Facial Expression Recognition using Local Binary Patterns

with classification based on Support Vector Machines

AALBORG UNIVERSITY
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Abstract:

Since the last decade, a lot of researches have been carried out about emotion recognition. The number of projects conducted in this field demonstrates the interest and the importance of systems which can recognize human mood.
In this project, an emotion recognition system is developed, using a Microsoft Kinect. This recognition is achieved in 3 steps: Face detection, extraction and classification of facial features, this structure being the usual modus operandi in emotion recognition research.
Face detection is performed using Viola-Jones' algorithm, then Local Binary Patterns (LBP) are used to extract facial features. Finally, Support Vector Machines (SVM) classify these features into six predefined emotions.
The system is implemented to run on a computer using a Kinect and works for one person in front of it. The classifier is trained with the Cohn-Kanade database, which includes enough different faces to obtain a satisfying result.

Preface

This report documents the semester project entitled *Facial expression recognition using Local Binary Patterns*. The project was carried out during the 9th semester of specialization *Vision, Graphics, and Interactive Systems* under the Department of Electronic Systems at Aalborg University in Autumn 2012.

The report is divided into four parts plus appendices: *Introduction*, *Feature Detection*, *Feature Classification*, *Implementation* and *Evaluation*. The first part review the general structure of a facial expression recognition system and its main issues, and concludes with a state of the art of existing systems. Analysis of possible solutions and design of our system are contained in the following two parts, and the fourth part describes our implementation. The last part evaluates the performance and accuracy of our system and concludes on the project as a whole.

References to secondary literature sources are made using the syntax [number]. The number refers to the alphabetically sorted bibliography found at the end of the report, just before the appendices.

We would like to thank our supervisor at Aalborg University Zheng-Hua Tan for supporting us in this challenging project.

A CD is attached to this report which includes:

- Source code of the developed program.
- PDF file of this report.

Aalborg University, October 18, 2012

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Part I

Introduction

Contents

First, this project is motivated by analyzing the need of robust facial expression recognition systems for various applications. Then already existing algorithms will be studied to choose one that is basic but effective in order to improve it. In the last part, the problem will be formulated.

Chapter 1

Motivation

A facial expression is a visible manifestation of the effective state, cognitive activity, intent, personality, and psychopathology of a person [6]; facial expressions play a significant role in human dialogue and in human interaction. Indeed, facial expressions carry other information than speech and humans relay on that for their interaction. Facial expressions have a considerable effect on a listening interlocutor; the facial expression of a speaker accounts for about 55 percent of the effect, 38 percent of the latter is conveyed by voice intonation and 7 percent by the spoken words [8].

Since antiquity, searchers have been interested in emotion and more particularly in emotion recognition. But one of the important works on facial expression analysis that has a direct relationship to the modern day science of automatic facial expression recognition was the work done by Charles Darwin [3]. In 1872, Darwin wrote a treatise that established the general principles of expression and the means of expressions in both humans and animals [5]. He also grouped various kinds of expressions into similar categories. This was the beginnings of facial expression recognition.

Now, with the emergence of new technologies and computers, researchers have put their interests on automatic facial expression recognition by computers. Because facial expressions are important in human interaction, this will add many possibilities in the domain of Human-Machine Interaction. Indeed with emotion recognition, the computers can be more responsive to the users' emotions and this way, interaction will not be as cold as the one we know.

Another domain that is really interested in facial expression recognition is robotics. With the advances in robotics, now robots tend to mimic human emotion and to react as closely as humans as possible, especially for the humanoid robots. But because robots become a more and more important part in our lives, they need to understand and recognize human emotions.

But there are various other domains where emotion recognition can be used: Telecommunications, Behavioral Science, Video Games, Animations, Psychiatry, Automobile Safety, Affect sensitive music juke boxes and televisions, Educational Software, etc [3].

A lot of real time applications have already been created. For example, Bartlett et

al. have successfully used their face expression recognition system to develop an animated character that mirrors the expressions of the user (called the CU Animate) [2]. They have also been successful in deployed the recognition system on Sony's Aibo Robot and ATR's RoboVie [2]. Another interesting application has been demonstrated by Anderson and McOwen, called the "EmotiChat" [1]. It is a chatroom where users can log in and start chatting. Their facial expression recognition system is connected to the chat and convert into emoticones the facial expression of the users. Because facial expression recognition system becomes more and more robust and more and more reliable, lot of innovative applications will turn out.

