Application of "Face Recognition" Technology for Attendance Management System

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***Abstract*—The attendance management system is a system that needed for learning activity in a University. In some University, the attendance management system has been used tapping system which using NFC technology. Actually, that attendance management system is effective for managing each of attendance information. However, until now we can still see many cheats for this attendance system. For example, leave their cards to their classmates and tell them to tap for them. For that, one of the many effective solutions to resolve that problem is to add face recognition technology in the current attendance system. In our experiment, we know that to add face recognition to the current attendance management system surely need a camera and also face dataset for the system. At the beginning, we need at least 9 images with different emotions and face positions to let the system recognizes one's face. To make this system more accurate at recognizing one's face, we would update the face dataset in every face recognizing process.**

***Index Terms*—attendance management system, face recognition, NFC, camera, Infrared, face, face dataset**

I. Introduction

A face recognition system is a technology which is able to identify and verify a person's identity from a digital image or a video frame from a video source. There are multiple methods in which face recognition systems work, but in general, they work by comparing selected facial features from given image with faces within a database. It is also described as a Biometric Artificial Intelligence based on application that can uniquely identify a person by analyzing patterns based on the person's facial textures and shapes.

In daily life, face recognition technology has been implemented in many aspects, especially on smartphone. For example, in Snapchat app, this application using face recognition to detect one's face and add an AR sticker depends on the face location and shape. Not only at Snapchat app, this technology is also used as biometric authentication for a smartphone security system, replace the fingerprint based system. Apple introduced Face ID on their iPhone X which has a facial recognition sensor that consists of two parts: a "Romeo" module that projects more than 30,000 infrared dots onto the user's face, and a "Juliet" module that reads the pattern. Because using IR technology, this face recognition also still can work in the dark.

The attendance management system is a system that needed for learning session in a University. As we know, the attendance system has many types, e.g. using manual attendance management system (using attendance note), tapping/card readers, fingerprint reader, biometric hand reader, face readers, and many more. In some university, the attendance management system has been used tapping system which using NFC technology. Actually, that attendance system is already effective to manage each of attendance information in an efficient way. However, until now we can still see many college students cheat for this attendance system. For example, giving their card to one of their classmates and tell them to tap it. Because of that, one of the effective solutions to resolve that problem is to add face recognition technology in the current attendance system. With the features from face recognition which can identify and verify a person from their face, the attendance management system can be more effective in terms of managing the college student's attendance and make sure that college student attends to the class session.

II. Theoretical Background

A. Face Recognition Technology

1) Camera

The most common technology used to recognize a face is using camera. At first, from camera we can get every frame from a video source that have caught by the camera before. After that, that frame processed in face image detector module to detect a face from this frame. After this module able to detect a face, it will continue processed by facial features extractor module to transforms the pixels of the facial image into a useful vector representation. After that, this facial feature will continue processed in face recognizer module. In this module, it will be compared with every face images in

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face database. If this module unable to find any face in person database that equal with that face, this face recognition system cannot recognize that face. On the other hand, if this module can find any face in person database that equal with that face, it will be recognized by the system. The framework of face recognition system can be seen in Fig. 1.

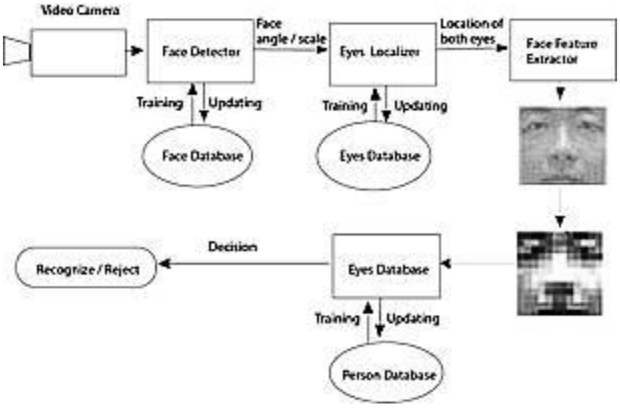

Figure 1. A framework of face recognition system using camera.

2) IR (Infrared)

Infrared is an Electromagnetic Radiation (EMR) with longer wavelengths than those of visible light, and is therefore generally invisible to the human eye, although IR at wavelengths up to 1050 nanometers (nm) from specially pulsed lasers can be seen by humans under certain conditions. IR wavelengths extend from the nominal red edge of the visible spectrum at 700 nanometers (frequency 430 THz), to 1 millimeter (300 GHz). The most of the thermal radiation emitted by objects near room temperature is infrared [1]-[4].

