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FACE RECOGNITION SYSTEM FOR ELECTRONIC MEDICAL RECORD TO ACCESS OUT-PATIENT INFORMATION

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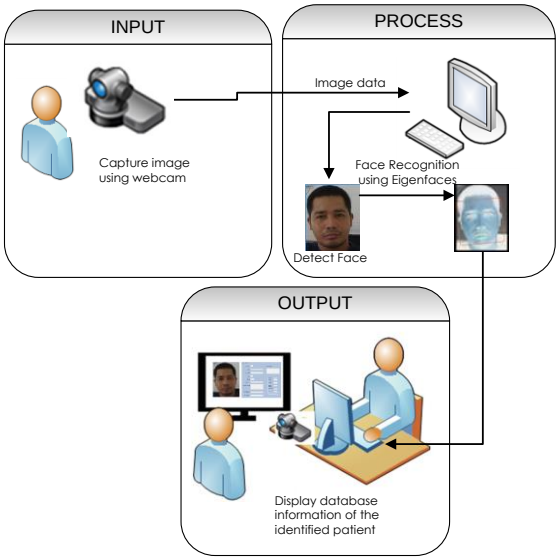
Graphical abstract



Abstract

The study aimed to create an enhanced monitoring and management system of patients' medical records for hospital clinics to provide easy identification of patients and give easy access to the doctors and nurses regarding patient's medical information. A face recognition system to access patient information was created by means of hardware and software integration. The hardware consisted mainly of a webcam for capturing the image of the patient's face. The webcam, together with the servos were connected to a gizDuino v4.0 microcontroller to allow the camera to track the face. An interface and software program using C# (.Net Framework 4) with the use of Viola-Jones algorithm code sources for face detection, Eigen-faces sources for face recognition, and Arduino IDE to program the microcontroller was developed. The content of the medical record were based on the conducted survey answered by medical professionals and saved in MySQL database. With the use of five-point Likert scale, the user-acceptability of the system was tested by doctors, nurses, medical technologists, and other medical professionals. A good result was obtained where 8 out of 10 questions were rated as 'strongly agreed' and the other two were rated 'agreed' by the survey respondents. The test for face detection yielded a 100% result and out of 30 trials conducted for face recognition, 25 were recognized with its respective record. This indicates that the system is functional and of good quality.

Keywords: Microcontroller, biometrics, database, algorithm

1.0 INTRODUCTION

Biometrics is defined [1] as technology for determining and examining the person's physiological or behavioural characteristics unique to individuals like face, fingerprint, voice, palm print, hand geometry, iris, retina scan, DNA, signatures, gait and keystroke. The implementation of biometric recognition [2] is becoming popular nowadays due to problems arising from current security systems. Face recognition is commonly used for confirmation of biometric characteristic of humans consisting of a capturing device equipped with face detection, a database, and a face recognition algorithm.

Principal Component Analysis (PCA) and Cascading Ha-ar classifier can be used as face detection algorithms.

A study on Ha-ar cascade classifier [3] used integral images with an array containing sum of the pixel intensity. The study compared the contrast values between adjacent rectangular groups of pixels, determining the light and darker areas with the result of 95% accuracy rate achieved for the detection of a human face. Another study was made on hardware architecture for face detection based on AdaBoost algorithm using Ha-ar features [4]. The presented design techniques were image scaling, integral image generation, and multiple classifiers to boost the processing speed of the face detection system.

PCA is a technique derived from matrix algebra through the statistics of eigenvectors and eigenvalues whereas Cascading Ha-ar classifier uses Viola-Jones algorithm by comparing its contrast values using a rectangular group of pixels in a photo. When it comes to image processing, the Viola-Jones algorithm is one of the most widely used face detectors which presents experiments on a difficult face detection dataset that includes illumination, scale, pose and camera variation [5]. It is popular in implementation with OpenCV where it shows its solid power in detecting faces [6].

The American Medical Association reported 98,000 preventable deaths per year due to information errors [7] and these errors which could well be reduced or avoided with properly implemented integrated information systems. The implementation of an Electronic Health Record (HER) within the Indian Health Service (IHS) was evaluated [8] with 223 care clinicians between 2003 and 2005. The result have shown that 66% favoured the EHR implementation process and 35% in the overall quality care improvement.

