Design and Development of Facial Recognition-based Library Management System (FRLMS)

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***Abstract*—In this paper we propose a facial recognition-based library management system namely Facial Recognition based Library Management System (FRLMS). This system aims to improve the user experience on library authentication process through facial recognition algorithm. This process would be simple and efficient as the authentication process is performed seamlessly. For the purpose of this study, feature extraction and image classification are obtained using OpenCV and TensorFlow, where the average recognition accuracy reaches up to 92.15%.**

Keywords—Face Recognition, biometric, identification, verification, Library Management System

I. INTRODUCTION

Face recognition (FR) is a biometric approach that employs automated methods to identify or recognize an individual face by analysing and comparing patterns of physiological characteristics (fingerprint, iris pattern and face) as well as behavioural patterns (hand writing and voice) [1]. Face recognition technology gradually evolves to be a universal biometric resolution because of its user-friendly, compared with other biometric options. Face recognition is non-intrusive and it verifies human identification in an efficient manner a natural and friendly way [1].

There are numerous application areas in which face recognition can be exploited. FR is commonly used on security, surveillance, identity verification, criminal justice systems, and other applications. In relation to student and academic activities, FR was successfully implemented in student attendance system [2]–[5]. Other than attendance system, student as well as faculty members sometime facing some problem when access to library. Every student as well as faculty member expects an efficient customer service and easier access to library resources. Most academic libraries expect students to be entirely independent and will aim to reduce the student-librarians communication to its best possibilities.

In the other hand, librarians also face problems where they are packed with their job scope that some data might be missed when tracking a student's/borrower's record in the library. For example a librarian or a student might not be up to date with their borrowing and return status thus he or she might pass the due date and will be charged with extra amount to pay.

Additionally, students often lose or damage their ID card due to unforeseen situations. This would cause difficulties in accessing the library and utilizing its resources when needed. For example, in Taylor' Taylor's University, there's a fine of RM50 for lost ID in the first occurrence and RM100 for the second [6]. This is an issue for students studying on a low budget.

Thus, the aim of this study is to develop a prototype of library management system based on FR, namely Facial Recognition-based Library Management Systems (FRLMS). The focus will be placed on designing the system that will accurately identify the student face. Additionally, the proposed system will show whether there are fines to pay due to overdue book returns or any other related record to the library matters.

The rest of this paper is organized as follows. Section II describe the previous work on FR. Section III explained about the proposed solution. While Section IV is about the Architectural Overview. Next, Technologies and Resources is explained in Section V. Section VI is discussed the experimental study. Finally, conclusion and future work is explain in section VII.

II. PREVIOUS WORKS

FR systems has become very popular in playing a vital role in various application as shown in Table 2. In security related aspects FR already implemented as an access control to buildings [7], mobile engagement [8], and immigration check point.

In surveillance, FR is employed to detect a city crime, such as robbery, murder, accident, etc [9]–[11]. For the purpose of identity verification, FR are applied for identify national ID, passports [12], driving licenses, employee ID, and student ID [2]–[5], etc. in the other hand, for criminal justice systems, FR was implemented as forensics [13]. FR also implemented in other application such as gender classification [14], emotion recognition [15]–[17], and health care [18], etc.

The data set used for FR are from freely available image or video data set namely Choke Point data set [10], Color Feret dataset [12], [14], Direcci´ on Nacional de Identificaci´ on Civil (DNIC) dataset [12], Morph [13], Atvs Forensic db [13], Cmu Face dataset [16], and Cohn–Kanade database [17], [18]. However, some other work generated their own data set. De-xin, et.al 2018, generated the video data set as

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explained on their previous work [9]. On the other hand, as depicted in Table 2, some others previous work generates image data set for the their study as explained at [2]–[5], [7], [8], [11], [15].

