Analyzation of the morphological features of the face

Structure of Computer Systems

George-Dorian Damian

2024

Table of Contents

[1 Introduction 2](#_Toc182493629)

[1.1 Context 2](#_Toc182493630)

[1.2 Objectives 2](#_Toc182493631)

[2 Bibliographic Research 3](#_Toc182493632)

[2.1 What is Facial Recognition? 3](#_Toc182493633)

[2.2 How to detect facial features? 3](#_Toc182493634)

[3 Analysis 4](#_Toc182493635)

[3.1 Project Proposal 4](#_Toc182493636)

[3.2 Project Analysis 4](#_Toc182493637)

[3.2.1 Face Detection with Haar Cascades 4](#_Toc182493638)

[3.2.2 Detection of Facial Features in Real-Time 4](#_Toc182493639)

# Introduction

## Context

The aim of this project is creating a system that can detect and analyze the facial features of a person. The analyzation of those features can determine a person’s identity, and therefore allowing them access to confidential data or higher security zones.

Detecting facial key points is a very challenging problem. Facial features differ greatly between individuals, but even considering one person, factors like 3D pose, size, viewing angle, and lighting conditions can cause significant variation. While computer vision research has come a long way, there are still many opportunities for improvement.

## Objectives

The project will be developed using Python programming language. The project also requires OpenCV (Open Source Computer Vision Library), which is a open source computer vision and machine learning software library. The system we design should be able to detect the features of someone’s face (eyes, mouth, nose etc.) by receiving a file input (image or video) or by taking real-time video using a webcam. The detected features should be contoured on the input received.

# Bibliographic Research

## What is Facial Recognition?

Facial Recognition is a way of identifying an individual’s identity using their face. Facial Recognition systems can be used to recognize people in photos, videos or in real-time.

Facial Recognition is a category of biometric security, along with other forms of recognition like Voice Recognition, Fingerprint Recognition or Iris Recognition.

The most common Facial Recognition Systems are used for securing smartphones. The more advanced systems are used in apartment building or businesses in order to identify a person by unique physiological features.

## How to detect facial features?

Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, „Rapid Object Detection using a Boosted Cascade of Simple Features” (2001). It is a machine learning-based approach where a cascade function is trained with a high volume of positive and negative images.

This approach works by using Haar-like features, which are simple patterns of adjacent rectangular regions that capture differences in pixel intensity, like edges, lines, or other structures in an image. The algorithm scans an image at multiple scales and positions to detect features like eyes, nose or mouth.

This method is fast and effective for real-time detection but can be less accurate in complex scenarios compared to more modern techniques.

# Analysis

## Project Proposal

This project proposes a real-time facial feature recognition system that can detect faces and their key features in video feeds and static images. Using Python and OpenCV, the system aims to demonstrate a modular approach to face detection. By capturing facial features, the project serves as a building block and start-up for various applications, including security, emotion detection, and human-computer interaction.

## Project Analysis

### Face Detection with Haar Cascades

Haar Cascades are a machine learning-based method for real-time object detection. It relies on "Haar-like features", which detect simple patterns, like edges or textures, by analyzing contrasts in image regions. Haar Cascades operate by sliding a window across the image, detecting regions that match pre-trained feature patterns.

By adjusting parameters such as *scaleFactor* and *minNeighbors,* the system can optimize detection speed and accuracy, balancing resource efficiency with real-time performance requirements.

Although fast and suitable for low-power devices, Haar cascades are less accurate than modern deep learning techniques, especially in complex backgrounds or under varying lightning.

### Detection of Facial Features in Real-Time

To enhance detection accuracy and efficiency, the system performs the feature recognition only within the detected face region, narrowing down the area where it looks for eyes and the mouth. This approach reduces computation and increases precision, allowing for smoother real-time processing. These improvements make the system effective for real-time applications, where rapid and accurate face recognition is essential.

# Design

## Face Detection Design

### Face Boundary Detection

The face boundary is detected first. It is later used as a reference for detecting the features like eyes and mouth. Using the pre-trained Haar Cascade classifier, the system is able to identify the rectangular regions that match the general structure of a human face. The detected face is then marked with a bounding box that will serve as the guide for the feature detection steps. This design choice improves performance by focusing detection on the face area, rather than the entire image.