LITERATURE REVIEW:

FACIAL RECOGNITION WITH DEEP NEURAL NETWORK AND A WORKING SYSTEM FOR RECORDING ATTENDANCE

Department of Computer Science

Middlesex university

Author: Kazi Nawasis Ahmed

M00704320

1. ABSTRACT

The task of recognizing face has been actively researched in the recent years because of its universality and uniqueness. It has become the most widely used and accepted biometric method. This review presents an overview of facial recognition history, its standard workflow and problems. Finally, this document also covers a brief summary of the work that has been done so far.

2. INTRODUCTION

Face recognition is a salient research problem spanning over numerous fields and disciplines. Biometric based methods have emerged as one of the most promising and robust way to recognize people in the 21st century. The field of biometrics considers a person's biological features as a potentially useful information in a person's identification.[1]. This is due to its vast possible application in the field of finance (banking), security and surveillance etc. In facial recognition a person is recognized using a digital facial image. An individual is recognized based on certain facial features which are unique to them.

2.1 History

A formal method of classifying faces was first proposed in [2]. The author proposed collecting facial profiles as curves, finding their norms and then classifying their profiles by their deviation from the [norms. Later in 1960's a new concept emerged "Automated facial Recognition". Wodrow W. Bledsoe devised a way to semi automate the process of face recognition. It was based on the method that facial features will be manually located on photographs of their subjects, then specific to a reference point, distance and ratios are calculated which in-turn enabled comparisons. In the period of 1964-1965 Woody Bledsoe and Helen Chan wolf and Charles Bisson worked together to recognized human faces using computer.[3]. In 1970, 21 subject specific features such as lip thickness and hair color etc. were sued to automate the process of the facial recognition.[4]. During this time all the measurements and calculations were done manually. In 1988 Sirvoich and Kirby attempted to solve the problem using "principal component analysis" or otherwise known as (PCA) method [5]. This method could normalize a facial image accurately. In 1991, Turk and Pentland found that implementing Eigenface method, the residual error could be used for facial recognition [6]. This method enabled the automation of the Facial Recognition system. In 1997 ZN-Software was developed and commercialized face recognition system. However, during this time, the impact of side-faced images were not taken into account which resulted at time for the accuracy to drop below 50% [7].

2.2 Workflow or FR Systems

All facial recognition algorithms consist of two major parts:

-Face detection and normalization

-face identification/verification

Any face recognition algorithms that have both parts is a fully automatic and one's containing only second part is called partially automatic. Partially automated system is given facial images with coordinates to facial features. Fully automated system is only provided with facial image.

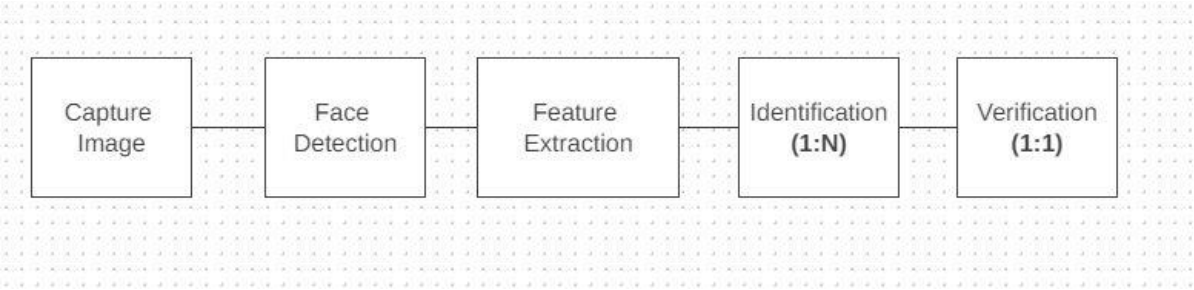

Figure 1. Workflow diagram of a face recognition system.

2.3 Problems with Facial Recognition

Complete accuracy in facial recognition is very challenging. Some of the major factors are discussed below:

- Illumination: a variable lighting condition can have a number of different effects on a person's facial image [8].

- Pose: generally referred to situation where individual is at an angle with the camera and the image is not full frontal facing.[9]

- Occlusion: any obstacle in the face can also cause an issue with generating feature points. Obstruction such as sunglasses or face masks.[10]

- Expression: it has been also studied that a person facial expression can also affect the facial recognition system as during the process of extracting the feature points different in position of the lips can be found in a rested face and a smiling face etc. [11].

- Age: with progression of age facial features can change tremendously which facial recognition system are equipped to deal with.