According to the study, the 87% of clinicians felt that the quality of care can be enhanced by information technology through the utilization of online information sources, telemedicine programs, and electronic health records. The idea of incorporating face recognition with Electronic Medical Record (EMR) emerged from the wide use of these technologies. Other biometric features such as fingerprints, eye and voice patterns, and hand measurements are commonly used. However, these characteristics were not applicable for people without hands and feet, the blind, the mute, and the deaf. For these reasons, face recognition was chosen. The system provides easy identification of patients and give easy access to the doctors and nurses regarding patient's medical information. Based on the initial survey conducted, 70% of the 35 respondents stated that the use of EMR can be efficient in clinics as shown in Figure 1.

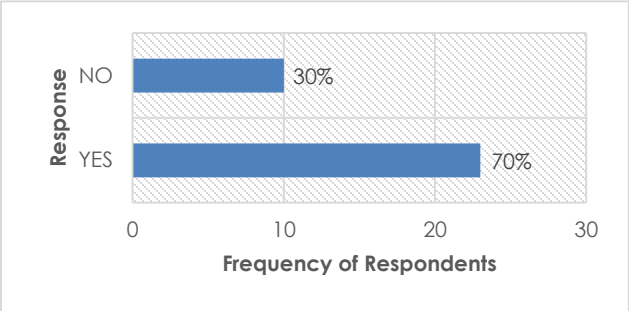


Figure 1 Survey results on the efficiency of the face recognition system for EMR in clinics

The summary of respondents with respect to their job classifications is shown in Table 1.

Table 1 Summary of composition of survey respondents

Respondents	N	%
Nurse	16	45.7%
Nurse/Midwife	5	14.3%
Medical Technologist	3	8.6%
Medical Technologist/Nurse	1	2.9%
Doctor	4	11.4%
Metabolic Clinical	1	2.9%
Pharmacy assistant	1	2.9%
Patient Care technician	1	2.9%
Others	3	8.6%
Total	35	100%

Table 1 shows the list of respondents who are the intended users of the system. As shown in the table, the highest percentage of respondents were nurses (45.7%), followed by nurse/midwife and doctors at 14.3% and 11.4% respectively. The greatest number of respondents were the nurses since they are most frequently assigned in the clinics' reception. Therefore, the creation of a face recognition system for an Electronic Medical Record has been conceptualized. It determines the hardware and software requirement needed for the system and creates a secure and user-friendly system that provides lesser time in retrieving data. The study envisions the creation of a better system for hospital clinics that will serve patients with greater efficiency by means of faster access to records, enhanced security of patient's identity, elimination of errors produced by paper-based system and reduction of the burden on doctors and nurses in accessing medical records of the patients. Face recognition is one of most successful applications in computer vision and pattern recognition. Its main objective is to recognize people from pictures or video using a stored database of faces [9]. In creating the face recognition system made up of algorithms, there will be a speedy face matching system to lessen time consumed in record-keeping and record retrieval. A

