FEDSecurity: Implementation of Computer Vision Thru Face and Eye Detection

Roxanne A. Ancheta, Felizardo C. Reyes Jr., Jasmin A. Caliwag, and Reynaldo E. Castillo

***Abstract*—Closed-Circuit Television (CCTV) cameras are placed everywhere in both public and private areas and used in a broad range of applications, especially for security purposes. CCTVs are managed by CCTV operators for twenty-four hours to ensure that there are no excessive activities in the area. FEDSecurity is a monitoring system that alarm and capture the images of CCTV operator whenever falls slumbering during the time of work. Face and eye detection used Haar-Cascade Algorithm, and Microsoft SQL Server Express used as storage. FEDSecurity is also capable of determining whether the user in front of the camera is a real human or a picture by gauging the time that a user is not blinking eyes. Worst case scenarios could prevent possible suspicious activities when using the system. The system acquired was an asset to the homeowners, companies and any other business firms. Agile Software Development Method adapted in developing the system. In testing the system's acceptability, the questionnaires were based on the ISO 9126 Standard. The respondents of the study are the IT professionals, CCTV operators such as security guard or security officers, and the management such as administrator or security head. The result of evaluation interpreted as very acceptable based on Likert's scale.**

***Index Terms*—computer vision, CCTV, face and eye detection, monitoring system.**

I. Introduction

Computer vision is a method of identifying and processing images in the same way that human vision performs, and then provides the correct output. Regarding security, computer vision tries to get information from the images as much as possible. This collected information will be used for object modeling, visualization, navigation, scene reconstruction, virtual reality, surveillance, and recognition. Computer vision can be applied in different areas such as augmented reality, biometrics, face recognition, robotics, character recognition, security and surveillance, and to name a few [1]. In recent years, computer vision has become increasingly important and useful due to its wide-spread applications in areas as varied as sports and recreation, health and medicine, robotics, drones, self-driving cars, and smart surveillance and monitoring [2]. The use of technology has become a new standard for us especially when it comes to safety and security. Alarms, security cameras, and even biometric securities are used to make sure everyone feels safe and secure. The Closed-Circuit Television (CCTV) security system is used to enable advanced services not only for surveillance but also for safety, automatic climate control, e-ticketing. [3]. Today, with the use of CCTV, security officers do not need to go around the community particularly in the middle of the night just to patrol the area and check if there are any suspicious actions are going on. But, what if the CCTV operators who are monitoring these CCTVs fell asleep? One possible problem is sometimes CCTV operators are sleepy and tired, for that reason they cannot carefully keep track what is going on in their screen monitor. Because of that, they won't be able to give immediate action at the time an incident occurs. Another problem is, the CCTV operator can easily exchange places with any other person and leave the assigned station with ease or skipping the time of their duty. Likewise, in some cases, the recorded images and videos in CCTVs can only be used for evidence and to review the recent incident happened. Is it much valuable if we use CCTV to monitor the actual scenarios and do action immediately to avoid unwanted incident? With those complications, the researchers ended up with a system that can avoid those problems especially if security head or management is not around to supervise their security officers.

This study aims to develop a monitoring system that will help the CCTV operators or security officers of San Pedro 9 Subdivision to be vigilant in monitoring the CCTVs thru computer vision.

Specifically, the study aims to:

- Use face detection using Haar Cascade Algorithm;
- Save captured images in the database that might serve as a basis for recognizing the users;
- Apply face and eye detection to capture an image of the user on the time the alarm is triggered and saves to the database;
- Determine whether the user in front of the camera is a real human or a picture; and
- Evaluate the developed system using the ISO 9126 Standard according to its functionality, efficiency, usability, reliability, and maintainability.

II. Related Studies

In study [4] stated that human face detection has been a challenging issue in the areas of image processing and pattern recognition. Haar Cascade Algorithm is an object detection algorithm that can be used to locate faces, pedestrians,

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Roxanne A. Ancheta, Felizardo C. Reyes Jr., and Jasmin A. Caliwag are with the College of Information Technology Education, Information Technology Department of the Technological Institute of the Philippines Quezon City, Philippines (e-mail: rancheta.it@tip.edu.ph, felizardo.reyes.jr@tip.edu.ph, jcaliwag.it@tip.edu.ph).

Reynaldo E. Castillo is with the College of Information Technology Education, Computer Science Department of the Technological Institute of the Philippines Quezon City, Philippines (e-mail: rcastillo.cs@tip.edu.ph).

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objects, and facial expressions [5]. Regarding speed and reliability for face detection from an image, Haar Cascade Classifier is one of the best detectors [6]. For the detection of the face, the main part of Haar Cascade Classifier is Haar features. These features are used to detect the presence of a feature in a given image while the Haar Cascade Classifier features can detect any object [5].

