Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT AND IMPLEMENTATION OF FACE RECOGNITION SYSTEM USING NEURAL NETWORKS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHANG KAI XIN

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

2021

DEVELOPMENT AND IMPLEMENTATION OF FACE RECOGNITION SYSTEM USING NEURAL NETWORKS

CHANG KAI XIN

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Faculty of Electrical and Electronic Engineering Technology

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2021

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Tajuk Projek : Development and Implementation of Face Recognition System using Neural Networks

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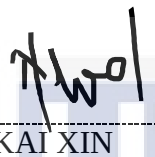
Signature : 

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Computer Engineering Technology (Computer Systems) with Honours.

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DEDICATION

To my beloved mother, Kho Yeok Peng, and father, Chang Choo Khean,

and

To my sister, Chang Kai Shan and

My brother, Chang Kai Yuan.

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ABSTRACT

One of the most widely used technologies in the world today is the facial recognition. It is used in biometric security systems to identify a person digitally before granting the access to the system or the data in it. The news of a female being kidnapped and murdered by a police officer in London has become a global topic and many are concerned about the safety of women in daily life. The researcher's motive is to help females and children under threat so that they can be rescued before it is too late. The objectives of this project are, to develop a device that will capture the image of a kidnapper as evidence for future reference and send the captured image to the family of the victim through email, to design a face recognition system to be used in searching kidnap suspects and to determine the best training parameters for the convolution neural network layers used by the proposed face recognition system. The system is divided into two parts, the hardware, and the software, where the hardware part consists of the ESP32-CAM programmed by Arduino IDE, which can capture image of the kidnapper and send it to the email of the victim's family through SMTP server; and the software which is a face recognition system built in MATLAB to match the image captured by the hardware with the faces stored in a database that resembles the database of the authorities. The system is tested with different images captured by the hardware and the software is able to recognise and compare the face with the image database and lastly provide the name or identity of the person. The hardware device of the system is small and compact to be carried around with ease, it can be attached to random items so that the user can easily trigger the button on the device to capture the image of the other person when they are in danger. The best training parameters for the proposed CNN model are kernel size of 5x5, 32 and 64 filters for first and second convolutional layers and learning rate of 0.001. The proposed system is robust as its overall face recognition accuracy is 98.48%.

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ABSTRAK

Sistem pengecaman wajah merupakan salah satu teknologi yang banyak diguna pada masa ini. Sistem tersebut digunakan dalam sistem keselamatan biometrik untuk mengenalpasti identiti seseorang secara digital sebelum memberi kebenaran untuk mengguna sistem atau data yang dilindungi oleh sistem. Berita mengenai seorang wanita diculik dan dibunuh oleh seorang pegawai polis di London telah menjadi topik global dan terdapat ramai yang risau tentang keselamatan wanita dalam kehidupan seharian. Tujuan projek ini adalah untuk membantu wanita dan kanak-kanak di bawah ancaman supaya mereka dapat diselamatkan sebelum terlambat. Objektif projek ini adalah untuk membina sistem yang dapat mengambil gambar penculik dan menghantar gambar tersebut kepada keluarga mangsa untuk diserahkan kepada pihak berkuasa dan disimpan sebagai rujukan masa depan, mengaturcarakan sistem pengecaman wajah untuk mencari suspek penculik, serta untuk mencari parameter yang terbaik untuk lapisan rangkai saraf konvolusi yang digunakan dalam sistem cadangan projek ini. Sistem ini dibahagikan kepada dua bahagian, iaitu hardware yang terdiri daripada ESP32-CAM diaturcarakan dengan Arduino IDE, komponen ini digunakan untuk mengambil gambar penculik dan hantar gambar tersebut ke akaun emel keluarga mangsa melalui SMTP dan software yang mengandungi sistem pengecaman wajah yang dibina dengan pergunaan MATLAB untuk memadankan gambar yang diambil oleh hardware dengan gambar yang disimpan dalam pangkalan data. Sistem pengecaman wajah yang diimplementasikan dalam bahagian software telah diuji dengan pelbagai gambar yang diambil oleh hardware. Sistem telah berjaya mengenalpasti identiti seseorang selepas perbandingan antara gambar yang diambil dengan gambar yang disimpan dalam pangkalan data. Bahagian hardware untuk sistem ini adalah kecil dan senang dibawa, ia boleh dipasangkan atas pelbagai barang supaya pengguna boleh tekan butang yang akan menghidupkan sistem untuk mengambil gambar pengancam apabila mereka berada dalam situasi yang bahaya. Parameter yang terbaik untuk lapisan rangkai saraf konvolusi adalah saiz penapis 5x5, 32 dan 64 penapis untuk lapisan konvolusi pertama dan kedua serta kadar pembelajaran 0.001. Sistem yang dicadangkan dalam projek ini adalah teguh kerana kadar pengecaman wajahnya mencapai 98.48% secara keseluruhan.

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ACKNOWLEDGEMENTS

My highest appreciation goes to my parents and family members for their love and support during the period of my study. Next, I would like to express my gratitude to my supervisor, Dr Jamil Abedalrahim Jamil Alsayaydeh for his precious guidance and patience throughout this project.