patented design [10] which is a face recognition system was made of a portable digital camera, cellular phone camera, embedded device, or handheld portable processor-based device. It could be indicated by audio, visual or mixture of images that can be retrieved from a database saved in the camera or in some other device that is connected to the camera, or another indicator. The stored information in the database is preferably biometric data and face data. Face recognition was used to get face information of a second digital image, the first digital face image which was saved in a database is displayed as a match to the second digital face image. A study on context-driven assisted face recognition tagging (CDAFRT) tools [11] were presented as a process in classifying individual face images with a specific probability. CDAFRT tools evaluate face images that are stored in the photo gallery of the user. This can be implemented as hardware, software, firmware, or combination of it. Face recognition is being used currently with surveillance cameras to identify wanted criminals and missing children for which a pictures and information are recorded in the database. London [12] and Indiana [13] used facial recognition technology to identify rebels and suspects. The Federal Bureau of Investigation or FBI [14] used face recognition to recognize the driver's license applicants and compared it with the criminal database. Many studies were done regarding face recognition algorithms and EMR, but there have been no specific studies on integrating face recognition with EMR. Therefore, the results of this study can benefit future studies on creating an EMR for use by physicians and hospitals in terms of managing the growing number of patients and records. The study's main objective was to create a face recognition system for Electronic Medical Records using existing algorithms, and appropriate hardware and software requirements needed for the system. The use of Viola-Jones algorithm for face detection and Eigen-Faces algorithm for face recognition was explored and then integrated into the EMR. The system used a database to store the data. A user-friendly interface was developed as well. In the design, a webcam was used for face recognition process, a system to detect and recognize a face to retrieve basic information and record was created. An existing algorithm was used for face detection and recognition for creating new algorithm. Also, the device used gizDuino v4.0 microcontroller to enable movement of servo. The face recognition system for EMR can support Windows operating system like Windows 7 and 8 and the system can be implemented to clinics that handle out-patients. Certain limitations in the study were encountered. For instances, the camera, lighting setup, background, and distance should be maintained for registration and recognition and for better system performance. Recognition of identical twins is an exemption due to its complexity and need for further study by the experts. Also, the system may not recognize a person if there are significant changes in the person's face or has undergone reconstructive surgery. The rules in exchanging or distributing electronic medical records was not included in the study. Also, the database can only be available in a specified clinic. Finally, only one username and password can be registered for the whole system.

2.0 EXPERIMENTAL

Figure 2 shows the framework of the design. The patient is asked to sit properly in front of the camera. The face is detected and the servos attached to the

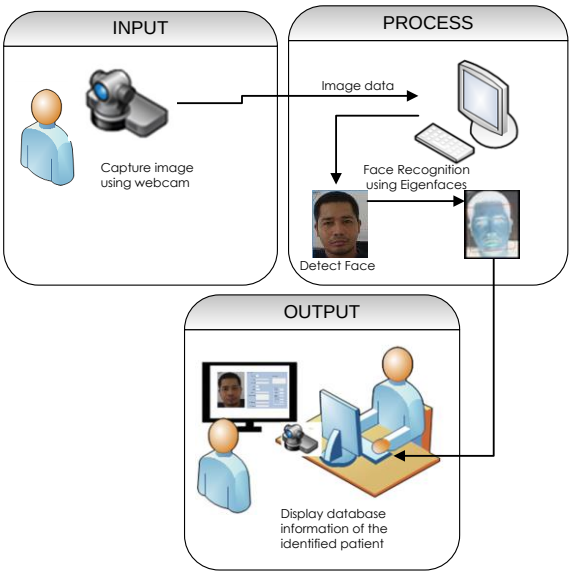


Figure 2 The flow of operations of the face recognition system

camera tracks the face and position it in the center screen. The program then recognizes the face of the patient. If recognized, the information saved in the database is retrieved and displayed.

Software Development. C# programming language was used for the software design of the system. It provided Viola-Jones algorithm code sources for face detection and Eigen-faces sources for face recognition. The software was programmed using Microsoft Visual Studio 2010 (C# .NET Framework 4.0) and database system of MySQL (v5.6.12.0). All files were stored in a MySQL database. The software could produce printable form using Crystal Report (v13 for Visual Studio). Figure 3 shows the simple implementation of the software in clinics.

Algorithm. The algorithm for face detection, used was haarcascade_frontalface_default.xml. The source code was from Emgu CV which is a C# wrapper of image processing library of Open CV and eigen object recognizer. cs for face recognition. The

haarcascade_frontalface_default.xml is based on the Viola-Jones Algorithm. The image is processed through certain parameters which are defined by the code. This parameters is the basis to determine if the input image has face like attributes. The Eigen object recognizer was based on the PCA (Principle Components Analysis) algorithm. Using Eigen vectors from the Eigen spaces, the input image was then analyzed to certain parameters, each initial images is treated as unknown images. After the analysis, the algorithm returns the value with the nearest to the initial image.

