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Developing an Intelligent Application for Human Being Identification using a Hybrid Approach

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I would like to thank my beloved parents for their encouragement who are so supportive to me throughout my life. My sisters, brothers deserve

my wholehearted thanks as well, to all my friends and all my classmates.

بسم الله الرحمن الرحيم

I dedicate this work:

- *To my dear father and mother.*
- *To my dear brothers and sisters.*
- *To my whole family.*
- *To all who have sacrificed their time for science and to all who use science for the good and prosperity of humanity.*

ملخص

نظام التعرف على الوجه هو تطبيق حاسوبي قادر على تحديد أو التحقق من شخص من صورة رقمية أو إطار فيديو من مصدرٍ فيديو. وفي هذا الموجز ، نعرض أبرز النُهج إزاء كشف الوجه واستخراجه ، فضلا عن نهج التعرف على الوجه. ونرى أيضا بعض الصعوبات في اعترافنا بالوجه. كما نقوم بشرح الخورازميتين صرا (التحليل الرئيسي للمكونات) و رة (تحويل كوسين منفصل) و طرق حسابهم الرياضية وكذلك كل مراحل عملهما ويتمثل العمل المقدم في هذا المشروع في تحقيق نظام التعرف على الوجه البشري باستخدام هاتين الخوارزميتين

الكلمات المفتاحية: كشف الوجه - التعرف على الوجه - التحليل الرئيسي للمكونات - تحويل كوسين منفصل - الوجوه الذاتية - التصنيف - الوجه

Abstract

A facial recognition system is a computer application capable of identifying or verifying a person from a digital image or video frame from a video source. We also see some of the difficulties in our facial recognition. We also explain the algorithms PCA (Principal Component Analysis) and DCT (Discrete Cosine Transform) and their mathematical calculation methods, as well as all the phases of their work. The work presented in this project is the realization of the human facial recognition system using these algorithms.

Keywords : Facial Detection - Facial Recognition - PCA - DCT - Eigenface - Classification - Face

Résumé

Un système de reconnaissance faciale est une application informatique capable d'identifier ou de vérifier une personne à partir d'une image numérique ou d'un cadre vidéo à partir d'une source vidéo. Nous constatons également certaines difficultés dans notre reconnaissance faciale. Nous expliquons également les algorithmes PCA (Principal Component Analysis) et DCT (Discrete Cosine Transform) et leurs méthodes de calcul mathématique, ainsi que toutes les phases de leur travail. Le travail présenté dans ce projet est la réalisation du système de reconnaissance faciale humaine à l'aide de ces algorithmes.

mots clés : Détection faciale - Reconnaissance faciale - APC - DCT - Eigenface - Classification - Visage

Abbreviations

SVM	Support Vector Machine
RBF	Radial Basis Function
LUT	Look up Table
CBIR	Content Based Image Retrieval
PCA	Principal Component Analysis
LDA	Latent Dirichlet Allocation
EGM	Elastic Graph-matching
ATMs	Automated Teller Machines
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
KLT	Kamunen-Loeve Transform

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General Introduction

Protection and safety is one of the most important foundations of our daily life in various sectors and institutions such as state institutions, banks, etc. Control of access to information and identification of persons is based on traditional methods such as the user's prior password identifier registered in the central system, but this technique is not very reliable because the user is able to forget about it and there is a method based on having physical objects such as keys, bank card, badge, etc. In fact, access control through these traditional identification methods is unreliable and does not constitute strong security.

Today, many research has been developed by researchers in the creation of new identification alternatives, since the advantage of biological features is unique to all individuals and permanent, meaning that they do not differ or replace with time. The power of this advantage lies in the inability to steal them and thus avoid maneuvering and cheating.

Face is one of the vital features used for identification and facial recognition is the new method of identification, and in recent years it has become one of the most successful and constantly evolving branches of computer vision.

The facial recognition system allows control and access to the identity of individuals. However, before verification of facial recognition, it is necessary first to detect the face and extract the facial components needed to perform the identification.

Several facial detection methods have been developed. In our project, we used the Eigenface method, the result of which will be passed to the classification process.Finally, the classification makes it possible to verify the identity of individuals, if the person is the one concerned. who is existing in database or not.

Chapter 1

Facial Detection

1.1 Introduction

The first step in facial recognition is facial detection.In this chapter we will present the evolution of facial detection technology and the methods used, as well as the pre-treatment phase. And in the end, we'll see some databases that provide us with facial images to apply to, as well as some applications that use this technology.

1.2 Why Facial Detection

Facial detection is an essential and important step in facial recognition systems and cannot be automatic if it has not been passed through an effective detection step. The detection step starts by capturing the scene containing a face and then extracting the face from the image taken by one of the detection images in order to preserve an area containing the basic facial components to which before treatment procedures will be applied.

1.3 Evolution of Facial Detection

Early efforts in face detection have dated back as early as the beginning of the 1970s, where simple heuristic and anthropometric techniques were used [1].

These techniques are largely rigid due to various assumptions such as plain background, frontal face a typical passport photograph scenario. To these systems, any change of image conditions would mean fine-tuning, if not a complete redesign. Despite these problems the growth of research interest remained stagnant until the 1990s, when practical face recognition and video coding systems started to become a reality. Over the past decade there has been a great deal of research interest spanning several important aspects of face detection. More robust segmentation schemes have been presented, particularly those using motion, color, and generalized information. The use of statistics and neural networks has also enabled faces to be detected from cluttered scenes at different distances from the camera. Additionally, there are numerous advances in the design of feature extractors such as the deformable templates and the active contours which can locate and track facial features accurately [2].

Because face detection techniques requires a priori information of the face, they can be effectively organized into two broad categories distinguished by their different approach to utilizing face knowledge. The techniques in the first category make explicit use of face knowledge and follow the classical detection methodology in which low level features are derived prior to knowledge-based analysis [3].

1.4 Facial Detection Approaches

There are several techniques for face detection. They can be subdivided into four different categories. [4]

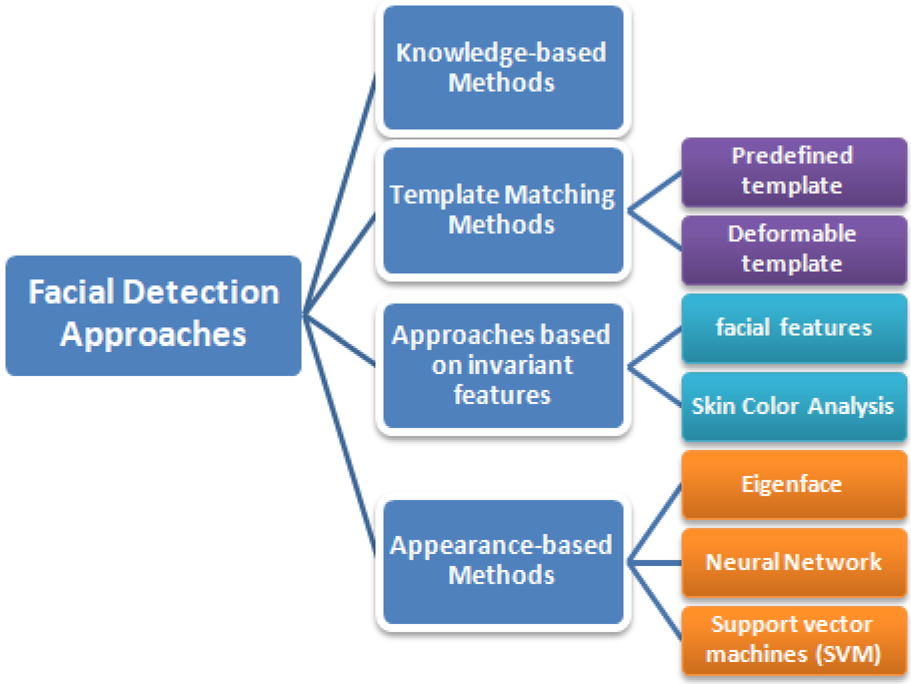

Figure 1.1: Facial Detection Approaches [4]

1.4.1 Knowledge-based Methods

These methods are based on the definition of strict rules based on the relationships between facial features. They are interested in the characteristic parts of the face such as the nose, mouth and eyes. These methods are designed primarily for localization of face [5] . Kotropoulous and Pitas [6] use a rule-based method. The facial features are localized using the projection method proposed by Kanade [7] to detect facial contours.

1.4.2 Template Matching Methods

Definition of templates matching is either "manual" or configured using function.the idea in this approach is to calculate the relationship between the filtered faces and the template. However, these methods still face problems of strength associated with differences in light,scale,etc.Sinha [8] uses a set of invariants describing the model of the face. To determine the invariants to changes in brightness to characterize different parts of the face,this algorithm calculates the ratio of luminance between the regions of the face and retains the directions of these reports.

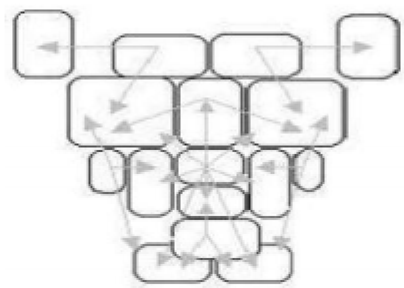

Figure 1.2: Face model consisting of 16 regions (rectangles) associated with 23 relationships (arrows) [5].

This predefined model corresponding to 23 relationships. These predefined relationships are classified into 11 key relationships (arrows) and 12 confirmations relationships (gray). Each arrow represents a relationship between two regions.A relationship is verified if the relationship between the two regions exceeds a threshold. The face is localized if the number of essential relationships and confirmation also exceeds a threshold.

Yuille et al [9] used a deformable Template to model facial features, they created a Template elastic adaptive to facial features such as eyes,mouth...etc. The Template parameterize this technique allows to describe the facial features.

1.4.3 Approaches based on invariant features

These approaches are used primarily to locate the face.The new algorithms are designed to create existing structural characteristics even if they are Construct, display, or change the state of lighting. They then use these invariant features to identify faces. The Algorithms of this approach can be divided into two families which are:

- Based on facial features
- Based on skin color analysis

1.4.3.1 facial features

In general these algorithms use first a hypothesis about the position of the upper face then the search algorithm runs up and down the face in order to find the axis of the eyes characterized by a sudden increase in the density of contours (measured by the black/white ratio along the horizontal planes). The length between the top of the face and the eye plane is then used as a reference length to build a flexible facial «template». This “template” covering features such as eyes and mouth is initialized from the input image. The initial form of the "template" is obtained using the anthropometric length respecting the reference length.The flexible template is then adjusted relative to the final positions of the features using a fine tuning algorithm that employs a contour-based cost function.Although these algorithms succeed in detecting the characteristics of different ethnicities since they are not based on gray and color level information, However, they fail to detect these characteristics correctly if the image of the face contains glasses or if the hair covers the forehead [5].

1.4.3.2 Skin Color Analysis

Detection methods based on skin color analysis are efficient and fast methods. They reduce the research space of the facial area in image. In addition, the color of the skin is a robust information about the rotations, the changes of scale and partial occultations. Several color spaces can be used to detect, in the image, the pixels that have the color of the skin. The effectiveness of the detection depends essentially on the chosen color space [5].

1.4.4 Appearance-based methods

These approaches generally apply machine learning techniques.Thus, the models are learned from a set of images representative of the variability of the facial appearance [5]. The main idea of these methods is to think that the problem of face detection is the problem of classification (face, no-face). Several techniques have been used for this approach such as: (Eigenface, Networks of neurons et Support vector machine "SVM")

1.4.4.1 Eigenface

The first to develop this method was Turk et pentland [10] in 1991. Eigenface is one of the most known methods of facial detection. The principle of this method is to display an image in space and then calculate the distance between the original image and its projection, encoding an image in space that serves to analyze the information found in the class.the image is not correctly represented in the space: it does not contain a face. This method gives rather encouraging results, but the calculation time is very important [11]

1.4.4.2 Neural Network

In Rowley et al [12], the authors propose a facial detection system based on classification by neural networks. Their technique is divided into two stages: location of faces using a neural network and verification of results obtained. The authors constructed a network of neurons that, from a pre-processed image 20x20 pixels, indicates whether it is a face or not.