The study [7] and [8] focuses on webcam-based accurate eye-central localization. The study used five different processes. One of the methods used was Haar-Cascade feature-based face detection algorithm.

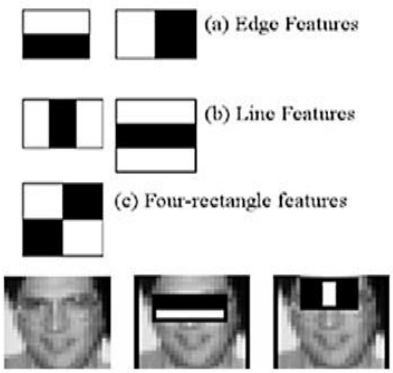

Fig. 1. Haar feature model.

Fig. 1 shows how the study of Viola and Jones [5] was developed. It is a machine learning based approach where a cascade function trained from the different amount of images both positive and negative. In that case, it is used to detect objects in other images. In this study, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier. Then need to extract features from it.

According to Soo [9] "A Haar-like feature considers neighboring rectangular regions at a specific location in a detection window, sums up the pixel intensities in each region and calculates the difference between these sums. The result of the difference is then used to categorize subsections of an image". Also, the study [10] apply the Haar-like features as one of the methods used in vehicle detection based stereo camera images.

Also, stated that one of the examples mentioned would be the detection of human faces [5] noted that the areas around the eyes of the person are darker than the areas on the cheeks regions. One example of a Haar-like feature for face detection is a set of two neighboring rectangular areas above the eye and cheek regions of the human faces. As well as in [7], stated an example of the related research that uses Haar Cascade algorithm in facial feature detection using Haar classifier.

Viola and Jones invented an algorithm called Haar Classifier [5], this algorithm successfully detect any object, together with human faces. In analyzing every pixel for face detection is time-wasting and hard to do because you need to consider different variations of face shape and pigmentation of a human face.

Similarly, in [7] also stated that detecting human facial features, such as the mouth, eyes, and nose requires the Haar classifier cascades trained first. In training the classifiers, two set of images are vital. One set of it contains an image or scene that does not contain an object; In this case, a facial feature is going to be detected. This set of images refers to as the negative images. The other set of images, the positive images, contain one or more instances of the object. Moreover, stated that "A cascade of boosted classifiers based on Haar-like features is used for fast detection of the eyes region. The frames differencing in combination with the thresholding are applied to detect the eyes closure and opening. The frame processing algorithm is pointed out to distinguish the involuntary blinks from the voluntary ones". And because of the different features mentioned about the Haar cascade, this algorithm was the best option to achieve the goal of this study. The system can detect the eyes of the user and also can make the system alarm by distinguishing the involuntary blinks from the voluntary ones.

The use of EMGU to perform Principle Component Analysis (PCA) and Parallel Optimisation, multiple face recognition was achieved [11]. Furthermore, [12] used PCA in face recognition, while real-time multiple face detection and tracking were implemented [13], and [14] used real-time multiple face detection from the live camera in checking attendance. In this study, the system can also detect multiple faces in front of the camera.

Based on the related studies conducted, the researchers found out that Haar cascade is one of the best algorithms when it comes to object detection since it has fast detection of the human face and eyes for the system to be able to capture and save it to the database as a picture image. Another feature of Haar cascade algorithm is the ability to capture moving objects that made detection easier. Hence, Haar cascade algorithm is selected to apply in this study.

III. Methodology

The study used the Agile Software Development Method model in developing the system which consists of four phases:

A. Planning Phase

The researchers conducted the survey and observation to get information from the target users. In this study, the target users are the Security Head (administration) and CCTV operators such as security officers or security guards. Also, the researchers searched possible future dilemmas that can affect the system during development and integrate the Haar Cascade Algorithm for face and eye detection to get accurate results.

B. Implementation Phase

In developing the system, C# programming language was used in implementing the Haar Cascade Algorithm for face and eye detection and Microsoft SQL Server Express for the database storage.

C. Testing Phase

This phase eventually the system will be tested in terms of debugging and error checking to ensure the acceptability of the system. The project was continuously test until objectives were met.

D. Evaluation Phase

In this phase, IT Professionals, Security Head and CCTV

Operators such as security officers and security guards are the different respondents who evaluated the system.