Infrared images (or thermograms) represent the heat patterns emitted from an object. Since the vein and tissue structure of a face is unique (like a fingerprint), the infrared image should also be unique (given enough resolution, surface veins of the face can be clearly seen). However, even at this low resolution, infrared images still can give good results for face recognition as shown in Fig. 2. [5].

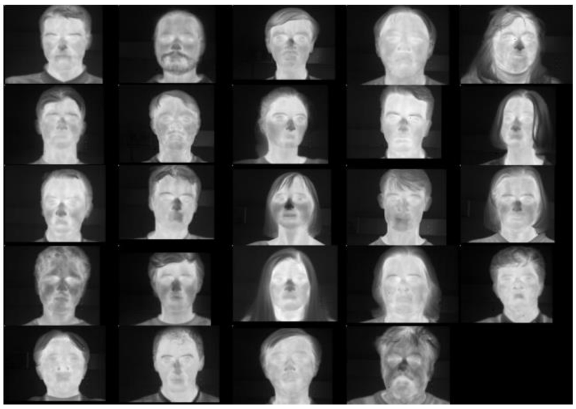

Figure 2. Dataset of infrared images.

B. Face Recognition Algorithms [6]

Until now, researchers have developed various recognition algorithms. In this section, we will describe two representative ones. The eigenface approach applies the Karhonen-Loeve (KL) transform for feature extraction. It greatly reduces the facial feature dimension and yet maintains reasonable discriminating power. The neural network approach, though some variants of the algorithm work on feature extraction as well, mainly provides sophisticated modeling scheme for estimating probability densities in the pattern recognition phase.

1) Eigenface

As mentioned, one of the goals that the feature extraction routine wishes to achieve is to increase the efficiency. One simple way to achieve this goal by using alternative orthonormal bases other than the natural bases. One such basis is the Karhonen-Loeve (KL). KL bases are formed by the eigenvectors of the covariance matrix of the face vector X. In the high dimensional "face" space, only the first few eigenvalues have large values. In other words, main energy located in the subspace constituted by the first few eigenvectors. Therefore, a great compression can be achieved by letting those eigenvectors with large eigenvalues to represent the face vector X,

$$X \cong \sum_{i=1}^{M} \hat{x}_i u_i$$

where U is the eigenvector and M is usually much smaller than the original vector dimension N. Since the eigenvectors associated with the first few eigenvalues look like face images, KL bases are also referred to eigenfaces.

The eigenface representation is well known in statistics literature as the principal component analysis. It is optimal in the sense of efficiency: for any given M<N, the KL representation has the minimum mean square error among all possible approximations of X that uses M orthonormal vectors. However, it does not mean that the KL representation is optimal in the sense of discriminating power, which relies more on the separation between different faces rather than the spread of all faces.

Pentland's Photobook is one implementation of the eigenface algorithm. It compresses a facial image with 128×128 pixels (16,384 pixels) into a vector with only 40 eigenfaces (80 bytes). It recognizes 95% of the 200 faces chosen from a large database with 7562 facial images (3000 different persons) (Pentland, 1994).

2) Neural network

In principle, the popular back-propagation neural network may be trained to recognize face images directly. For even an image with moderate size, however, the network can be very complex and therefore difficult to train. For example, if the image is 128×128 pixels, the number of inputs of the network would be 16,384. To reduce complexity, neural network is often applied to the pattern recognition phase rather than to the feature extraction phase. Sung and Poggio's face detection algorithm (Sung, 1995) down-samples a face image into a 19×19 facial feature vector before they apply the elliptical K-Mean clustering to model the distributions of the "face samples" and the "non-face samples". Rowley *et al.* (Rowley, 1998)] also reduce the dimension of the facial image to 20×20 by down sampling before the facial image is fed into their multi-layer neural network face detector.

One example of the neural classifier is the Probabilistic Decision-based Neural Network (PDNN) (Lin, 1997). PDNN does not have the fully connected network topology. Instead, it divides the network into K subnets. Each subnet is dedicated to recognize one person in the database. PDNN uses the Gaussian activation function for its neurons, and the output of each "face subnet" is the weighted summation of the neuron outputs. In other words, the face subnet estimates the probability density using the popular mixture-of-Gaussian model. Compared to the AWGN scheme, mixture of Gaussian provides a much more flexible and complex model for approximating the true probability densities in the face space.

