Face Recognition and Face Detection Benefits and Challenges

Roweida Remone Tizee February
Master's Student in Computer Application
Kalinga University,
Raipur, C.G., India
roweidartfebruary@gmail.com

Ms. Sushree Sasmita Dash
Assistant Professor, Department of Computer Science
Kalinga University,
Raipur, C.G., India
sushreesasmita.dash@kalingauniversity.ac.in

***Abstract*—Face Recognition has been used for many applications concerning security, identification, and authentication. This research paper examined 60 years of face recognition history and highlighted the difference between face detection and face recognition. The benefits and challenges of using a face recognition system are discussed. The programming languages and libraries used to develop face detection and face recognition systems were examined. The research investigated the process of creating a software application to assist lecturers and teachers in taking classroom attendance using face detection instead of performing this manually. The research was carried out by examining 34 Namibian lecturers and teachers to determine if a face detection system would work as a school/university attendance system. The study found that the majority respondents were willing to use a face-detection attendance system. There are still numerous challenges to overcome before schools or universities can take full advantage of a face-detection attendance system.**

Keywords-Face Recognition, Face Detection, Programming, Application, Attendance System, OpenCV.

I. INTRODUCTION (HISTORY OF FACE RECOGNITION TECHNOLOGY)

Face recognition technology has been incorporated into our daily life, whether it is used on mobile phones, laptops, personal computers (PC), or traffic surveillance. Facial recognition computer programming first started in 1964, which measured the size of the mouth and eyes[1]. An additional 21 facial markers were added in 1977. In 1988, linear algebra was used to interpret, simplify and manipulate human markers on images[1]. Massachusetts Institute of Technology (MIT) introduced the first successful example of facial recognition technology known as Eigenfaces in 1991. Eight years later the Defense Advanced Research Projects Agency (DARPA) developed a database composed of 2400 images for 850 people[1]. In 2005, a competition known as Face Recognition Grand Challenge (FRGC) designed existing face recognition initiatives[1]. In 2014, Deepface was an internal algorithm used by Facebook to recognize faces. In 2018, a smart monitoring system used live facial recognition to identify 50,000 people in a crowd, to assist Chinese police to arrest a suspect of economic crime[1]. A more recent development in face recognition occurred in China in 2019, where individuals' faces needed to be checked by the operator to buy a new phone[1]. The aforementioned indicates that facial recognition has been widely used for almost six decades.

II. BACKGROUND

A. Differences Between Face Recognition and Face Detection

Face detection, in most cases, is a subset of face recognition. Face recognition is a visual pattern recognition that consists of face verification and face identification, whereas face detection is the first step to an automated face recognition system[1]. Thus, for face recognition to be able to recognize a face, it will need to detect it first. Figure 1 provides a graphical representation of the differences between face detection and face recognition, and Table 1 offers a tabular view of the differences. According to Datta *et al*., face detection is divided into a feature-based approach as well as an image-based approach. In this review, we'll only look at a feature-based approach where low-level analysis is located. The types of low-level analysis are Color, Gray levels, Edges, and Motion [4], which will be dealt with in more detail in the next section.

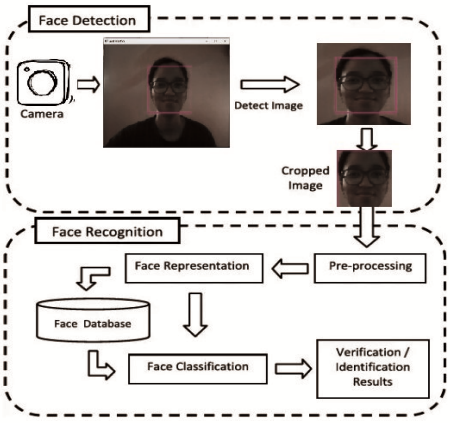

Fig.1 System diagram of a typical face detection/face recognition system based on [3]

Table 1: Difference between face detection and face recognition

Face Detection	Face Recognition
Face detection is a subset of face recognition.	Face Recognition consists of face identification and face verification.
The initial step to face recognition.	face recognition to be able to recognize a face.
Detects face and crop image to be preprocessed.	Checks the database whether face identity is present.

Based on findings from [1]

B. Low-Level Analysis for Face Detection

Low-level analysis in face detection, segments visual features using pixel properties such as grayscale and color[4]. The low-level analysis consists of Edges, Grayscale, Color, and Motion feature extraction methods.

Edge feature extraction is applied to the earliest face detection work, based on analyzing line drawings of faces from photographs, and aims to locate facial features.

Grayscale also known as the gray-level analysis extraction algorithm searches for local gray minima within the facial segmented region[4]. In grayscale, the input image is first enhanced by contrast-stretching then grayscale morphological routines improve the quality of dark patches, making detection easier[4].

