Face Recognition

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ABSTRACT

Images play an important role in todays information age. A single image represents a thousand words. They are produced at a high rate, and can be found everywhere. A reason for all this is because cameras and other photo equipment has become cheap and easily accessible. Today we have image retrieval systems like Googles image search, where we can easily search for images using keywords. But getting the computer to understand the semantics inside of images isn't easy. The reason for this is simply because the computer isn't able to understand the context. In this paper we will talk about a problem that is very complex and common, namely face recognition. Identifying and comparing faces in images is a very complex task, this is probably why it has attracted so many researchers in the latest years. We will also describe some of the problems you will meet when designing a face recognition system, and we will take a closer look on how real-life systems solves these issues. Common methods like feature extraction, holistic matching and hybrid methods will be discussed. We will also take a closer look on a promising approach that uses 3D modeling.

Keywords

Face Recognition

Introduction

Research on automatic face recognition systems have been conducted now for almost 40 years. The first paper talking about face recognition can be traced back to the 1950's in psychology[3]. The first work concerning automatic face recognition was done in 1970 by Kelly[7]. His thesis describes a computer program which performs a complex image processing task. The task was to find the same person in a set of images taken by a TV camera.

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Interest concerning face recognition is spread among different research environments, not only computer scientists. It all started by the psychologists, but over the last 40 years, extensive research has been conducted by psychophysicists, neuroscientists, and various types of engineers[9].

Psychophysicists and neuroscientists have been concerned with issues such as wether face perception is a dedicated process or not. This issue is still being debated in the psychology community.

During the 1980's, work on face recognition had no progress. But the interest grew rapidly again from the beginning of the 1990's. [9] gives some reasons why the research interest increased: real-time hardware became more available, and the importance of surveillance-related applications increased.

This paper contains four sections. The first section describe problems designers meet when creating a face recognition system. The second section describes various approaches taken in designing a face recognition system, it also describes some real-life systems. The third section tries to describe the future. The fourth section concludes this paper.

1. PROBLEM

In identifying a face we usually give an image as input to a face recognition system. The process in recognizing the face is done in three key steps: (1) Face detection, locating the face in the image. (2) Feature/component extraction, a feature/component may be the eyes, the nose or the chins. (3) Recognition, comparing the input image with the ones in the database[9]. The result of this process will hopefully be a set of images that are similar to the input image. The result will be returned to the user of the system.

A face recognition system needs to compare its input images to a set of known images. These images are often stored in databases. There are several problems that may occur when comparing a database image with an input image. The main concern is of course that all images of the same face are heterogeneous.

When image databases are created they contain good scenario images. These images are often taken in good conditions. But this isn't always the case. Examples of bad scenarios is when the face area is unfocused and to small, this is often the case of input images. A face recognition system needs to solve the problem concerning different facial expressions as well. The system must be able to know that two images of the same person with different facial expressions actually is the same person.

Other issues face recognition systems need to solve is:

Figure 1: Kanade's approach to convert a regular image to a binary image.

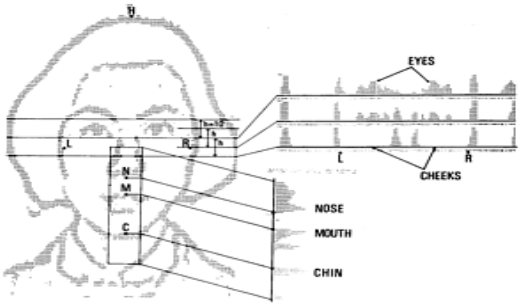

Figure 2: How slits are used to locate features in the face.

makeup, posing positions, illumination conditions, and comparing images of the same person with and without glasses.

2. DIFFERENT APPROACHES

In the beginning of the 1970's, face recognition was treated as a 2D pattern recognition problem[7, 2, 6]. The distances between important points where used to recognize known faces. E.g measuring the distance between the eyes or other important points or measuring different angles of facial components. But the main focus has been on making face recognition systems fully automatic.

2.1 Feature extraction methods

Feature extraction is the task where we locate facial features, e.g the eyes, the nose, and the chins etc. This task may be performed after the face detection task. Or they may be performed at the same time, but that is if the face detection task locates features in order to find out where the face actually is inside the image.

[9] distinguishes between three different extraction methods: (1) generic methods based on edges, lines, and curves, (2) feature-template-based methods, (3) structural matching methods that take into consideration geometrical constraints on the features.

A big challenge for feature extraction methods is feature "restoration", this is when the system tries to recover features that are invisible due to large variations, e.g. head pose when we are comparing a frontal image with a profile image.

2.1.1 Feature extraction example

Feature extraction was the first approach developed to recognize faces in images. Kanade[5] was one of those who actually managed to extract features automatic in a quite simple manner and to recognize faces, previous systems had a manual extraction approach such as[2]. Kanade's approach was to convert a regular image into a binary image, as shown in Figure 1, which later was used as input to the extraction program. The extraction program made slits[1] over the face to find the different features in the face.

Figure 2 illustrates how he is able to locate the eyes, cheeks, nose, mouth and the chins by using slits.

The results Kanade had with his system was quite impressive. In a database with 670 images he managed to extract features from 608 images correctly when the faces had no glasses and no beard. When the faces had glasses he only managed to get 2 out of 77 correct. But with different turn or tilt on the face he managed to get 63 out of 79 correct.

[1]A slit is a horizontal or vertical part of the image used for analysis.

2.2 Holistic methods

Holistic methods uses the whole face region as the input to a recognition system[9]. One of the best examples of where this approach is used is in eigenfaces[8].