The commonly used FR technique are Principal Component Analysis (PCA) that implemented in the previous work done by Poornima et.al, 2017, Dargham et.al, 2017, Sreelakhsmi et.al, 2017, and Li et.al, 2017 [3], [10], [11], [14]. The average result of PCA was achieved 91%. On the other hand, Mehta et.al, 2016, Samet et.al, 2017, and Lema et.al, 2013, utilize Local Binary Patterns (LBP) [2], [5], [12], with carry out the average result 91.60%. Poornima et.al, 2017 and Marsico et.al, 2014, use Viola–Jones in their previous study, with average accuracy achieved 83.33% [3], [8]. Finally, Support Vector Machine (SVM) was implemented in Mehta et.al, 2016, and Adeyanju et.al, 2015 with average result 95.66% [2], [15].

A study done by Priyanka Wagh et.al, 2015 [19] shows that the usage of facial recognition would solve the problem of fake proxies using a student's ID card to enter the library. One of the biggest problems faced by a library is unauthorized entry by non-students through sharing or passing of cards. In addition to that, there are reports of stolen cards being used to borrow books. Additionally, most of the prior research only focus on a still image. However, the video data is not much utilized. A Still Image data do not have information on the subject from different position and angle. Thus, there is a need to have a system that utilizes the video as training data that will generate more accurate datasets, due to the subject data can be collected from different position and angle. The main objective of this study is to develop a prototype of library management system based on FR namely FRLMS. FRLMS would be used to enter and borrow books, eliminating proxies and unauthorized entry.

III. Proposed Solution

A. Mechanics of the Solution

FRLMS contain three main integrated sub-systems, namely, user data collection, entrance authentication and borrow book authentication. This is illustrated in Figure 1.

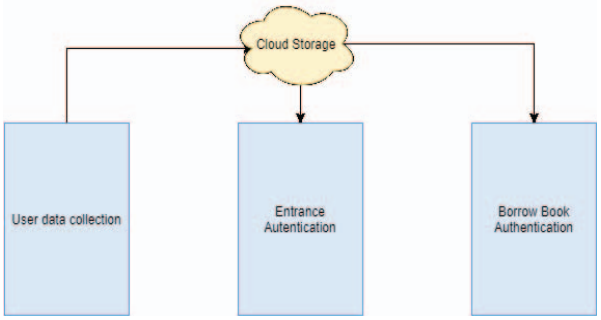

Fig. 1. Interaction Between The 3 Subsystems

User data collection subsystem is the point where data is fed into the facial recognition system to be used as baseline data. Data that is collected would then be stored on a cloud storage for computing. We recommend the data collection process to take place when students register at the institution at which the library is located. A computer with a webcam is sufficient hardware at this stage. Here the user or admin staff must enter the student's ID number as unique tokenized identifier of the dataset. Upon which a simulation would show the user how their face should be rotated in order for the camera to analyses and obtain images of the face. Similarly with R. Brunelli and T. Poggio [20], the software would identify geometric features of the face such nose length and width, mouth position, and chin shape. The collected dataset would then be stored on a database located in the cloud.

The cloud storage would also be equipped with a server and machine learning algorithms that would continuously learn and refine identification techniques thus increasing speed. Each time a user uses the FRLMS, the machine learning algorithm would improve its data set to help faster identification of a face. In the next section we will outline in detail how the machine learning and facial recognition algorithms works.

The second subsystem, Entrance Authentication would be implemented at the entrance gates of the library and would replace the existing access card reading station. Here a simple set up with a web camera, screen and a Raspberry-Pi would be sufficient. According to previous work done by Kavita et.al, 2017 the collected data can be transmitted to the cloud server through transmission between Pi and an internet terminal [21]. Upon transmission, the data would be computed on the cloud server and as soon as a successful match is obtained, the cloud server would relay back the success message to the Pi. Based on the message the system would allow or deny access to the student.

The third subsystem would incorporate book borrowing process to the FRLMS. As of now, in order to borrow a book, a student must scan their card and enter their pin which is a tedious and time consuming process. With FRLMS, they can simply look into the camera at the borrowing station and proceed to scan their books. Similar to the second subsystem, there would be a Raspberry-Pi that would transmit the data collected to the cloud through an internet terminal and all the computation would be done at the cloud server.