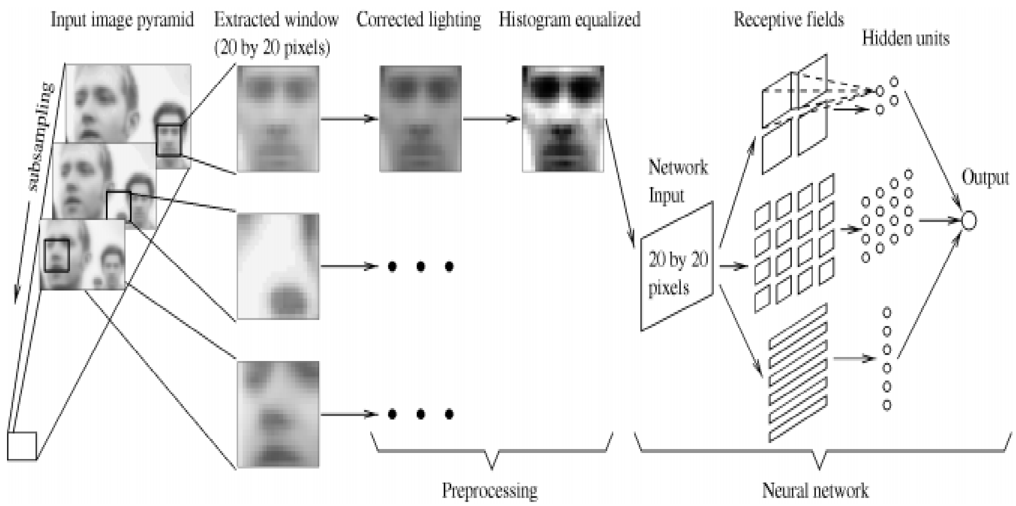

Figure 1.3: Rowley et al neuron network modal [12]

1.4.4.3 Support vector machines (SVM)

One of the first statistical methods based on information theory for face detection, SVM is considered as a new model to classify training polynomial function, neural network or radial basis function (RBF).

Most of the aforementioned training classifications are based on the minimization of training error "empirical error", SVM operates with another principle called "structural risk minimization" which is intended to minimize higher jumps on likely generalized errors.

During learning for each pixel pair in the training set a histogram is used to create probability functions for face classes and non-face classes because pixel values depend on the values of their neighbors, For training Colmenarez and Huang [13] they used a large image set of size 11*11 pixels of face and not face, the learning outcomes form a Look up Table (LUT) set with probability ratios, for the purpose of improving performance.

1.5 Comparison between the different Face Detection Approach

Approach	**Advantages**	**Disadvantages**
Knowledge-based Methods	-reduce the calculation time necessary by use of sub-sampled images	-causes many false detection -difficult to translate the human knowledge in well-defined rules
Template Matching Methods	-Simple at the level of detection process. -Gives fairly good results encourage.	-Update to each change in focus
Approaches based on invariant features	-Resists the small ones lighting changes and the face position -reduced skin color the search box	-The use of the method based on the color of the skin requires processes to complete the detection of face.
Appearance-based methods	-Eigenface gives good results. -Neural networks robust to noise	-Lots of calculation time -difficult to build -learning phase difficult to conduct

Table 1.1: Represents the advantages and disadvantages of each Approach.

1.6 Pre-treatment

The pre-treatment phase comes before the detection phase. It makes it possible to prepare the image face so that it can be used in the enrollment phase. It is also called normalization phase since it returns all images extracted from the raw image. It usually consists of a centering of the face in the image and a elimination of non informative areas.

To ensure the proper performance of the face recognition system, it is important that all images are of the same size, scale and format for colors.This undoubtedly improves the functioning of the signature extraction step and therefore the quality of the signature extraction step. Normalization consists of two processes: geometric and photometric.

1.6.1 Geometric Normalization

is necessary because the size of the face inside the acquired image may vary depending on the distance between the acquisition module and the person. The face must therefore be extracted from the image and a geometric transformation, to obtain a fixed size, is applied. The standard approach is to define the location of the eye centers in a constant position within the output image.

1.6.2 Photometric Normalization

Photometric normalization: attempts to eliminate or reduce the effects of the illumination of the image.

1.7 Facial Detection Applications

Face detection technology can be useful and necessary in a wide range of applications, including biometric identification, video conferencing, indexing of image and video databases, and intelligent human–computer interfaces. In this section we give a brief presentation of some of these applications

1.7.1 Face Recognition Systems

As mentioned earlier, face detection is most widely used as a preprocessor in face recognition systems. Face recognition is one of many possible approaches to biometric identification; thus many biometric systems are based on face recognition in combination with other biometric features such as voice or fingerprints. In BioID [14], a model-based face detection method based on edge information [15] is used as a preprocessor in a biometric systems which combines face, voice, and lip movement recognition. Other biometric systems using face detection include template-based methods in the CSIRO PC-Check system [16] and eigenface methods [17] [18] in FaceID from Visage Technologies.

1.7.2 Images and Videos

With the increasing amount of digital images available on the Internet and the use of digital video in databases, face detection has become an important part of many content based image retrieval (CBIR) systems. The neural network-based face detection system of Rowley et al [12]is used as a part of an image search engine for the World Wide Web in WebSeer [19].

The idea behind CBIR systems using face detection is that faces represent an important cue for image content; thus digital video libraries consisting of terabytes of video and audio information have also percieved the importance of face detection technology. One such example is the Informedia project [20]which provides search and retrieval of TV news and documentary broadcasts. Name-It [21]also processes news videos, but is focused on associating names with faces. Both systems use the face detection system of Rowley et al [12].

1.7.3 Video Conferencing Systems

In video conferencing systems, there is a need to automatically control the camera in such a way that the current speaker always has the focus. One simple approach to this is to guide the camera based on sound or simple cues such as motion and skin color. A more complex approach is taken by Wang et al [22],who propose an automatic video conferencing system consisting of multiple cameras, where decisions involving which camera to use are based on an estimate of the head's gazing angle. Human faces are detected using features derived from motion, contour geometry, color, and facial analysis. The gazing angle is computed based on the hairline (the border between an individuals hair and skin).

1.8 Conclusion

We presented in this chapter the basic concepts of facial detection as well as all the approaches used in the process and what was used, and after comparing the various approaches to detection later briefly presented the intermediate process between facial detection and facial recognition. Finally, we showed some applications based on facial detection technology.

This study has shown that face detection is a significant step in the facial recognition system. We highlighted the various methods involved in automatic facial detection, which allowed us to clearly identify the main features of the face (mouth, nose, eyes...). In the next section, we offer different facial recognition methods and techniques.

Chapter 2

Facial Recognition

2.1 Introduction

Facial recognition has become an imperative in the current era because it ensures the protection of individuals and institutions. Facial recognition-based security and protection systems are reliable compared to other password-based and other systems that can easily be penetrated, because facial recognition systems are based on the main part of the human face.

Facial recognition is the step that comes after facial detection in this section get into the Main facial recognition difficulties as well as the approach to improving facial recognition systems that are divided into three general gliding: Global, local and hybrid approaches.Finally, we mention some of the applications that work with these systems.

2.2 Definition Facial Recognition

Face recognition is a technique of identifying persons based on their faces, Since the sixties this technique has grown and has been widely applied to identify individuals and suspects in the largest security companies and government [23].

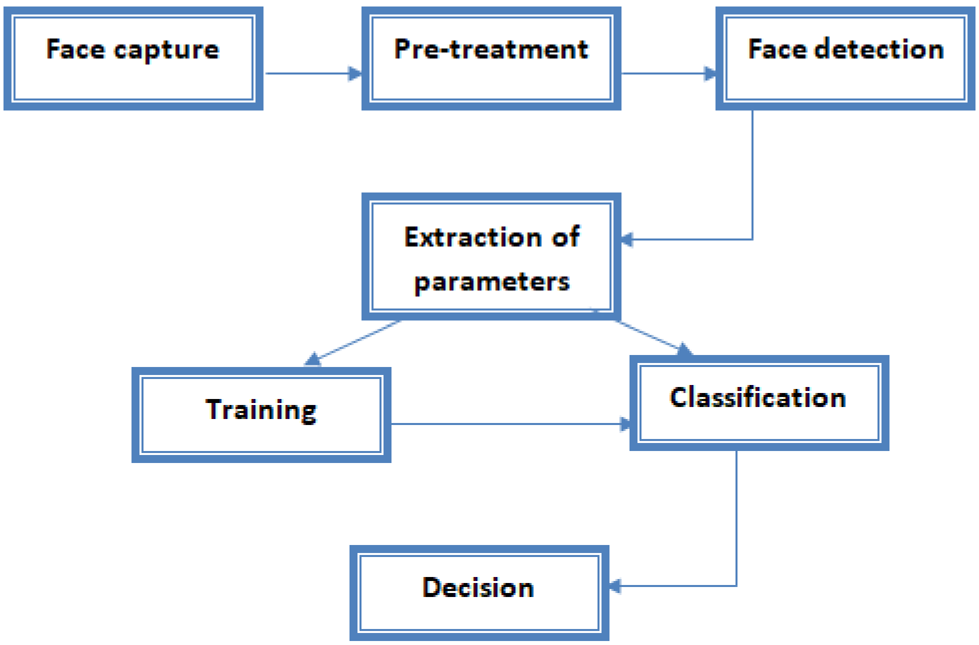

Figure 2.1: Representation of a facial recognition system

2.3 Main difficulties of face recognition

Facial recognition for the human brain is a high-level visual task. Although humans can easily detect and identify faces in the landscape, building an automatic system that performs these tasks is a major challenge. This challenge increases when conditions for acquisition of images are highly variable. There are two types of differences associated with facial images: Inter- and internal differences. Differences between subjects are limited by physical similarities between individuals.

However, the variation within the topic was broader. It can be attributed to several factors that we analyses below.

2.3.1 Change in illumination

The appearance of a face in an image varies greatly depending on the illumination of the scene during shooting Figure 2.2. Variations in lighting make the face recognition task very difficult. Indeed, the change in the appearance of a face due to illumination, is sometimes more critical than the physical difference between individuals, and can result in a poor classification of the input images. This was experimentally observed in Adini et al [24] where the authors used a database of 25 individuals. Facial identification in an uncontrolled environment therefore remains an open area of research.The evaluations revealed that the problem of variation of illumination is a major challenge for facial recognition.

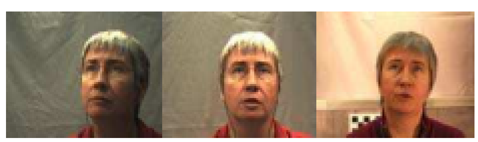

Figure 2.2: Example of lighting variation

2.3.2 Variation in Pose

The face recognition rate decreases considerably when variations in pose are present in the images. This difficulty has been demonstrated by evaluation tests developed on the FERET and FRVT bases [25] [26]. The variation in pose is considered a major problem for facial recognition systems. When the face is in profile in the image plane (orientation 30°), it can be normalized by detecting at least two facial features (passing through the eyes). However, when the rotation is greater than 30°, geometric normalization is no longer possible Figure 2.3.

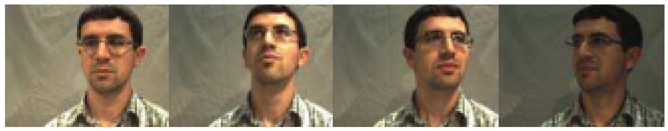

Figure 2.3: Example of Variation in Pose

2.3.3 Facial expressions

Another factor that affects the appearance of the face is facial expression Figure 2.4. The deformation of the face due to facial expressions is localized mainly on the lower part of the face. Facial information in the upper part of the face remains almost invariable. It is generally sufficient to make an identification. However, since facial expression changes the appearance of the face, it necessarily leads to a decrease in the recognition rate. The identification of face with facial expression is a difficult problem that is always topical and that remains unresolved. Temporal information provides additional knowledge which can be used to solve this problem [27].

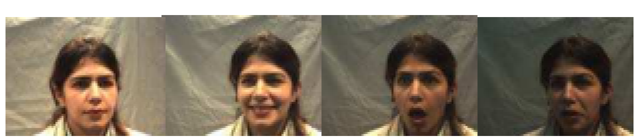

Figure 2.4: Example of facial expressions

2.3.4 Presence or absence of structural components

The presence of structural components such as beard, moustache, or glasses can dramatically alter facial features such as shape, color, or face size. In addition, these components can hide the basic facial features causing a failure of the recognition system. For example, opaque glasses do not make a clear distinction between the shape and color of the eyes, and a mustache or beard changes the shape of the face.

2.3.5 Partial occultations

The face can be partially masked by objects in the scene, or by the port accessories such as glasses, wrap... In the context of biometrics, the proposed systems must be non-intrusive, that is, they must not rely on active cooperation on the subject. Therefore, it is important to recognize partially hidden faces. Gross et al [27] studied the impact of wearing sunglasses, and the masking of the lower part of the face on facial recognition. They used the AR [28] database. Their experimental results suggest that under these conditions, the performance of the recognition algorithms remains low.

