Vol. 99, No. 1, Month 2099, pp. 1~1x

IJIES (INTERNATIONAL JOURNAL OF INNOVATION IN ENTERPRISE SYSTEM)

Journal homepage: https://ijies.sie.telkomuniversity.ac.id

e-ISSN: 2580-3050, DOI: 10.11591/ijies.v99i1.paperID

Dual Authentication using Fingerprints and/or Faces in MTQ/STQ Information System

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ARTICLE INFO

Article history:
Received 00 Month 20xx
Accepted 00 Month 20xx
Published00 Month 20xx

ABSTRACT

Individual recognition with multiple biometrics using fingerprints and/or faces is generally used for security systems such as automatic doors or attendance. Individual recognition using fingerprints and/or faces in MTQ/STQ is facilitated by a computer program equipped with a USB fingerprint reader and webcam, intended to detect changes in participant identity and to ensure that only participants with registered identities can take part in MTQ/STQ.

Keywords:
Individual recognition; Fingerprints; Faces; Haar Cascade Classifier; Local Binary Pattern Histogram

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1. INTRODUCTION

Competition of the national level of MTQ/STQ since it was first held in 1968 until now has contested at least 23 (twenty-three) MTQ competition groups and 10 (ten) STQ competition groups. Each class of competitions in the MTQ/STQ has a maximum age requirement. Competition categories on the MTQ/STQ have age divisions of participants where there are competition groups starting from children to adults. For example, in the Al-Qur'an reading art branch, there is a *tartil* competition with a maximum age of 13 years, *children* with a maximum age of 15 years, *youth* with a maximum age of 25 years, *adults* with a maximum age of 41 years, and the *blind* with a maximum age of 49 years. With this age gap, participants can improve their abilities so that with increasing age participants can take part in competitions at the next age level.

Quoting the website page of the Ministry of Religion of the Republic of Indonesia, it is suspected that there are participating jockeys [1]. Participants are registered using valid registration documents (KTP/KK), however during the MTQ/STQ competition the jockeys take part. One way to prevent jockey participants is to use biometric recognition such as using fingerprints, irises, faces, palms, and other biometrics.

Fingerprint recognition according to Bambang (in Verawati, 2014) is a common technology used by the general public to identify a person, and has even become a technology that is quite reliable because of its effectiveness and easy use [2]. In the use of fingerprint identity there are also obstacles where there are people with unreadable fingerprints that make it impossible to recognize fingerprints. To ensure that each individual can be recognized, a second biometric recognition is used in the form of facial recognition. Facial recognition is also made easier, simply by using a webcam and also increasing the ability of image/video processing software [3].

The implementation of multiple individual recognition using fingerprints and faces is more widely applied for security aspects such as automatic doors [4] or ATM machines [5]. Individual recognition on MTQ/STQ makes it possible to recognize more individuals with a relatively fast recognition time span, so it is necessary to choose a fast and efficient algorithm.

Fingerprints are the result of reproductions of prints that are deliberately taken, stamped with ink, or marks left on objects because they have been touched with the skin of the palms of the hands or feet. Because of its uniqueness, fingerprints can be used to become the main identity used to identify someone [2]. One method of fingerprint recognition is the minutiae extraction method. These methods include fingerprint image acquisition, pre-processing, feature extraction processes, and matching [6].

The DigitalPersona U.are.U SDK allows applications to perform fingerprint recognition. Supported fingerprint data formats include DigitalPersona, ANSI, and ISO fingerprint formats [7]. This SDK provides development APIs including C/C++, Java, .NET, ActiveX, Java POS, and OPOS. Supported platforms include Windows, Linux, Windows CE, and Android.

Facial pattern recognition is a science in the field of computer vision. The computer can analyze a facial image and find the identity or personal data of the facial image by comparing it to the stored facial image data. In general, facial recognition is done from the front side with even lighting across the face. However, several problems arose, such as face position, face scale or distance, orientation, age, facial expressions and the tools used around the face that allowed detection errors to occur [8].