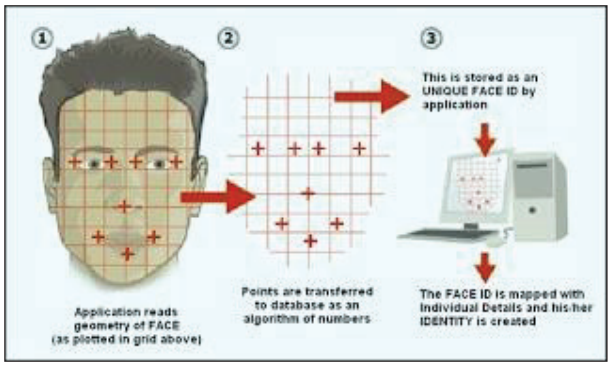

Fig. 2. Facial Recognition Algorithm [22]

B. Facial Recognition Algorithm

Figure 2 describes how the facial recognition algorithm that identifies and uses facial geometry to differentiate between faces. A map of the data is then stored and each time a face is scanned it would compare it against the stored map.

Sreelakhsmi et.al, 2017 used Eigenface as an approach to do facial recognition [11]. It starts by collecting a set of images of the person for storage where each image would differ slightly in terms of angle. The algorithm then does a series of vector transformation that are stored in the database. It

proceeds to create an average of the images collected which acts as the baseline data and would be used to compare in the future.

When the same face is scanned again in the future, the image is added to the original set of familiar faces and the eigenface is recalculated making the average face more accurate. This can be considered as the learning process. Each time someone scans their face, the image is compared to the average created and it used to identify a match.

IV. Architectural Overview

The architectural structure of the system is divide into 3 separate modules (Training Module, Processing and Storage Module, Recognition Module). Figure 3 shows the high-level architectural overview of the system and the transfer of data among the different modules. The modules shown here are directly correlated with the 4 vital steps needed to construct a facial recognition model as identified by Xia et.al, 2017 which are image pre-processing, training, validation and testing [17].

The Training Module in the proposed system conducts image pre-processing and training. Image pre-processing performs the conversion of image format and the extraction of the images. Extraction of the images is performed based on the vital features that determine the location of a face such as position of eyes, nose and the mouth. For the later part which performs facial recognition, the system also keeps records of a variety of other features such as colour of skin, skin tone, face cuts etc.

The Processing and Storage Module acts as the core of the entire system and intermediates with other modules in the system. This module would be cloud-based as scalability of the system would be easier and because the system relies heavily on performance. The module houses the machine learning and facial recognition algorithms needed to perform authentication. Besides that, the module also serves as a storage base for all the facial models captured over time.

The Recognition Module which would consists of a Raspberry Pi attached with a RasPi Cam captures a live video stream which relays it back to the Processing and Storage Module for authentication to be performed against any faces detected in the video stream. The Recognition Module also acts as a relay point to receive information pertaining authentication status from the Processing and Storage Module before granting access into the library.

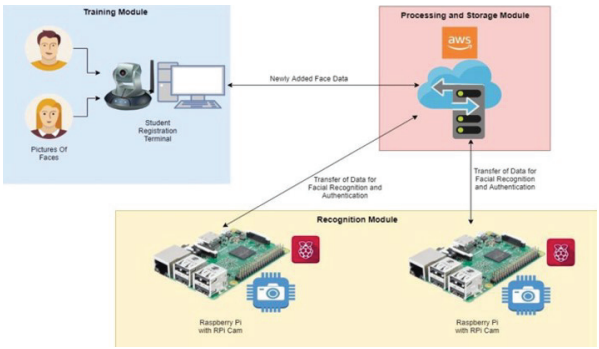

Fig. 3. Architectural Overview of System

V. Technologies & Resources

FRLMS uses a combination of both hardware and software. Factors such as cost, speed and portability were taken into consideration for the usage of these technologies.