Although grayscale extraction provides the basic representation for image features, color is a more powerful tool for detecting object appearance[4]. The extra dimensions in color assist with differentiating human skin composition. The most widely used model is RGB, which is a combination of red, green, and blue to represent different colors[4].

Motion-based analysis is convenient for locating a moving face if a video is used. Motion information achieves motion segmentation by frame difference analysis[4]. This frame difference analysis can detect a moving foreground regardless of the background content[4].

Taking all the aforementioned low-level analysis categories into account, this research used color-based analysis, because of the added advantage it provides in face recognition.

C. Identification and Verification

Face recognition output system consists of two approaches: identification and verification (authentication). Face identification is a one-to-many mapping where a face is checked against a database of known faces, whilst, face verification is a one-to-one mapping, where a face is checked with an identity in the database[10]. According to Mustapha *et al*., identification advances verification to a higher level, which is important when dealing with digital purchasing[10]. Deep learning has very high recognition accuracy ratings for a large number of high-quality images captured for identification and verification[10]. The main aim of identification and verification applies resolution algorithms or cross-resolution algorithms to low-resolution face images to improve the efficiency of the face recognition system[10]. Identification and verification are summarized in Table 2.

Table 2: Summary of identification and verification approach

	Identification	Verification
Known as	1:N matching problem	1:1 matching problem
Explanation	The unknown face is compared with all the faces in the database of known identities.	The identity of the query face is compared with the face data of the claimed identity in the databases.
Type of task/result	•closed-set – a person is known to be in the database. • open-set – a person is unknown to be in the database.	•confirmed. •rejected.

Summary Based on [10]

III. FACE DETECTION USING OPENCV.

The free software library used for face detection and face recognition is known as OpenCV which stands for Open-Source Computer Vision Library[7]. OpenCV provides a framework in which you can work with images and video without worrying about allocating and deallocating memory for your images[6]. OpenCV library was primarily created for C++, it can be used in Java for Android applications [7] and Python programming. Datta *et al*. state that OpenCV can train and detect different parts of the human body, not only the face. It is an open-source set of libraries/projects that can be downloaded from www.opencv.com. OpenCV contains many pre-trained classifiers for faces. The XML (extensible markup language) file for Haar-cascade face training is stored in the opencv/data/haarcascades/ folder[5].

IV. MATERIALS AND METHODS

A. Software and Hardware used for the Face Detection system:

The software used to code the face detection attendance system includes VSCode/Microsoft Visual Studio 2022 using C++ programming language and OpenCV for image processing. The hardware used includes an 11th Generation Asus ZenBook 13 Laptop, with 8.00 GB RAM, a 64-bit operating system, and a webcam. The developed face detection attendance system did not contain a database but stored the users' credentials in text files as shown in Figure 2. The text file is saved as the user's username, consisting of the password and the detected image saved in JPEG (Joint

The Software was based on Author's Final year project

Photographic Experts Group) image format. The sample group for the study was 34 lecturers and teachers from Namibia, who received a survey questionnaire on whether they would consider moving over to face-detection attendance software. To obtain the statistical information for the research, SurveyMonkey was used. SurveyMonkey is a cloud-based software that creates sophisticated surveys and assists with data visualization[11]. Figure 2, the personalized text file for the user's credentials such as the username, password, and the detected image.

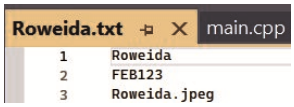

Fig 2. Text file with the user credential

V. Benefits Of Face Recognition

Here are some of the benefits of using face detection over other biometric identification methods such as iris recognition or fingerprint biometrics[3]. Face recognition is considered reliable and socially accepted compared to iris and fingerprint biometrics[3]. In other words, people are generally more willing to share their face images in the public domain because of the increasing interest in social media applications (e.g., Facebook)[9]. Face recognition works well in places with a large population of unaware visitors, which provides a great balance between security and privacy[3].

Compared to fingerprint recognition systems, face recognition can capture data at a longer stand-off distance using non-contact sensors[9]. Face recognition can convey not only face images, but emotions as well (e.g., happiness or sadness) as well as biographic information (e.g., gender, ethnicity, or age)[9].

VI. Disadvantage of Face Recognition

The most common defect of face detection is that it is prone to spoof attacks. Spoof attacks use a facial photograph of a valid user to spoof the face recognition system [3], which can be seen in Figure 3 using a student ID card. A needle camera can be used to capture a video of a valid user to spoof the system as well[3]. A spoof attack can be prevented by liveliness detection, which aims to recognize human physiological activities, such as facial expression variation, mouth movement, head rotation, or eye change[3].

Fig 3. ID card for face registration error.

Illumination is another challenge faced by face detection, when factors such as lighting conditions and camera characteristics also affect the appearance of the face. This process is shown in Figures 4 and 5.