One of the facial recognition methods is Haar Cascades, which is a combination of the concepts of Haar Features, Integral Image, Ada Boost, and Cascade Classifier. This method includes stages including facial image acquisition, conversion of facial images to grayscale, scan per sub-window, Haar feature selection with Ada Boost, calculating Haar feature values with Integral Image, sub-window selection with Cascade Classifier, and image description [9].

There are several facial recognition algorithms, including Eigenfaces, Fisherfaces, and Local Binary Pattern Histogram (LBPH) [10]. Eigenfaces was developed by Matthew Turk and Alex Pentland in 1991 [11]. Eigenfaces is based on Principal Component Analysis (PCA) with the stages of preparing training data, calculating the difference in the average training data, calculating the covariance matrix, calculating eigenvectors and eigenvalues, and selecting the main components [12]. Fisherfaces was developed by Peter N. Belhumeur, Joao P. Hespanha, and David J. Kriegman in 1997 [13] with improved recognition accuracy through Fisher's Linear Discriminant (FLD). Local Binary Pattern Histogram (LBPH) is the result of a combination of two methods, namely the Local Binary Pattern (LBP) method combined with the Histogram of Oriented Gradients (HOG) [14].

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In research related to facial recognition, Detila et al reported that the average accuracy of facial recognition using LBPH was 83%, Eigenfaces was 46% and Fisherfaces was 54%. So, this study using the LBPH algorithm for facial recognition.

OpenCV is a library in computer vision and machine learning. OpenCV supports 2500 optimized algorithms consisting of basic algorithms and advanced algorithms in computer vision and machine learning. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in a video, track movement in a video, and other computer vision processing needs. OpenCV provides interfaces in C++, Python, Java, and MATLAB and can run on Windows, Linux, Android, and Mac platforms.

Along with the increasing number of participants in each MTQ/STQ, the Information System uses a parallelism approach to identify participants. Parallelism in Node.js can be achieved by using napa.js, web workers, child processes, and clusters [15]. Napa.js is a multi-threaded implementation with the concept of a zone, a web worker is a standard thread supported by the W3C through the web worker API which is a thread that runs in the background. Child processes and clusters are native modules of Node.js, both achieve parallelism by creating new processes but different ways of communicating, child processes use IPC communication while clusters share server ports.

2. METHOD

The method used in this study consists of:

2.1. Literature study

Literature study is carried out by comparing references from various sources including books, journals, and scientific articles. The literature as a reference in this study is in the form of fingerprint recognition, facial recognition, the required devices and software support for system development.

2.2. System design

System design produces Software Requirements (SKPL) that will be used for system development, which includes use case diagrams, activity diagrams, sequence diagrams, class diagrams, entity relation diagrams, and interface design.

2.3. System development

System development is focused on producing an individual recognition system capable of recognizing individual biometrics in a relatively short span of time including the use of parallel processes or multiple processes.

2.4. Testing

System testing includes the stage of recording a new biometric identity as well as using an existing biometric identity, then individual biometric identification is carried out and measuring the time needed to carry out the recognition.

2.5. Analysis of results

Describes the test results and provides an analysis of the system that has been built.

3. RESULT AND DISCUSSION

3.1 Required Device

Individual recognition using fingerprints and/or faces makes it possible to detect changes in identity or prevent individuals who are not registered. Individual fingerprints are recognized by a computer program through a fingerprint reader, while faces are recognized by a computer program by utilizing computer vision software from facial images taken using a webcam.

The fingerprint recognition hardware device used uses a USB interface to make it easier for participants to access the fingerprint reader device. The U.are.U 4500 series fingerprint reader from DigitalPersona is the preferred fingerprint reader as shown in Figure 1.

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Figure 1 - DigitalPersona U.are.U 4500 fingerprint reader[1]

Facial images are captured directly using a webcam with a USB interface to make positioning easier when taking pictures of participants' faces. One example of the webcam used is shown in Figure 2.