2.4 Facial Recognition Approaches

There are many facial recognition approaches and these have been classified into 3 categories according to Tan et al [29] we can devise or classify approaches to facial recognition into three large families that are:

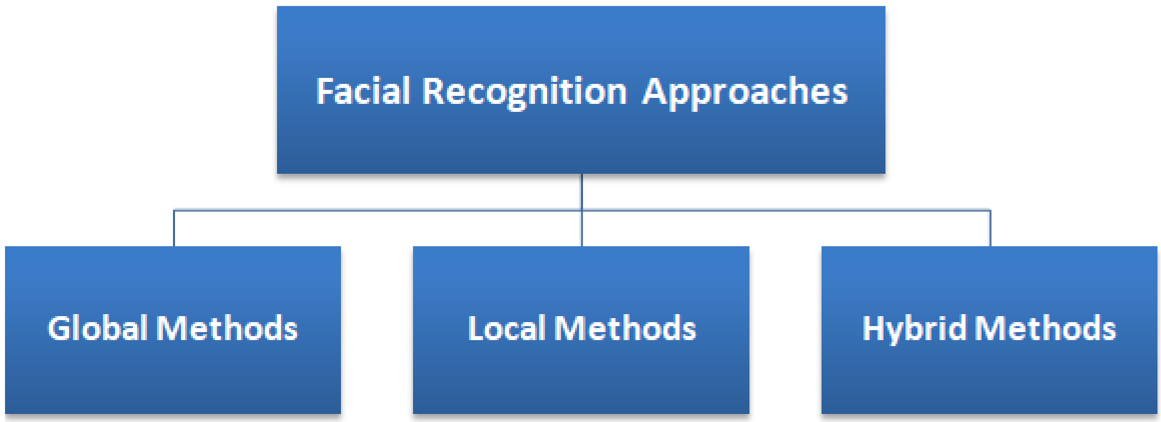

Figure 2.5: Facial Recognition Approaches

2.4.1 Global Methods (Holistic Methods)

And is called the holistic approach, The principle of this approach according to O'Toole et al [30] is to represent the image of the face by a single vector of large dimension n x m, in concatenating the gray levels of all the pixels of the face.The advantage of this representation is that it implicitly preserves the texture and shape information needed for face recognition. In addition, it allows a better capture of the overall aspect of the face than local representations [30] However, its major disadvantage lies in the very large size of the image space it requires, which makes classification very difficult.

Xiao guang Lu [31] distinguished two types of techniques among global methods, linear and non-linear techniques.

2.4.1.1 Principal Component Analysis (PCA)

Also called "Eigenfaces" a very popular method in the field of recognition proposed by Turk and pentland [10]. A mathematical method used to simplify and reduce the dimensions of a data set and to represent facial images that can be reconstructed from a standard face and a set of points.It is a matter of finding all the main components of face in an image set of faces.

The PCA is a simple, popular and fast technique, offers good results in the identification systems, as well as the projection is optimal for the reconstruction of a base of reduced size. The problems or rather the disadvantages of this technique are sensitivity to lighting problems, facial expression and pose.

In the next chapter, we will elaborate on this algorithm and how it works.

2.4.1.2 Latent Dirichlet Allocation (LDA)

It's also known as "Fisherfaces" Belhumeur et al []are the first ones who introduced this algorithm in 1997, it performs a class separation and to be able to use it it is necessary to organize a learning base of images in several classes, one class per person and several images per class.

This method is used effectively in many classification and dimension reduction. However, if the data are too large, it is not possible to apply this method directly to the images without first decreasing the size of the data. In this case, instead of using the image pixel value directly, a PCR is first applied to the data and it is the image representation in the face space that is used [32].

2.4.2 Local Methods

Local methods use local facial features for recognition face. They are relatively mature compared to holistic methods. In these methods, the face is represented by a set of characteristic vectors of small dimensions, rather than by a single vector of large size [33].The local approach can be divided into two categories:

- **Methods based on local features:** extractions and location of features points
- **Methods based on local appearances:** scores of facial images in the regions features

2.4.2.1 Methods based on local features

Features point extraction approaches can be subdivided into two categories: geometric approaches and graph-based approaches.

Geometric approach: This technique is based on extracting the relative position of the elements that make up the face (such as eyes, mouth and nose). Most engineering approaches use points of interest for these elements.This approach has some disadvantages in pure geometric, including:

- geometric characteristics are generally difficult to extract, especially in complex cases: variable illumination, occultations.
- geometric characteristics alone are not enough to represent a face

Graph-based approaches: It is a graphical representation of the local characteristics of the face, these techniques formulate the problem of facial recognition as a problem of mapping graphs, Man in 1992 [34] validated the effectiveness of this technique on a database of 86 images that contains variations of facial expressions and pose the result is represented by a recognition rate of 90% on average. [35]
Once the topological graph is built it cannot be changed, but the Entering facial images is variant in terms of changing expressions, posing, etc. To solve this problem several techniques have been developed such as: Elastic Graph-matching (EGM), Elastic Buch Graph Matching (EBGM), etc... [35]

2.4.2.2 Local appearance-based methods

These methods are based mainly on the different regions of the face, the overall model is defined from the combination of local models which does not influence the facial regions by the different variations, such as: the smile, the wearing of glasses... etc.

There are two parameters to define the local regions of the face: The Wheat and Size and characteristics of these local regions are determined using an analysis of the greyscale values. [36] and represents or preserves the information of texture.

2.4.3 Hybrid methods

Hybrid methods are approaches that combine holistic methods with local methods to improve facial recognition performance. In fact, local and global characteristics each have quite different characteristics. It is hoped that their integration can be used to improve classification.

Factors for change	**local feature**	**Global feature**
illumination	very sensitive	sensitive
expression	not sensitive	sensitive
Pose	sensitive	very sensitive
noise	very sensitive	very sensitive

Table 2.1: Comparison of methods based on local or global characteristics.

2.5 Facial Recognition Applications

Facial recognition technology has become a necessary technology in some applications. In fact, the use of this technology is not only in the computer science industry but can be provided in many applications useful to all types of industries, such as educational systems and law.

2.5.1 Security

Face recognition technology can be used as another form of authentication when attempting to access personal accounts. Whether that be personal computers, banking accounts, or even email accounts having an extra layer of security can be invaluable when a person's livelihood is on the line. Automated Teller Machines (ATMs) already have cameras installed to help prevent tampering. This camera can instead be used as a form of identification, only allowing the user to access their account if their face is in the system. Securing this data behind a biometric security system, such as face recognition, can be vital. Facial recognition is already being used as a form of access control. Jeffrey S. Coffin developed a security method that uses face recognition to identify individuals in order to determine their clearance access (Coffin, 1999). In the media,biometric security measures are generally boiled down to retinal scans, and finger print scans.Facial recognition is a very powerful biometric security system that can improve any access system [37].

2.5.2 Attendance Systems

The educational systems have some processes that can be improved by employing facial recognition technology. Taking attendance is an important part of class time to ensure that all students are present; however, the larger the class the more difficult and longer it takes to check.The problem is compounded in classes that fill entire auditoriums. These systems, though not used often, already exist.

Abhishek Jha developed an automated attendance system that can invaluable in the education industry [38]. This system can help cut down the amount of time needed in class by allowing the professor to jump straight into the material rather than waste time calling everyone's name one at a time. Many universities have already forgone the use of attendance because sometimes it just isn't feasible with the number of students they receive.By automating this process, the university can track which students are attending lectures.

2.5.3 Law Enforcement

Law Enforcement is another industry that can benefit from facial recognition software.One of the jobs required of policemen is tracking down criminals. Face recognition software can automate this process by automatically tracking these criminals without needing any manpower besides making the arrest. Cameras are set up all around the country, from traffic cameras, street cameras, to private security cameras. The law enforcement officials can feed their database of criminals into a facial recognition algorithm and use these cameras to track criminals all around the world. Writing speeding tickets is another job police officers bog their time down with.Sensors can be set up to check whether the car is going too fast. Then cameras can recognize the face and automatically send a speeding ticket. Setting up cameras and speeding sensors may not be very cost effective now; however, as technology progresses the cost of these things continue to lower. [37].

2.6 Face Image Databases

Data Set	**Location**	**Description**
MIT Database [10]	ftp://whitechapelmediamitedu/ pub/images/	Faces of 16 people, 27 of each person under various illumination conditions, scale and head orientation.
FEBET Database [39]	http://www.nist.gov/humanid /feret	A large collection of male and female faces Each image contains a single person with certain expression.
UMIST Database [40]	http://images.ee.umist.ac.uk/ danny/database.html	564 images of 20 subjects. Each subject covers a range of poses from profile to frontal views.
University of Bern Database	ftp://iamftp.unibesch/ pub/Images/Facelmages/	300 frontal face images of 30 people (10 images per person) and 150 profile face images (5 images per person).
Yale Database [41]	http://cvc.yale.edu	Rice images with expressions, glasses under different illumination conditions.
AT&T (Olivetti) Database [35]	http://www.uk.research.att.com	90 subjects, 10 images per subject.
Harvard Database [42]	ftp://ftp.hrl.harvard.edu/pub/ faces/	Cropped, masked face images under a wide range of lighting conditions.
M2VTS Database [43]	http://poseidon.csd.auth.gr/ M2VTS/index.html	A multimodal dat4vacP containing various image sequences.
Purdue AR Database [28]	http://rvILectpurdue.eduraleix/ aleixface DB.html	3,276 face images with different facial expressions and occlusions under different illuminations.

Table 2.2: Face Image Database.

2.7 Conclusion

In this chapter, we presented facial recognition and our most important difficulties in facial recognition and then we presented different approaches to facial recognition, and then we introduced some applications that use facial recognition and some databases that provide some facial images.

In the next chapter, we will present the algorithms Principal Component Analysis (PCA) and Discrete Cosine Transform (DCT) as well as explain the steps of their work as well as the method of calculating Euclidean distance.

Chapter 3

Classification and Extraction of parameters

3.1 Introduction

In facial recognition we need to extract facial features and compare them to facial features found in databases using custom algorithms. In this chapter, we will present the two algorithms that we will use to extract and classify properties, as well as how they work mathematically, as well as the method of calculating Euclidean distances.

3.2 Principal Component Analysis

3.2.1 Definition

The function of facial recognition is to distinguish image data from several categories (i.e. persons). These data are quite disturbing (e.g. noise from different lighting), the input images are not completely random and despite their differences there are patterns that occur in any input signal. These patterns which can be observed in all signals, can be in the field of facial recognition. The presence of certain elements (eyes, nose or mouth) in any face as well as the relative distances between these objects. These characteristics are called eigenface in facial recognition. They can be extracted from the original image data by a mathematical tool called principal component analysis (PCA).

The idea of using principal components to represent human faces was developed by Sirovich and Kirby [44] in 1987, and was used by Turk and Pentland [10] in 1991 for facial detection and recognition.The eigenface approach is considered by many to be the first practical facial recognition technology, and has served as the basis for many facial recognition technology products. Since its initial development and dissemination, there have been many extensions of the original method and many new methods.

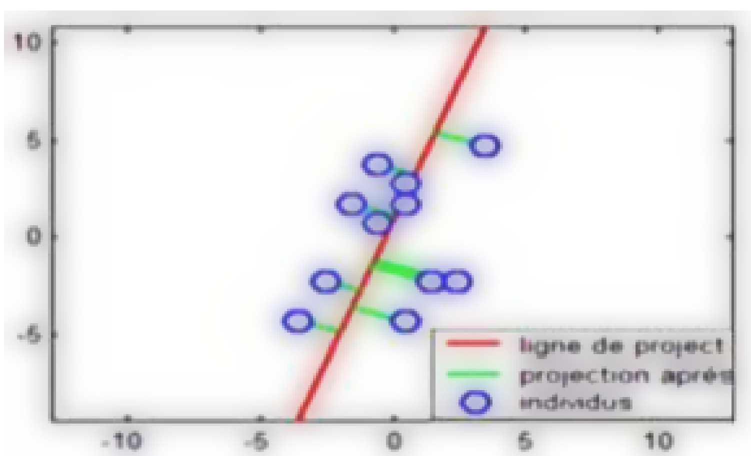

Figure 3.1: Example of projection following PCA .

3.2.2 PCA Algorithm

The steps of the eigenfaces calculation are :

3.2.2.1 Prepare the data

A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image × columns of image) representing a set of sampled images. Then the training set becomes: Γ1, Γ2, Γ3.....ΓM.