3. LITERATURE REVIEW

This section gives an overview on major facial recognition methods that has been developed so far. Methods considered are "knowledge-based methods", "Template Matching", "Appearance based methods".

3.1 Knowledge Based Methods

Also known as 'rule-based methods', during the development of this method it tried to capture knowledge of faces and then translating it into a set of rules. The difficulty with this method is the formulation of an accurate set of rules, these cannot neither be made too rigorous or too general [12]. In certain situation where facial invariant features are not detectable or visible this method fails to work efficiently. An instance for choosing skin tome was given as follows :

$0.4 \leq r \leq 0.6,\ 0.22 \leq g \leq 0.33,\ r > g\ (1-r)/2$ ...(1)

$1 \leq H \leq 0.2,\ 0.3 \leq S \leq 0.7,\ 0.22 \leq V \leq 0.8$ ...(2)

Where ‘r’ and ‘g’ are RGB color model and HSV represents Hue Saturation Value model.

Considering this a picture of a same person taken in different brightness(illumination) can affect the algorithm’s accuracy. [13]

3.2 Template matching

A simple version of template matching is that a test image represented as two-dimensional array of intensity values is compared using a suitable metric, such as the Euclidean distance, with a single template representing the whole face. There are several sophisticated versions of template matching on face recognition, where multiple face template can be considered from different viewpoints to represent one individual’s face. A face from a single viewpoint can also be represented by set of multiple distinctive smaller templates. Template matching method attempted to consider regions of faces, rather than capturing features such as skin tone etc, regions of faces can be represented as templates. The pixels of an input image are compared against a template image (commonly measured using Euclidian distance). [14]. For an input image a set of four regions eyes, nose, ear and whole face were selected from a template and was applied to the face. The drawback of template-based approach is its computational complexity. Another ambiguity comes in to play with the description of these templates. In general template-based approach compared to feature extraction method are more logical.

3.3 Appearance-based methods

This method is a derivative of template matching but relies on statistical techniques and machine learning to find specific facial features.

3.4 Eigen-based method

Also known as ‘Karhumen-Loeve’ method, claimed any face image could be approximately reconstructed by small collection of weights for each face image. The weights describing each face are obtained by projecting face image onto an eigen picture. Each face can be represented exactly by a linear combination of eigenfaces. The best X eigenface makes a X dimension space (also referred as face space). This method obtained over 96% accuracy. However, this approach requires a full-frontal image.

3.4.1 Linear Discriminant Analysis

Widely known as ‘Fisher’s discriminant analysis’, can be described as dimension reduction technique. This method used a way of feature selection which can overcome the problems with PCA (Principal Component Analysis). This method is also based on the Euclidian distance but this is a supervised method. It uses labeled information for enhancing separability between different classes [15]. It also focuses on reducing variation within classes [16]. In LDA dependent face recognition approaches PCA is used for dimensionality reduction, and the LDA is applied to maximize the discrimination power of feature selection. The disadvantage for this method was accuracy hits were more for relatively small sample size.

3.4.2 Graph Matching Technique

Graph matching is a different approach to face recognition [17]. In graph matching a dynamic link structure for distortion invariant object recognition, which used elastic graph matching to find the

closest stored graph in the database. In EGM(elastic graph matching) a graph is generated for each individual face. On the face specific nodes, known as fiducial point are selected, it can be better described as wavelength components. In the recognition phase two graphs are simply compared.

The disadvantage of this approach that it was computationally very expensive. In a test conducted on a dataset of about 86 face picture the computation time was over 25 seconds.

3.4.3 Neural Network

The solution to the problems encountered in the linear method was provided by non-linear methods such as neural network [18]. The feature extraction step using neural network is more efficient than linear method discussed earlier due to the non-linearity. Using the method an accuracy of over 96% was achieved. The way of constructing facial feature is crucial for a system with good accuracy. For a face detection multi-layer perceptron [19] and convolutional neural network [20]. For face verification a multi-resolution pyramid structure is used. Reference [20] proposed a hybrid neural network which combines local image sampling, Self-Organizing Maps(SOM) neural network and convolutional neural network. The self-organizing maps provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby on output space .

3.4.4 Support Vector Machine

Support Vector Machine is a learning technique that is considered an affective method for general purpose pattern recognition because of its high generalization performance with out the need to add another knowledge [21]. In Reference [22], the face recognition problem is formulated as a problem between different space.

