Oto-ID: Ear Recognition and Shape-based Human Detection for User Identification

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***Abstract*—This paper introduces Oto-ID: Ear Recognition and Shape-based Human Detection for User Identification. It is a user identification system that is designed to provide security over prolonged user interaction. It aims to provide solution to misrepresentation in asynchronous examination. It implements ear recognition for login and uses the human shape to continuously detect user presence. Principal Component Analysis and Feature Extraction are the approaches implemented in this study.**

***Index Terms*—user identification, security, ear recognition, shape-based human detection, asynchronous examination**

I. Introduction

While asynchronous learning is now widely used as approach to distance learning, it still poses security issues such as misrepresentation in its examinations. This issue is a form of cheating wherein another individual takes the original students' place. [1] The inability of the e-learning environments to authenticate exam takers has been addressed as a major challenge in security. Security in applications is often managed through the use of user login systems or through the use of more innovative user identification, the biometrics. Identity recognition systems that makes use of face, iris, fingerprint and such, could be used for user identification over prolonged user interaction but some requires direct contact from user or may be affected by other physical or behavioral factors. Meanwhile, ear recognition has received less attention than the other biometrics yet it promises results that are as good as face recognition.

Ref. [2] Asynchronous examinations start by checking the user identity, a process referred to as authentication. Misrepresentation happens when a student asks for someone to take his place in an online examination. In this special context, the users (i.e. students) might collaborate with other people who help them cheat. They will happily pass on their password, ID card or insert their finger into a fingerprint-device and then let their friend answer the exam for them.

There are numerous biometrics that helps in preventing cheating in e-examinations such as fingerprint scanning, keystroke and mouse dynamics. These methods were reviewed in a study made by Gao and how can they help in misrepresentation. [3] According to this study, with the existing methods, it is necessary to ask the students to provide two or more biometrics multiple times for the duration of an examination even though it may cause some inconvenience. As emphasized in the study, a good authentication system should include one physiological biometrics and one behavioral biometric for prolonged user interaction.

Ref. [4] A physiological biometrics makes use of unique physical characteristics to identify a single identity. Meanwhile, behavioral biometrics makes use of the behavioral characteristics of an individual. The use of ear recognition as a recognition system is a relatively young topic in biometrics compared to face, iris and others but it delivers great results just like face recognition. [5] Ear Recognition has certain advantages over the more established biometrics, as ears have a stable structure that does not suffer from the changes of age, emotions, skin-color, cosmetics and hairstyles.

Ref. [6] Ears, just like palm vein structure and fingerprint, have an average permanence over time compared to iris, retina and DNA that are the most permanent biometric identifier, and to facial structure, signature and voice biometric characteristics that are most likely to undergo variation over growth, wear and tear, aging, dirt, injury and regeneration. [7] Ear growth is proportional after first four months of birth and changes are not noticeable from the age of 8 up to 70. [8] There was a study made by Burge wherein he gathered 10,000 samples of ears to study, to prove the distinctiveness of ears. His work proves that the structure of ear does not change radically over time. [9] In a study made by El-Bakry, the basics of using ear as biometric for person identification and authentication are presented. This study introduced the error rate and application scenarios of ear biometrics.

For examinations which elicit prolonged user interaction, recognition systems that can recognize or detect a user over the whole duration of exposure is important. [10] Shape-based human detection approach is commonly used in either still images or videos. [11] Detections that make use of human shape are commonly used for detection of intrusions of early threat assessment in open and remote environments. Detection systems use simple electronic motion detection sensors to monitor motion or the location of objects within the perimeter. This makes it appropriate for use as user detection in

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examination which requires a student to behave most likely in a proctored examination where unnecessary movements are prohibited. [12] In terms of visual cues, shape or silhouette has been the most dominant cue for detecting humans due to large appearance availability.

