COMENIUS UNIVERSITY BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS

PERSON IDENTIFICATION WITH PARTIALLY OCCLUDED FACE

Diploma Thesis

2022

Bc. Anna Camara

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Study programme:	mAIN/k - Applied Computer Science (Conversion Programme)
Field of Study:	Computer Science
Department:	FMFI.KAI Departement of Applied Informatics
Supervisor:	RNDr. Zuzana Černeková, PhD.

Bratislava, 2022

Bc. Anna Camara

Comenius University in Bratislava
Faculty of Mathematics, Physics and Informatics

THESIS ASSIGNMENT

Name and Surname:	Bc. Anna Camara
Study programme:	Applied Computer Science (Conversion Programme) (Single degree study, master II. deg., full time form)
Field of Study:	Computer Science
Type of Thesis:	Diploma Thesis
Language of Thesis:	English
Secondary language:	Slovak

Title:	Person identification with partially occluded face
Annotation:	The goal of the thesis is to identify a person in case when face is partially occluded for example with sunglasses or face mask. Study the topic of person identification based on the face. Analyze the performance of the existing solutions published in the literature. Propose a new method based on a neural network, which can find and identify a person. Create a dataset for training and testing purposes. Evaluate the proposed method and draw the conclusions.

Supervisor:	RNDr. Zuzana Černeková, PhD.	
Department:	FMFI.KAI - Department of Applied Informatics	
Head of department:	prof. Ing. Igor Farkaš, Dr.	
Assigned:	24.09.2018	
Approved:	03.10.2018	prof. RNDr. Roman Ďurikovič, PhD. Guarantor of Study Programme

....

Student   Supervisor

Čestne prehlasujem, že túto diplomovú prácu som vypracovala samostatne len s použitím uvedenej literatúry a za pomoci konzultácií s môjou školiteľkou.

Bratislava, 2023 ....

Bc. Anna Camara

Poďakovanie

Touto cestou by som sa chcel v prvom rade poďakovať môjmu školiteľovi .... za jeho cenné rady a usmernenia, ktoré mi veľmi pomohli pri riešení tejto diplomovej práce. Takisto sa chcem poďakovať mojím kolegom ...... za rady ohľadom implementácie a v neposlednom rade chcem tiež poďakovať .....

Abstract

Key words: facial identification, facial recognition,

Abstrakt

Kľúčové slová: tvárová identifikácia, rozpozanie tvárií.

Contents

Chapter 1

Introduction

More and more, facial identification is becoming part of our lives. We are hearing terms like facial identification, facial recognition, verification, biometric and others. First let's clarify what this terms mean and what is the difference between them.

The International Organization for Standardization (ISO) [6] provides following definitions:

Biometric Characteristic is a biological and behavioural characteristic of an individual from which distinguishing, repeatable biometric features can be extracted for the purpose of biometric recognition.

Biometric Recognition/Biometrics is an automated recognition of individuals (referring to only humans) based on their biological and behavioural characteristics. Biometric recognition encompasses *biometric verification* and *biometric identification.*

Biometric identification is a process of searching against a biometric enrolment database to find and return the biometric reference identifier(s) attributable to a single individual.

Biometric verification is a process of confirming a biometric claim through comparison.

In simpler words, when we speak of biometrics or biometric recognition we mean biological and behavioral measurements that can be used to identify individuals. This is a broad term for both verification and identification. In verification we are comparing (1:1) one input against one control point. Basically we are asking *"Is this the same person as the one saved control point?"* or *"Are you who you say you are?"*. In identification we are comparing (1:N) one input against a whole database. We are asking *"Who, from our database, is this?"* or *"Who are you?"*.
This of course includes more than recognition based on ones face. In current age we are able to identify a person from many sources some of which are fingerprints, voice, scan of retina and face.

Now when we have these definitions it is simple to clarify what is facial recognition. **Facial recognition** is biometric recognition based on persons face. This theses will focus on facial identification, specifically on facial identification with partially occluded face by face mask.