Figure 2 - Logitech C505e 720p webcam[2]

3.2 Device Specifications

The required research equipment consists of hardware and software with the following specifications:

1. Hardware
   a. Laptop (i7 processor, 12GB ram, 2TB ssd, FHD resolution)
   b. USB fingerprint reader (DigitalPersona U.are.U 4500)
   c. 720P camera/webcam
2. Software
   a. Operating system: Windows 11
   b. Microsoft Visual Studio Code
   c. Node.js
   d. Electron
   e. SQLite
   f. OpenCV

As side node, different hardware specifications used may produces different results.

3.3 Recognition Method

The individual recognition stage in the MTQ/STQ Information System is carried out 2 (two) times, consisting of:

1. The registration or recording stage, individual authentication to ensure identity matches and there is no change, and biometric identity recording for new individuals,
2. Identification stage, individual authentication to recognize only individuals/participants according to certain groups based on the branch/group of the competition.

The biometric recognition method at the registration and recording stage is shown in Figure 3 which is described as follows:

1. Participants register themselves.
2. Perform fingerprint recognition, if recognized, go to step 5.
3. Perform facial recognition, if recognized, continue with step 5.

[1] https://1ss-solution.com/product/ss-u-are-u-4500/
[2] https://www.logitech.com/id-id/products/webcams/c505e-business-webcam.960-001372.html

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4. Enter the participant's identity data.
5. If the participant can be identified by his biometric identity, then check the personal data document whether it is the same as the identity data that has been identified, if not the participant is rejected.
6. Data validation is in accordance with the requirements, if it meets then registration can be continued otherwise the participant is rejected.
7. The participant then chooses the participant number.
8. If the participant does not have a fingerprint identity, record the fingerprint.
9. If the participant does not yet have a facial identity, do a facial recording.
10. Perform recognition again to ensure identity matches.
11. Registration is complete.

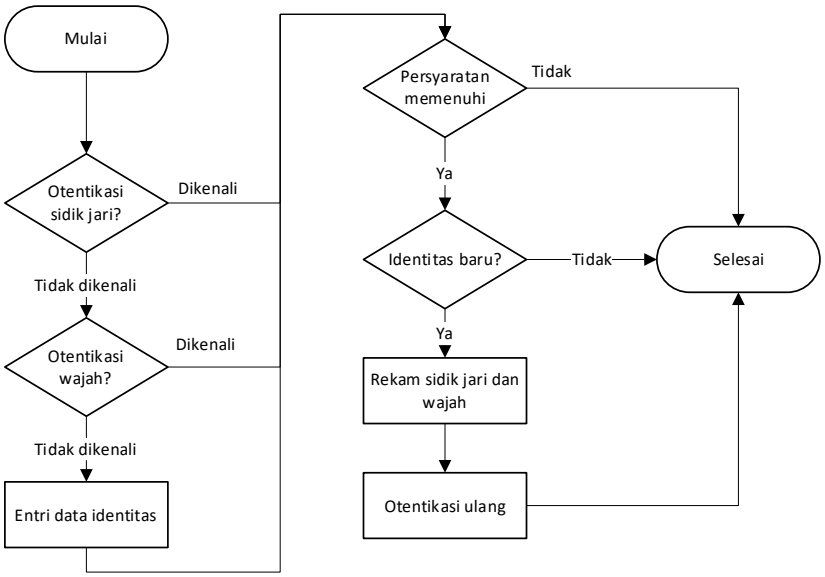

Figure 3 - The flow of the biometric identity registration/recording stage

The biometric recognition method at the identification stage is shown in Figure 4 below which is described as follows:

1. Activate the identity according to the selected group.
2. Recognize the participant with fingerprints, if it can be recognized the participant has the right to be scored.
3. Recognize the participant by face, if recognized the participant has the right to be scored.
4. Participants who cannot be identified by their biometric identity are declared not eligible to be scored.

