Thermal Face Recognition

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1 Introduction

1.1 Purpose of this document

The main purpose of this document is to make a clear and understandable document for the software designers to have them reached the idea of this project and be able implement its requirements and functions properly and in a right way.

1.2 Scope of this document

A- Project Objective: Develop a system that will be able to recognize human faces based on their thermal images after making a comparative study between the algorithms that have been used in related systems and testing them on our database to come up with the best algorithm that can be used in real-time and have the best accuracy. w

B- Deliverables:

- Developing an application that can be specialized in making universities control rooms more secured by having a thermal face recognition system that allows desired people to enter the rooms based on their authorities.

C- Milestones:

- Proposal Document – October 2016
- Software Specification Document – February 2017
- First Prototype – March 2017
- SDD - April 2017
- Integrated System – May 2017
- Final Thesis – June 2017

D- Technical Requirements:

- Start-up and processing in less than 10 secs
- Low memory consumption

E- Constraints:

- Thermal Camera isn't brought yet , due to its high cost
- Best Algorithm to be applied
- System isn't working in real time yet

1.3 Overview

The delivering product will be able to identify people's faces based on their thermal images. Thermal images had been proven to have a better identification accuracy than the classic or visible one, so a product that could be able to identify thermal images would be much better and more useful[1].

1.4 Business Context

Thermal face recognition can be used and implemented in many real world applications. Based on a survey that has been done, this project can be most usefully in identifying faces in security[2]. With the system's ability, the system that will be able to recognize faces based on their thermal images in universities' control rooms in order to be more secured by having a thermal face recognition system that allows desired people to enter the rooms based on their authorities.

2 General Description

2.1 Product Functions

The project works as follows; first, enrollment of the desired people that will be using the application has to be done; by saving their details, information and authorities. There are two different stages, training stage and testing stage. In training stage, the training process is applied on the thermal images, it detects the shown and available faces in the desired area, then applying segmentation on the images in order to help having a better accuracy and clearer images to work on. Features are being extracted from the images after applying the segmentation stage, these features are being extracted and stored in the database to be able to compare results with them in the testing stage. And finally, we classify the image based on its face in order to identify the face in the testing stage. In testing stage or real time stage, the system detects the acquired face in the area. Segmentation step is applied to work only on the desired area which is the face region. Then features are extracted from these images and comparing them with the stored ones to be able to classify the images from the previously

tested ones. Then deciding whether to give the person the permission to access the rooms or not.

2.2 Similar System Information

1- Thermal face recognition using convolutional neural network, IEE 2016. [3]

Mentioning that similar work used some of the traditional thermal recognition methods which requires more efforts from human to select and extract features, they faced some problems like the improvement of recognition rate, the methods were not capable enough to describe the details; or even traditional methods that have some shortcomings such as the complicated process. Alternative method Convolutional Neural Network(CNN) is a deep learning algorithm, it has been proposed because it can automatically learn new features from raw data, also it combines features extraction and classifying into one step that can reduce the workload for the humans. In a multi-layer neural network architecture, each node undergoes some calculations and serves the next node with them, each node's value is relevant to its previous node.

In Convolutional Neural network, is can optimize the normal neural network structure (9 layers). To test the CNN model, The RGB-D-T Face Database was used, its images were collected from different types of cameras. Images were taken of 51 students with respect to three main aspects; head rotation, facial expression and illumination variation. So 100 images for 51 students with 3 aspects, there are 15300 (51x3xlOO) images in the database to be trained and tested with.

Experimental results had been done and compared with three competitive algorithms which are; LBP, HOG, Moment Invariant. It showed that with due to respect of the three previously mentioned aspects, head rotation affects the most in the recognition rate of the images, whereas illumination variation has the least effect of the three on the rate. In the below table, a comparison has been done to show the results, and it shows that CNN outperforms the three other algorithms in the recognition rate.

	Head Rotation	***Expression***	***illumination***
LBP	79.33	96.27	98.35
Moment Invariant	59.37	91.76	94.51
HOG	90.27	98.78	99.18
Their Method	98.00	99.40	100.00

2- Human Thermal Face Recognition Based on Random Linear Oracle (RLO) Ensembles[1]

They started talking about classic face recognition where there has been remarkable progress in it. However, they faced many problems like image variation due to many differences in head positions, expressions and poses. So infrared image recognition has been employed to solve this problem, at the beginning it has not received much attention due to many limitations, but recently these limitations are being broken one by one and they can solve the problems classic face recognition faced. Mentioning that every person has a unique thermal signature for him depending on temperature and characteristics.

