retailers to recognise VIP guests/customers so that a platinum service can be delivered.
* Most commonly face recognition is being used in surveillance and Security. Crowd control. Lost device services.
* Extended face recodnition research investigates the use of thermal cameras to collect image data. This allows a better representation of a 3D face model as it does not detect facial items such as glasses and records only heat signature data. <https://en.wikipedia.org/wiki/Facial_recognition_system>

## Implementation

The use of third party maths libraries such as Jama Matrix toolkit and apache commons math library to compute eigen decomposition. JavaCV

It is common practice to select a sub set of the computed Eigen values. The highest variations is distance of the eigen values are removed as they represent high frequenicies of data.

## Testing: Verification and Validation

Inanimate images/photos can be held in front of the camera and a face is successfully detected. Open CV’s trained classifiers are robust enough to detect images with very little features. This poses a security issue as user recognition can be spoofed without the necessary precautions being implemented to counter such forgery.

## Discussion

## Conclusion

This system can be fooled by holding an image which is then successfully detected. So if an unknown user is attempting to login they would simply have to find a reasonable high resolution image of the user they wish to impersonate and present this to the face detection process whilst producing a login image.

## Project Commentary

## Social, Legal, Health & Safety and Ethical Issues

There are many ethical arguments to the analysis and storage of biometrical data. Biometrics uniquesly identify a person with biometric data and can’t be changed easily. If your authentication password or forms of identity such as bank card become compromised they can easily be changed although human like features such as the face are much harder to modify.

The ethical and social use of face recognition has been questioned much already. With the ever growing technical strive to innovate methods of human computer interaction biometric analysis.

## Reflection

To ensure a reliable and secure authentication system scenarios such as user image spoofing where the unknown user attempting to log in holds up an image of a known user must be consider.

The project deliverable defined in the PID where unrealistic. Which ones why, what took up time.

JNI (Java Native Interface) can be used to utlise C++ code. The native C++ openCV library offers a very robust FaceRecognizer class that can determine the age and gender of a user. It also features live detection functionality that can differentiatre between a live and inanimate subject. This functionality cleverly exploits the movement of eyes and skin tone changes to conclude whether the user is a real person [ref to live detctor]

## References

[1] University of Reading, PID reference. Available at:

[] Network World, US intelligence wants to radically enhance facial recognition software [online]. Available at : <http://www.networkworld.com/article/2225788/applications/us-intelligence-wants-to-radically-advance-facial-recognition-software.html>

[viola ref]

## Appendices