APPLICATION OF FINGERPRINT IDENTIFICATION FOR THE SMART ACADEMIC CALENDAR MANAGEMENT SYSTEM

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ABSTRACT

Currently, the tracking and monitoring student's classroom participation are mostly done by lecturers before and/or after each lesson. In fact, this procedure had several inconveniences, such as time consuming, errors or confusion, etc... With a system scan and fingerprint identification is placed in front of the class, the student's class attendance will be checked by themselves quickly and accurately. Developing completely a smart academic calendar management system consists of major functions such as: monitoring of lecturer's teaching time; monitoring of student's academic: attendance, tardiness, leaving early, absence, etc... The smart academic calendar management system consists of: 1) Developing a cloud computing software which used to monitor and manage both of student's academic calendar and lecturer's teaching time based on fingerprint's student at in/out time of the class; 2) Designing a database used to store collected student's fingerprint data from fingerprint scanners, which allows students, parents, lecturers, managers can access via internet browser. The system has been installed and operated experimentally within one year at the Faculty of High Quality Training (FHQ), Hochiminh City University of Technology and Education (HCMUTE) and has been get good results. This system may deploy widely for the entire university, other universities, colleges, etc...

Keywords: *student attendance, fingerprint identification, smart academic calendar management system, cloud computing software, tracking and monitoring student.*

TÓM TẮT

Hiện nay, giám sát việc tham gia lớp học của học sinh, sinh viên chủ yếu là dựa vào việc điểm danh của giảng viên trực tiếp đứng lớp giảng dạy trước hoặc sau mỗi buổi học. Một thực tế đặt ra là việc điểm danh bằng tay đôi khi cũng có những bất cập, ví dụ như mất thời gian của buổi học, sai sót hoặc nhầm lẫn, giáo viên ngại mang tiếng là phải điểm danh thì sinh viên mới tham gia đi học đầy đủ,... Lâu nay, các giảng viên thực hiện việc điểm danh sinh viên tại lớp mất nhiều thời gian nhưng đôi khi cũng không thực chất do có tình trạng điểm danh hộ. Với hệ thống quét và nhận dạng dấu vân tay được đặt ngay trước cửa các lớp học việc điểm danh sẽ do chính các sinh viên thực hiện một cách nhanh chóng và đảm bảo chính xác. Những dữ liệu điểm danh này cũng sẽ được gửi về cho phụ huynh trong những trường hợp cần thiết. Thiết kế hoàn chỉnh một hệ thống quản lý lịch học thông minh bao gồm các nội dung chính như sau: 1) Nghiên cứu thiết kế phần mềm quản lý thời gian của sinh viên và giảng viên lên lớp thông qua nhận dạng vân tay lúc vào lớp và giờ ra khỏi lớp; 2) Thiết kế hệ

cơ sở dữ liệu để lưu trữ các dữ liệu thu thập được từ các máy quét vân tay, từ đó cho phép sinh viên, phụ huynh, giảng viên, nhà quản lý có thể truy xuất qua trình duyệt internet. Hiện tại hệ thống này đã được lắp đặt và vận hành thử nghiệm trong vòng một năm tại Khoa Đào tạo Chất lượng cao (FHQ), Đại học Sư phạm Kỹ thuật Thành phố Hồ Chí Minh (HCMUTE) và đã thu được các kết quả thử nghiệm rất khả quan. Hệ thống này có thể triển khai rộng ra cho toàn trường, hoặc cho các trường đại học, cao đẳng khác trong cả nước,….

Keywords: *điểm danh sinh viên, nhận dạng dấu vân tay, hệ thống quản lý lịch học thông minh, điện toán đám mây, giám sát và quản lý lịch học sinh viên.*

1. INTRODUCTION

Each person's fingerprints are not the same, that is special feature about biometric. Specially, a person's fingerprints are unique and consistent over time. Therefore, fingerprints used for the identification of individuals. In addition, along with the outstanding development of science and technology, nowadays, electronic devices allowed the acquisition of fingerprint data becoming much easy, more accurate and real-time. Normally, each person has ten fingers, the numerous fingers means there are numerous sources data for the data acquisition, this is also help the identification of individuals becoming more feasible, accurate and trustful, etc.