There have been numerous researches that sought to answer the problem of security in prolonged user interaction especially in asynchronous learning. These researches proved that to verify a user's identity, biometric authentication systems are the most viable solution. Most biometric systems used by the studies are fingerprint scanning technology, face recognition, and keystroke analytics. While these techniques proved to be efficient for identity authentication, fingerprint and face recognition have drawbacks that ear biometrics may not encounter. Few, if not none, have indulged in ear biometrics as user identification for asynchronous user interaction. Ear recognition proves to be an effective biometric system for authentication as the human ear is unique, does not change over a long period of time and is not affected by changing facial expressions. In example, the face recognition may be inefficient when the user changes his expression. This change of expression will not affect the ears. And if prolonged user interaction is concerned, a single biometric authentication may not provide the best secure solution but two recognition system to continuously identify a user's identity. Shape-based human detection is proven to effectively detect the presence of a human in front of the camera. Shape-based human detection and ear biometrics may be a viable solution in user identification for prolonged period of user interaction.

II. The Developed System

The system is developed using Visual C# and MATLAB for its front-end and MS SQL for its back-end. It requires the use of the camera connected to the computer for its ear image capture. The system uses ear recognition for user identity identification and shape-based monitoring for presence monitoring. It provides access and user information to any user correctly identified using its ear and abrupt access when the half-body shape is not detected anymore. In ear recognition, it is to be provided that the user has registered ear in the system. For conformity, only the right ear is to be used in the system. Normal ears are easily detected by the system. However, it may not be able to detect an ear with any deformities.

A. System Architecture

At the start of the system, the user's right ear is captured by the camera. The captured ear image must be in JPEG (Joint Photographic Experts Group) format. In the pre-processing step, the images are cropped to a size of 400×500 pixels. The normalization step includes geometric normalization, masking and photometric normalization. In this phase, all the images are scaled to a standard 130×150 size. Next all non-ear areas, like hair, background, etc. are masked. In the Training phase, the eigenvalues and eigenvectors are extracted and the eigenvectors are chosen based on the top eigenvalues. The result of this process is an image in JPEG format with eigenvectors. The resulting image will be tested against the registered images to check if it is a registered user. If not, the system will prompt a warning message. If the user is identified, the system allows the user an access. During user access, the shape-based human detection is present for monitoring the presence of the user. In the shape-based human detection, the system will capture a still image of the user. With the use of Feature Selection Algorithm and Principal Component Analysis (PCA), detecting and filtering of human shape will be done. The process is just repeated if the system continues to detect the human shape. If not, the system will automatically block access and return to the main interface. The system architecture is described as designed in Fig. 1.