1. Dissimilarities between faces of the same of the same person, and
2. Dissimilarities between faces of different people,

By modifying the interpretation of decision surface generated a similarity metric between faces. Reference [23] presented a component-based technique and two global techniques for face recognition and evaluated their performance with respect to robustness against pose changes. The component-based system detected and extracted a set of 10 facial components and arranged them in a single feature vector that was classified by liner SVMs. The system detected the whole face, extracted from the image and used as input classifier. The database of each person is clustered and trained on a set of view-specific SVM classifier. The component-based system outperformed all other global systems even though more powerful classifier were used. This research showed facial component instead of the whole face pattern as input features significantly simplifies the test of face recognition.

3.5 Conclusion

There are a lot of useful methods that have been proposed in various publications that are mentioned in this document. The crucial thing I have came across is learned features produce better results than manually crafting features considering provided a large enough sample size of dataset. The most useful method I found is neural network because it helps to override most of the non-linear problems encountered in the previous methods for feature extraction. The send method (using SVM) that outperforms component-based system given the system have to be trained on a view specific SVM classifier. I will consider combining and using the most useful methods that aids to better accuracy for this project.

4. INITIAL STEPS

I have created a conceptual model for the working system for automatic attendance capturing system.

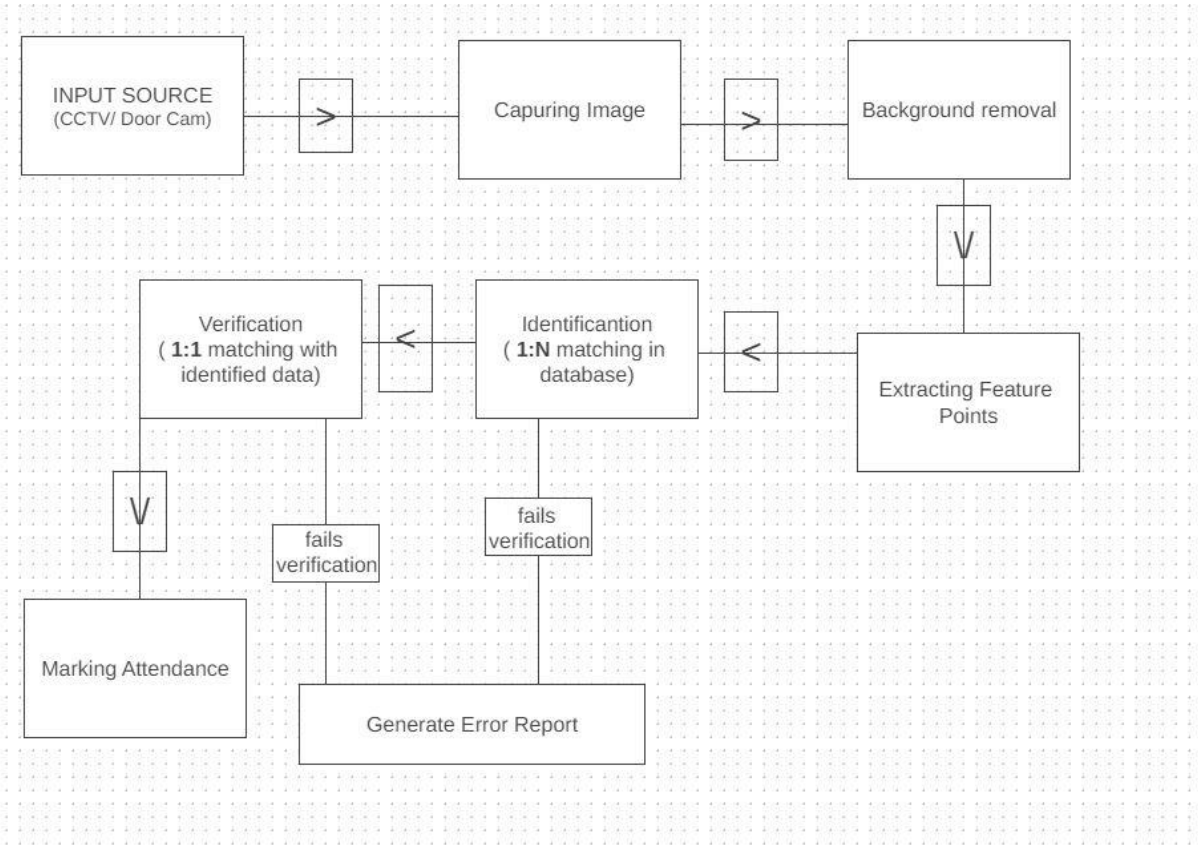

Figure 2. Representation of conceptual model architecture and workflow.