Each fingerprint consists of set of key features, and this set is unique and consistent over time. In 1968, M. Malpighi examined fingerprints under a microscope and recognized that fingerprint contains a series of ridges and loops [1]. In 1823, J. Purkinje noted there are at least nine different fingerprint patterns [1]. However, Purkinje may did not realize the value of fingerprints in the identification of individuals, therefore he gave no mention this value. In 1858, W. J. Herschel became the first in the history using fingerprints on native contracts [3]. According to the patterns of criss-cross lines on the fingertips or palms of an individual remain unchange from birth till death, he usually required locals print their fingers on every contract for the identification purpose. He believed that all fingerprints were unique to the individual, as well as permanent throughout that individual's life, inspired him to expand their use. In 1863, P. J. Coulier [4] published his observations about how to develop fingerprints on paper by iodine fuming, and explaining how to preserve such developed impressions. Especially, he mentioned the potential for identifying suspects' fingerprints by use of a magnifying glass. In 1880, H. Faulds published an article in the journal Nature [5]. He discussed fingerprints as a means of personal identification, and the use of printers ink as a method for obtaining such fingerprints. He is also credited with the first fingerprint identification of a greasy fingerprint left on an alcohol bottle. In 1892, F. Galton published his book, "Fingerprints" [6], establishing the individuality and permanence of fingerprints. The book included the first classification system for fingerprints. Galton's primary interest in fingerprints was as an aid in determining heredity and racial background. While he soon discovered that fingerprints offered no firm clues to an individual's intelligence or genetic history, he was able to scientifically prove what Herschel and Faulds already suspected: that fingerprints do not change

over the course of an individual's lifetime, and that no two fingerprints are exactly the same. According to his calculations, the odds of two individual fingerprints being the same were 1 in 64 billion. Galton identified the characteristics by which fingerprints can be identified. A few of these same characteristics (minutiae) are basically still in use today, and are sometimes referred to as Galton Details.

Nowadays, fingerprints and fingerprint identification has become popular in the personal identification serving many different purposes in life, as in criminal identification, personal identification with ID card , bank, etc.

The article is organized as follows: Section 1 introduces about the history of fingerprints and researchers who used to study and work relative to fingerprints. Section 2 overviews the algorithms of identification and classification for fingerprints. Section 3 explains the methodology of our research, the use of fingerprint identification algorithm for the smart academic calendar management system. Section 4 illustrates experimental results and several discussions according to those achieved results. The conclusions are presented in Section 5. Final section lists the reference papers.

2. BACKGROUND

Normally, a fingerprint is composed of ridges and valleys on the surface of a fingertip, as shown in Figure 1. A fingerprint is a pattern of curving line structures called ridges, where the skin has a higher profile than its surroundings, which called the valleys. In most fingerprint images, the ridges are black and the valleys are white. The fingerprint of an individual is unique and remains unchanged of over a lifetime [7].

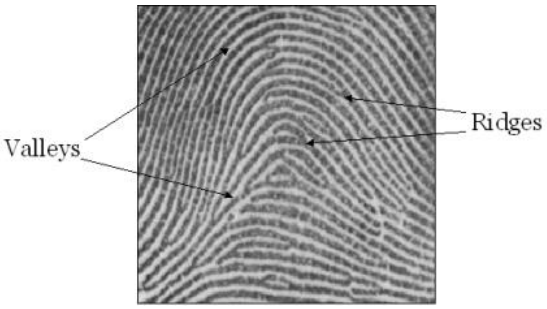


Figure 1. *A fingerprint is composed of ridges and valleys on the surface of a fingertip [8].*

Basically, a system of fingerprint identification must identify and investigate the following five major problems: digital fingerprint acquisition, image enhancement, feature (e.g., minutiae) extraction, matching, and indexing/retrieval. Figure 2 shows a typical fingerprint identification system.