Improving the recognition rate based on Terravic Facial IR Database was their main motivation to work on. Similar works have been done before, in [8], PCA has been used for dimensionality reduction, and then two different classifiers have been used to identify the image. Based on Terravic Facial IR Database, recognition rate reached 94.11 percent. In [8], Wavelet transform has been used for features extraction, then providing them to the classifiers. Based on Terravic Facial IR Database, recognition rate has reached 93 percent.

This paper proposed an approach with two variants based on Random Linear Oracle Ensembles (RLO). Segmentation based Fractal Analysis(SFTA) algorithm was used for features extraction, then RLO ensembles was used to recognize the face from its thermal image. For the dimensionality reduction, one variant (SFTALDA-RLO) was used the technique of Linear Discriminant Analysis (LDA) while the other variant (SFTA-PCA-RLO) was used the Principal Component Analysis (PCA).

The proposed model consists of two phases; training phase and testing phase. In the training phase, the training data or images are collected, then (SFTA) algorithm is used to extract features from every one of them, then PCA and LDA are used for dimensionality reduction which are used to build the RLO model, which is later on used in the testing phase. In the testing face, the unknown or test image is captured, extracting features from it using (SFTA), then project the extracted features from the dimensioned vectors from the training phase and match them with the results.

Experimental results, the Terravic Facial IR Database was used to evaluate our two variants. The dataset set consists of 20 classes with greyscale images (360 x 240) and each class represents one person. In this paper, we have used 17 classes as three classes were corrupted. For each class, 200 grey-scale images were used.

2.3 User Characteristics

Users of the system are preferably to have a general background about computers systems and technology overall, not so much of experts but have a good

knowledge that will make them a able to understand how the system works and use it in their own domains and applications as the system does not have much interaction between the user and it but only in training the system to store new images and data. No specific age or gender is required as long as the user has enough knowledge and ability to use the system.

2.4 User Problem Statement

Visible or classic face recognition does not meet all the user's requirements of doing the job effectively as it has many backwards and problems such as head pose, position, facial expression and also the image has to be well lit [1]. Thermal face recognition was employed to solve these problems that faced the visible face recognition.

2.5 User Objectives

The user's main objective is to have a system that can work properly under the circumstances and problems that faced the visible faced recognition to be able to identify people's faces easily. Many applications the user can benefit from the system in them, mainly in security and forensics as has been mentioned before they were top priorities to people in the survey. But we are aiming to make an application for the universities' control rooms to improve its security.

2.6 General Constraints

1. Having a thermal camera that provides thermal images due to its high cost.
2. Deciding the best algorithm to be used after testing many.
3. Being able to work in real-time.

3 Functional Requirements

3.1 Admin login

Description: The admin will have a login credentials in order to have the ability to edit and updates the data of the users.

Input: Login credentials.

Output: Informs the admin whether he entered his credentials correctly or wrongly.

Action: The admin will login to the system if his credentials were right.

Criticality: This function is very important as the admin will not be able to make any modifications to the system if he does not login to it.

3.2 User Enrollment

Description: The admin will register the details and information of the desired people to be using the system.

Input: Captured images.

Output: Informs the user if the images are stored correctly.

Action: The user will be asked to enter the class or person's name of the captured image.

Criticality: This function is very important as the details and authorities of the users have to be stored.

3.3 Capturing training images

Description: The admin will capture images of the targeted people that the system will be working on.

Input: Captured images.

Output: Informs the user if the images are stored correctly.

Action: The user will be asked to enter the class or person's name of the captured image.

Criticality: This function is essential and very important in the process as it's a vital one in completing it.

3.4 Applying Segmentation to training Images

Description: The captured images of the users will go through the segmentation stage by segmenting the images to work on the face area only which can help in having better accuracy in the classification stage.

Input: Thermal images.

Output: Showing the segmented images.

Action: Segmentation stage will be applied to the images by focusing on the face area only and removing the environmental distractions.

Criticality: This function is important in the system as it will help in having better accuracy in the classification stage.