To implement this model, essentially the first step would be to extracting facial features. Currently, I am building the system in python using 'dlib' and 'openCV' libraries. The system now can correctly detect faces from a cluster of faces and remove the background completely. I am currently trying to develop a learning algorithm that can detect human faces and removes the rest of the picture without using any predefined libraries. The project is currently progressing as planned Gnatt chart.

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Student Name:	Kazi Nawasis Ahmed	Email: ka1064@live.mdx.ac.uk
Research project title:	COMPUTER VISION: FACIAL RECOGNITION WITH DEEP NEURAL NETWORK AND A WORKING SYSTEM FOR RECORDING ATTENDANCE	
Programme of study/module:	CST3990	
Supervisor Name:	Stylianos Kapetanakis	Email: s.x.kapetanakis@mdx.ac.uk

Please answer whether your research/study involves any of the following given below:		
1. [H]ANIMALS or animal parts.	☐ Yes	☒ No
2. [M]CELL LINES (established and commercially available cells - biological research).	☐ Yes	☒ No
3. [H]CELL CULTURE (Primary: from animal/human cells- biological research).	☐ Yes	☒ No
4. [H]CLINICAL Audits or Assessments (e.g. in medical settings).	☐ Yes	☒ No
5. [X]CONFLICT of INTEREST or lack of IMPARTIALITY. If unsure see "Code of Practice for Research" (Sec 3.5) at: https://unihub.mdx.ac.uk/study/spotlights/types/research-at-middlesex/research-ethics	☐ Yes	☒ No
6. [X]DATA to be used that is not freely available (e.g. secondary data needing permission for access or use).	☐ Yes	☒ No
7. [X]DAMAGE (e.g., to precious artefacts or to the environment) or present a significant risk to society).	☐ Yes	☒ No
8. [X]EXTERNAL ORGANISATION – research carried out within an external organisation or your reseach is commissioned by a government (or government body).	☐ Yes	☒ No
9. [M]FIELDWORK (e.g biological research, ethnography studies).	☐ Yes	☒ No
10. [H]GENETICALLTY MODIFIED ORGANISMS (GMOs) (biological research).	☐ Yes	☒ No
11. [H]GENE THERAPY including DNA sequenced data (biological research).	☐ Yes	☒ No
12. [M]HUMAN PARTICIPANTS – ANONYMOUS Questionnaires (participants not identified or identifiable).	☐ Yes	☒ No
13. [X]HUMAN PARTICIPANTS – IDENTIFIABLE (participants are identified or can be identified): survey questionnaire/ INTERVIEWS / focus groups / experiments / observation studies.	☐ Yes	☒ No

14. [H]HUMAN TISSUE (e.g., human relevant material, e.g., blood, saliva, urine, breast milk, faecal material).	☐ Yes	☒ No
15. [H]ILLEGAL/HARMFUL activities research (e.g., development of technology intended to be used in an illegal/harmful context or to breach security systems, searching the internet for information on highly sensitive topics such as child and extreme pornography, terrorism, use of the DARK WEB, research harmful to national security).	☐ Yes	☒ No
16. [X]PERMISSION is required to access premises or research participants.	☐ Yes	☒ No
17. [X]PERSONAL DATA PROCESSING (Any activity with data that can directly or indirectly identify a living person). For example data gathered from interviews, databases, digital devices such as mobile phones, social media or internet platforms or apps with or without individuals'/owners' knowledge or consent, and/or could lead to individuals/owners being IDENTIFIED or SPECIAL CATEGORY DATA (GDPR) or CRIMINAL OFFENCE DATA.	☐ Yes	☒ No
[X]PUBLIC WORKS DOCTORATES: Evidence of permission is required for use of works/artifacts (that are protected by Intellectual Property (IP) rights, e.g. copyright, design right) in a doctoral critical commentary when the IP in the work/artifact is jointly prepared/produced or is owned by another body	☐ Yes	☒ No
18. [H]RISK OF PHYSICAL OR PSYCHOLOGICAL HARM (e.g., TRAVEL to dangerous places in your own country or in a foreign country (see https://www.gov.uk/foreign-travel-advice), research with NGOs/humanitarian groups in conflict/dangerous zones, development of technology/agent/chemical that may be harmful to others, any other foreseeable dangerous risks).	☐ Yes	☒ No
19. [X]SECURITY CLEARANCE – required for research.	☐ Yes	☒ No
20. [X]SENSITIVE TOPICS (e.g., anything deeply personal and distressing, taboo, intrusive, stigmatising, sexual in nature, potentially dangerous, etc).	☐ Yes	☒ No

M – Minimal Risk; X – More than Minimal Risk. H – High Risk

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Based on the details provided in the self-assesment form, I confirm that:	Insert Y or N
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