3.2.2.2 Subtract the mean

The average matrix Ψ has to be calculated, then subtracted from the original faces (Γi) and the result stored in the variable Φi:

$$\Psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n \tag{3.1}$$

$$\Phi_i = \Gamma_i - \Psi \tag{3.2}$$

3.2.2.3 Calculate the co-variance matrix

In the next step the covariance matrix A is calculated according to:

$$A = \Phi^T\Phi \tag{3.3}$$

3.2.2.4 Calculate the eigenvectors and eigenvalues

In this step, the eigenvectors (eigenvectors) Xi and the corresponding eigenvalues λi should be calculated.

3.2.2.5 Calculate eigenfaces

$$[\Phi]X_i = f_i \tag{3.4}$$

where X_i are eigenvectors and f_i are eigenfaces

3.2.2.6 Classifying the faces

The new image is transformed into its eigenface components. The resulting weights form the weight vector Ω_{new}^T :

$$\omega\kappa = \Omega k T \Gamma_{new} - \Psi \quad \text{and} \quad k = 1.2.3....M \tag{3.5}$$

$$\Omega_{new}^T = [\omega_1 \omega_2 \omega_3 .... \omega_M] \tag{3.6}$$

The Euclidean distance [13-19] between two weight vectors d(Ωi,Ωj) provides a measure of similarity between the corresponding images i & j. If the Euclidean distance between Γ_{new} and other faces exceeds some threshold value θ, one can assume that Γ_{new} is not a face at all, d(Ωi,Ωj) also allows one to construct "clusters" of faces such that similar faces are assigned to one cluster [45]

3.2.3 Distance Measures

When comparing two characteristic vectors from the Biometric Feature Extraction Module, either a similarity (resemblance) or a distance (divergence) measurement can be performed. The first category of distances consists of Euclidean distances and are defined from the distance of Minkowski of order p in an Euclidean space RN (N determining the dimension of the Euclidean space) [46].

Consider two vectors $X = (x_1, x_2, ..., x_n)$ et $Y = (y_1, y_2, ..., y_n)$, the distance of Minkowski of order p noted L_p is defined by:

$$L_p = \left(\sum_{i=1}^{n} |x_i - y_i|^p \right)^{1/p} \tag{3.7}$$

3.2.3.1 Euclidean distances:

- Distance City Block (L1) Pour p = 1, on obtient la distance City-Block (ou distance de Manhattan) :

$$L_1(x, y) = \sum_{i=1}^{n} |x_i - y_i| \tag{3.8}$$

- Euclidean distances (L2) For p = 2, the Euclidean distance is obtained:

$$L_2(x, y) = \sqrt{\sum_{i=1}^{n} |x_i - y_i|^2} \tag{3.9}$$

The objects can then appear in very different ways depending on the distance measurement chosen.

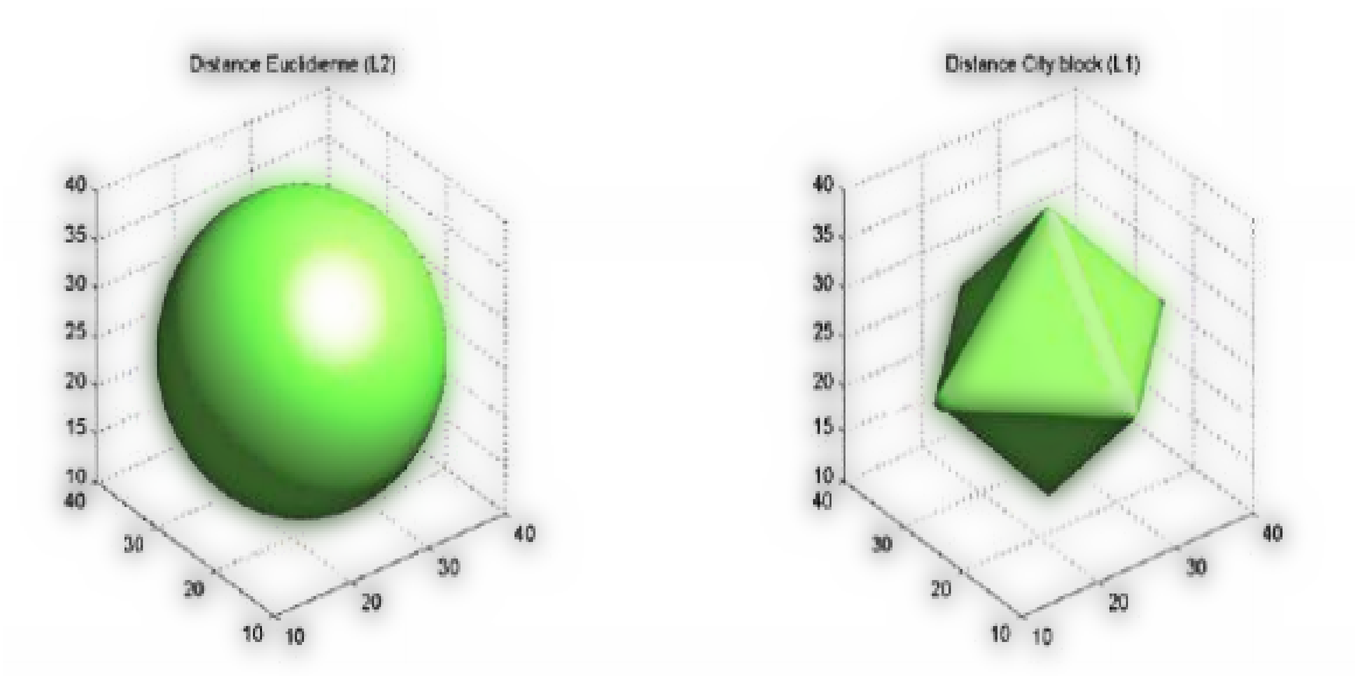

Figure 3.2: Representation of a sphere with the Euclidean distance and the City-Block distance [46]

3.3 Discrete Cosine Transform

3.3.1 Definition

DCT is a technique which owes a great part of its popularity with the field of image and video compression. It was used by Ahmed et al. in 1974 to transform an image signal from a space representation into a frequential representation. In 1992, the first international standard for the compression of images, JPEG, was established. It used a coder-decoder containing DCT for encoding and decoding images. The use of DCT in face recognition field is one of the most recent methods. It uses the discrete transformation into a cosine to eliminate the redundancies in an image and extract from them the most significant elements (i.e. coefficients) in order to use them for recognition [47].

3.3.2 Discrete Cosine Transform Encoding

3.3.2.1 The One-Dimensional DCT

The general equation for a 1D (N data items) DCT is defined as follows:

$$F(u) = \alpha(u) \sum_{i=0}^{N-1} A(x) * \cos\left(\frac{u(2x+1)\Pi}{2N}\right) \tag{3.10}$$

for u = 0,1,2,....,N-1 . Similarly, the inverse transformation is defined as

$$A(x) = \sum_{u=0}^{N-1} \alpha(u) F(u) \cos\left(\frac{u(2x+1)\Pi}{2N}\right) \tag{3.11}$$

for x = 0,1,2,....,N-1 . In both equations Equation 3.10 and Equation 3.11 $\alpha(u)$ is defined as

$$\alpha(u) = \begin{cases} \sqrt{\frac{1}{N}} & \text{for} \quad u = 0 \\ \sqrt{\frac{2}{N}} & \text{for} \quad u \neq 0 \end{cases} \tag{3.12}$$

It is clear from Equation 3.10 that for u = 0

$$F(u=0) = \sqrt{\frac{1}{N}} \sum_{x=0}^{N-1} A(x) \tag{3.13}$$

the first transform coefficient is the average value of the sample sequence. In literature, this value is referred to as the DC Coefficient. All other transform coefficients are called the AC $Coefficients$[4].

The plot of $\sum_{x=0}^{N-1} \cos\left(\frac{u(2x+1)\Pi}{2N}\right)$ for N = 8 and varying values of u is shown in Figure Figure 3.3. In accordance with our previous observation, the first the top-left waveform (u = 0) renders a constant (DC) value, whereas, all other waveforms (u = 1,2,...,7) give waveforms at progressively increasing frequencies [48].

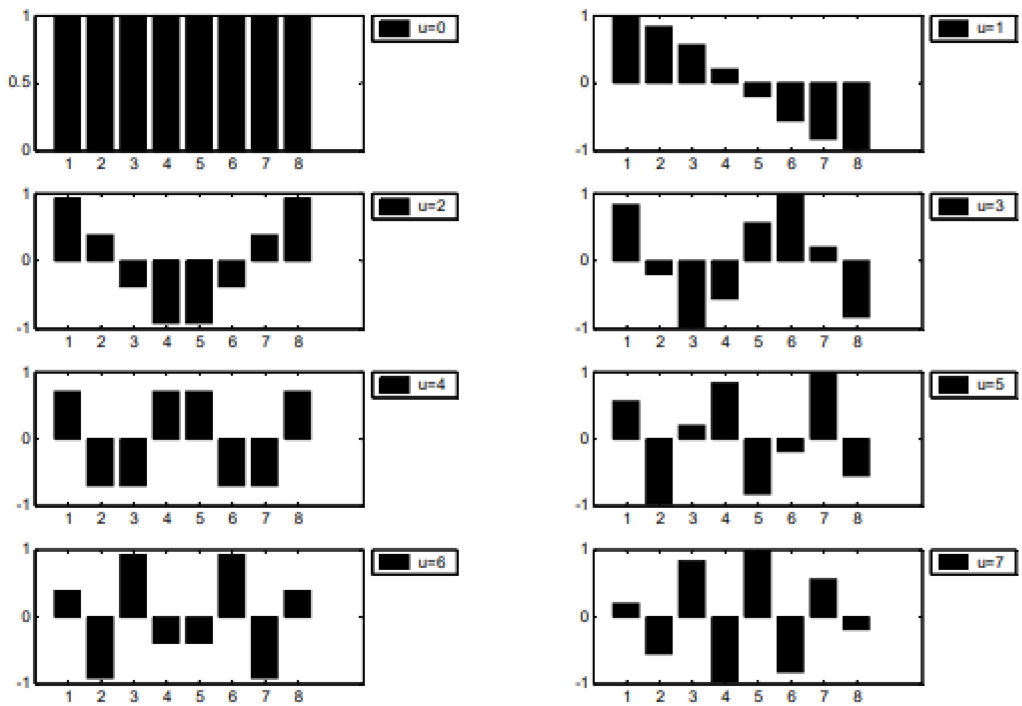

Figure 3.3: One dimensional cosine basis function (N=8).

3.3.2.2 The Two-Dimensional DCT

The objective is study the efficacy of DCT on images. This necessitates the extension of ideas presented in the last section to a two-dimensional space. The

2-D DCT is a direct extension of the 1-D case and is given by

$$F(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} A(x,y)\cos\left(\frac{u(2x+1)\Pi}{2N}\right)\cos\left(\frac{v(2y+1)\Pi}{2N}\right) \quad (3.14)$$

for u ,v = 0,1,2,...,N-1 and $\alpha(u)$, $\alpha(v)$ are defined in Equation 3.12. The inverse transform is defined as

$$A(x,y) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} \alpha(u)\alpha(v)F(u,v)\cos\left(\frac{u(2x+1)\Pi}{2N}\right)\cos\left(\frac{v(2y+1)\Pi}{2N}\right) \quad (3.15)$$

for x,y = 0,1,2,...,N-1

The 2-D basis functions can be generated by multiplying the horizontally oriented 1-D basis functions (shown in Figure 3.4) with vertically oriented set of the same functions [48]. The basis functions for N = 8 are shown in. Again, it can be noted that the basis functions exhibit a progressive increase in frequency both in the vertical and horizontal direction. The top left basis function of results from multiplication of the DC component in Figure 3 with its transpose. Hence, this function assumes a constant value and is referred to as the DC coefficient.

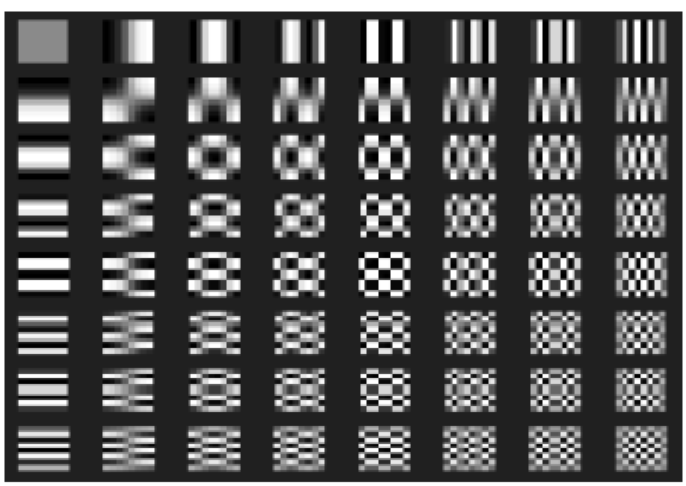

Figure 3.4: Two dimensional DCT basis functions (N = 8). Neutral gray represents zero,white represents positive amplitudes, and black represents negative amplitude [48]

3.3.3 Properties of DCT

In the previous section, it established a mathematical basis for DCT. However, the intuitive view of the image processing application was not presented. We outline (with examples) some of the characteristics of The DCT that are particularly valuable in image processing applications.