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LIST OF ABBREVIATIONS

$2D$	-	2-Dimensional
$3D$	-	3-Dimensional
ANN	-	Artificial Neural Networks
BP-ANN	-	Backpropagation Artificial Neural Networks
CNN	-	Convolutional Neural Networks
CONV	-	Convolution Layers
DGWT	-	Discrete Gabor Wavelet Transform
DT	-	Decision Tree
EM	-	Expectation-Maximalization
ENN	-	Elman Neural Networks
FC	-	Fully Connected Layers
FFBPL	-	Feed Forward Back Propagation Learning
HMM	-	Hidden Markov Models
HOG	-	Histogram of Oriented Gradient
HSI	-	Hue, Saturation, Intensity
ICA	-	Independent Component Analysis
ICP	-	Iterative Closest Point
KNN	-	K Nearest Neighbour
LBPH	-	Local Binary Pattern Histograms
MLP	-	Multilayer Perceptron
NN	-	Neural Networks
PCA	-	Principal Component Analysis
POOL	-	Pooling Layers
ReLu	-	Rectified Linear Unit
RGB	-	Red Green Blue
ROI	-	Region of Interest
RPN	-	Region Proposal Networks
SMTP	-	Simple Mail Transfer Protocol
SSID	-	Service Set Identifier
SVM	-	Support Vector Machine

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CHAPTER 1

INTRODUCTION

1.1 Background

One of the most widely used technologies in the world today is the facial recognition technology. With the use of facial recognition, a biometric system can identify a person digitally before granting the access to it or the data in it. Complicated and unrealistic biometric security systems are often portrayed by computer graphics in many futuristic movies; however, Apple had taken one step forward and release a face unlock feature for its iPhone X in 2017. This breakthrough uses a sensor to scan the face of the user and save it as the face ID. The phone can be unlocked when the face of the person unlocking the phone matched with the face ID. The release of this new authentication method has made a big impact in the smartphone industry and all the latest smartphones have started to implement the same face unlock feature in their systems. Facial recognition technology is also used in other systems, for instance, it is used in airport security, law enforcement, attendance systems and to search for a person.

In this project, neural network is used in the development and implementation the face recognition system. Neural network can be trained to process and analyse data, recognise patterns, and make prediction about specific operations. Generally, the programmer needs to provide numerous examples to train neural network, in order for it to learn the patterns [1]. This project proposed a face recognition system to be used for searching a person who is being suspected of committing crime. The proposed system works with a hardware device that captures the face of the suspect.

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1.2 Problem Statement

There are many kidnappings or abduction cases happen around us. In early March 2021, there was a news that caused global anger, Sarah Everard, a 33-year-old female, was kidnapped and murdered by a police officer in London. Females and children are often the target of kidnappers, the fate of the victim remains unknown until the suspect is found and arrested. In the cases of victims being rescued in time by the authorities, the victims who suffer from post-traumatic stress disorder (PTSD), it is likely that they could not recognise or remember the face of the kidnapper during their testimony in court. Therefore, the purpose of this project is to develop a device to capture the image of the suspect as evidence and alert the victim's family through email when the victim triggered the device and use the image as an input to the face recognition system to identify the suspect.

1.3 Project Objective

The main aim of this project is to propose an idea which combines hardware with image capturing features and software with face recognition system, the aim is to capture the image of a kidnapper and reduce the time taken for the authorities to find the suspect. The objectives of this project are listed below:

i) To develop a device that will capture the image of kidnappers as evidence for future reference and send the captured image to the family of the victim through email.

ii) To design a face recognition system to be used in searching kidnap suspects.

iii) To determine the best training parameters for the convolution neural network layers used by the proposed face recognition system.

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1.4 Scope of Project

The scope of this project are as follows:

a) Hardware which includes the ESP32-CAM to capture image of a kidnapper and send the image to the victim's family.

b) Software which implements the face recognition system.

c) Image database with images separated into training set, validation set and testing set.

d) Comparison between input image and database image to find the identity.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Being one of the most widely discussed topics in the research of computer-related field, face recognition technology has become a close to perfect solution to accommodate the demands of identification and verification of identity claims in systems or organizations that use biometric security systems. With the latest face recognition technology, many tasks which used to depend on manual internal control environments in the past such as transactions, building access control and security-related tasks have overcome some limitations since the machines that use face recognition technology are able to provide higher accuracy in identifying and verifying an identity claim [2], the implementation of face recognition technology in such systems and organizations has greatly increased productivity as the time taken for identification and verification is reduced. Besides, there are some flaws in traditional recognition systems. For instance, systems that use PINs and passwords for authentication are less user-friendly for people who are forgetful because there are chances that the PINs and passwords are forgotten by the users. This method is also less reliable because passwords that are not updated regularly are more likely to be hacked and leaked by attackers, whereas access cards, keys, tokens and the other physical devices can be misplaced, stolen or duplicated. As a result, the traditional recognition systems are more vulnerable and less secure. On the other hand, biological characteristics and traits of an individual are distinctive and unique in their own way, facial features cannot be stolen or misplaced like physical items. Furthermore, even if an individual forgets how he or she looks, the face recognition system would still recognise its user because the data is saved in

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the database. Face recognition technology is more favourable than other biometric systems because, unlike fingerprint and iris recognition systems, face recognition systems do not require physical contact to activate the identification and verification processes [3].