2.2.1 Holistic example

The first successful demonstration of machine recognition of faces was made by Turk and Pentland[8] in 1991 using eigenfaces. Their approach treats face recognition as a two-dimensional recognition problem. The flowchart in Figure 3 illustrates the different stages in an eigenface based recognition system. (1) The first stage is to insert a set of images into a database, these images are called the training set, this is because they will be used when we compare images and when we create the eigenfaces. (2) The second stage is to create the eigenfaces. Eigenfaces are created by extracting characteristic features from the faces. The input images are normalized to line up the eyes and mouths. They are then resized so that they have the same size. Eigenfaces can now be extracted from the image data by using a mathematical tool called Principal Component Analysis (PCA).(3) When the eigenfaces have been created, each image will be represented as a vector of weights. (4) The system is now ready to accept incoming queries. (5) The weight of the incoming unknown image is found and then compared to the weights of those already in the system. If the input image's weight is over a given treshold it is concidered to be unknown. The identification of the input image is done by finding the image in the database whose weights are the closest to the weights of the input image. The image in the database with the closest weight will be returned as a hit to the user of the system[9].

2.3 Hybrid methods

Hybrid face recognition systems uses a combination of both holistic and feature extraction methods.

2.3.1 Hybrid example

An example system where a hybrid approach is used is a system developed by Huang[4]. In the system a 3D morphable model is created by using three input images of the

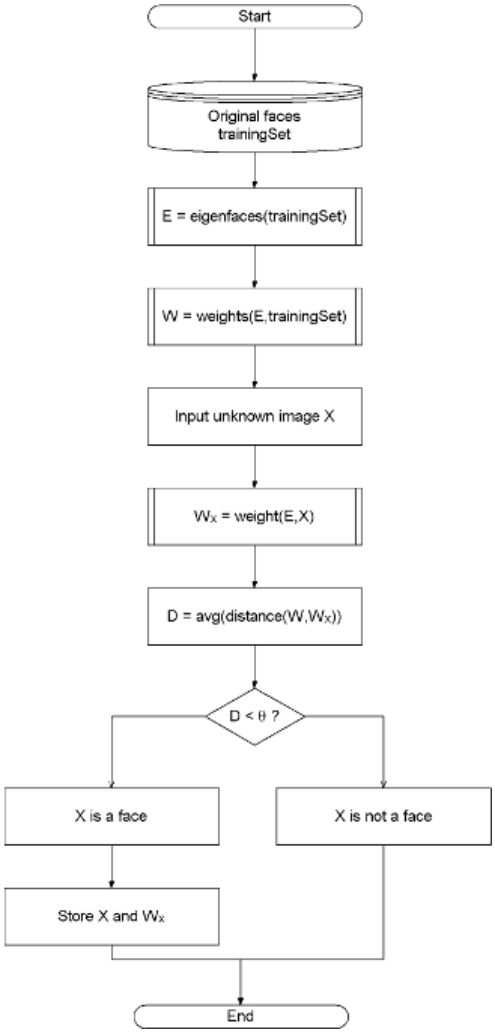

Figure 3: High-level flow chart of the eigenface-based algorithm.

same person. For each person a 3D morphable model is created. The model makes it possible to change the pose and the illumination on the face. This is illustrated in Figure 4 where a single image of the famous Mona Lisa is used to create the 3D morphable model.

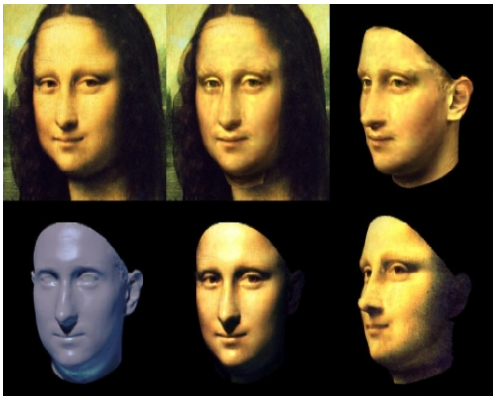

Figure 4: A morphable 3D model created by a single input image. Pose and illumination can be changed as we can see in the synthethic images.

Creating the 3D morphable model is the holistic part of this hybrid system. The advantage of having this 3D morphable model is huge because it gives the opportunity to create hundreds of so called synthetic[2] images of the same person. In their experiments they generated 200 synthetic images per person, the images where taken of 6 different people. All images where taken with different illumination and pose. These 1200 images where then stored in a database ready to be queried.

The second part of this system the feature extraction method. They use a component-based detector that detects the face in a given input image, then they extract 14 facial components which later are used to recognize the face. The extracted facial components are given to the recognition component. Only 9 of the extracted components are used, 5 components were eliminated because they strongly overlapped with other components. A feature vector is then created for each person, which is used when comparing the input image with the ones in the database.

Their system achieved a recognition rate of 90%.

3. THE FUTURE OF FACE RECOGNITION

Since the beginning of year 2000 there have been produced numerous papers concerning face recognition. The website www.face-rec.org holds a list over recently released work and also a list with links to different research groups.

The future of face recognition systems looks bright, there is over 50 groups spread around the world working on the issue today.

4. CONCLUSION

In this paper we have looked at three different approaches on how to design a face recognition system. The first approach was the feature extraction method. This method is widely used to create individual vectors for each person in a system, the vectors are matched when an input image is being recognized.

The second approach was the holistic extraction method. This method used the whole face as input to the system.

[2]A synthetic image is a image created by using a special pose and illumination in the 3D morphable model.

The eigenface method by Turk and Pentland is considered to be the first successful approach.

The third approach was the hybrid method. This method uses both the feature extraction and the holistic method.

The work done by Blanz and Vetter[1], and Huang[4] took face recognition to a new level. By being able to use a morphable 3D model to create synthetic images has proven to give good results. It is a very applicable approach that solves many of the problems mentioned earlier. We will probably see more of this approach in the future.

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