3.3.3.1 Decorrelation

The principle advantage of image transformation is the removal of redundancy between neighboring pixels. This leads to uncorrelated transform coefficients which can be encoded independently. The normalized autocorrelation of the images before and after DCT is shown in Figure Figure 3.5. Clearly, the amplitude of the autocorrelation after the DCT operation is very small at all lags. Hence, it can be inferred that DCT exhibits excellent decorrelation properties.

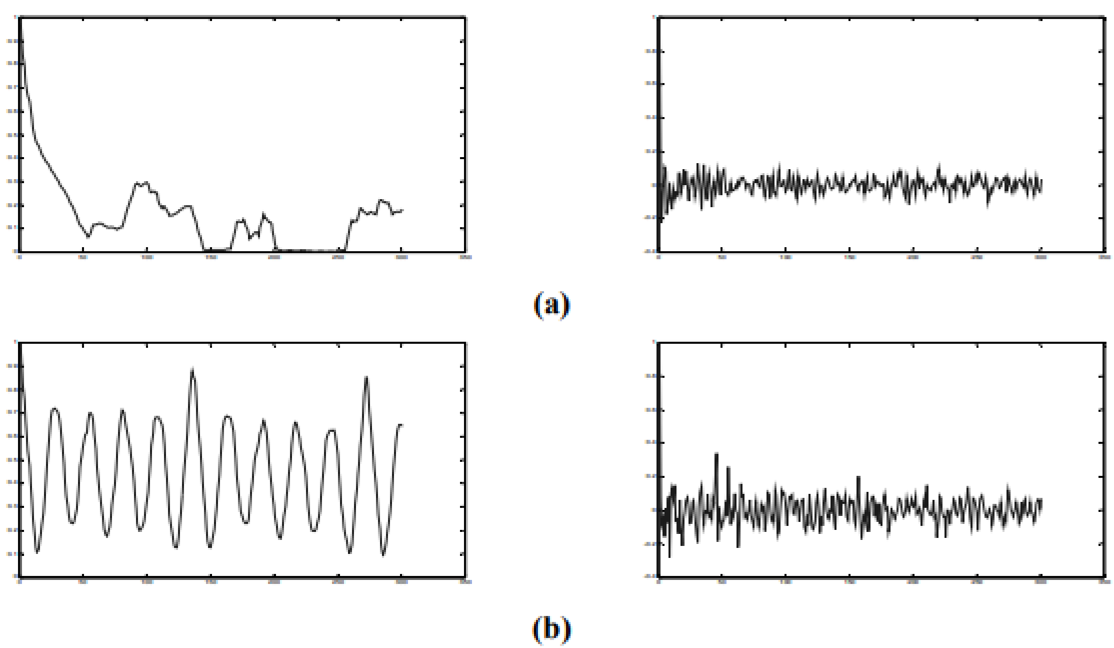

Figure 3.5: (a) Normalized autocorrelation of uncorrelated image before and after DCT- (b) Normalized autocorrelation of correlated image before and after DCT.

3.3.3.2 Energy Compaction

Efficacy of a transformation scheme can be directly gauged by its ability to pack input data into as few coefficients as possible. This allows the quantizer to discard coefficients with relatively small amplitudes without introducing visual distortion in the reconstructed image. DCT exhibits excellent energy compaction for highly correlated images.

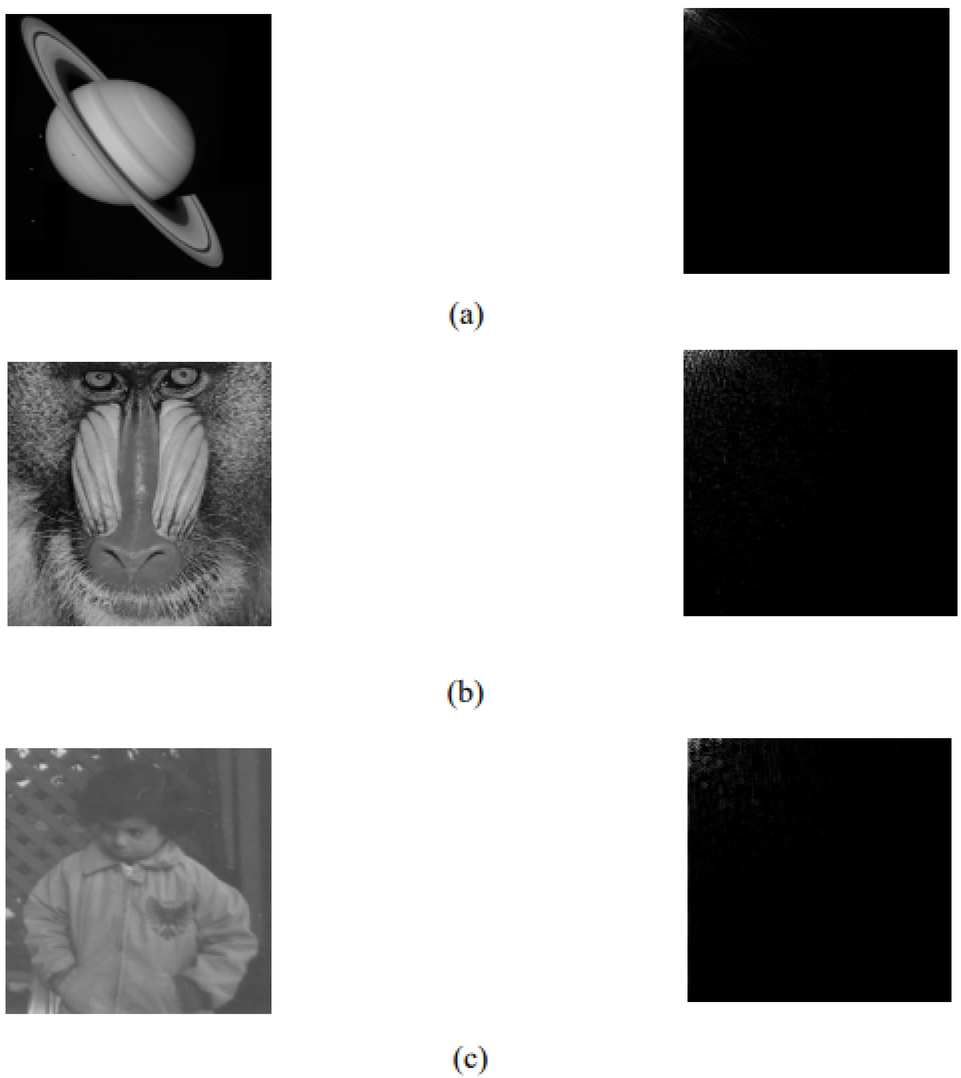

Figure 3.6: (a) Saturn and its DCT-(b)Baboon and its DCT-(c)Child and its DCT

The application of the DCT to these images provides very good energy compaction in the low-frequency region of the transformed image. Therefore, from the previous images, it can be noted that the DCT makes an excellent energy compaction for correlated images.

3.3.3.3 Separability

The DCT transform equation Equation 3.14 can be expressed as

$$F(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\cos\left(\frac{u(2x+1)\Pi}{2N}\right)\sum_{y=0}^{N-1}A(x,y)\cos\left(\frac{v(2y+1)\Pi}{2N}\right) \quad (3.16)$$

for u ,v =0,1,2,...,N-1.

This property, known as separability, has the principle advantage that C(u, v) can be computed in two steps by successive 1-D operations on rows and columns of an image. This idea is graphically illustrated in Figure Figure 3.7. The arguments presented can be identically applied for the inverse DCT computation [49].

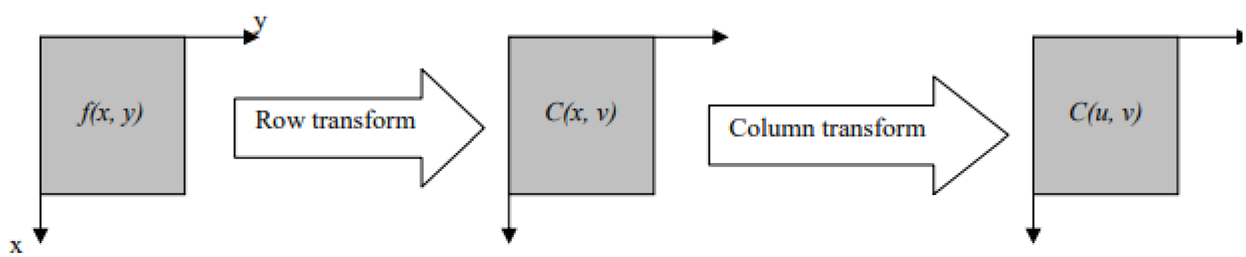

Figure 3.7: Computation of 2-D DCT using separability property

3.3.3.4 Symmetry

Another look at the row and column operations in Equation page 51 reveals that these operations are functionally identical. Such a transformation is called a symmetric transformation. A separable and symmetric transform can be expressed in the form [50].

$$T = kfk \quad (3.17)$$

where k is an N*N symmetric transformation matrix with entries a(i,j) , given by:

$$a(i,j) = \alpha(j) \sum_{j=0}^{N-1} \cos\left(\frac{i(2x+1)\Pi}{2N}\right) \tag{3.18}$$

and f is the N*N image matrix. This is an extremely useful property since it implies that the transformation matrix can be pre-computed offline and then applied to the image thereby providing orders of magnitude improvement in computation efficiency.

3.3.3.5 Orthogonality

In order to extend ideas presented in the preceding section, let us denote the inverse transformation of Equation 3.17 as :

$$T = k^{-1} f k^{-1} \tag{3.19}$$

As discussed previously, DCT basis functions are orthogonal. Thus, the inverse transformation matrix of k is equal to its transpose i.e. $k^{-1} = k^T$.Therefore, and in addition to its decorrelation characteristics, this property renders some reduction in the pre-computation complexity.

3.3.4 DCT versus DFT and KLT

DCT = Discrete Cosine Transform

DFT = Discrete Fourier Transform

KLT = Kamunen-Loeve Transform

At this point it is important to mention the superiority of DCT over other image transforms. More specifically, we compare DCT with two linear transforms: 1) The Karenina-Loeve Transform (KLT). 2) Discrete Fourier Transform (DFT).

The KLT is a linear transform where the basis functions are taken from the statistical properties of the image data, and can thus be adaptive. It is optimal in the sense of energy compaction, i.e., it places as much energy as possible in as few coefficients as possible. However, the KLT transformation kernel is generally not separable, and thus the full matrix multiplication must be performed. In other words, KLT is data dependent and, therefore, without a fast (FFT-like) pre-computation transform. Derivation of the respective basis for each image sub-block requires unreasonable computational resources. Although, some fast KLT algorithms have been suggested, nevertheless the overall complexity of KLT is significantly higher than the respective DCT and DFT algorithms.

In accordance with the readers' background, familiarity with Discrete Fourier Transform (DFT) has been assumed throughout this document. The DFT transformation kernel is linear, separable and symmetric. Hence, like DCT, it has fixed basis images and fast implementations are possible. It also exhibits good decorrelation and energy compaction characteristics. However, the DFT is a complex transform and therefore stipulates that both image magnitude and phase information be encoded. In addition, studies have shown that DCT provides better energy compaction than DFT for most natural images. Furthermore, the implicit periodicity of DFT gives rise to boundary discontinuties that result in significant high-frequency content. After quantization, Gibbs Phenomeneon causes the boundary points to take on erraneous values.

3.4 Conclusion

And in the penultimate chapter, we showed the two most popular algorithms used in facial recognition, where their most important characteristics were highlighted.

So we defined PCA algorithm and detailed its algorithm steps as well as the method of calculating Euclidean distances. , and then we defined the DCT algorithm and introduced its mathematical method in one-dimensional and two-dimensional, and we also highlighted the most important characteristics of the DCT and compared it to the DFT and KLT.

Chapter 4

Conception and Implementation

4.1 Introduction

In this last chapter, we will look at the application aspect of what we talked about in the previous chapters, where we will show the working environment, the techniques used, the interactive interfaces of the application shown in the web system, as well as the conception of the application, as well as the functions used in the background of the application.