2.2 Factors that Affect the Accuracy of Face Recognition Systems

According to [3], the factors that might affect the accuracy of face recognition systems are classified into two main categories, intrinsic and extrinsic factors. Physical conditions of the human faces are considered as intrinsic factors, for example, aging and facial expressions. Extrinsic factors are made up of partial occlusion, pose variance and illumination. Reference [3] also mentioned that biological characteristics in a biometric system must be consistent and permanent because they act as the key to identify or authenticate a person.

2.2.1 Aging

First of all, aging is an inevitable natural growth process in every human's life. It is uncontrollable and every individual experience it differently, depending on the genes and other external factors [4]. When people go through the aging process, the shape and texture of their faces might slightly change and thus the accuracy of face recognition will be lower. It is difficult to collect the data regularly and keep the system up to date because the speed of aging differs from person to person.

2.2.2 Facial Expressions

Next, one of the most used non-verbal ways we use in daily communication is using facial expressions. It is easy for human brains to identify and recognise a person even when the person shows different facial expressions, but it is still a big challenge for computer to

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perform the same task. More researchers have taken this factor into consideration and many solutions are proposed to improve the accuracy of the face recognition system, however, it only works in controlled environments. Research conducted by [5] states that it is difficult to separate the feature spaces of all possible expressions, to put it another way, when a person makes two different expressions, the facial feature may be very close in the feature space, while the facial features of two people making the same facial expression may be far from each other, in short, the feature extraction is very complicated when dealing with various facial expressions. Moreover, in some cases, the facial expressions for two different emotions, for instance, sad and fear, can be very similar [5].

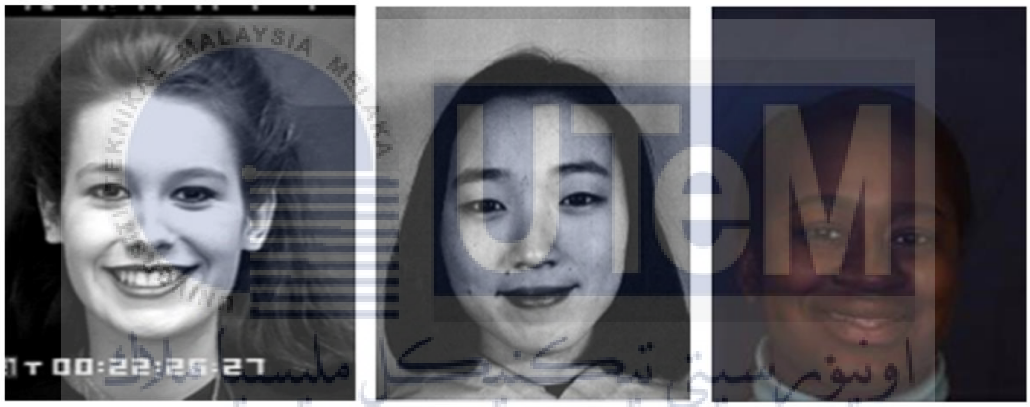

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Figure 2.1 Happy expression shown by three people [5].

From Figure 2.1, without mentioning the differences in lighting and background, it is clear that the images vary from each other because the way that each person smiles is unique, despite the fact that all of these expressions convey the same emotional state, which is happiness [5].

2.2.3 Partial Occlusion

Extrinsic factors are external factors that cause changes on the facial features. Occlusion refers to natural or artificial obstacles in an image [3]. Face masks have become part of our daily lives since the COVID-19 pandemic began, people wear face masks in

public to protect themselves and others. The face recognition systems lack the ability to recognise an identity who has his or her nose and mouth covered, for instance, some iPhone users have experienced this inconvenience, they need to take off their face masks in order to unlock their iPhone with Face ID. Personal belongings such as sunglasses, caps, scarves and face masks are the common occlusion and sometimes shadows caused by lighting or reflection from glasses, earrings, necklace and other reflective objects are also degrading the performance of the facial recognition system. In the study conducted by [3], they have stated three approaches to face recognition with partial occlusion, namely Part Based Methods, Feature Based Methods and Fractal-Based Methods. They also stated another local approach which is dividing the faces into different parts to eliminate some of the features that caused an inaccurate result in recognition.

2.2.4 Pose Variance

Next, no one will have the exact same pose when taking a picture, some people like to cover one side of their face while some like to show their full profile. Therefore, it is difficult for the face recognition system to recognize the faces from images with different poses. An ideal face recognition system should have the capability to recognize face even when the poses of the person are changing. The current solutions to this problem are general algorithms, 2D methods for face recognition across pose and face recognition across pose with the assistance of 3D models, researchers are working on this problem but there is no system with 100% accuracy available in the market yet [3].

2.2.5 Illumination

The final extrinsic factor suggested by [3] is the illumination variation. The performance of the face recognition system is affected when the lighting is too much or too

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