1.1 Goals

The goal of this thesis is to improve facial identification techniques to be able to identify masked faces. In this process I would like to focus on two groups of questions:

1. Face identification with facial mask:

    - What different techniques are currently used for facial identification?

- How well do facial identification models/softwares perform on masked faces?
- Are these systems able to identify a person that is wearing a mask even when there are no masked people in the database? If they are not, how can we achieve it?

2. Racial bias:
    - How do current systems perform on people of different colors? I would like to do separate evaluation on different groups.
    - How to reduce this bias?

TO DO : WHY IS ANSWERING THESE QUESTIONS IMPORTANT...
-nieco ako motivaciu prace - How do current systems perform on people of differt colors -> Toto je hlavne dolezite preto ze mame viac socialneho bias voci people of color(ZDROJ) a tympadom su castejsie odsudeny na sudoch. prepojit s tym ako sa momentalne pouzvaja identifikacia tvarii.
+ ukazat ze sa tomu nevenuje dostatok studii, ze tieto otazky neboli dostatocne zodpovedane

maybe add short intro on how facial recognition works. Like in here [10]
TO DO: Dodat organizaciu prace. aka co sa kde nachadza.

Chapter 2

Facial recognition

This chapter provides a short description of facial recognition to gain basic understanding of the topic.

As mentioned in chapter 1, facial recognition is biometric recognition based on persons face. It comprises both identification, comparing one identity to many(1:N) and verification, where we match one to one (1:1). To put it in plain words, facial recognition is an automated system for finding a person's identity based on an image of their face.

How it works

–this wants too be a short section that describes in short the three major steps of FRT–

– this is just an outline – 1. Face detection - crop just the face from the picture

2. Extracting features from the image - we no longer work with the image, feature vectors is

3. Face matching

2.1 Viola Jones

–in this section shortly mention Viola Jones algorithm and how it contributed to FRT. That even nowadays some parts of it are used–

2.2 Deep neural networks

–in short describe how FRT with DNN works, what are the main steps used. Different variations like reconising only front facing face, handeling rotations. Similarities and differences of models (most use triplet loss function are there some that don't?)
Problems and struggles that are still in question whit this methods. –

"In early times, research interests were mainly focused on face recognition under controlled conditions where simple classical approaches provided excellent performance. Today, the focus of research is on unconstrained conditions in which deep learning technology has gained more popularity as it offers strong robustness against the numerous variations that can alter the recognition process. In addition, many academics struggle to find robust and reliable data sets for testing and to evaluate their proposed method: finding an appropriate data set is an important challenge especially in 3D facial recognition and facial expression recognition." [1]

2.2.1 Data

–the inportance of data
what databases are available
what isn't availabe

my modification of data for this research –

Chapter 3

Current facial recognition technologies (FRT)

For us humans it is most natural to identify one another by recognizing the face of an individual (if we have sight). Therefore, even though it may be less precise compared to other biological triads, like fingerprints, it is our first choice. Thus the idea of face recognition has existed for a very long time. First, we could recognize people only from their physical presence, then paintings and other visualizations came along and later on with the invention of photography we started creating "databases" of identities. Not only for personal use, these collections have been used in forensic examinations, as referential databases, to find the identity of an individual [1]. A photography comparison as evidence in order to verify a person's identity was used in an English court as early as 1871 [9]. Needless to say, back then the comparison was done manually by humans. This was even before forensic techniques for this kind of face recognition were yet to be born. Since then technology completely changed the way we view facial recognition and widened the possibilities of its usage.

Compared to other methods of biometrics face recognition is non-invasive and non-contact. In fact it does not need any participation of the subject, which can be viewed both as a positive and a negative. On one hand subject does not need to make any effort to be identified but on the other hand it can be used without us knowing. Remarkably, both of these factors increase the popularity of face recognition.