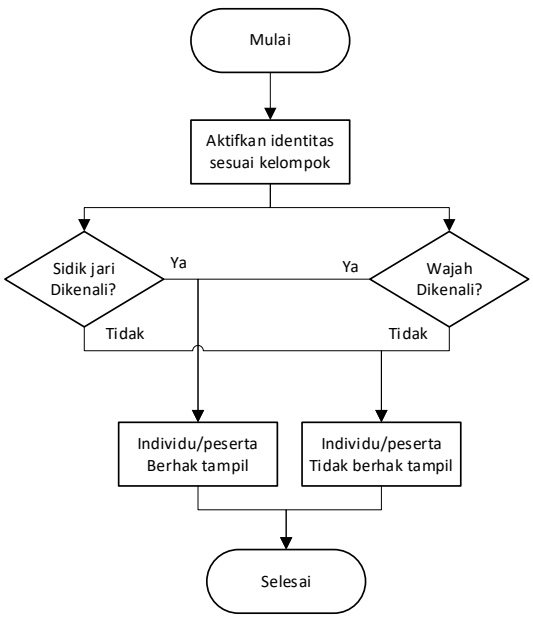

Figure 4 - Flow at the individual identification stage

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3.4 Interface Design

The individual recognition interface on the MTQ/STQ Information System at the registration/recording stage is shown in the following Figure 5:

