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, November 7, 2012

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Part I

Introduction

Contents

The main motive of this project is to understand real-time facial expression recognition systems and their applications. Then a review of the architecture of such systems will be done, along with a state of the art of already existing algorithms for each step. After this study, one algorithm for each step will be chosen, considering their difficulty and their efficiency, in order to improve it. In the last part, the problem will be formulated.

Chapter 1

Motivations

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 interaction. Indeed, facial expressions carry more informations than mere speech, informations on which humans can relay for interaction. Facial expressions have a considerable effect on a listening interlocutor; a speaker facial expressions 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 [10].

Since Antiquity, researchers have been interested in emotion and more particularly in emotion recognition. But one of the important studies on facial expression analysis impacting on the modern day science of automatic facial expression recognition was the work carried out by Charles Darwin [3]. In 1872, Darwin wrote a treatise that established general expression principles and expression means for both humans and animals [5]. He also classified various kinds of expressions. This can be considered as the beginning of facial expression recognition.

Now, with the emergence of new technologies and computers, research is now focused on computer-based automatic facial expression recognition. Because facial expressions are major factors in human interaction, this research field will broaden the domain of Human-Machine Interaction. Indeed, emotion recognition will enable computers to be more responsive to users' emotions, and allow interactions to become more and more realistic.

Another domain where facial expression recognition is an important issue is robotics. With the advances made in robotics, robots nowadays tend to mimic human emotion and react as as human-like as possible, especially for humanoid robots. However, since robots are being more and more present in our daily lives, they need to understand and recognize human emotions.

A lot of real time applications in the robotics field 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 CU Animate) [2]. They have also been successful in deploying the recognition system on Sony's Aibo Robot and ATR's RoboVie [2]. Another interesting application has been demonstrated by Anderson and McOwen, called "EmotiChat" [1]. It is a regular chatroom, except the fact that their facial expression recognition system is connected to the chat and convert the users' facial expressions into emoticons. Because facial expression recognition systems' robustness and reliability are constantly increasing, lots of innovative applications will appear.

There are also various other domains where emotion recognition can be used: Telecommunications, behavioural science, video games, animations, psychiatry, automobile safety, affect-sensitive music jukeboxes and televisions, educational software, etc [3].

Our project focuses on real-time facial expression recognition from a video stream. Indeed, facial expression recognition can be performed *statically* on input images, or *dynamically* on video sequences. Systems can also be *obtrusive*, or *non-obtrusive*, the former based on a device mounted on the user's head or body, therefore following each of his movements and perform facial expression recognition without much losses, while the latter can encounter difficulties if the user is not properly situated. However, non-obtrusive systems allow more natural user interactions. We chose our system to be non-obtrusive, and will detail further its setup in the next section.

1.1 Environment Setup

Our system will use the camera embedded into a Microsoft Kinect to record the user's video input, and we will consider a casual use of the camera, with the user sitting in front of the computer, the camera being next to it, as seen in **Insert figure & ref to figure**. This camera provides a 640×480 pixels frame resolution, while recording at 30 FPS.

For development and training purposes we will use some pre-existing emotion datasets, in order to validate the efficiency of the system before testing it in real conditions.