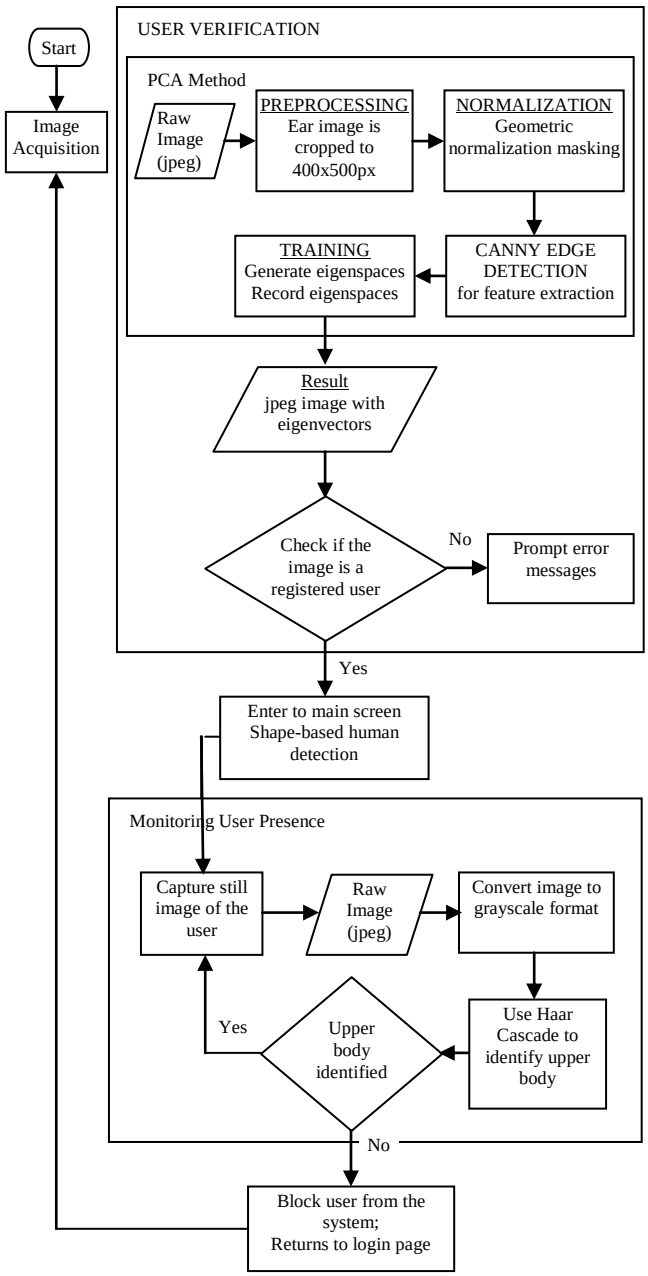

Figure 1. System architecture

B. Ear Registration Process

A user needs to be registered first to the system to provide necessary user information and ear image for later identification. In ear registration, the side face image of the user will be processed first in image acquisition. The image must be in a JPEG format. PCA method will be used to preprocess and normalize the raw image. The image will undergo training wherein the image will be generated with eigenspaces and eigenvectors. The result of this method will be stored to the corresponding user record in a database where the images will be compared to the current processed image in the user identification phase. The ear registration process is depicted in Fig. 2.

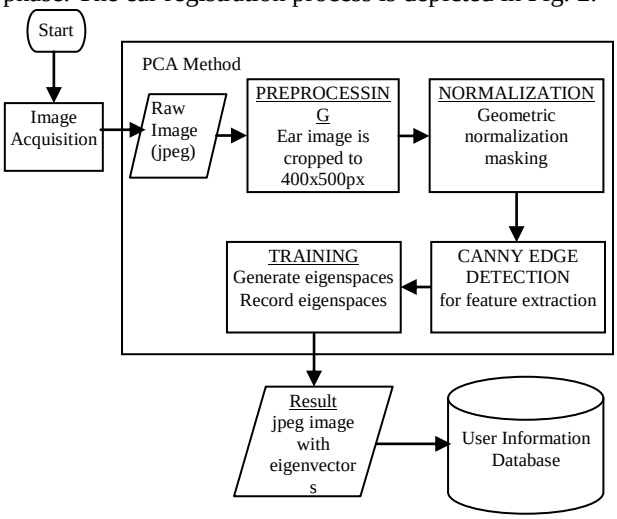

Figure 2. Ear registration process

C. Research Design

Ref. [13] The proponents implemented Experimental Research Method in the study wherein it is a method procedure involving the manipulation of conditions for the purpose of studying the relative effects of the various treatments applied to members of the sample. The purpose of our research is to assess the system's accuracy under different possible setup of the various variables that may affect its performance in providing security. For ear recognition, the variables are lighting condition, occlusion, pose variation, and distance from the camera. And for shape-based human detection, the variables are lighting condition and user distance from the camera.

III. Results And Discussion

The study aims to know the degree of accuracy of the system given by the parameters under lighting condition, distance, occlusion and pose variation of the user and its effectiveness in user identification. After conducting an experiment, the researchers used the formula of finding the accuracy rate and performance rate. The summary of the computed degree of accuracy for each variable are shown on Table I.

Table I shows the computed accuracy rates for ear recognition under different variables. The lighting condition under fluorescent light achieved the highest accuracy rate of 87.82. For occlusion, earrings achieved higher accuracy rate of 86.08. For pose variation, a 90° angle achieved the highest accuracy rate of 87.50. And for distance, a distance of 40cm or 50cm achieved highest accuracy rates of 100.