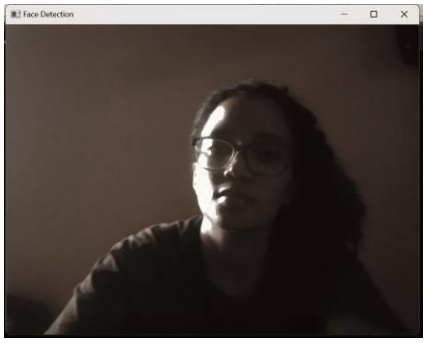

Fig 4. Overexposed to light face not detected.

In Figure 4 the program is unable to detect the face of the user logging in due to the light exposure coming from the left side of the face. As soon as the light source is shielded (in the case of Figure 5 by the individual's hair), the program can detect the user's face again.

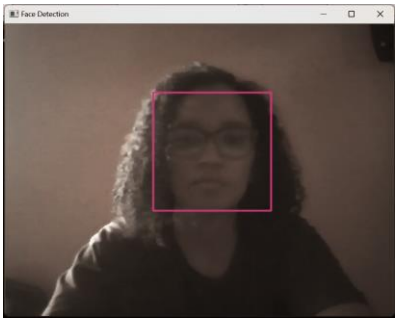

Fig 5. Immediately detects face once the light source is shielded.

The face detection system does not detect the user's face if the face is overexposed to light. This is a problem other researchers experienced, one article suggested equalization techniques [8] to solve this issue.

Occlusion is where faces are partially blocked by other objects. This can be seen in Figure 6, where one of the faces is cut off due to the individual accidentally appearing in the frame, causing the face detection to only detect one face. In an image of a group of people, some faces can partially block other faces.

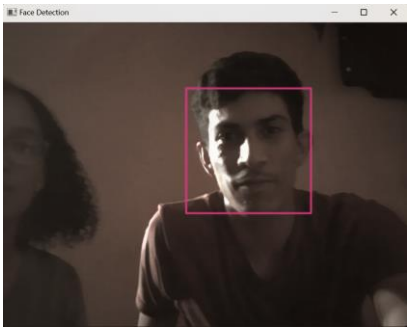

Fig 6. An individual moving in & out of the frame quickly.

Another form of facial occlusion that causes partially covered faces, is abstracted by facial artifacts [1] (for example glasses, shades, masks, scarf, or a hat. An example of a face partially covered can be seen in Figure 7, where the face detection system can only detect a pattern on the mask.

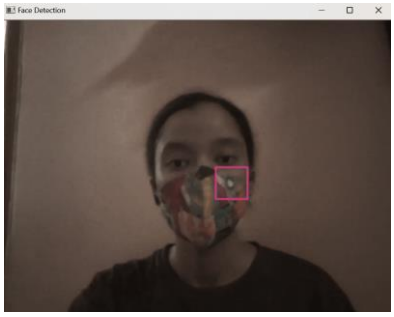

Fig 7. Another form of occlusion (no glasses and a facemask)

Poses affect the face detection system as well, with images of a face changing due to camera-face pose.

VII. RESULTS

Would a face detection system work as a school attendance system? Smitha *et al.* created a face recognition-based attendance system to assist with the tedious task of taking manual attendance still implemented in many schools and colleges[12]. Manual attendance is a time-consuming task. During the survey with the sample group within the study, one of the questions that was asked is "If face recognition was implemented as a new way of marking attendance for students, would you implement it in your classroom?" the response to strongly agree or agree came to 52.94% and 38.24% respectively from the 34 Namibian lecturers and teachers. The result of the lectures and teachers' responses to the previous question is shown in the graph displayed in Figure 8 and more detail is given in Table 3.

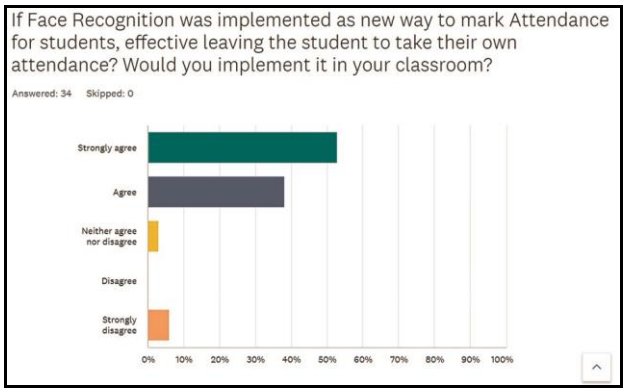

Fig 8. The percentage of Namibian lecturers & teachers considering implementing face detection attendance system

Table 3. The percentage of teachers and lecturers considering implementing face detection attendance system

Answer Choices	RESPONSES	
Strongly agree	52.94%	18
Agree	38.24%	13
Neither agree nor disagree	2.94%	1
Disagree	0.00%	0
strongly disagree	5.88%	2
TOTAL		34

Responses based on the sample group.