3.5 Applying Features extraction to training Images

Description: Every face has unique features that are different in many ways,these features need to be extracted and stored using many techniques and algorithms in order to make the classification stage much easier and more accurate.

Input: Segmented thermal images.

Output: A feature vector of the extracted features.

Action: Segmented Images will go through features extraction step in order to have a feature vector.

Criticality: This function is an essential one as we need the feature vector of the features from every image in order to apply the classification based on it.

3.6 Uploading testing thermal image

Description: After the training stage, the specified thermal image face will be uploaded to begin the testing stage.

Input: Thermal image face.

Output: The thermal image will be shown in a picture box in the system.

Action: The image will be segmented and shown the output image in the picture box.

Criticality: This step is important as the user has to have a testing image to begin the testing stage.

3.7 Applying Segmentation on testing images

Description: After uploading the thermal image, segmentation stage is applied to the image by applying threshold and restoring the original pixels.

Input: Thermal Face Image.

Output: Segmented Image.

Action: Threshold algorithm will be applied to the thermal image, the face

area will be binarized and the corresponding pixel will be restored from the original image.

3.8 Applying the feature extraction stage on testing images

Description: In this step, the user will apply the feature extraction stage to the image after uploading the segmented one.

Input: Segmented image.

Output: The output image will be shown in a new picture box after applying feature extraction to it.

Action: Feature extraction stage will be applied to the segmented image and shown in a new picture box.

Criticality: This step is very essential in the identification process as the classification step will be applied based on it.

Dependencies: This step depends on the previous one as the feature extraction step will be applied on the segmented image.

3.9 Testing images classification

Description: In this step, the user selects to classify the specified image based on the trained images.

Input: The output image after the feature extraction step.

Output: Informing the user about the identity of the specified image.

Action: The image is classified after extracting the features from it and comparing them with the trained images to identify the thermal face in order to know whether to allow the acquired person the access to the rooms or not.

Criticality: This is the vital and final step of the process to identify the images, so it is a very essential one.

Dependency: The classification step is dependent on the segmentation and feature extraction step, so that the classification can work properly.

4 Interface Requirements

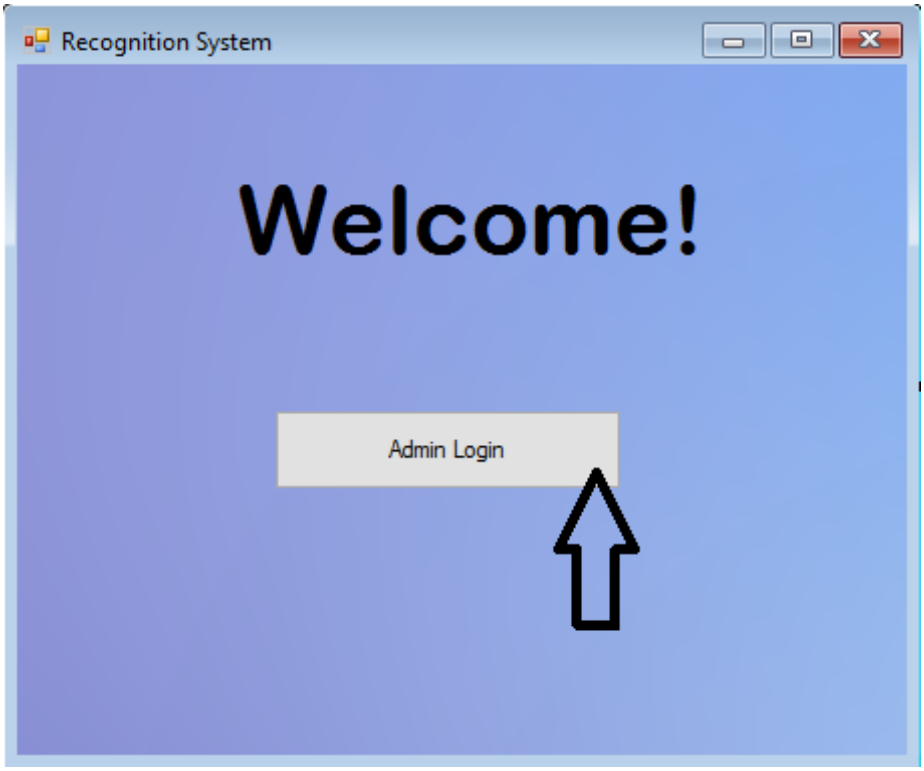
The interface of the system requires the presence of a camera frame for the admins in order to have the ability to add a new user that can have the access to the system. The admins should have access to enroll a new person or user in the system.