C. Comparison between Camera & IR

Camera is a technology that can be found in many of many technology platform, for example in smartphone, laptop, CCTV and others. Camera can be used to take a picture and video from real life, and also for face recognition the camera can be used to take every frame that will be used to detect and recognize the face. If we're talking about the cost, camera has cheaper price. Many cameras that have a cost between 10-20$. But, cameras have a weakness which can't detect one's face and recognize it in the dark.

Infrared is a wave that can make a camera get heat pattern video frame which every of that frame can be used to detect and recognize the face. Because this technology using IR (Infrared), this technology can still work in the dark. But, until now this device is very expensive. IR camera Thermal can be found with a cost up to 100$.

For face recognition system which will be used to manage attendance information in most University is way much better using camera than using IR camera thermal. Because camera is much cheaper than using IR camera thermal. Also in most Universities, every class has its own lights, so we don't have to worry about not being recognized by the camera.

III. Research Method & Result

A. Scheme

Because at most Universities have an attendance management system by using Tapping System, we have an idea to combine that attendance management system with face recognition technology. For more detail Fig. 3 show the full scheme.

First, college students have to tap their identity card to NFC reader. Second, NFC reader will send card information to College Student's Card and Face Database. If the server can find that card information in database, the server will turn on the camera only for 10 second. It's for a better security, and also to let another college student to verify their attendance. After camera turned on, the college students have to put their face in front of the camera. If the system recognizes that college student's face, the system will confirm that the college students attend the class activity and verify her/his attendance. Otherwise, if the system doesn't recognize that college student's face, the college student can try from tapping a card again.

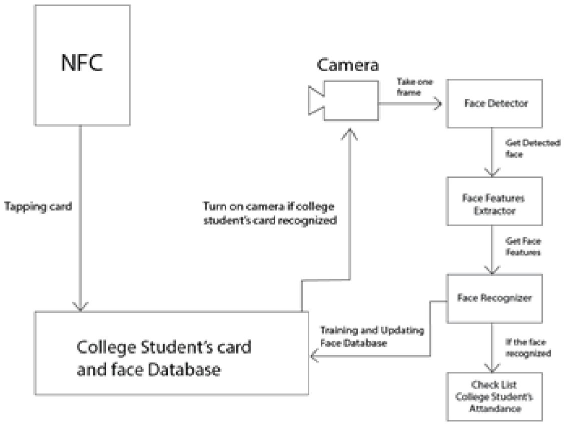

Figure 3. Framework for attendance management system using face recognition technology.

B. Class Situation, Camera Position, and Face Recognized Indicator

In every University's class, it has different number of lamps. But most Universities are concerned about their class environment, especially about lighting. To make a better situation in class, every University has provided many lamps that can make the classroom stay bright. Because of that, the camera still able to recognize the college student's face as well. In every class also has wide windows. So, in the mid-day, it is fine not to turn on the lights. The camera still able to catch enough light from the window to recognize the college student's faces.

About camera position, the best position for camera is near NFC reader, both left or right of NFC reader as shown in Fig. 4. That's for a better efficiency and let college students easily to do face recognition after they tapped their card without moving to another place.

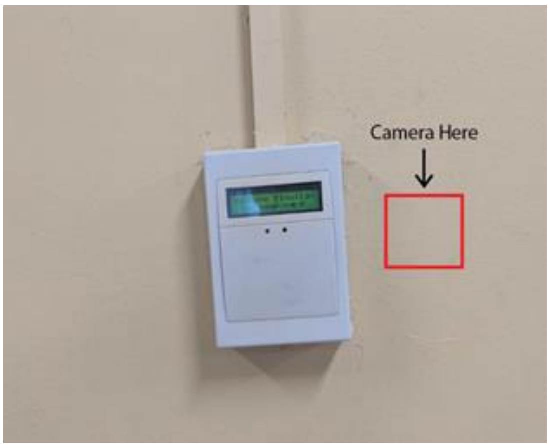

Figure 4. Camera position next to NFC reader.