4.2 Work Environment

we will present the hardware and software environments of our work.

4.2.1 Hardware Environment

We used a computer which has the following characteristics:

- **Type:** Lenovo G510
- **Processor:** Intel(R) Core(TM) i5-4200M CPU @ 2.50GHz 2.50 GHz
- **RAM:** 8.00 Go
- **Hard Drive:** 500 Go
- **System Type:** Microsoft Windows 10

4.2.2 Software Environment

We implemented the application in Python language under the Visual studio code environment

4.2.2.1 Python(Django)

Python : is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse.
Django : is a Python-based free and open-source web framework that follows the model template views (MTV) architectural pattern.

4.2.2.2 Visual Studio Code

Visual Studio Code is a freeware source-code editor made by Microsoft for Windows, Linux and mac-OS. Features include support for debugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and embedded Git. Users can change the theme, keyboard shortcuts, preferences, and install extensions that add additional functionality.

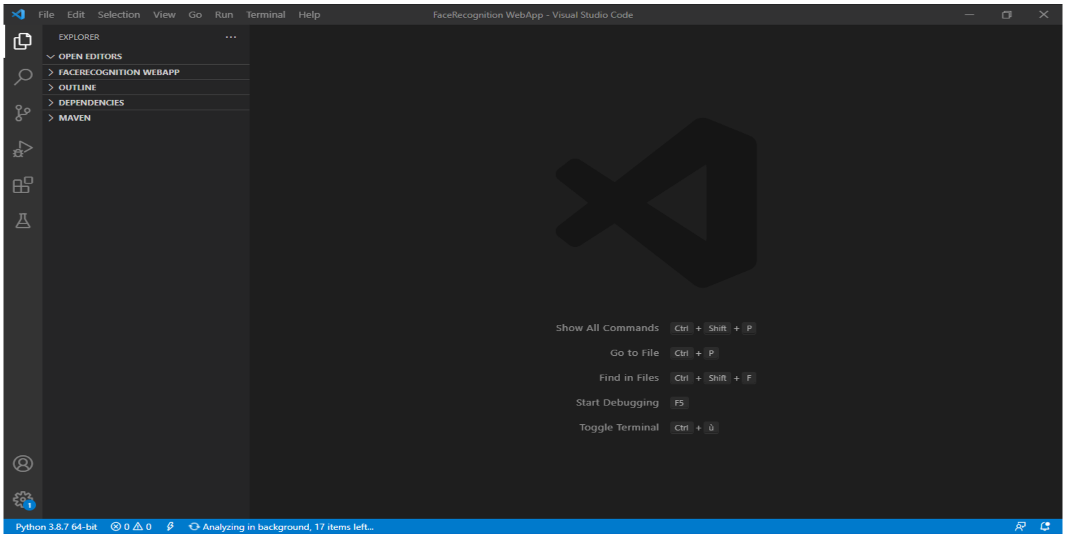

Figure 4.1: Visual Studio Code Environment

4.2.2.3 OpenCV

OpenCV (Open Source Computer Vision Library) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then Itseez (which was later acquired by Intel). The library is cross-platform and free for use under the open-source Apache 2 License. Starting with 2011, OpenCV features GPU acceleration for real-time operations.

Figure 4.2: OpenCV Environment

4.2.2.4 MySQL

MySQL is an open-source relational database management system (RDBMS). Its name is a combination of "My", the name of co-founder Michael Widenius's daughter, and "SQL", the abbreviation for Structured Query Language. A relational database organizes data into one or more data tables in which data types may be related to each other; these relations help structure the data. SQL is a language programmers use to create, modify and extract data from the relational database, as well as control user access to the database. In addition to relational databases and SQL, an RDBMS like MySQL works with an operating system to implement a relational database in a computer's storage system, manages users, allows for network access and facilitates testing database integrity and creation of backups.

Figure 4.3: MySQL Database

4.3 Conception of the application

4.3.1 System Use Cases

4.3.1.1 Classes Diagram

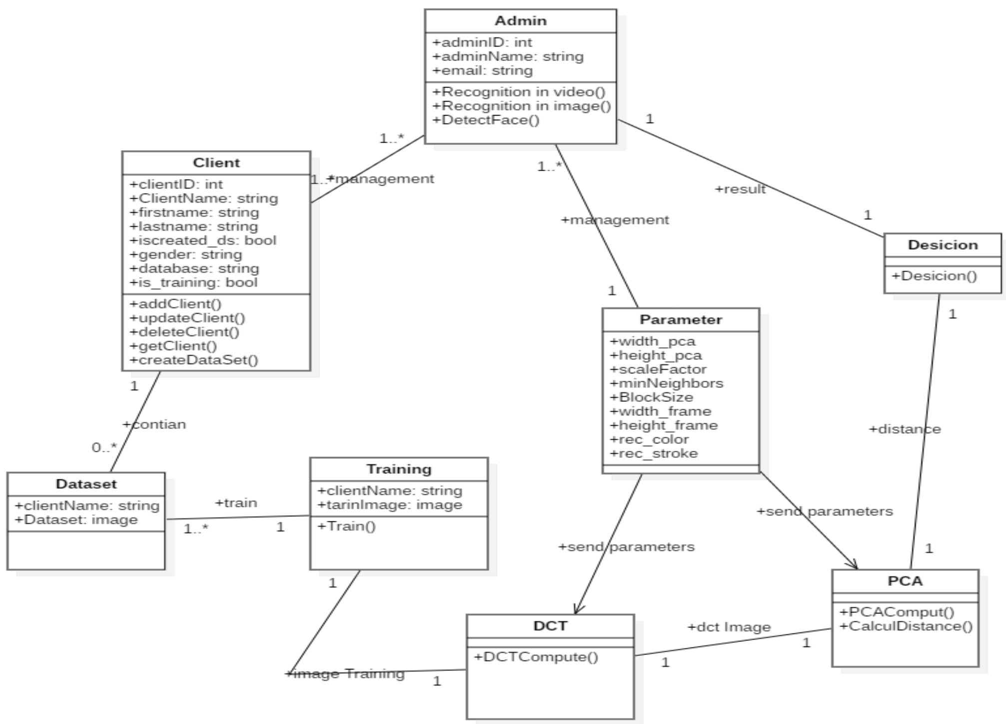

Figure 4.4: classes diagram for application

4.3.1.2 Recording

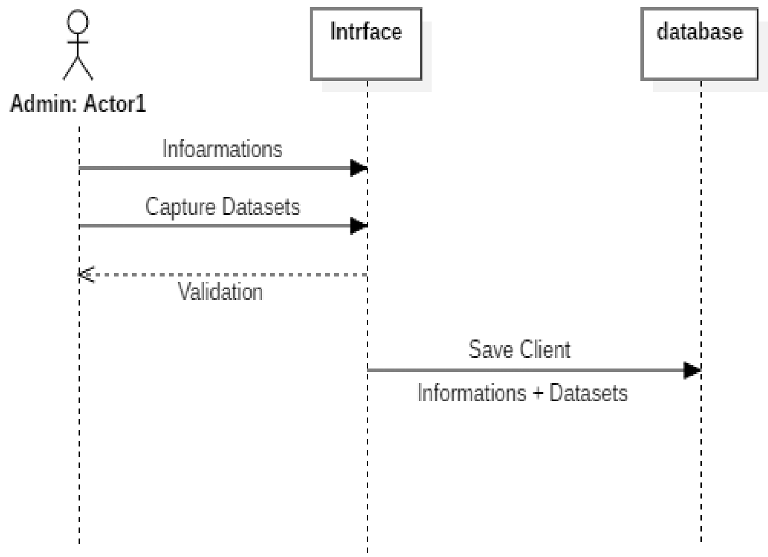

Figure 4.5: sequence diagram for registration of a client in the database

4.3.1.3 Training

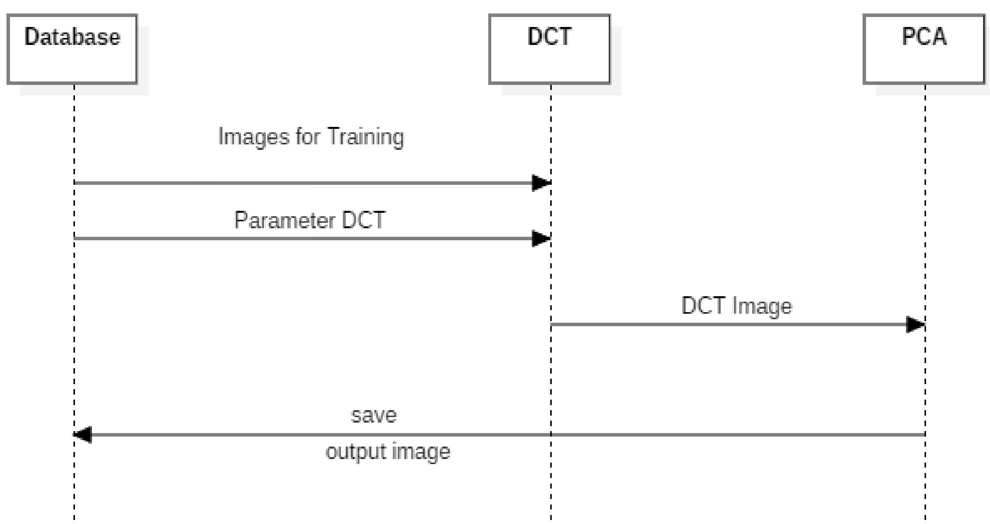

Figure 4.6: Sequence Diagram For Training

4.3.1.4 Recognition

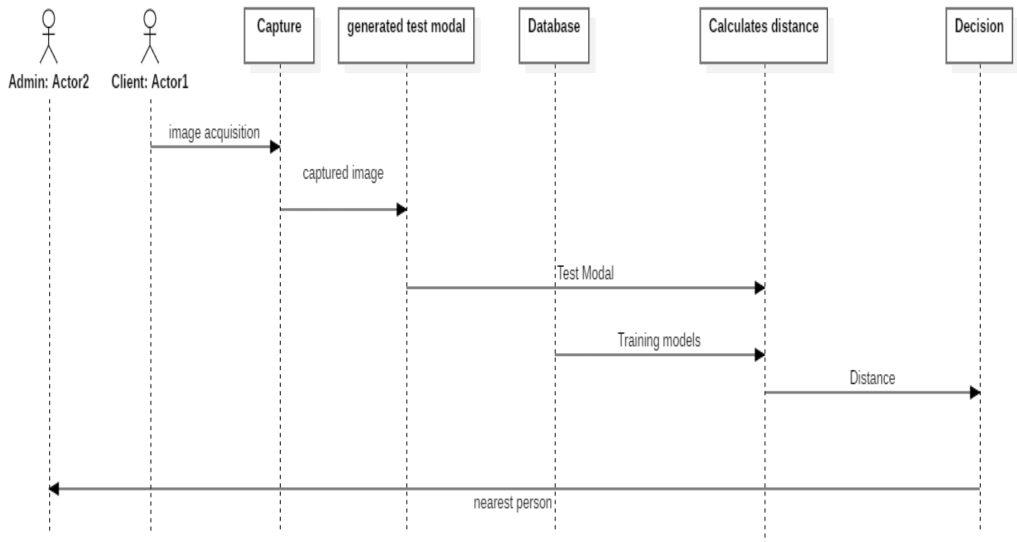

Figure 4.7: Sequence Diagram For Recognition

4.4 data structure and Implementation

4.4.0.1 Detection and Recognition

Methods

- **Recognition_Video:** For facial recognition in a video
- **Recognition_image:** For facial recognition in pictures
- **Detect_face:** For facial detection in the video
- **unFlatten:**
- **dist:** For the calculation of distance

4.4.0.2 Clients and Training

Methods

- **addClient:** To add a new client
- **Clients_list:** For the presentation of all clients
- **Client_profile:** To display all client information and datasets
- **Client_delete:** For client deletion
- **Client_edit:** To modify client information
- **create_dataset:** To take pictures of the client's face by camera.
- **upload_dataset:** To upload client face images from the device
- **Train:** To train the client's face images in one image

4.5 Presentation of the application

In this part, we're going to explain our application, most of its pages, and how the facial recognition technology that we explained in the past works.