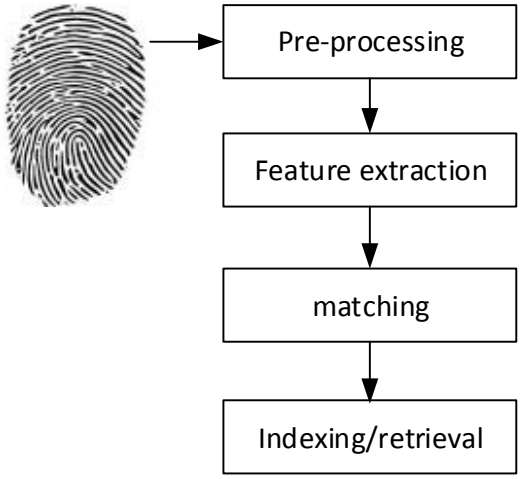
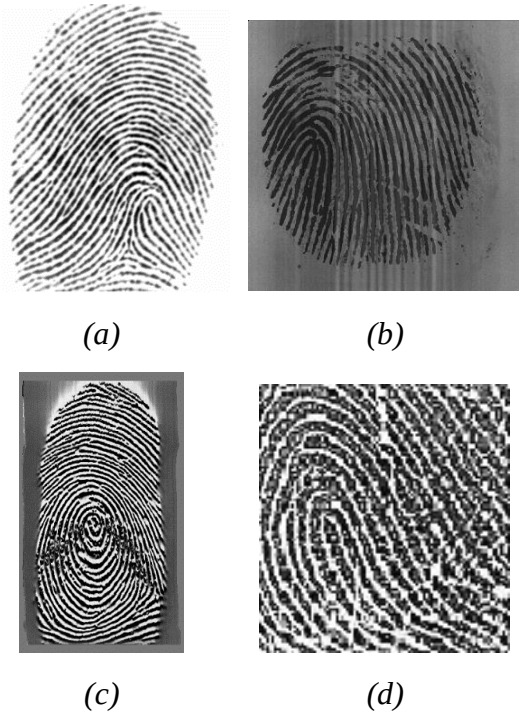


Figure 2. *Five major problems for a fingerprint identification system.*

A simple method to fully take a fingerprint is using a thin coating of ink over a finger and rolling the finger from one end of the nail to the other end of the nail while pressing the finger against a paper card [6]. Since the early 1970s, fingerprint sensors have been built that can acquire a “livescan” digital fingerprint image directly from a finger without the intermediate use of ink

and a paper card [9], [10]. The fingerprint image quality is crucial for the performance of a fingerprint recognition system. Many factors may influence the fingerprint image quality [11], such as, the type of sensor used to capture the image (optical, capacitive), rough fingertips (manual worker, elder people, allergic skin), fingertip condition (wet, dry), image resolution (500 dpi, 250 dpi), poor contact of the finger with the sensor, presence of noise, latent images (traces from the previous user), etc. **Figure 3** shows fingerprint image quality taken by using various fingerprint sensors.



(a) *(b)*

(c) *(d)*

Figure 3*. Fingerprints were taken by diffrent sensors: a) optical sensor, b) capacitive sensor, c) thermal sweeping, d) electric.*

The problem of wet or dry fingerprint is very common, as it depends much of environmental condition (temperature, humidity) and contact of the finger with stuffs [12]. Dry fingerprint are caused normally by low temperatures or after wiping just washed hands. The image obtained from dry fingerprint presents interrupted ridges, as it is shown in Figure 4.

A low quality of fingerprint can also obtained by absence or poor defined ridges, as shown in Figure 5. Aging is a important factor related to the quality of the fingerprint, elder people have worse fingerprint than the younger. Certain occupations, such as construction and farming, are also known to damage fingerprint details over time as well as the constant contact of finger with chemical products.