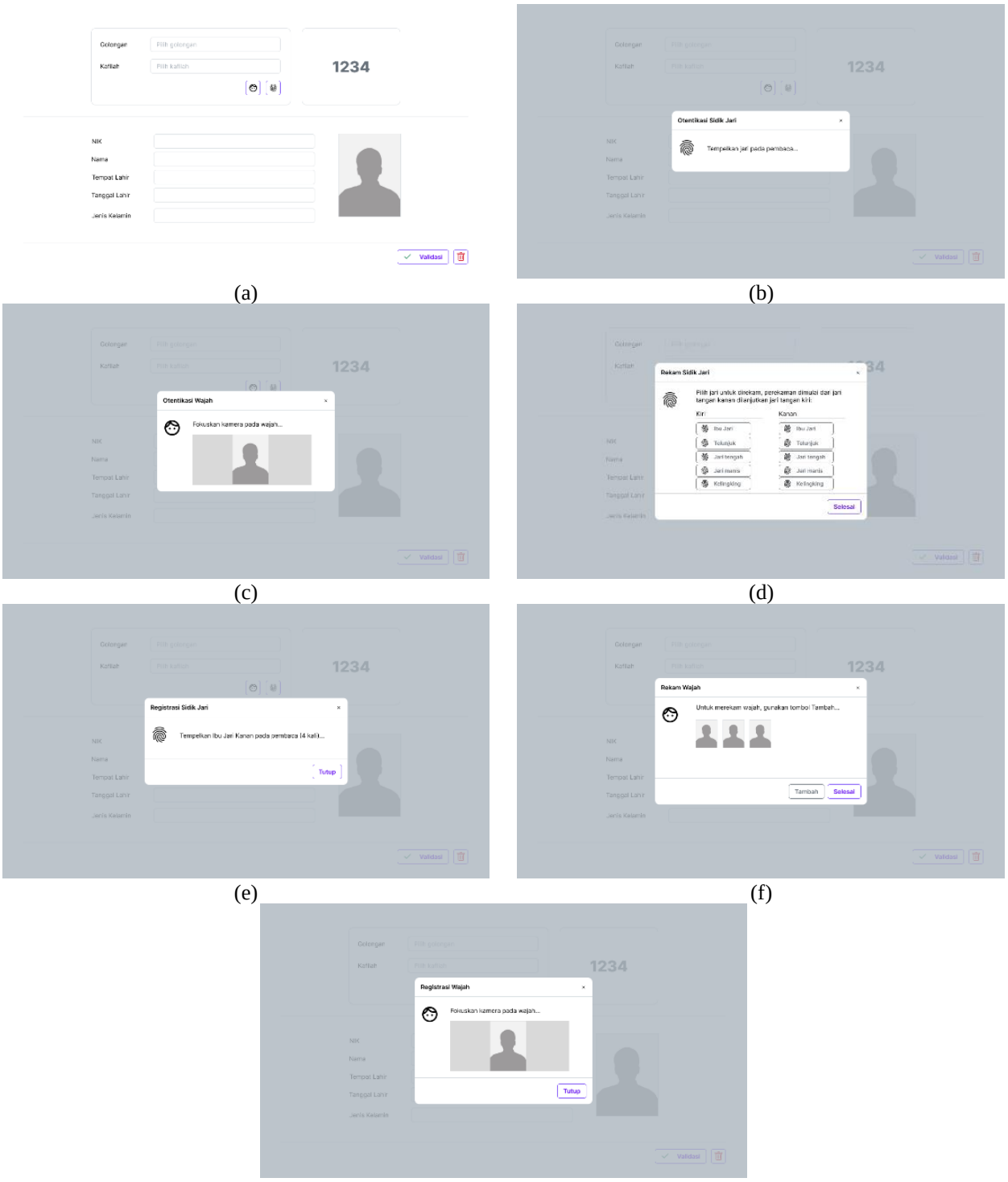

Figure 5 - Identity registration/recording interface; (a) main interface; (b) fingerprint recognition; (c) face recognition; (d) fingerprints enrollment; (e) enroll a fingerprint; (f) faces enrollment; (g) enroll a face

The interface at the individual identification stage is shown in the following Figure 6:

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(a) (b)

(c)

Figure 6 - Individual identification interface; (a) participant selection (b) identification using fingerprints; (c) identification using faces

3.5 Recognition System Development

Fingerprint recognition using the DigitalPersona API consists of a recording and identification process. In the recording process, each recorded finger is read 4 (four) times to produce fingerprint data (Fingerprint Minutiae Data - FMD). Meanwhile, in the identification process, it is sufficient to compare the stored FMD with the fingerprints to be identified.

The facial recording process using OpenCV is carried out with the following steps:

1. Change the captured image to a gray image
2. Use the Haar Cascade Classifier to detect faces, the classifier uses pre-trained data HAAR_FRONTALFACE_ALT2.
3. Save the detected facial image.

While in the identification process the steps taken are:

1. Normalize the stored facial data to a size of 80x80 pixels.
2. Train the LBPH face recognizer with the normalized facial data.
3. Change the facial image to be detected to gray and detect faces using the Haar Cascade Classifier
4. Prediction using LBPH to identify faces in step 3 above.

The identification process, either fingerprint identification or facial identification, is carried out in a sub-process that applies parallelism. Both the DigitalPersona API and OpenCV are Node.js addons modules written in C++ and there are several ways to create Node.js addons. Node.js addons can be built with the Node-API, nan, or directly using the V8 library, libuv, or the Node.js library. The parallelism used in the MTQ/STQ Information System is web workers and clusters.

Identification steps using parallelism are shown in Figure 7 below and described as follows:

1. Collect all identities in a Map (n = 50).
2. Determine the number of workers, generally workers can be a number of available processor threads (w = 4).
3. To identify each worker can only identify a certain number of identities at one time (m = 10).
4. Determine the number of iterations required (i = n / m = 50/10 = 5)
5. Enable workers to identify the identity according to their respective portions (w1 = 1-10, w2 = 11-20, w3 = 21-30, w4 = 31-40).
6. If one of the workers has found a match, end the process of other workers identification.
7. If a match is not found and the loop is not finished, then repeat step 5, otherwise the identity is not found.