1.2 Emotion Datasets

Introduction bla bla bla

1.2.1 JAFFE Database

bla bla bla

1.2.2 KDFE Database

bla bla bla

1.2.3 MSFDE Database

bla bla bla

Chapter 2

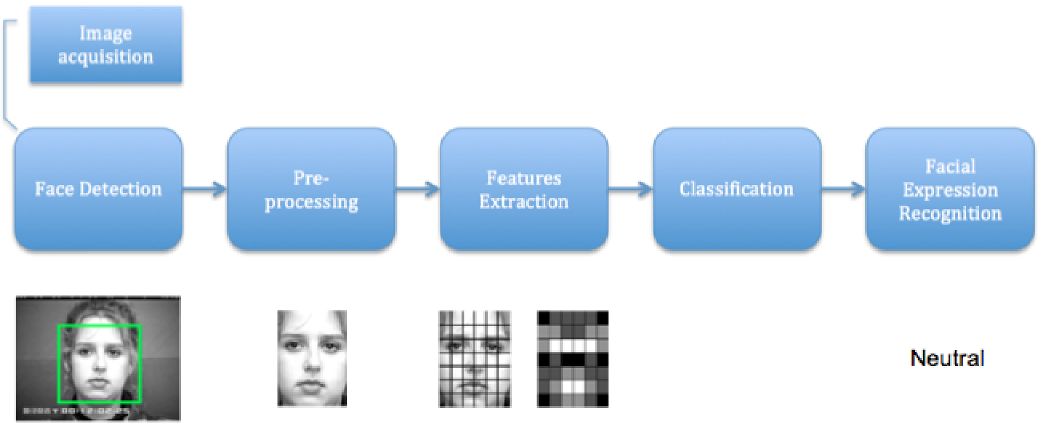
Facial expression recognition

Introductory paragraph of the chapter

2.1 General structure

Facial expression recognition is a system enabling an automatic recognition of emotions displayed by a human face. Facial expression recognition can be image or video-based; it can also be computed real-time. Most of the time, researchers try to recognize emotions out of images of human faces. This can also be achieved real-time on video streams : While the person displays his/her emotions, the facial expression recognition system analyses the video, and detect in real-time the displayed emotion.

In both cases, facial expression recognition process is structured as follows:



2.1.1 Image Acquisition

First step of the process is "Image Acquisition". Images used for facial expression recognition can be static images or image sequences. Image sequences give more informations about the facial expression, as the steps in muscles movement. About static images, facial expression recognition systems usually need 2D greyscale images as inputs. We can however expect future systems to use colour images; first because of the increasing affordability of technologies and devices capable of capturing images or image sequences; then because colours can give more information on emotions, i.e blushing [4].

2.1.2 Face Detection

Second step is "Face Detection". Indeed, in a static image and even more in an images sequence, this is an obvious need. Once the face has been detected, all other non-relevant information can be deleted, since only the face is needed. It could hence be included in the next step, which is "Pre-processing", but because of its importance it represents a step in itself. In a real-time facial expression recognition system working with image sequences, the face has to be detected, but also tracked. One of the most used and famous detection and tracking algorithm is the Viola-Jones Algorithm, which we will explain in detail later in this report. This algorithm can be trained to detect all kind of objects, but is mostly used for face detection.

2.1.3 Pre-processing

Third step is "Pre-processing", which is about applying image processing algorithms to the image, in order to prepare it for the next step. Pre-processing is usually about noise removal, normalization against the variation of pixel position or brightness, segmentation, location, or tracking of 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 solve this problem, the image can be geometrically standardized. References used for this standardization are usually the eyes [4].

2.1.4 Features Extraction

Once the image has gone through the "Pre-processing" step, the next one is "Features Extraction". In this step, data is converted into a higher representation of shape, motion, colour, texture, and spatial configuration of the face or its components. One of the main goals of this step is to reduce the dimensionality of the input data. The reduction procedure should retain essential information possessing high discrimination power and high stability [4]. There are a lot of features extraction methods. The most famous are : Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Problem Based Learning (PBL), Hidden Markov Models (HMM), Eigenfaces, Gabor Wavelets. The extracted data is then used in the "Classification" step.

2.1.5 Classification

INSERT PARAGRAPH ON CLASSIFICATION - explanation
- existing algorithms : PCA et LDA, mais aussi neural networks, svm

2.2 Existing systems

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. **Introductory paragraph on which methods are we going to focus on, appearance-based & geometry-based**

2.2.1 Principal Component Analysis (PCA)

This 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].

2.2.2 Linear Discriminant Analysis (LDA)

Linear Discriminant Analysis is also a statistical method, 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].

2.2.3 Local Binary Patterns (LBP)

This is an appearance-based method. It can be used to describe texture and shape. LBP extracts some informations from the neighbourhood of a central pixel. It compares the intensity values of the neighbourhood pixels with the intensity value of the central pixel [7]. This method is the one that will be used for this Facial Expression Recognition system.

2.2.4 Hidden Markov Models (HMM)

These models are a set of statistical models used to characterize the statistical properties of a signal [12]. It is developed to recognize expressions based on the maximum likelihood decision criterion [9].

2.2.5 Eigenfaces

Eigenfaces are a set of eigenvectors which are derived from the covariance matrix of a set of face images in a high-dimensional vector space. The eigenvectors are ordered and each one represents the different amount of the variation among the face images. It all together characterizes the variation between face images [13].

2.2.6 Gabor Filters

Gabor filters are applied in order to extract a set of Gabor wavelet coefficients. When convolving these Gabor filters with a simple face image, filter responses are obtained. These representations display desirable locality and orientation performance [8]. However, it has a limitation which is the processing time of Gabor feature extraction. It is very long and its dimension is prohibitively large [11].

2.3 Issues

bla bla bla

2.4 Requirements

bla bla bla

Part II

Feature detection

Contents

Bla bla bla

Part III

Feature classification

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Bla bla bla

Part IV

Implementation

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Bla bla bla

Part V

Evaluation

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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