(a) *(b)*

Figure 4. *The fingerprint image quality is also influenced by environmental condition such as wet or dry fingerprints: a) dry fingertip, b) wet fingertip.*

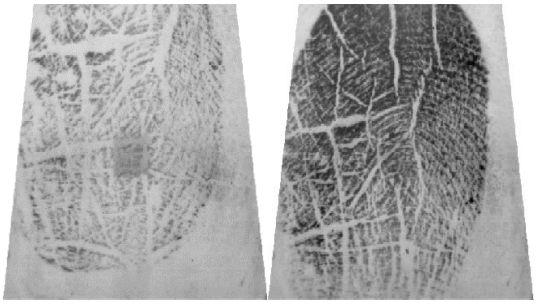


Figure 5*. Low quality fingerprint images*

Before extracting the feature of a fingerprint, it is important to separate the fingerprint regions (presence of ridges) from the background. This limits the region to be processed and therefore reduces the processing time and false feature extraction. A correct segmentation may be, in some cases, very difficult, especially in poor

quality fingerprint image or noisy images, such as presence of latents. The same information used for quality extraction, such as contrast, ridge orientation and ridge frequency can be used for the segmentation or inclusive the quantified region quality may be used directly by considering as background the regions with quality below some threshold. Normally, the segmentation is also computed by block in the same way as the quality extraction. In Figure 6 shows the contour of the segmented region superimposed over the original image.

(a) *(b)*

***Figure 6**. Fingerprint segmentation: a) original image, b) image with segmentation.*

Due to the quality of the fingerprint image is influenced by many factors which sometime may be difficult to control, therefore a fingerprint system must be able to handle also the image of medium and low quality (recoverable). In some cases, it is possible to improve significantly the image quality by applying some image enhancement technique. The main purpose of such procedure is to enhance the image by improving the clarity of ridge structure or increasing the consistence of the ridge orientation. In noisy regions, it is difficult to define a common orientation of the ridges. The process of enhancing the image before the feature extraction also called pre-processing.

There are a lot of complex techniques for image enhancement such as image normalization and Fourier transformation (FFT), etc. [13]. The enhancement may be useful for the following cases:

- Connecting broken ridges (generally produced by dry fingerprint or cuts, creases, bruises).
- Eliminating noises between the ridges.
- Improving the ridge contrast.

The Fourier transformation is widely used in signal and image processing. In particular, for detection of high or low frequencies. As the ridges has structure of repeated and parallel lines, it is possible to determine the frequency and the ridge orientation using FFT transform. Figure 7 illustrates the use of enhancement using FFT transform.

(a) *(b)*

***Figure 7**. Illustrating the use of enhancement using FFT transform: a) original image, b) enhanced image using FFT.*

A fingerprint is characterized by a pattern of interleaved ridges (dark lines) and valleys (bright lines). Generally, ridges and valleys run in parallel and sometimes they terminate or they bifurcate. At a global level, the fingerprint may present regions with patterns of high curvature, these regions are also called singularity. At the local level, other important feature called minutiae can be found in the fingerprint patterns. Minutiae mean small details, and this refers to the behavior of the ridges discontinuities such as

termination, bifurcation and trifurcation or other features such as pores (small holes inside the ridges), lake (two closed bifurcations), dot (short ridges), etc. Most system uses only the termination and bifurcations. With the objective of matching the fingerprints we need to extract the fingerprint features such as minutiae and singularity points. From the fingerprint we can also extract other global information such as orientation and frequency of the ridge regions.

The local feature such as minutiae and global feature such as singularity are very important for a reliable matching. Besides, other features such as orientation map which will be used directly for the minutiae and singularity extraction. The orientation is an angle formed by the ridge inclination and the horizontal line as showed in the figure below. As the ridge has no direction, the term orientation are used instead and the angle varies from 0 to 180. Each region of the fingerprint, except the region of singularities, has a common ridge orientation, therefore instead of computing the orientation at each pixel point, generally they are computed for each block. An example of orientation map is shown in Figure 8.