4.1 User Interfaces

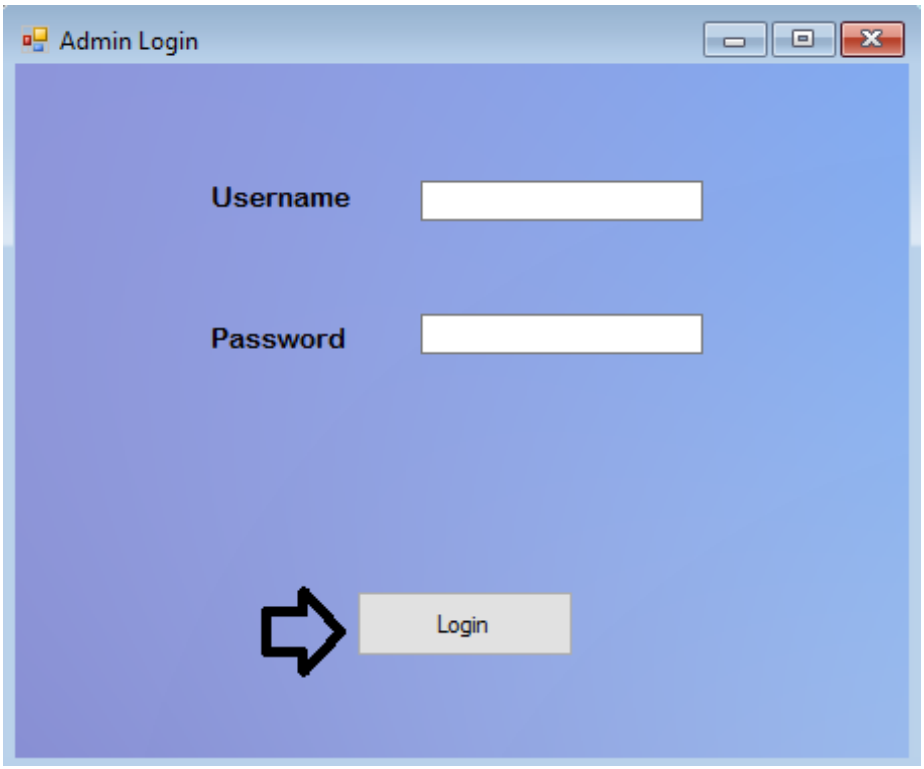
Here in this section, the Graphical User Interface (GUI) will be discussed and shown through images and screen-shots of the system.

4.1.1 GUI

Here is an image of the homepage of the application. The admin will be asked to enter his credentials in order to login.