TABLE I. Degree of Accuracy of Ear Recognition Under Diffrerent Variable Setup

Dependent Variables		Accuracy Rate
Lighting Condition (90˚ angle of head to the left; 40cm distance; no occlusion)	Dim Light	87.80
	Fluorescent Light	87.82
	External Bright Light	82.79
Occlusion (captured under Fluorescent Light : 320-500 lux; 90˚ angle of head to the left; 40cm distance)	Earrings	86.08
	Hair	78.98
Pose Variation (captured under Fluorescent Light: 320-500 lux; 40cm distance; no occlusion)	45°	62.50
	60°	75.00
	90°	87.50
Distance from the camera (captured under Fluorescent Light:320-500 lux; no occlusion; 90˚ angle of head to the left)	40 cm	100.00
	50 cm	100.00
	60 cm	93.75
Average		**85.66**

TABLE II. Degree of Performance of Shape-Based Human Detection

Dependent Variables		Detection Rate	False Alarm Rate
Lighting Condition	Dim Light (20-100 lux)	100%	40%
	Fluorescent Light (320-500 lux)	89%	17%
	External Bright Light (10000-20000 lux)	70%	60%
Distance from the camera	50 cm	90%	20%
	60 cm	90%	0%
Average		88%	27%

Table II illustrates the performance rate of shape-based human detection based on the computed detection rate and false alarm rate of the system under two different variables of lighting condition and distance. Detection rate and false alarm rate are both substantial in determining the performance of a detection system.

Among the tests performed for the shape-based human detection system under varying lighting conditions, the dim light setup gathered the highest detection rate of 100% but the fluorescent light setup achieved the lowest false alarm rate of 17%. This implies that the two variable setups may be used as possible setting. For distance, both distance of 50cm and 60cm gathered 90% detection rate but 60cm distance got 0% false alarm rate which makes it better than distance of 50cm.

IV. Conclusion

Based from the findings of the study Ear Recognition and Shape-Based Human Detection for User Identification, the researchers have yielded the following conclusions through the experiment:

- During the experiment, the researchers learned that the results may vary because of environmental conditions and different variables.
- Interrelations of different factors may help achieve the possible highest accuracy rate of Ear Recognition and Shape-based Human Detection for User Identification.
- In the ear recognition experiment, the results shows that lighting condition under 320-500 lux, distances of 40 cm and 50 cm, ear occlusion of stud earrings or none and a pose variation of 90° are the variables that garnered highest accuracy rates and if these factors are used as a setup for ear recognition, the highest possible accuracy rate may be achieved.
- The researchers learned that lighting condition under 320-500 lux and a distance of 60 cm reached the highest detection rate and lowest false alarm rate during the experiment thus; these can be used as possible setup in shape-based human detection to achieve highest possible performance rates.
- In the application of the proposed system in a customized automated examination, the data gathered and interpreted by the researchers are sufficient to consider the system for use as a user identification system for an automated examination. The expectations are met by manifestation of results.

V. Recommendations and Future Works

To increase the performance of the proposed system, the researchers noted significant recommendations. The following are:

- Based on the experiment, the researchers recommend the use of a web cam with a megapixel higher than 2mp so images will have better quality and feature extraction will be more accurate.
- The researchers recommend the use of a different algorithm to make the ear recognition more accurate, Principal Component Analysis (PCA) algorithm is the most basic of all recognition algorithms.
- To further increase the recognition the researchers also recommend to add other image processing techniques to extract more features.
- In order to use the proposed system for asynchronous examination, future researchers must develop more features for the avoidance of other forms of cheating like looking for the answers in the Internet, books and other reference materials. Possible solution can be the detection of eye movements of the user.
- In the implementation of the developed system on an examination setup, the researchers provided the customized automated examination. In order to further prove the effectiveness of the system for asynchronous learning, the researchers recommend that the study must be applied in a learning management system.

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