(a) *(b)*

Figure 8*. Orientation map extraction: a) original image, b) image with orientation map.*

The global features, such as singular points, are the regions where large changes of orientation happens and they are classified in core and delta. The singularities are very useful for fingerprint classification and for alignment purpose used during the matching (e.g., fingercode based matching). Figure 9 shows an example of core and delta extraction.

(a) *(b)*

Figure 9*. Core and delta extraction: a) original image, b) core (red) and delta (green).*

The local features, such as minutiae, can be extracted by using a traditional method consisting of major steps: binarization, thinning and minutiae detection. The results of minutiae extraction are shown in Figure 10.

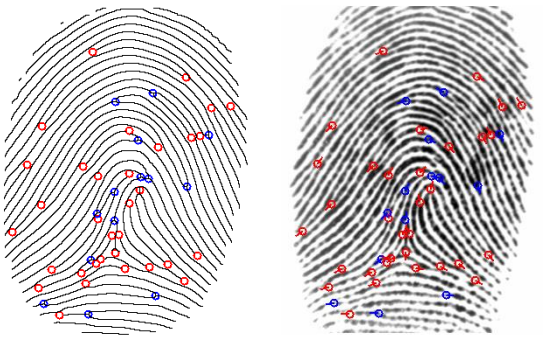


Figure 10. *Example of minutiae extraction.*

The minutiae extraction is difficult in low image quality image, therefore, other information such as ridge shape and texture could be used to match the fingerprints, although they are not too distinctive as the

minutiae. To solve this problem, a finger code is a vector of fingerprint feature, is extracted by applying a convolution to the original image with a Gabor filter (generally dimension 32x32). This vector are stored the value of the standard deviation of each region. An example of convolution, the original image with the Gabor filter is shown in Figure 11.

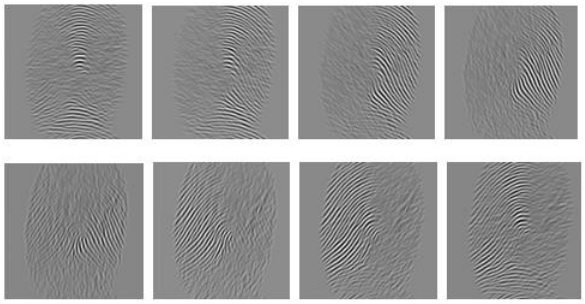


Figure 11. *Result of convolution of the image with the Gabor filter in eight directions (0°, 25.5°, 45º, 67.5º, 90º, 112.5º, 135º, and 157.5º).*

Matching of fingerprint consists of comparing two fingerprints and find out if they belong to the same finger. Mathematically, any matching algorithm computes the degree of similarity, using the feature information of each fingerprint and return some score (e.g., between 0 and 1) which represents the probability that the two finger are from the same finger. Therefore depending of the resulted score, a fingerprint recognition system decides if there is matching or non-matching. Automatically fingerprint image matching is a challenging problem due to many factors such as displacement, rotation, non-linear distortion, partial overlapping, noise, skin condition, etc. Many algorithms have been proposed in the pattern recognition literature. The large number of approaches can be classified in the following three classes: correlation based matching, minutiae based matching and ridge feature based matching.

3. METHODOLOGY

In order to develop the smart academic calendar management system applying technology of fingerprint identification, we structured the system by two following modules: 1) database of characterized reference fingerprints and 2) data management.