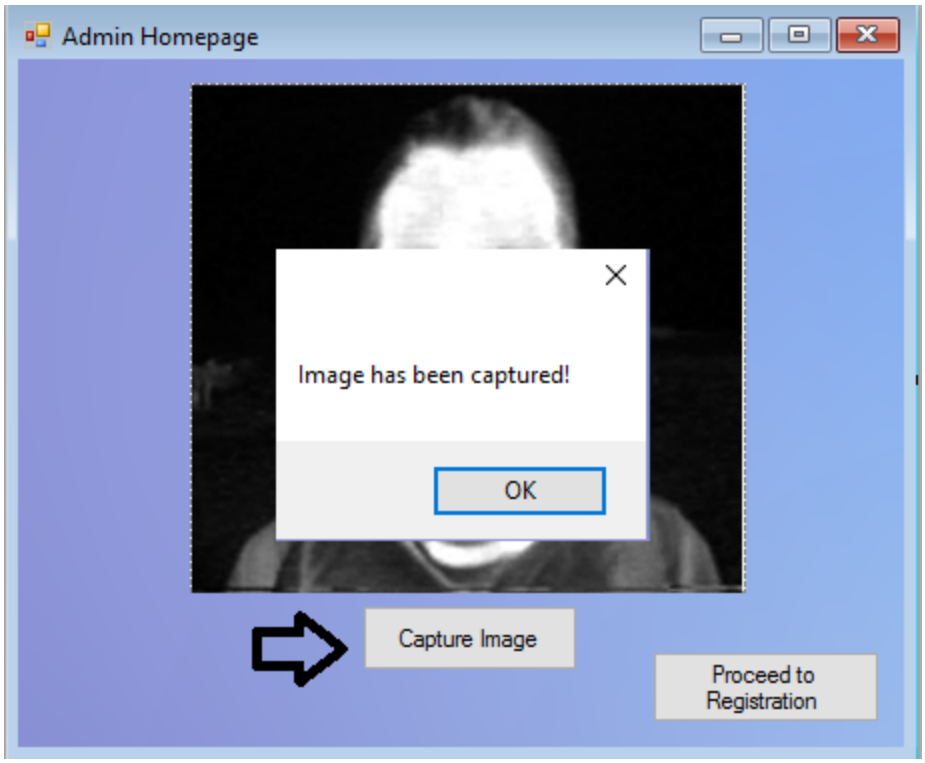


Here is an image of the login page for the admin to enter his credentials.



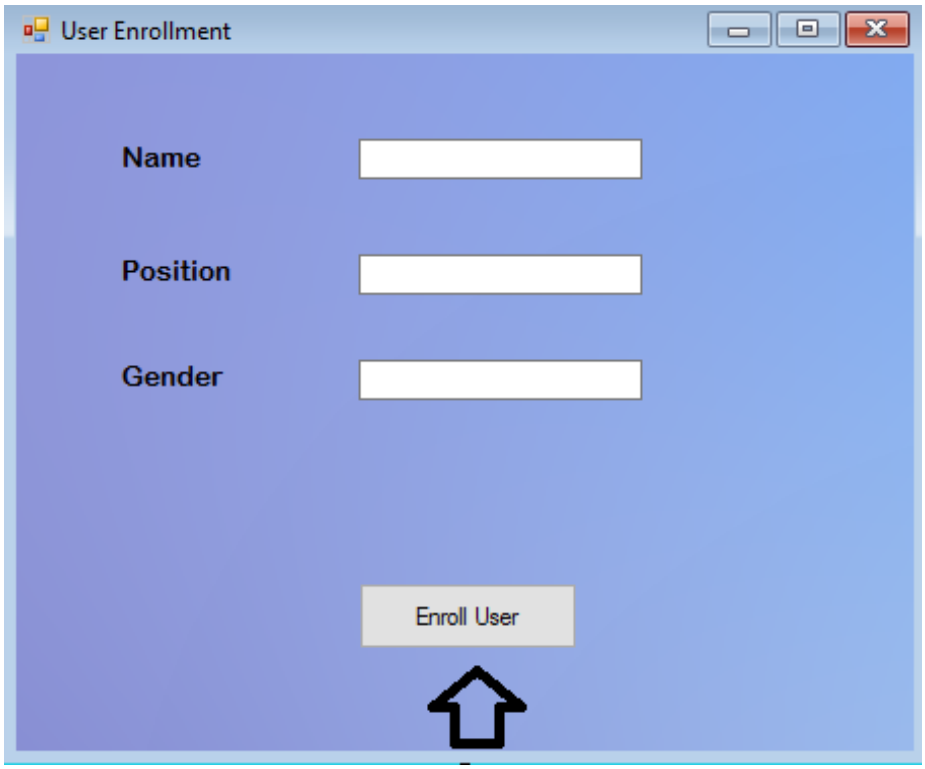
Here is an image of the system when the admin is capturing an image of the user.

Here is an image confirming that the thermal image has been captured.