IV. System Architecture

Fig. 2 shows a simplified graphical representation of the system's architecture. In the presentation tier, the user interface described, the system allows the user to create accounts that can be used to log-in inside the system. It also collects face angles for better detection of the user's face. Under the logic tier, the system uses the Haar cascade algorithm to detect the face and eyes of the user that can use for easy recognition to the user. The system stores all the information in the database including the images taken for tracking purposes under the data tier. Once it gathered enough information, the system is now ready to use for eye blinking detection that produces an alarm whenever the user falls asleep or exceeded in the time expected the eyes to blink.

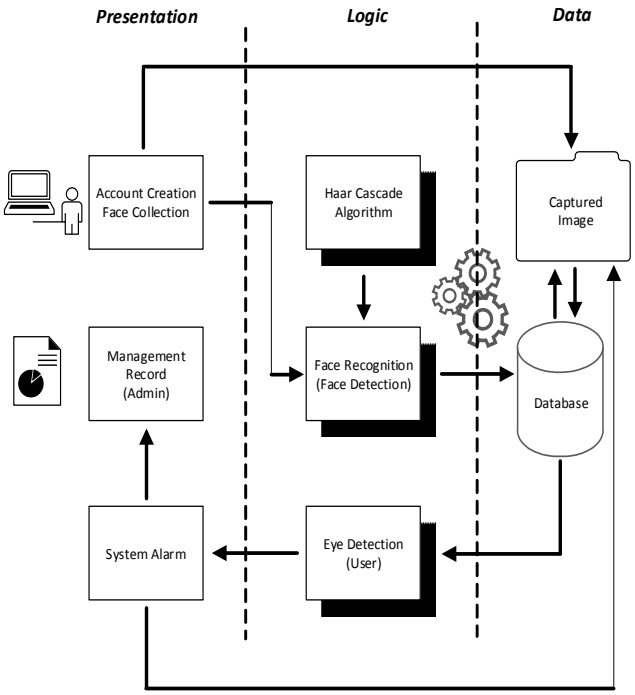

Fig. 2. System architecture of FED security.

The average blink of a person is up to 15 to 20 times per minute or about 3 to 4 seconds [15]. For that reason, the study adapted the maximum speed of 4 seconds in eye blinking. If the expected maximum time of eye blinking was exceeded then, the system produces a loud sound as an alarm to the user to be able to be alert in monitoring the CCTVs.

V. Results and Discussions

The developed face and eye detection system applied computer vision principles in achieving its objectives. The study focused on one type of computer vision which is object detection and utilized Haar Cascade algorithm to execute its primary function. Since this algorithm is used primarily on object detections including human faces; henceforth, the researchers end up by utilizing this algorithm for face and eye detection.

A. Face Recognition

Fig. 3 shows the different angles saved in the database. To be able to recognize the human face in who is in front of the camera each user is required to capture at least thirty (30) different angles upon creating a new user account and those images will store in the database. These images will be using to match the human face in front of the camera to easily recognize and access its own account during logging-in.

Fig. 3. Users saves different angles of face in the database.

Face Recognition used to recognize the user's face in front of the camera and the saved captured images in the database. The study used Haar Cascade Algorithm features called EigenRecognizer to match the user's face stored in the database. Using EigenRecognizer, the system can recognize the user by detecting their faces in the front of the camera. To do this recognition first is declaring the variables called EigenRecog to get the match value of the face from the stored database and recognize the user in front of the camera.

Using (haarcascade_frontalface_default) file, the system can detect the user's face and recognize who it is. This file can detect a specific object like the human face by the rectangular frame. In order to get the exact location of the face, the system needs to trained faces and set the properties of the frame. To set the frame properties to detect the face, declare again the FacesDetected object of Haar Cascade Algorithm by the x and y axis to create the rectangular frame and focus on the object was detected. Next set the height and width for the sizes of the rectangular frame in order what frame size you want.

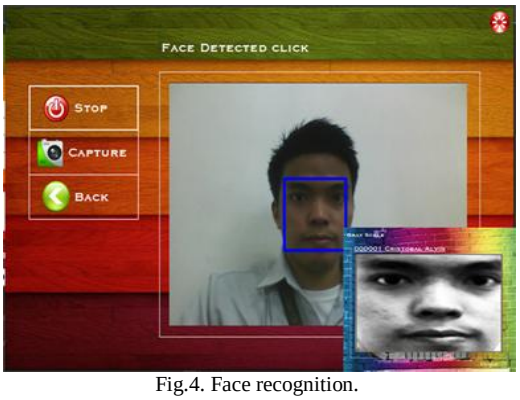

Fig.4. Face recognition.

Fig. 4 shows the blue frame symbolizes the face detection and at the lower right box symbolizes the face recognition of the user in front of the camera.