The first module is to build a database of all of fingerprints that taken by using fingerprint sensors. In the first step, template fingerprints of all students are collected using fingerprint scanners. Normally, in order to increase the accuracy in recognition, each student was required providing at least four template fingerprints from four his/her different fingers. These template fingerprints are then analyzed by applying various algorithms of image processing such as the segmentation algorithm to classify the fingerprint and background, the image enhancement algorithm to enhance the image by improving the clarity of ridge structure or increasing the consistence of the ridge orientation, and the feature extraction algorithm to characterize the fingerprint by a pattern of interleaved ridges (dark lines) and valleys (bright lines), so the fingerprint's local and global features, minutiae and singularity, respectively, are extracted. The set of fingerprint's characteristics is then stored in the database as reference for identification latter. Figure 12 shows the flowchart of building the database of sets of characterized fingerprints.

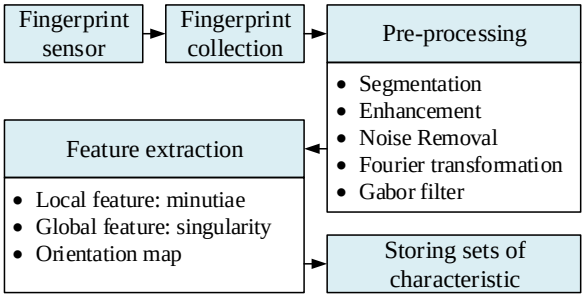


Figure 12. *The module for building the database of sets of characterized fingerprints.*

The second module is for data management, it consists of the following main functions: 1) manage the list of students, 2) manage the student's timetable, manage classes' schedule, 3) setup the timetable, 4) report the times of tardiness, leaving early, absence, etc... for each student, 5) report the times of tardiness, leaving early, absence, etc... for every students in each class, 6) install holidays, 7) setup accounts for both of students and lecturers, 8) upload and install the timetable, which is provided from the Academic Affairs Office, for all students for each semester, etc. Figure 13 shows an overview of the module for data management.

The main problem is how to match the query fingerprint with the reference fingerprint, which is stored in the database in advance, to find out if they belong to the same finger. Mathematically, any matching algorithm computes the degree of similarity, using the feature information of each fingerprint and return some score (e.g., between 0 and 1) which represents the probability that the two finger are from the same finger. Therefore depending of the resulted score, a fingerprint recognition system decides if there is matching or non-matching. Automatically fingerprint image matching is a challenging problem due to many factors such as displacement, rotation, non-linear distortion, partial overlapping, noise, skin condition, etc. Many algorithm have been proposed in the pattern recognition literature. The large number of approaches can be classified in the following three classes: correlation based matching, minutiae based matching and ridge feature based matching.