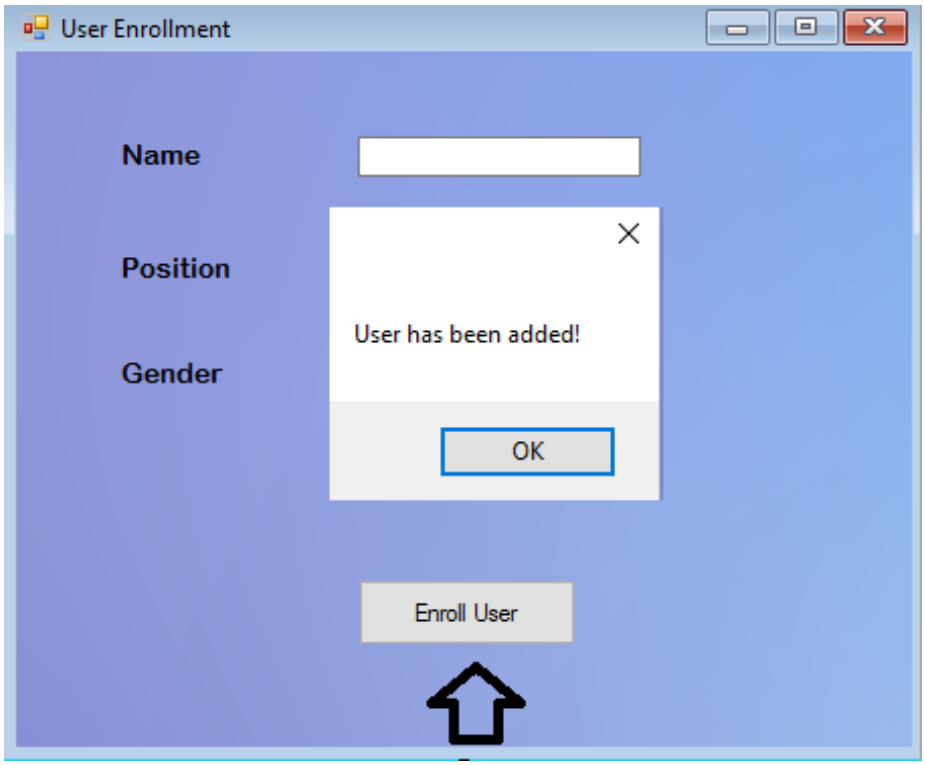


Here is an image after confirming capturing the image and wanting to proceed to user registration.

Here is an image of the user registration form.



Here is an image confirming adding the user details and successfully enrolling the data.



5 Performance Requirements

We are focusing on three cores in our project performance, Firstly the accuracy of the recognition as the system needs to be very accurate to recognize the person in-front of the Camera or the inputed image, Also the speed is one of the main cores as the system need to be fast in the recognition as we may use it in security. The final core is the memory the system should have a large memory to save the trained images in the database and to compare it with the person infront of the camera.

6 Design Constraints

There are some design constraints that will be facing us, the availability of the PC that will be able to run the desktop application. Also, a thermal image camera will be required in case of using

7 Other non-functional attributes

Specifies any other particular non-functional attributes required by the system. Examples are provided below.

7.1 Security

In the system you will need a username and an encrypted password to access the database or add a new trained images for a person.