B. Face and Eye Detection

Fig. 5 shows the detection of face and the eyes of the user

with the grayscale image processing and producing an alarm if the system cannot detect the eyes of the user. By using a haarcascade file named the "haarcascade_frontalface_default" for detecting the face of the user and "haarcascade_eye" for detecting the eyes of the user, these files can detect a specific object like the face and the eyes by the rectangular frame shown in the Fig. 5. In order to get the exact location of the face, the system needs to trained faces and set the properties of the frame. To set the frame properties to detect the face same for the eyes frame, declare the FacesDetected and EyesDetected object of Haar Cascade Algorithm by the x and y axis to create the rectangular frame and focus on the object was detected. Next is set the height and width for the sizes of the rectangular frame in order what frame size you want. In Fig. 5 shows how the system detects the face and the eyes of the user using the rectangular blue frame for the face and the rectangular small white frame for the eyes.

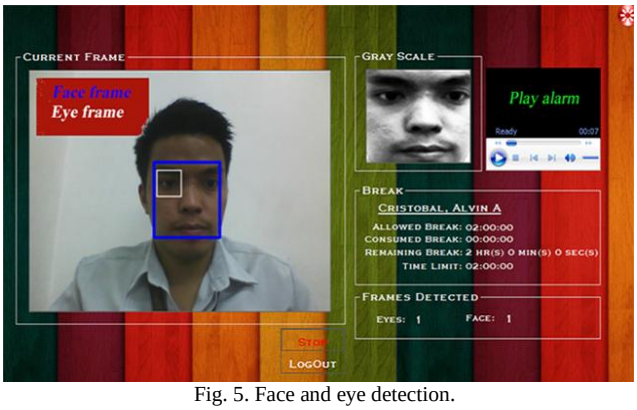

Fig. 5. Face and eye detection.

The system can alarm by producing a loud sound based on the eyes frame. Once the eyes of the user are not detecting considering the speed of the blinking of the eyes that the time the system produces a loud sound to be able to awake the users once falls asleep and camera automatically capture saved in the database. By using the variables of eyesOpen for the statement of true and eyesClose for the statement of true in order to detect and not detect the eyes of the user. If the statement is true, the system will produce a loud sound if the eye of the user was not detected within 4 seconds.

C. Recognizing Real Human or a Picture

Considering the eye blinking speed of the users the system can recognize a real human or a picture by setting the frame of the eyes in the use of eyeBlinked variables. If the user did not blink within 10 seconds, the system also produces a loud sound and automatically capture and save it in the database for the possibility of recognizing it as a picture or the user falls asleep because [15] stated that most of the people blink in 3 to 4 seconds.

Fig. 6 shows if the time exceeded in 10 seconds then the system alarm will be triggered, captured the event, and saved the event in the database automatically. Also shows the result of recognizing the real human or picture in front of the camera.

The records of all users can be managed and monitor by the management or the administrator. In addition, the administrator or security head can also generate and print a report based on the user's preferences such as the name of employees or users, event images captured, specified date and time.

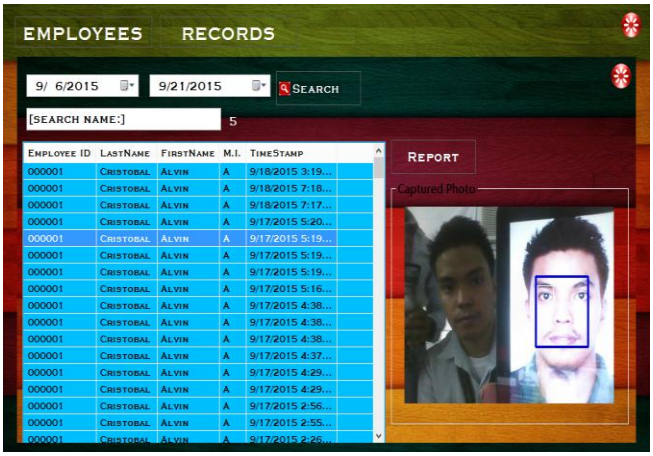

Fig. 6. Recognizing real human or a picture.

The system requires a white background to focus the detection of the face and eyes of the user without detecting any unnecessary objects. Each user must create an account as employee and capture at least 30 angles of the user's face. The more angles captured by the user, the more accurate the recognition will be. The user should be at a distance of not more than 1 and a half feet from the PC-webcam to prevent not detecting the face and eyes. The system requires at least 3.2 megapixels camera on your PC to quickly detect the eyes and recognize the users. Microsoft SQL Server Express was used to stores all the transactions and images of the system.