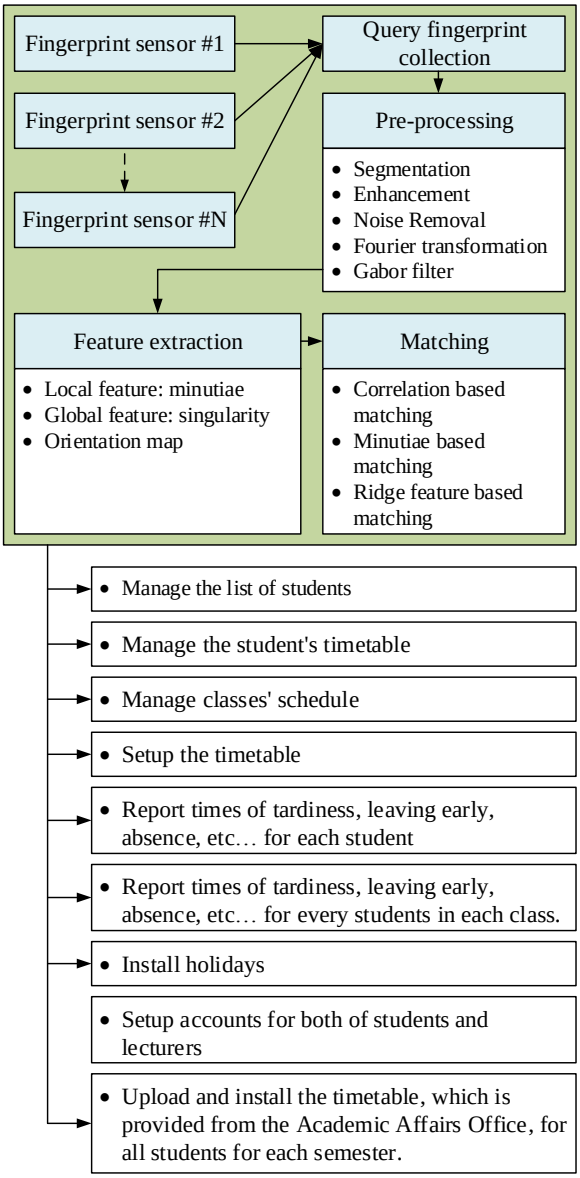


Figure 13*. The module for data management.*

4. EXPERIMENTAL RESULTS AND DISCUSSION

In this research, a smart academic calendar management system applying technology of fingerprint identification has been developed, it consists of two major

functions as follows:

- A cloud computing software which used to monitor and manage both of student's academic calendar and lecturer's teaching time based on fingerprint's student at in/out time of the class. The developed software can connect to fingerprint scanners for monitoring and managing: 1) lecturer's teaching time, 2) monitoring of student's academic: attendance, tardiness, leaving early, absence, etc...
- A database used to store collected student's fingerprint data from fingerprint scanners, which allows students, parents, lecturers, managers can access anytime, anywhere in the world with any internet-connected device, such as a computer, tablet, smartphone, etc....

Particularly, the developed software is decentralized for three levels: 1) administrator, 2) lecturer and 3) student. At the student level, students can access functions as view their study's timetable as well as provisions about the time. Besides, students can also view reports about their classroom participation, how many times tardiness, leaving early, absence, etc... Especially, the system also support students can review the history of fingerprint scanning. At the lecturer level, beside of functions as at the student level, lecturers can access other functions as view the list of students, view reports about student's classroom participation for every classes they are teaching. For admin account, the administrator can access entire functions, beside of functions as at the student and lecturer level, other functions are: 1) setup the timetable, 2) report the times of tardiness, leaving early, absence, etc..., 3) absence warning, 4) install holidays, 5) setup accounts for both of students and lecturers, 6) upload and install the timetable, which is provided from the Academic Affairs Office, for all students for each semester, etc.

5. CONCLUSION

In this research, we proposed a feasible solution for tracking and monitoring student's classroom participation by using the fingerprint scanners for data collection and applying the algorithm of fingerprint identification for the collected data analysis, called the smart academic calendar management system. Especially, a real system has been installed and operated experimentally within one year at the Faculty of High Quality Training (FHQ), Hochiminh City University of Technology and Education (HCMUTE).

The developed system works well with accurate results, it reports full information relative to student's academic such as attendance, tardiness, leaving early, absence, etc... Especially, the student's class attendance will be checked by themselves quickly, accurately and automatically, therefore lecturers can focus on their teaching without loss of time for student attendance. Another advantage of this system is that the software for tracking and monitoring student's classroom participation is designed and developed as a cloud computing software which is installed on a server. It allows students, parents, lecturers, managers can access anytime, anywhere in the world with any internet-connected device, such as a computer, tablet, smartphone, etc...

However, because of limitation of the memory, the fingerprint scanner only can store maximum 2000 fingerprints, while the FHQ's number of students is more than 2000 students. Actually, this drawback of hardware can be overcome by using many fingerprint scanners for data collection, but this will increase the investment cost for the

entire system. There are several special cases such as students having no fingerprints or blur, the fingerprint scanners almost impossible to take fingerprints. To solve this case, the system also support other two solutions for data collection, one is using RFID card and one is using the numeric keypad. Besides, the internet network is also important to make the system operates effectively, the data is uninterrupted.

After one year of installation and operation, the smart academic calendar management system may apply practically and deploy widely for the universities, colleges, etc..., in the academic management for students.

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