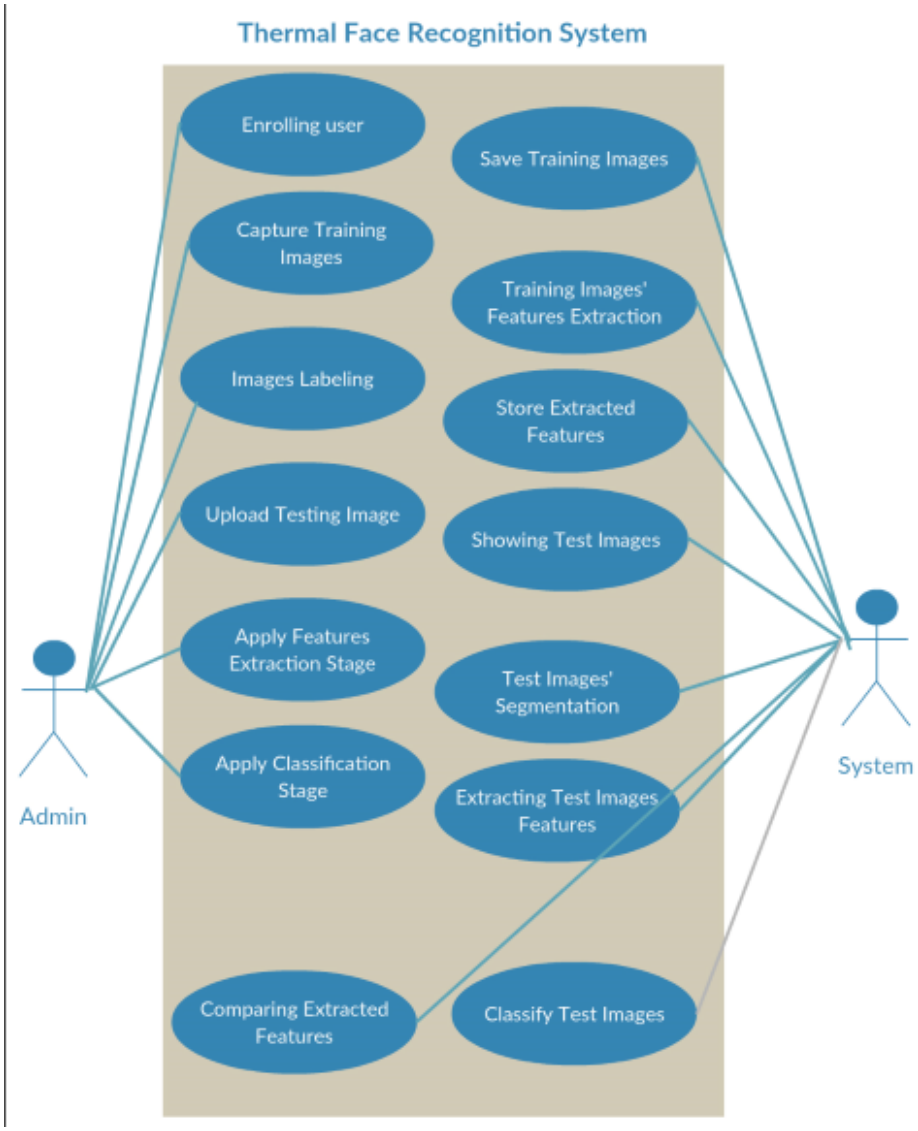
7.2 Accuracy

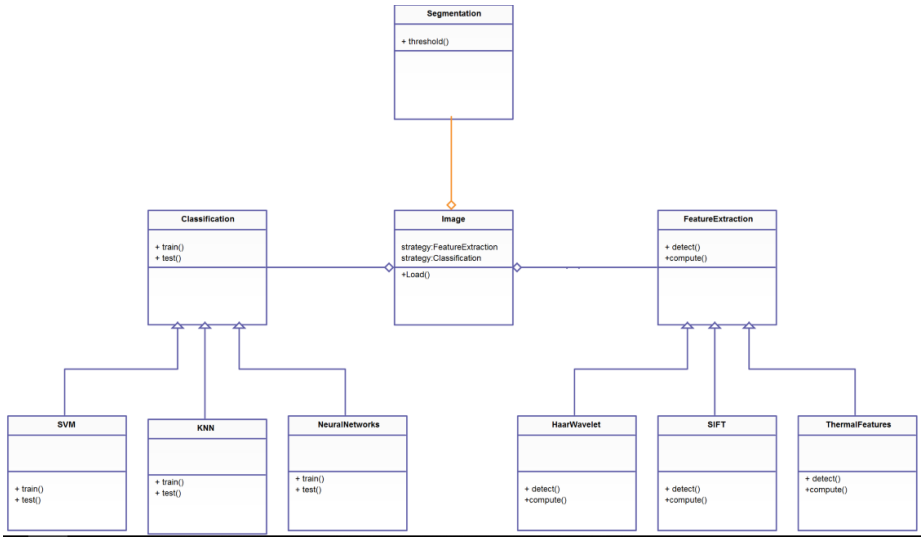
our System Accuracy depend on the trained images as we need a well trained dataset so it can be easier to detect the person in front of the camera.

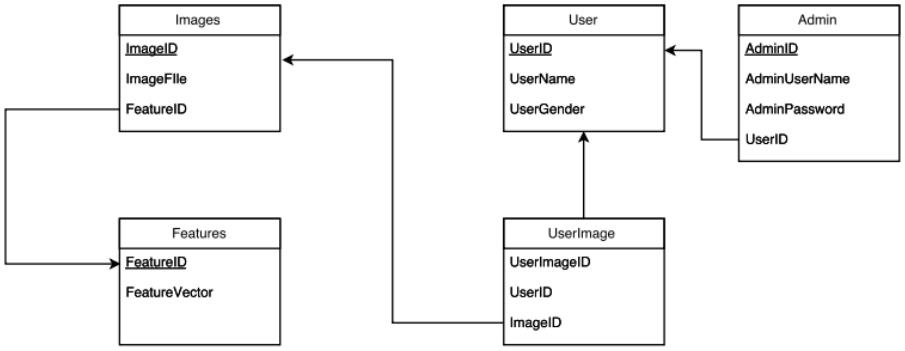
7.3 Performance

The System should classify whether the person in front of the camera have an access to enter the room or not in range of 5 to 8 seconds.