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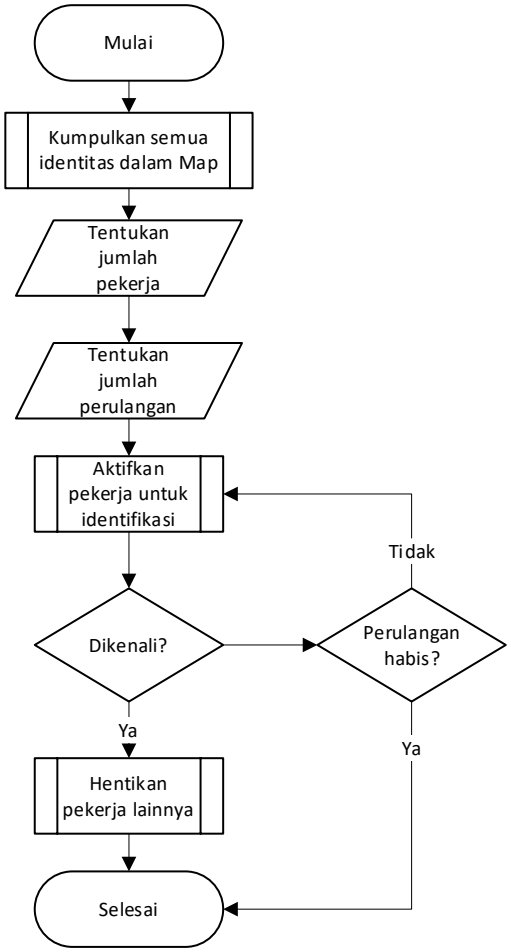

Figure 7 - Identity recognition in parallelism

3.6 Test Results

The test is carried out by registering a maximum of 10 (ten) fingerprints for each individual and a maximum of 3 (three) facial images. Then individual identification is carried out using fingerprints but it is limited to a maximum of 4 (four) fingers per individual and the time it takes to identify the individual is recorded. Likewise with identification with faces. Figure 7 shows how the identification time is measured. DigitalPersona provides a standard fingerprint format so that the number of fingerprint samples used in this test can use existing fingerprint samples.

```
GET /penjurian1/1/ajax/fp-ready 200 1.428 ms - 29
07-06 10:13:49.512 FP> Starting identify 5943eb70 with 6563 sample(s) for b7eb1d3c
07-06 10:13:50.254 FP> Still waiting 5943eb70 ... 8 worker(s) to finish for b7eb1d3c
07-06 10:13:51.215 FP> Done 5943eb70 in 1702 ms, match is 14283 for b7eb1d3c
POST /penjurian1/1/ajax/fp-verify 200 1715.947 ms - 231
```

(a)

```
GET /penjurian1/1/ajax/face-ready 304 1.484 ms - -
POST /penjurian1/1/ajax/face-verify 200 59.256 ms - 16
07-06 14:15:25.433 FACE> Starting identify fffbcfa0 with 15 sample(s) for daddbc52
07-06 14:15:25.544 FACE> Done fffbcfa0 in 110 ms, match is 14 for daddbc52
POST /penjurian1/1/ajax/face-verify 200 200.898 ms - 232
```

(b)

Figure 8 - Measurement of identification time; (a) fingerprints identification; (b) faces identification

Testing for fingerprint and facial identity recognition in the MTQ/STQ Information System was carried out on a number of identity samples as shown in Table 1 below:

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Table 1 - The number of identity samples in the test

NR	IDENTITY	TOTAL
1	Fingerprints	6563
2	Faces	15

The results of fingerprint and facial recognition testing are shown in Table 2 below (in seconds):

Table 2 - Fingerprint and face identification test results

NR	USER	FINGERPRINTS	FACES
1	User 1	1,425	0,360
2	User 2	5,595	0,129
3	User 3	3,263	0,112
4	User 4	4,894	0,357
5	User 5	3,133	0,121
	AVERAGE	**3,622**	**0,216**

4. CONCLUSION

From the test results it can be concluded that individuals can be recognized either by fingerprints or faces. The use of dual authentication can provide assurance that each individual can be recognized using at least one of the fingerprints or facial biometric identities.

The use of parallelism in the recognition process also gives a fairly good time result with an average of 3,622 seconds for a total of 6563 fingerprint samples.

This research can be further improved by optimizing the recognition process so that the time required for identification is relatively short even though fingerprint or face data has increased significantly.

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