4.5.0.1 Home Page

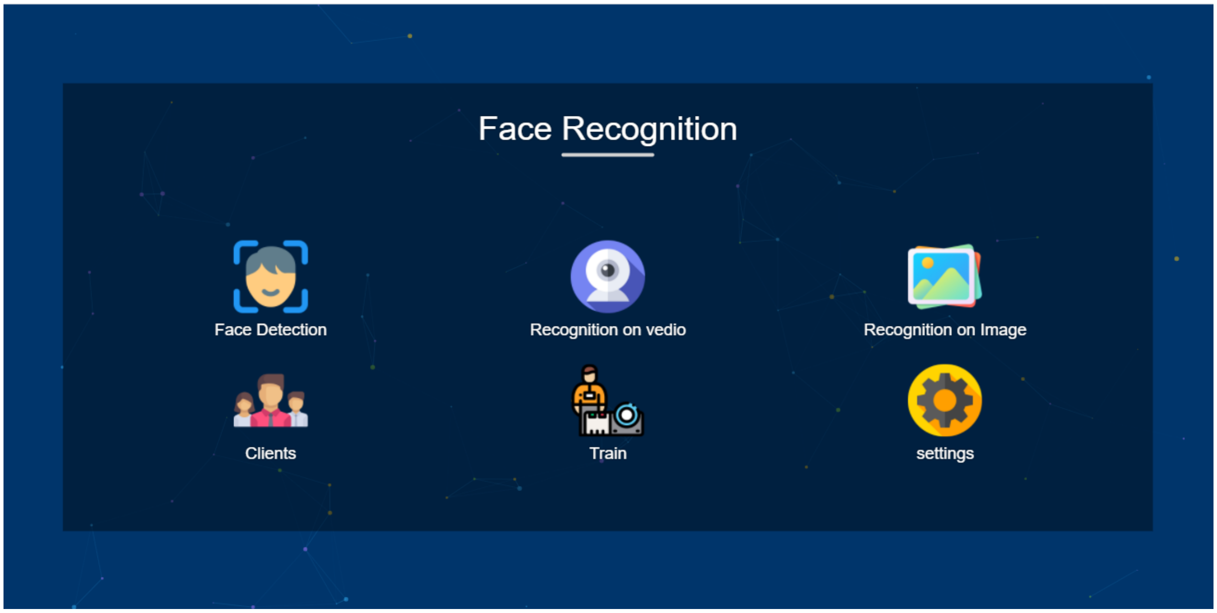

Figure 4.8: Application Homepage

On this page we find the main tasks of the application:

- **Face Detection :** Page containing facial detection in an image or video.
- **Recognition on video :** A page containing facial recognition from a video source.
- **Recognition on Image :** Page containing facial recognition in an image.
- **Clients :** Page containing client list.
- **Train :** Page containing the process of training client facial images.
- **Settings :** Page containing application settings.