8 Preliminary Object-Oriented Domain Analysis





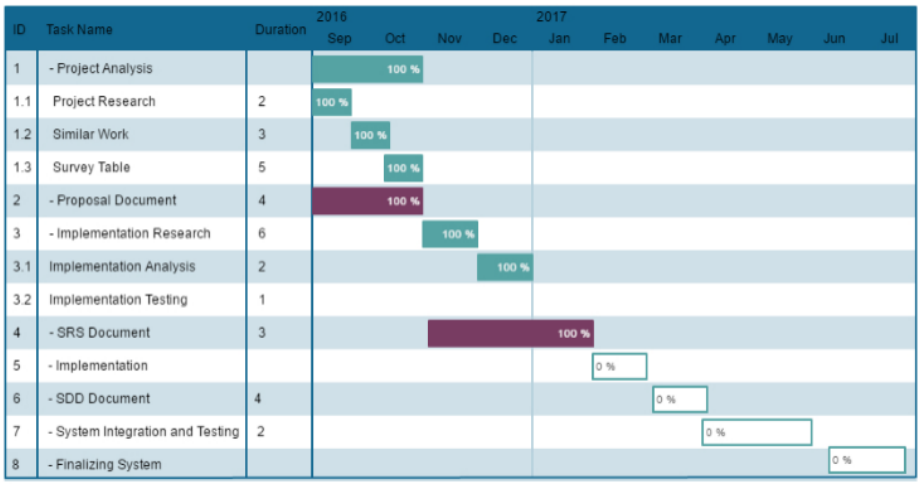


9 Operational Scenarios

The targeted users information that will be using the application has to be registered and stored in the systems database in order to have clear detailed data about them. Images of the targeted users have to be captured to be processed and trained later on in the identification process.The captured images of the users will go through the segmentation stage by segmenting the images to work on the face area only which can help in having better accuracy in the classification stage. Every face has unique features that are different in many ways, these features need to be extracted and stored using many techniques and algorithms in order to make the classification stage much easier and more accurate. In real time, the system has to detect the face area of the targeted users that will be using the system in order to start applying the identification

stage. After detecting the face, segmentation of the face region will be applied in order to apply the process on the face area only and remove the environmental distractions.Extracting the Features of the face area is the most vital and important step in the process as they need to be extracted from the targeted users faces in order to use it later on in the classification stage.After extracting the features from the face, these features will be compared with the already stored ones in the database to reveal this persons identity to decide whether this person has the authority to enter the room or not. Taking action based on the persons identity whether allowing him to enter the rooms after identifying his face and revealing his authorities, or not giving and allowing him the access to these rooms.

10 Preliminary Schedule Adjusted



11 Appendices

11.1 Definitions, Acronyms, Abbreviations

1)FLIR: It is an abbreviation to Forward Looking Infrared Radiometer, it is the world leader in the design, manufacture, and marketing of thermal imaging infrared cameras.

11.2 Collected material

Thermal Face Images databases were available online, they contain static thermal face images to be used and tested [4],[5].

12 References

[1] Gaber, Tarek, et al. "Human Thermal Face Recognition Based on Random Linear Oracle (RLO) Ensembles." Intelligent Networking and Collaborative Systems (INCOS), 2015 International Conference on. IEEE, 2015.

[2] C. Ding and D. Tao, A comprehensive survey on poseinvariant face recognition, arXiv preprint arXiv:1502.04383, 2015.

[3] Wu, Zhan, Min Peng, and Tong Chen. "Thermal face recognition using convolutional neural network." Optoelectronics and Image Processing (ICOIP), 2016 International Conference on. IEEE, 2016.

[4] ¡OTCBVS ThermalnVisible Face Database¿: http://www.cse.ohiostate.edu/OTCBVS-BENCHibench.html

[5] ¡Equinox Infrared Face Database¿ http://www.equinoxsensors.comlproductsIHID.html