A. Hardware Tools

1) Raspberry Pi

The Raspberry Pi 3 Model B was chosen for the hardware implementation of the system as the nature of the system was intended to be Internet-Of-Things (IOT) based. Costing merely $35, the Raspberry Pi comes with a 1.2GHz 64-bit quad-core ARMv8 CPU, 802.11n Wireless LAN, Bluetooth 4.1 and Bluetooth Low Energy (BLE) as identified in a study by S. Syed Ameer Abbas et al. [11].

2) Raspberry Pi Camera Module

The Raspberry Pi Camera Module which is able to connect directly with a Raspberry Pi via the CSI (Camera Serial Interface) is used to capture live video stream and relay it to the cloud server for processing. The Raspberry Pi 3 Model B together with its camera interface connected via a ribbon cable can be seen in Figure 4.

Fig. 4. Complete Hardware Implementation

B. Software Tools

1) OpenCV

Open Source Computer Vision Library, better known as OpenCV is an open-source library of programming functions focusing mainly of machine learning and real-time computer vision. The library consists of more than 2500 optimized algorithms and interfaces well with a variety of programming languages, namely C++, Python, Java, MATLAB etc.

In terms of speed, a study conducted by Kruti Goyal et al. had mentioned that since OpenCV uses C/C++ library functions, this directly provides the computer with machine language code, thus resulting in a quick execution [23].

2) TensorFlow

TensorFlow is an open-source software library used for high performance numerical computation. TensorFlow was initially developed by Google for its internal use before being made open, and it supports a number of neural network models, namely, convolutional neural network (CNN), recurrent neural network and many others, as identified in a study by Xiao-Ling Xia et al. [17].

3) Amazon Web Services (AWS)

AWS provides on-demand cloud computing platforms based on a subscription basis. AWS's suite offers more than 100 different solutions for clients ranging from hosting, storage, analytics etc. It's convenient as there is no need for setting up physical storage and servers locally. Besides that, it is highly scalable as the service capacity can be upscaled or downscaled at any given moment.

VI. Experimental Study

A. Participant

Three young and healthy males participants volunteered to participate in this experiment. They are undergraduate students from School of Computing and Information Technology (SOCIT) Taylor's University.

B. Procedure

The subjects were briefed about the experiment and their rights through a verbal explanation. Experiment was divided into two phases, first is data collection, and second is testing. During the data collection, subject wore round neck t-shirts, had no hair on the face and wore no glasses, makeup or jewelry.

While during testing, subject has no restriction on wearing clothes as well as glasses and accessories. Each subject was conducted the testing experiment in 5 different times.

C. Result

TABLE I. Testing Result from Three Subjects

Subject ID	Trial	Accuracy (%)	Remarks (Granted threshold set at 95%)	Additional Remarks
1	1	100	Granted	Normal expression
	2	85	Denied	Looking sideways
	3	93	Denied	Hair combed downwards
	4	98	Granted	Normal expression with different background
	5	97	Granted	Smiling expression
2	1	100	Granted	Not wearing spectacles
	2	95	Granted	Wearing spectacles
	3	86	Denied	With facial hair
	4	81	Denied	With bright background (high glare)
	5	Face Not Detected	Denied	Squinting eyes
3	1	100	Granted	Normal expression
	2	95	Granted	Squinting eyes
	3	100	Granted	Wearing spectacles
	4	Face Not Detected	Denied	Long Hair Fringe (Covering Eyebrow)
	5	68	Denied	Long Hair Fringe (Not Covering Eyebrow)

D. Discussion

The accuracy of the experiment are shown in Figure 5. Each subject were conduct five times testing experiment. From the result above, subject one failed two times, first because of looking sideways and second caused by hair combed downwards. Over all result for subject one, was success with average accuracy 98.33%.