For indicator, we can use the LCD Display 16×2 in the NFC reader. The first before tapping, the LCD Display will show a text, "Welcome Student. Tap your card." Second, if the system doesn't recognize that card, the LCD Display will show a text "Wrong card. Please tap again." On the other hand, if the system recognizes that card, the LCD Display will show a text, "Card Detected. Please verify", third, college students have to verify their attendance by standing in front of the camera to do face recognition. If the face recognized, the LCD Display will show a text, "Face Recognized. Attendance verified." On the other hand, if the face wasn't recognized, the LCD Display will show a text, "Can't Recognize. Please try again".

C. Collect Face Information For Face Database

The face information can be obtained on the day when the student makes their first identity card. To make the face recognition more accurate in recognizing the college student's face, we have to get many positions and many expression of college student's face image. In this case, we can get a combination of 3 emotions (basic, smile, and happy) and 3 positions (front, left and right). The nine taken image's samples can be seen in Fig. 5.

Figure 5. Dataset for many emotion and position.

Not only that 9 images will be used for face recognition system. In every face recognition process, the dataset will always be updated and trained by taking the new face image from the college student. With this algorithm, the face recognition can be more accurate to recognize the college student's face.

So, basically in our experiment we can see that not every time the camera will recognize one's face that quickly. Number of face images in the face dataset could affect the accuracy of the camera. We made a chart Table I (an estimation) that shows the accuracy of the camera.

TABLE I. ACCURACY BASED ON THE NUMBER OF FACE IMAGES

**	Images in Face Dataset	Accuracy (%)
1	9	55
2	20	60
3	50	75
4	75	85
5	100	92

Based on the chart Fig. 6, we can say that every face should have at least 9 face images in the dataset to make sure the camera can recognize one's face with accuracy up to 50%.

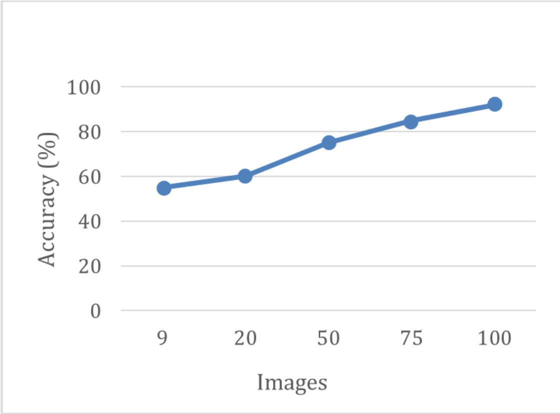

Figure 6. Graph of Accuracy based on the number of face images.

D. Validation System

Attendance management system in most Universities, the attendance management system starts from 30 minutes before the class activity started. The attendance management system will be closed 30 minutes after the class activity started, this validation system is applied for lecturer and college students.

To make the attendance management system using face recognition works effectively, we can change some of the current validation system. The attendance system will be opened after the lecturer tap her/his card in range time between 30 minutes before and 20 minutes after the class activity started (For students, 30 minutes after the class started). To make sure that the college students attend in the class, verification session is needed. It's opened 30 minutes before class activity ended. This modification has a purpose to reduce the chance of students to cheat their attendance management system, e.g. leave the class after attendance verified.

E. Challenges

Basically, face recognition system could recognize someone's face easily. But, in application of this technology, there are still many challenges that can affect the result of this system. There are many challenges which might be faced by this system.

1) Pose variations

Head's movements, which can be described by the egocentric rotation angles, i.e. pitch, roll and yaw [7], or camera changing point of views [8] could lead to substantial changes in face appearance and/or shape and generate intra-subject face's variations automated making face recognition across pose a difficult task [9].

Since AFR is highly sensitive to pose variations, pose correction is essential and could be achieved by means of efficient techniques aiming to rotate the face and/or to align it to the image's axis as detailed in reference [9].

2) Presence/absence of structuring elements/occlusions

The diversity in the intra-subject face's images could also be due to the absence of structuring elements or the presence of components such as beard and/or moustache, cap, sunglasses, etc. or occlusions of the face by background or foreground objects [10].

Thus, face images taken in an unconstrained environment often require effective recognition of faces with disguise or faces altered by accessories and/or by occlusions, as dealt by appropriate approaches such as texture-based algorithms [11].