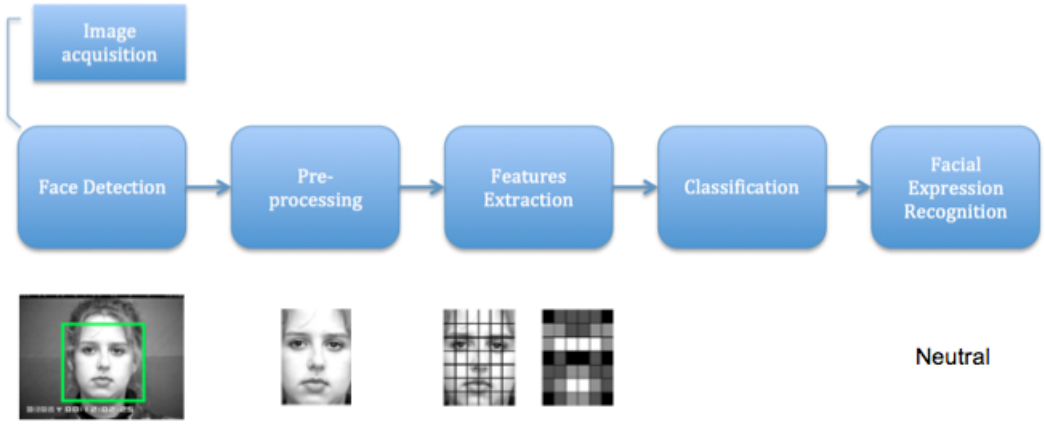
Chapter 2

Facial expression recognition

2.1 General structure

Facial Expression Recognition is a system that allows to recognize emotion on a human face in an automatic way. Facial Expression Recognition can be based on images or on videos; it can be real time or not. Most of the time, searchers use images of human faces and try to recognize the emotion. But this can also be done in real time by using video. While the person is having and expressing his emotions, the Facial Expression Recognition system is analyzing the video and detect in real time the emotion of the person.

In both cases, Facial Expression Recognition process is composed as follows:



The first step of the process is "Image Acquisition". The images used for Facial Expression Recognition can be static images or a image sequences. Image sequences gives more information about the facial expression, as the steps in the movement of the muscles of the face to get to the facial expression. Concerning the static images, most of the time, 2D grey-scale images are used for automatic Facial Expression Recognition system. But in the future, more and more systems will potentially use more and more colour images. First because the technologies capable of capturing images or image sequences become more affordable. And then, because colours can give more information on emotion as blushing [4].

The second step is "Face Detection". "Face Detection" is a step that can be included in the 'Pre-processing' one. But because it is necessary to do it; it represents a step in itself. Indeed, in a static image and even more in an image sequence, the need of detecting the face is obvious. Once the face has been detecting, all the other information in the image can be deleted; only the face is needed. In a Facial Expression Recognition system working in real-time with image sequences, the face needs to be detected but also to be tracked. The most used and famous algorithm capable of doing that is the Viola-Jones Algorithm. It can be trained to detect all kind of objects; but it is mostly used for face detection.

The third step is "Pre-processing". It consists of applying different processing to the image. This way the image processed is optimized for the next step that is "Features Extraction".The most used processing are: noise removal, normalization against the variation of pixel position or brightness, segmentation, location, or tracking of the parts of the face. Emotion recognition is also sensitive to transformation, scaling and rotation of the head in the image or image sequence. In order to supplant this problem, the image can be geometrically standardized. Usually, this standardization is based on references that make the eyes [4].

Once the image has been prepared while the "Pre-processing" part, the next and fourth step is "Features Extraction". It is this step that converts image data into a higher representation of shape, texture, color, etc... The extracted data are used for the next step that is "Classification". One of the main goals of this step is to reduce the dimensionality of the input space. The reduction procedure should retain essential information possessing high discrimination power and high stability [4]. There is a lot of features extraction methods. The most famous are : Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Problem Based Learning (PBL), Hidden Markov Model (HMM), Eigenfaces, Gabor Wavelets.

2.2 Existing systems

Principal Component Analysis (PCA) : Principal Component Analysis is a statistical method; one of the most used in linear algebra. PCA is mainly used to reduce high dimensionality of data and to obtain the most important information from this data. Because Facial Expression Recognition needs to reduce the dimensionality of data during features extraction, PCA is commonly used. It helps transforming high dimensionality of data to a new coordinate system of lower dimensions while still preserving the most important information. PCA computes a covariance matrix and a set of values called the eigenvalues and eigenvectors from the original data [7].

Linear Discriminant Analysis (LDA) : Linear Discriminant Analysis is a statistical method as PCA, used to classify a set of objects into groups. It is done by observing

a set of features that describe the objects. LDA as PCA are used to establish a linear relationship between the dimensions of the data. The main difference is that LDA uses the linear relationship to model the differences into classes of objects and PCA does not take any differences into account in the linear relationship. The idea is to perform a linear transformation on the data to obtain a lower dimensional set of features [7].

Problem Based Learning (PBL) : Problem Based Learning is a features extraction method with an appearance based approach. It can be used to describe texture and shape. PBL extracts some informations from the neighborhood of a central pixel. It compares the intensity values of the neighborhood pixels with the intensity value of the central pixel [7].

Hidden Markov Model (HMM)
Eigenfaces
Gabor Wavelets

2.3 Issues

bla bla bla

2.4 Requirements

bla bla bla

Before developing a facial expression recognition project, it is important to know what already exist; the state of the art of facial expression recognition system. In this chapter, an overview will be given of the existing systems before to decide on a system for the project.

Part II

Feature detection

Contents

Bla bla bla

Part III

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Bla bla bla

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Bla bla bla

Conclusion

In case you have questions, comments, suggestions or have found a bug, please do not hesitate to contact me. You can find my contact details below.

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Appendix A

Appendix A name

Here is the first appendix