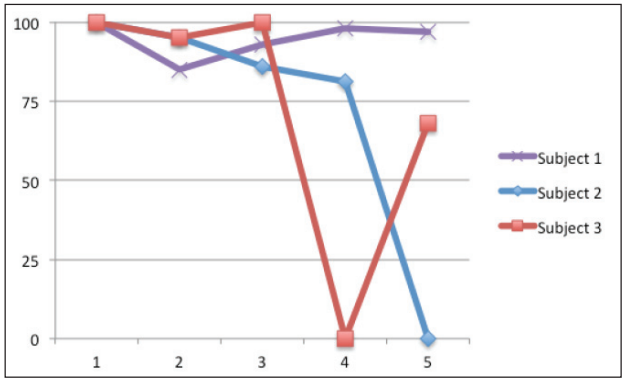

Fig. 5. Accuracy of Subject Identification

In the other hand, subject two was failed three times. First the subject was has the facial hair. Second failure because of the bright background. The last failure case is because of squinting eyes. In average, subject two were get the access granted in 97.5% accuracy.

Similar with subject one, subject three were failed two times during testing experiment. First, while the subject has long hair fringe covering eyebrow as well as not covering eyebrow. Overall result, subject three has 98.33% success accuracy.

VII. Conclusion and Future Work

In this paper, we intend to leverage on machine learning algorithms to produce a FR system capable to ease access into library resources for students across universities. This will be done so using the proposed FRLMS which would involve studying and developing a FR model.

FR is a technology that is becoming more common nowadays as it provides an attractive solution for easier identification and verification. Thus, more functions and applications can be integrated into this system to cover all the requirements possible in a university environment.

The current system will deny student access to the library due to overdue books. In the future, more rules will be added to enhance the security of the system. For example when the system scans the student's face, details will show on whether there's fines to pay due to overdue book returns.

Librarians often face problems in keeping the library clean and a quiet place to study, this is due to some students not being able to follow the common library rules such as "no food allowed" or "keep your voice down". Thus in the future, in the cloud storage there will be a set of rules recorded by the librarians for the students to follow, if the student is spotted violating these rules, the librarian can set a number of times for the repeated offences, if it exceeds that

number, then the student will be banned from entering the library for a certain period of time.

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SCREESHOOT OF FRLMS

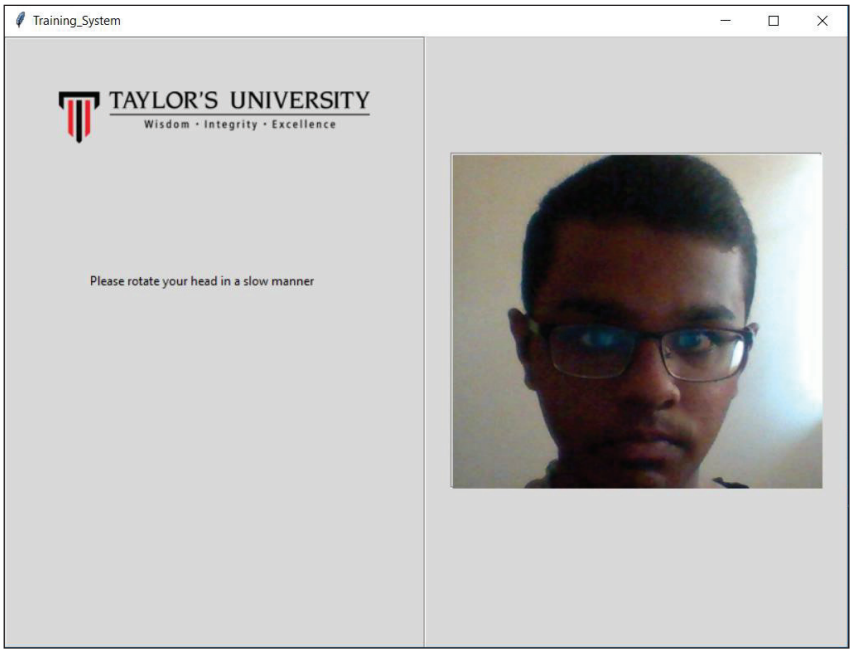

Fig. 6. Training System (During Data Collection Process)