3) Facial expression changes

Some more variability in face appearance could be caused by changes of facial expressions induced by varying person's emotional states [12]. Hence, efficiently and automatically recognizing the different facial expressions is important for both the evaluation of emotional states and the automated face recognition. In particular, human expressions are composed of macro-expressions, which could express, e.g., anger, disgust, fear, happiness, sadness or surprise, and other involuntary, rapid facial patterns, i.e. micro-expressions; all these expressions generating non-rigid motion of the face. Such facial dynamics can be computed, e.g., by means of the dense optical flow field [13].

4) Varying illumination conditions

Large variations of illuminations could degrade the performance of AFR systems. Indeed, for low levels of lighting of the background or foreground, face detection and recognition are much harder to perform [14], since shadows could appear on the face and/or facial patterns could be (partially) indiscernible. On the other hand, too high levels of lights could lead to over-exposure of the face and (partially) indiscernible facial patterns. Robust automated face detection and recognition in the case of (close-to-) extreme or largely varying levels of lighting apply to image-processing techniques such as illumination normalization, e.g. through histogram equalization [15]; or machine-learning methods involving the actual image global image intensity average value [14].

5) Image frame resolution and quality

Other usual factors influencing AFR (Automatic Face Recognition) performances are related to the quality and resolution of the face image and/or to the set-up and modalities of the digital equipment capturing the face [16]. For this purpose, ISO/IEC 19794-5 standard [17] has been developed to specify scene and photographic requirements as well as face image format for AFR, especially in the context of biometrics. However, real-world situations of face image acquisition imply the use of different photographic hardware, including one or several cameras which could be omnidirectional or pan-tilt-zoom [18], and which could include, e.g. wide-field sensors [18], photometric stereo [19], etc. Cameras could work in the range of the visible light or use infrared sensors, leading to multiple modalities for AFR [20]. Hence, faces acquired in real-world conditions lead to further AFR challenges.

For example, in some situations, a face could be captured at distance resulting in a smaller face region image compared to the one in a large-scale picture. On the other hand, some digital camera could have a low resolution [21] or even very low resolution [22], if the resolution is below 10×10, leading to poor quality face images, from which AFR is very difficult to perform. To deal with this limitation, solutions have been proposed to reconstruct a high-resolution image based on the low-resolution one [22] using the super-resolution method [23], [24].

All of these five challenges could affect the accuracy of this system. To see if these challenges and the accuracy of this attendance system related, we did a simulation. In this case, we would take some worst condition based on these 5 challenges which might be faced in daily life, as a sample for this simulation. The worst condition is low light, smoky room, face changes, unusual pose, and unusual expression.

As we know, the low light and smoky room could make the camera more difficult to take a good quality frame because the light from the face couldn't be caught by camera as well. Face changes, unusual pose, and unusual expression can make the system confuse to recognize because there are not much face images sample from the face dataset. By having many algorithms which can solved the low light case, we predicted that might reduce the accuracy up to 10%. The worst case of the smoky room could reduce the accuracy up to 30%. Face changes might reduce the accuracy up to 20%, because by inventing the texture-based algorithms which could solve this problem, Unusual pose can reduce the accuracy up to 40%. Unusual expression can reduce the accuracy up to 25%. For more detail, these are the differences between accuracy in normal condition and the worst conditions based on how much face images in the face dataset, which shown in Fig. 7. Low light, Fig. 8. Smoky room, Fig. 9. Face changes, Fig. 10. Unusual pose, and Fig. 11 unusual expresion.

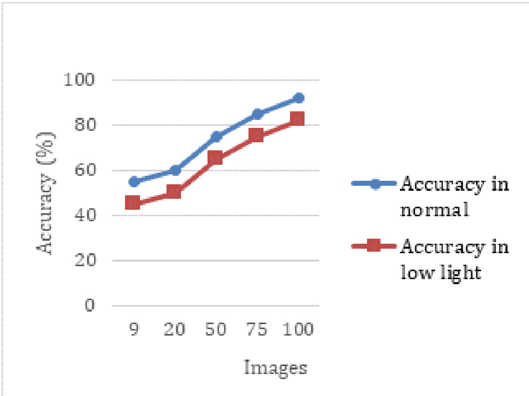

Figure 7. The difference of the accuracy between normal condition with the low light condition based on number of face images.