3.1 Usage of FRT

–vsetky informacie a zdroje tu treba overit a podlozit este nejakymi dalsimi–

–fields of usage:

security

*phone/computer unlocking

*when issuing identity documents (probably not in SR)

*border checks - airport in Paris since 2018

*police checks - in US at least 26 states allow law enforcement to run searches against their databases of driver's license and ID photos. The FBI has access to driver's license photos of 18 states.

*surveillance in the public sector

**Find missing people

**Identify and track criminals.

**accelerate investigations

banking and retail (still kinda secutity)

*access to bank-account

*open a bank account

*facial recognition payment system (I am not sure if I belive this)

**Since 2017, KFC (American fast food), and Alibaba(Chinese retail and tech giant) have been testing a face recognition payment solution in Hangzhou, China.
** metro in Moscow(2021 -if they actually implemented it)

helth
*detecting some genetic diseases
*Patient check in and check out
*Access control
*Employee time clock - I hope this is not really being used
*Care-taking robots reading emotions (ofc emotions are complex so it's just matching the 6 basic emotions from classic emotoion theory)

=> corona has widened the usage of FRT
... TO BE CONTINUED...

3.1.1 In EU or SR

3.2 Regulations and data protection

3.3 Current models

–According to THALES:
1. Academia - **The GaussianFace algorithm** developed in 2014 by researchers at The Chinese University of Hong Kong - identification
2. Facebook - **DeepFace** - verification
3. Google -**FaceNet**
=> open source version **OpenFace**

4. Microsoft - "A study done by MIT (https://www.eurekalert.org/news-releases/587454) researchers in February 2018 found that Microsoft, IBM, and China-based Megvii (FACE++) tools had high error rates when identifying darker-skin women compared to lighter-skin men. At the end of June 2018, Microsoft announced that it had substantially improved its biased facial recognition technology in a blog post. " [10]–

As shown in section 3.1 face recognition technologies have very wide usage, that is only growing, therefore there is no surprise that the the top algorithms on the market are developed by powerful companies.

I will mention three of the most used algorithms: **DeepFace** developed by Facebook, **FaceNet** from Google and open-source version that arose from it, **OpenFace**.

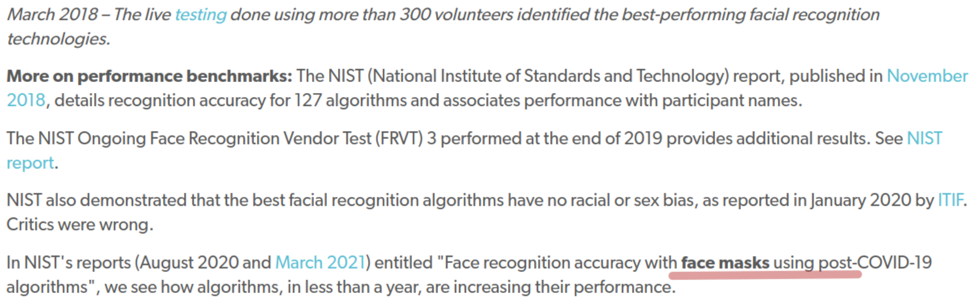
3.3.1 DeepFace

3.3.2 FaceNet

3.3.3 OpenFace

3.4 Performance of current models on masked data

please check this out on Thales[10] later



March 2018 – The live testing done using more than 300 volunteers identified the best-performing facial recognition technologies.

More on performance benchmarks: The NIST (National Institute of Standards and Technology) report, published in November 2018, details recognition accuracy for 127 algorithms and associates performance with participant names.

The NIST Ongoing Face Recognition Vendor Test (FRVT) 3 performed at the end of 2019 provides additional results. See NIST report.

NIST also demonstrated that the best facial recognition algorithms have no racial or sex bias, as reported in January 2020 by ITIF. Critics were wrong.

In NIST's reports (August 2020 and March 2021) entitled "Face recognition accuracy with **face masks** using post-COVID-19 algorithms", we see how algorithms, in less than a year, are increasing their performance.

on general database that systems use

on racialy separated data

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List of Figures