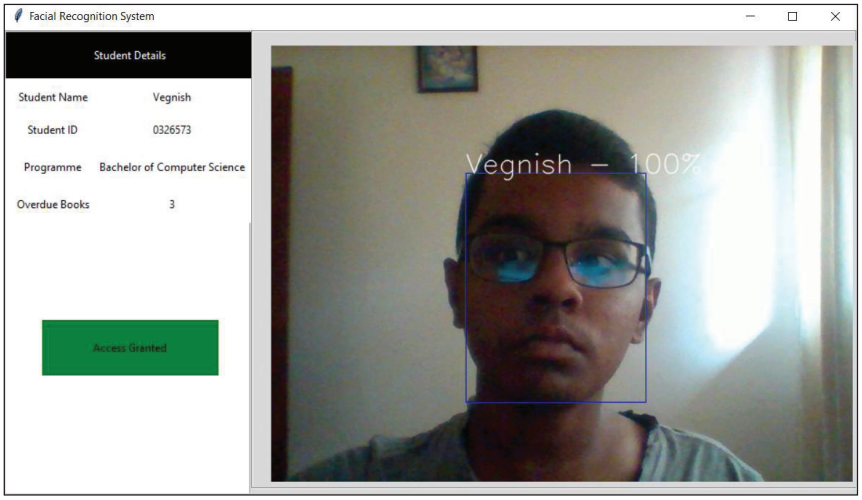

Fig. 7. Access Granted while Student Access the FRLMS

TABLE II. PREVIOUS WORKS ON FR APPLICATIONS

No	Author	Application	Data Set	Techniques	Result
1	[7]	Face Recognition Security System, which can detect intruders to restricted or high-security areas, and help in minimizing human error	Face images	Image Processing Tool Box from MATLAB	90%
2	[8]	FIRME: Face and Iris Recognition for Mobile Engagement as a biometric application based on a multimodal recognition of face and iris, which is designed to be embedded in mobile devices	The dataset used to test the performance of FIRME is composed of images of 49 participants faces and irises	Viola–Jones, SQI	Not reported
3	[10]	Face Recognition for Surveillance Applications	The color video images of the ChokePoint Dataset	PCA	Gray Scale 100%, Others 96%
4	[9]	Application of robust face recognition in video surveillance systems	20 hours video surveillance data	FPCA	Glasses 97.13%, Beard 98.39%, Scarves 99.32%
5	[11]	Unconstrained Face Recognition in Law Enforcement and Security Area	300 images	PCA	94%
6	[12]	Evaluation of a face recognition system performance's variation on a citizen passports database	Color FERET dataset, DNIC dataset	LBP	98%
7	[13]	Functional feature-based approach useful for real forensic caseworks, based on the shape, orientation and size of facial traits, which can be considered as a soft biometric approach	MORPH and ATVS Forensic DB	SFFS	ATVS database 100%, MORPH database 75%
8	[14]	Gender Classification using Face Recognition	FERET database	PCA, and LDA	PCA 82% LDA 85%
9	[15]	Performance Evaluation of Different Support Vector Machine Kernels for Face Emotion Recognition	714 face emotion images	SVM, PCA	99.33%.
10	[16]	Emotion Recognition from Face Dataset Using Deep Neural Nets	CMU Face dataset	RBM, DBN, SAE and SM	RBM 25.52% DBN 25.52% SAE+SM 99.68%
11	[18]	Automatic facial emotion recognition using weber local descriptor for e-Healthcare system	Cohn–Kanade database	WLD	WLD 99.28 %
12	[2]	Attendance Management Sytem	12 faces	LBP, HOG, SVM	92%
13	[17]	Emotion Recognition retrain facial expression dataset	The Extended Cohn-Kanade dataset	Inception-v3 model of TensorFlow platform	97%
14	[3]	Attendance Monitoring System	30 training images	Viola jones face detection, skin color detection algorithms, and PCA	83.33%
15	[4]	Student attendance system	16 students situated in classroom setting	DWT and DCT, and RBF	82%
16	[5]	Face Recognition-Based Mobile Automatic Classroom Attendance Management System	11 students faces	Eigenfaces, Fisherfaces and LBP	84.81%