With the system that was developed during the research, a student's face is detected similarly as shown in Figure 5. The user can select whether to log in or register. When a user selects to log in, the user must enter their username and password as well shown in Figure 9.

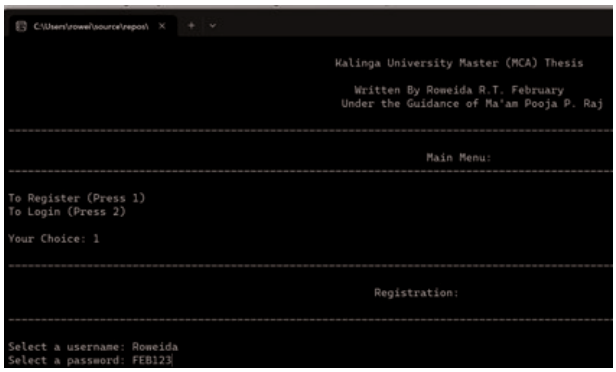

Fig 9. Log in/register page

Once the user's details are entered, the system confirms whether there is a matching text file as shown in Figure 2. If there is a matching text file, the user gains access to the Dashboard shown in Figure 10 allowing them to mark their attendance.

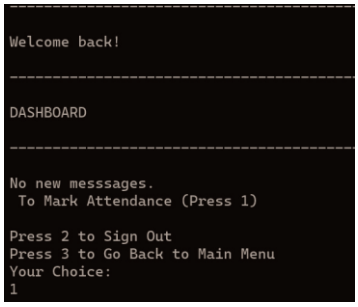

Fig 10. Dashboard to mark attendance

If a matching text file is not available, the user receives an "Invalid Login" error message and takes the user to the main page where they can register. To register a user, the program detects the user's face, saves it to a text file, and requests a username and password. The system saves the username, password, and image to a personalized text file and thereafter brings up the Dashboard. A flowchart is provided to see the flow of the process of the system in Figure 11.

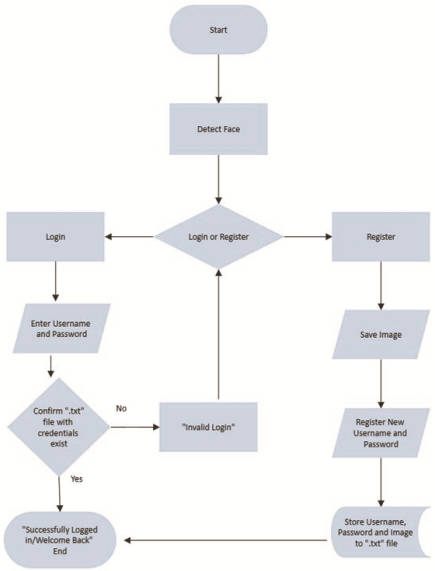

Fig 11. Flowchart of face detection attendance system

VIII. Discussion/ Future Scope

For future research, using this face detection attendance system, two faces can be saved as one individual student as shown in Figure 12, but this only occurs if both individuals are remaining still for the photo. Rather than accepting the image and saving it to the text file, an error message can pop up, and not allow the user to save the image.

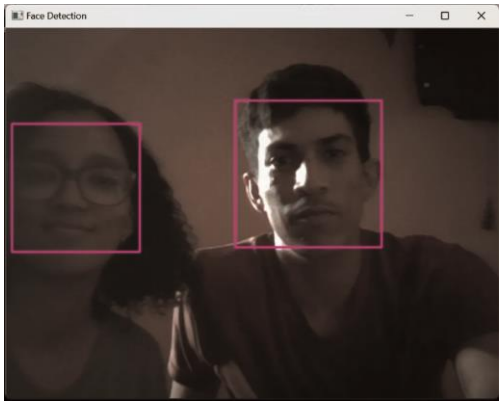

Fig 12. Multiple faces for one individual account

As stated in the disadvantages, illumination is due to overexposure to light on the user's face as shown in Figure 4. Illumination is a problem that other researchers have experienced, Solomon *et al.* suggested equalization techniques can assist in solving this issue[8], as well as working on liveliness to reduce/avoid spoof attacks as shown in Figure 2. From the sample group of Namibian lecturers and teachers, one respondent mentioned late coming of the students is not accounted for. To compensate for this, a time stamp can be added to the system.

IX. Conclusion

In conclusion, face detection and recognition have many great benefits. It is considered reliable, socially accepted, and least intrusive compared to other biometric identification systems. Face detection and recognition have challenges as well, including spoof attacks, occlusion, illumination, and pose variation. Nonetheless, lecturers and teachers would still opt for a face-detection attendance system compared to manual attendance. There is a lot of progress that must be made before educational institutions can fully experience the benefits of a face detection system. It is expected that many improvements will likely be made within the coming years.

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