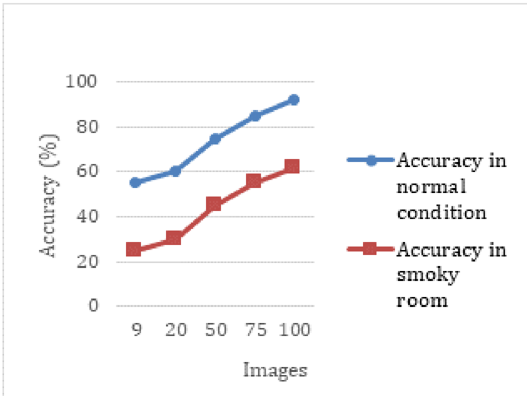

Figure 8. The difference of the accuracy between normal condition with the smoky room condition based on number of face images.

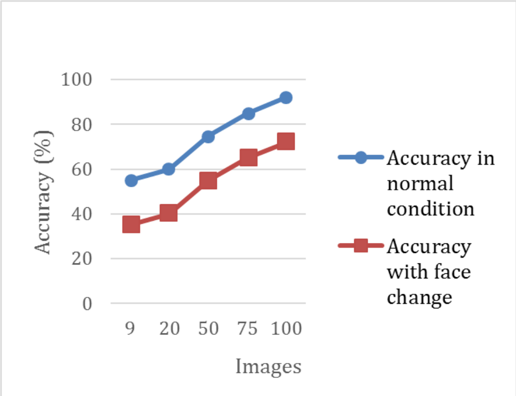

Figure 9. The difference of the accuracy between normal condition with the face changes condition based on number of face images.

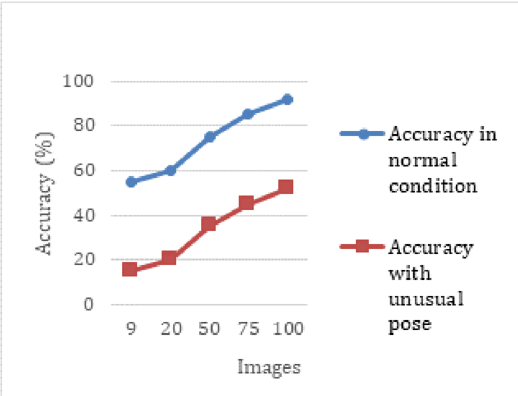

Figure 10. The difference of the accuracy between normal condition with the unusual pose condition based on number of face images.

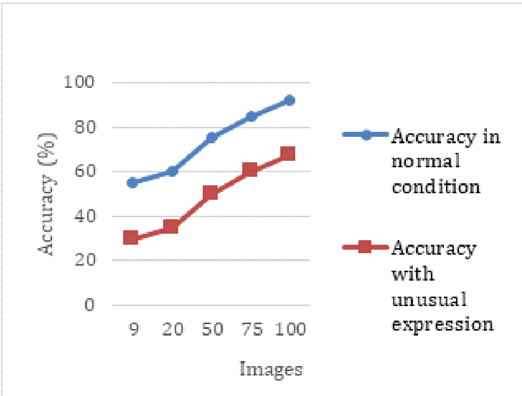

Figure 11. The difference of the accuracy between normal condition with the unusual expression condition based on number of face images.

The differences accuracy between many worst conditions that already tried in our experiment can be seen in Table II.

TABLE II. CHART OF THE ACCURACY IN MANY WORST CONDITIONS

Images	Accuracy In The Worst Conditions (%)				
	Low Light	**Smoky Room**	**Face Change**	**Unusual Pose**	**Unusual expression**
9	45	25	35	15	30
20	50	30	40	20	35
50	65	45	55	35	50
75	75	55	65	45	60
100	82	62	72	52	67

IV. CONCLUSION

Based on what we discussed from the beginning, we conclude that to increase every University's security system in managing attendance information, we'd like to add a new security system by using face recognition system after the college students tapped their identity card. It means every class will do a double-verification system through face recognition (before the class session starts) and manual absent (before the class session ends). It will greatly reduce the students' chance to cheat their attendance information and they'll no longer leave their card to their friends. So basically this technology is more effective than before.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest. And they do not have any financial relationship with any organization.

AUTHOR CONTRIBUTIONS

Chandra provided the idea on this research. Muhammad Feisal Fransditya Mulyananda did the survey papers and provided the report on the findings from the literatures. Michale Andrew Gunawan provided the experiments. Ford Lumban Gaol did the validation and verification of the result and explored with the future work of the research. Tanty Oktavia provided the final checking of the research result. All authors discussed the results, commented on the manuscript and approved the final version.

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