VI. Project Evaluation

The study is evaluated using ISO 9126 Standard by IT professionals, CCTV Operators such as security officers or security guards, and the management or security head (see Table I). The study decided to use it as means of collecting data for the current system. The results from the IT professionals helped the researchers a lot in terms of identifying the weakness of the system. The results from the CCTV Operators and the management helped the researchers in designing Graphical User Interface that is appropriate for them as target users.

Table I shows the frequency distribution of the respondents who evaluated the system. The IT Professionals are from Information Technology Education working as an instructor at the different college schools while the other respondents are from San Pedro 9 Subdivision CCTV Operators such as security officers or security guard, also evaluated by the security head of the subdivision acting as the administrator of the system.

TABLE I: Frequency Distribution of Respondents

Type of Respondents	No. of Respondents
Security Officers/Security Guard who operates CCTVs (CCTV Operators)	13
IT Professionals	5
Security Head (Management)	2
TOTAL	20

The evaluation used the scaling from 1 to 5 wherein 1 is the lowest and 5 is the highest. (see Table II).

TABLE II: LIKERT'S SCALE

Score	Scale	Interpretation
5	4.51-5.00	Strongly Acceptable
4	3.51-4.00	Very Acceptable
3	2.51-3.00	Acceptable
2	1.51-2.00	Not Acceptable
1	0.51-1.00	Strongly Not Acceptable

The statistical treatments of data used for the computation of the results of the evaluation tool are as follows:

$$\overline{X} = \frac{\sum fx}{N}$$

where:

$\bar{x}$= Arithmetic Mean

$\sum fx$ = Sum of products of frequency by midpoint

N = Number of Respondents

Table III shows the summary results of evaluation of respondents. With an average of 4.28 and interpreted as Very Acceptable, this simply shows that the system has met the standards for developing a system.

TABLE III: SUMMARY OF EVALUATION RESULTS OF THE RESPONDENTS

Criteria	CCTV Operators	IT Professionals	Security Head	Mean	Interpretation
Functionality	4.20	4.27	4.50	4.32	Very Acceptable
Efficiency	4.40	4.20	4.00	4.20	Very Acceptable
Usability	4.40	4.20	4.50	4.37	Very Acceptable
Reliability	4.10	4.00	4.20	4.10	Very Acceptable
Maintainability	4.40	4.40	4.50	4.43	Very Acceptable
Mean Average				4.28	Very Acceptable

VII. CONCLUSION

FEDSecurity is a monitoring system that helps the San Pedro 9 Subdivision safe and secured. After the testing and evaluation phase, the researchers were able to conclude that the system developed efficiently satisfied its objectives. To meet the objectives of the study, the researchers applied the computer vision principle using object detection particularly the face and eye detection using Haar Cascade Algorithm which is proven useful in object detection. For further improvement of the study, future researchers may consider the lesser amount of lightning in the room in face recognition process. Be able to accept any background of the user and not limited to a white background in adding new images to the database that are used to match and recognize users in front of the camera. Also, decrease the required captured images (different angles of the face) of the users that are used for face recognition.

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Roxanne A. Ancheta graduated with a BS in information technology from Technological Institute of the Philippines (T.I.P.) Manila in 2009. She obtained her master's degree in information technology from T.I.P. Quezon City (QC) in 2012. She became a full-time faculty member and currently an assistant professor IV of Information Technology Department at T.I.P.QC. Her research interests in mobile development, big data analytics, computer vision, and applications of data mining in the computing and educational disciplines. Also, she is pursuing her doctoral studies in information technology in the same institution.

Felizardo C. Reyes Jr. is an assistant professor and currently the program chair of the Information Technology Department at the T.I.P. Quezon City. He holds a BS in computer science, masters in information technology and engineering management specializing in systems management and is currently finishing his doctorate degree in Information technology at T.I.P. Currently, he is working on various projects and researches together with government agencies and other higher education institutions on the integration of computing to solve societal problems.

Jasmin A. Caliwag has 20 years' experience in education. She served as academics head and thesis coordinator, assistant professor from different colleges currently an OJT Faculty-in-Charge at College of IT Education, T.I.P. Quezon City. She has a bachelor's degree in computer science, master's in IT and pursuing a doctoral degree in IT. Her research interests include big data analytics for information security, mobile technology, artificial intelligence and applications.

Reynaldo E. Castillo is a faculty member of the ComSci Department at the T.I.P. Quezon City from 2012 up to present. He finished his BS in computer science in 2012 and master of information technology in 2015 at the T.I.P. He was involved in the Instruction, Research, and Sectoral Engagement Grants of the Commission on Higher Education in partnership with the Knowlegde Chanel Inc. as the team leader for game development. His research interests lie in the field of mobile application development, multimedia technologies, information security, modeling and simulation.