4.5.0.2 Face Detection Page

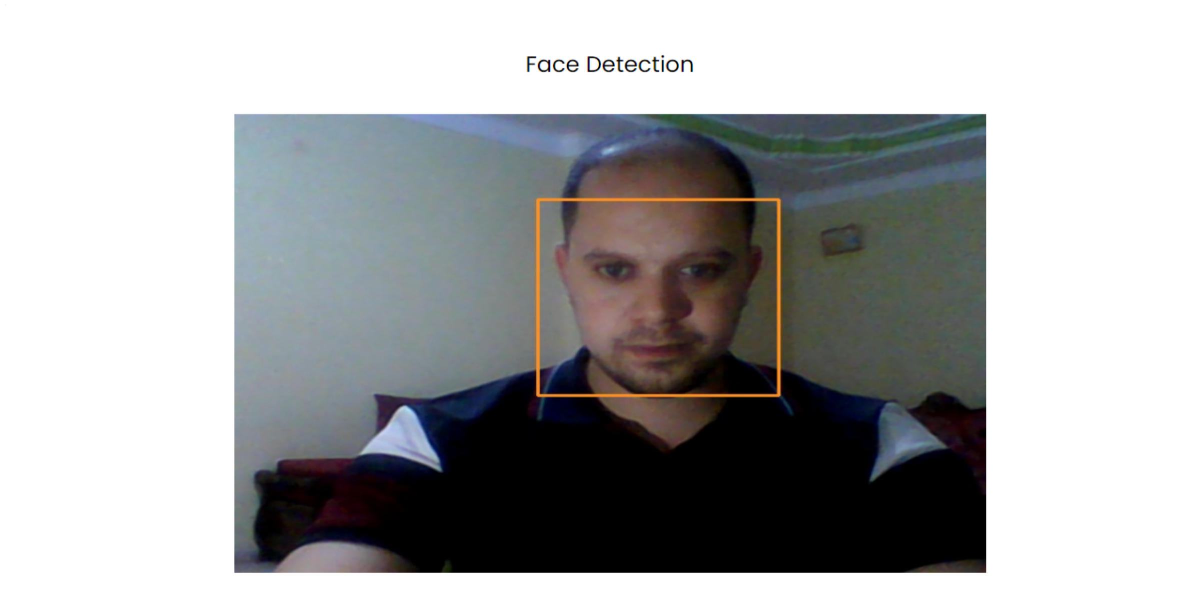

Figure 4.9: Face Detection Page

4.5.0.3 Recognition in Video Page

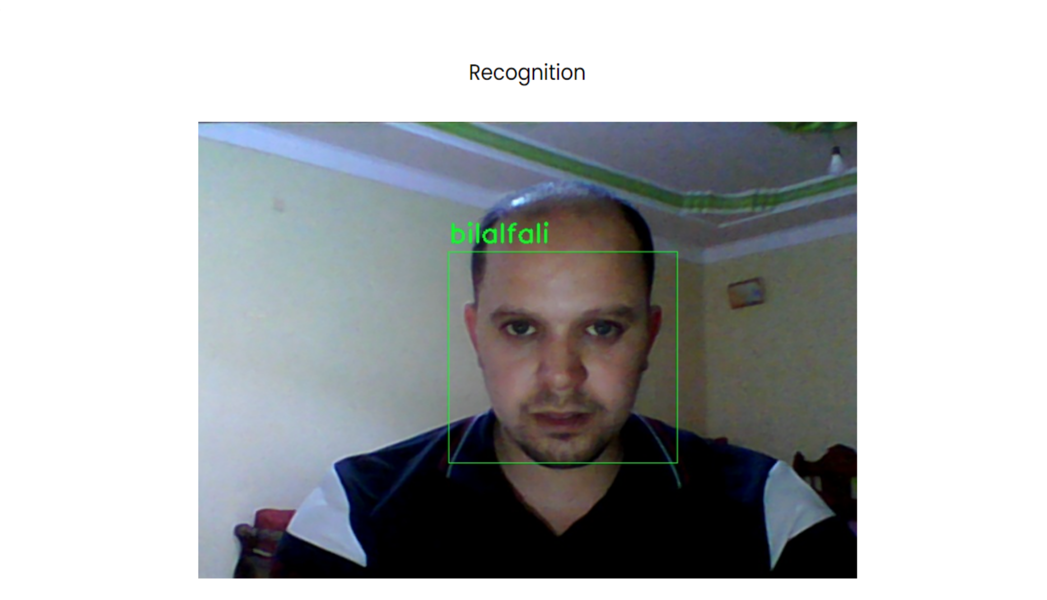

Figure 4.10: Example Recognition in Video

4.5.0.4 Recognition in Image Page

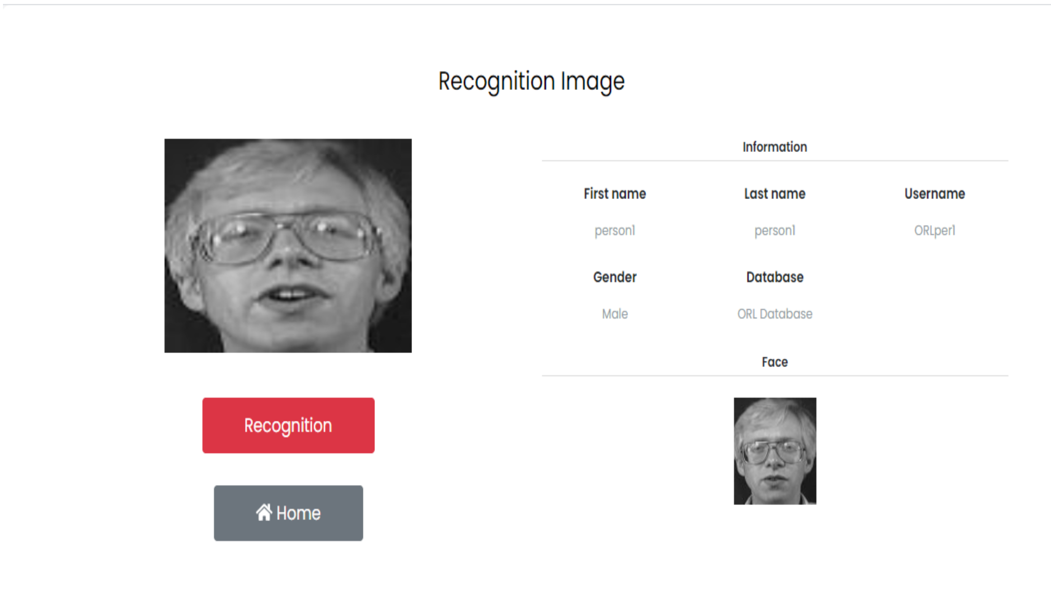

Figure 4.11: Example Recognition in Image

4.5.0.5 Clients Side

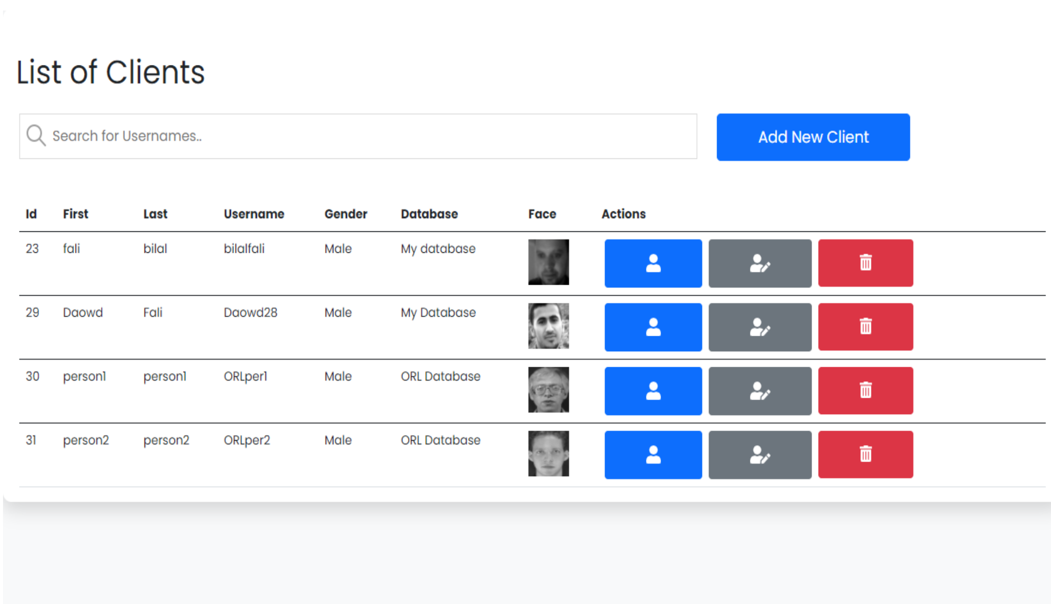

Figure 4.12: Clients Page

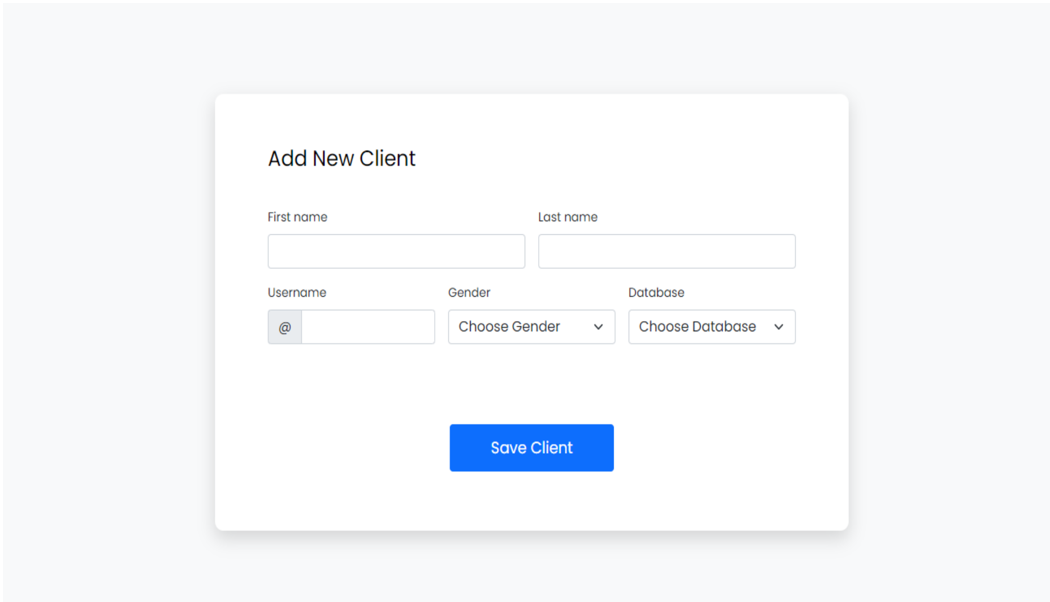

Figure 4.13: Add New Client Page

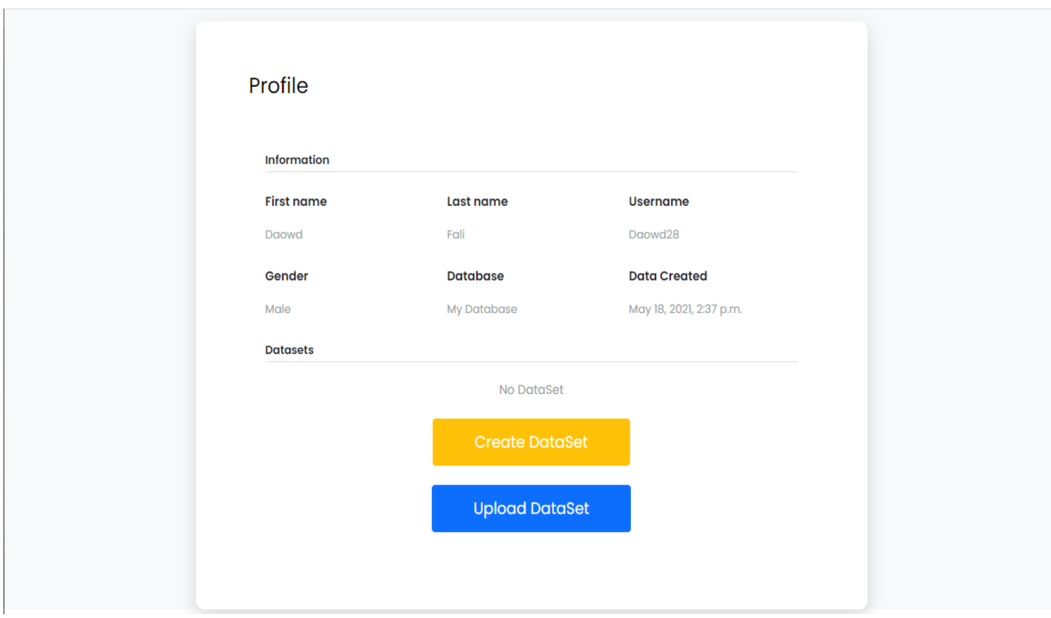

Figure 4.14: Client Profile Page Without Datasets

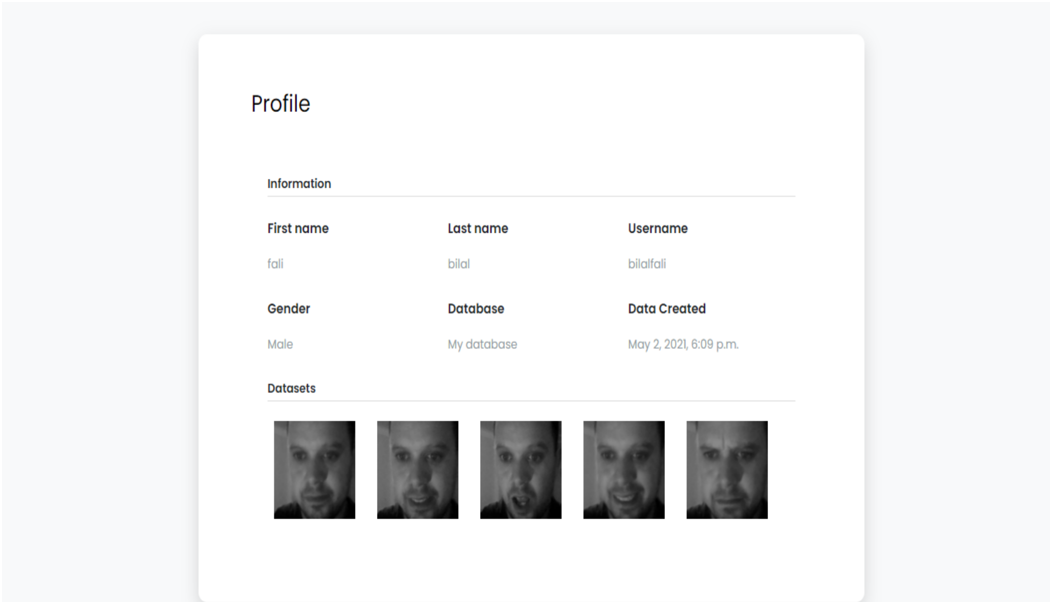

Figure 4.15: Client Profile Page

4.5.0.6 Training Page

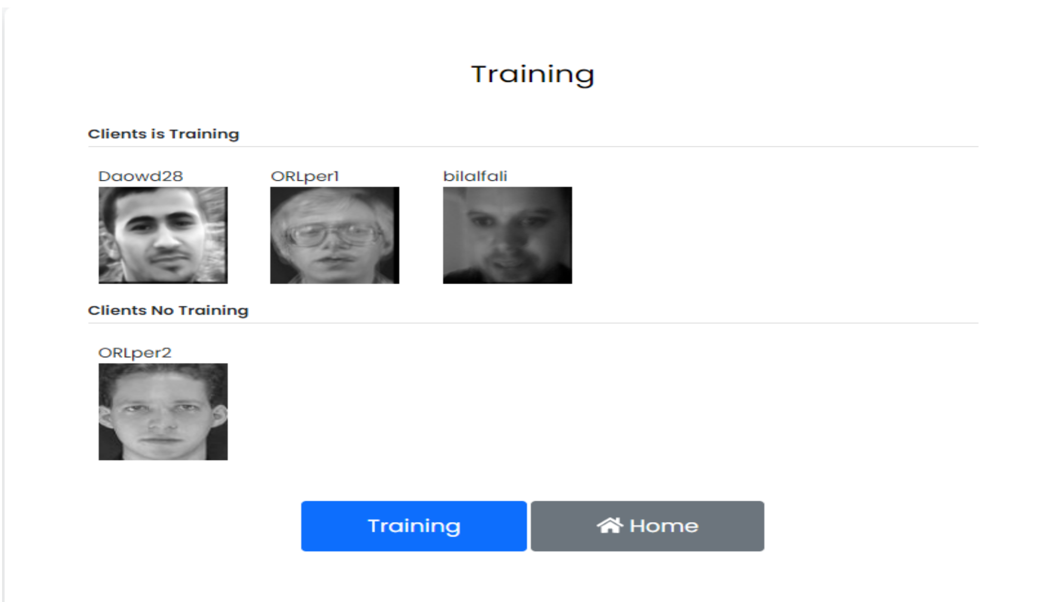

Figure 4.16: Training Page

4.5.0.7 Settings Page

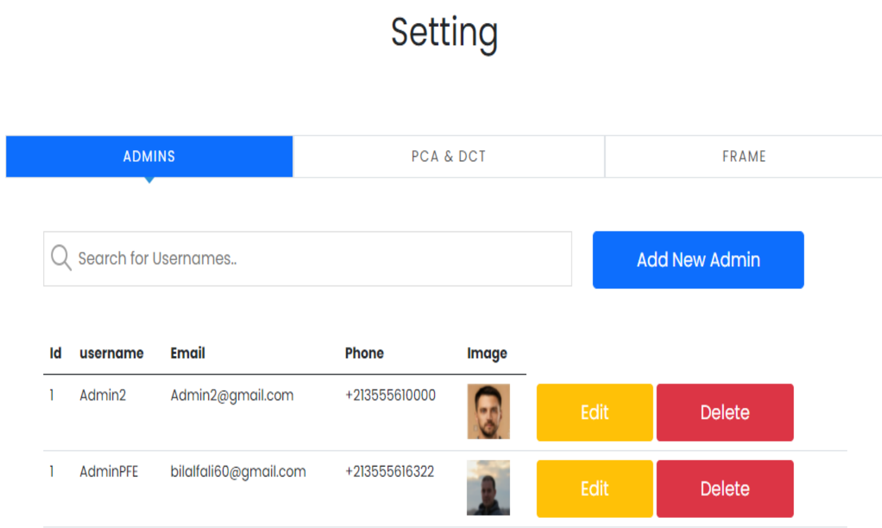

Figure 4.17: Settings Page

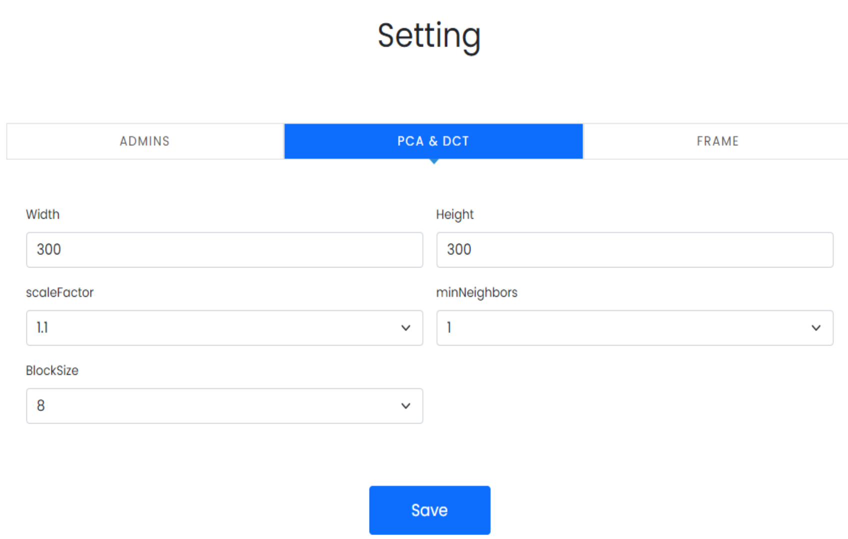

Figure 4.18: PCA & DCT Settings

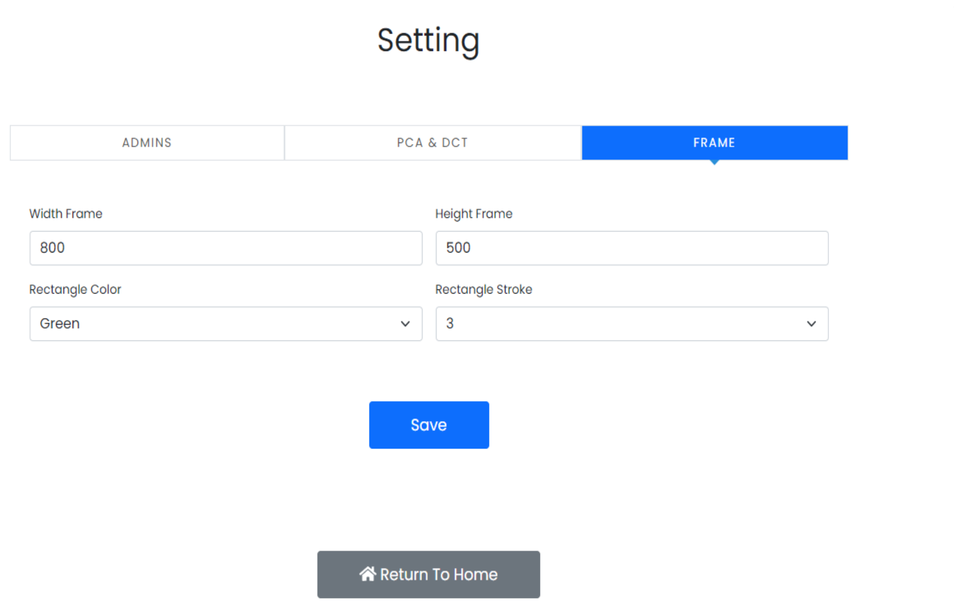

Figure 4.19: Frame Settings

4.6 Conclusion

In this last chapter, we presented the application of this project and how the previous two algorithms could be applied to some people. We also described how people and their data entered the application-related databases and all the application-related procedures, as well as the application structure in terms of functions and instances of system use, as well as the work environment for the application's development.

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