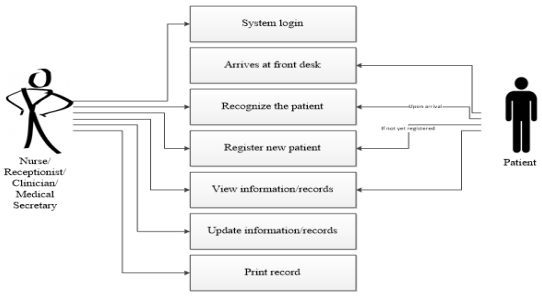


Figure 3 Use-case diagram of face recognition system for EMR

Hardware Development. The gizDuino microcontroller was programmed with the servos. One servo was for tilt (up and down) and the other was for pan (left and right). The camera was attached to the servo which enabled it to move in accordance with the position of the face image being captured. The camera used was a simple 5 megapixel webcam. As shown in Figure 4, the pan servo which moves in X-axis was connected to pin 3 of digital I/O and the tilt servo which moves in Y-axis was connected to pin 2. The red wire was connected to 5V source while the black wire was connected to ground (GND). The servo motors were programmed using Arduino IDE (v1.0.5). A webcam driver (for A4 Tech H) was used for the installation of webcam while Emgu CV (v2.2.1.1150) for image processing.

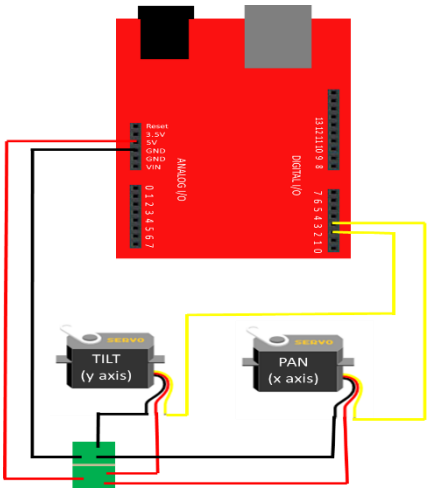


Figure 4 Connection of giz Duino microcontroller and servos

System Integration. Figure 5 illustrates how the system works.

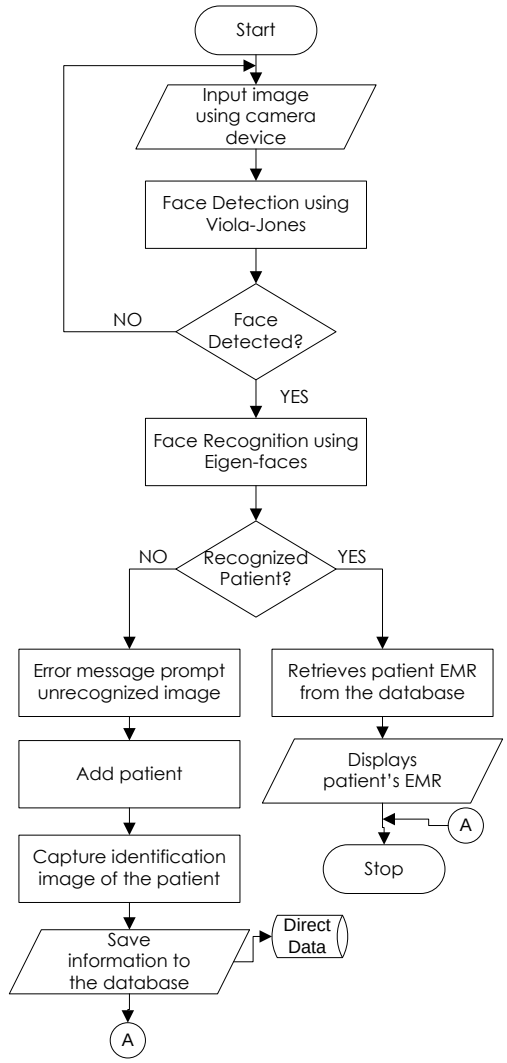


Figure 5 System design operation

Initially, the patient is positioned steadily in front of the device. The features captured are inputted into the system. A rectangle shows up once a face is detected. The captured input is then compared from the saved images of patients in the database. As soon as the patient is recognized, the system can now access the patient's information. Else, the patient will fill up the necessary data to have an electronic medical record in that clinic. During the patient registration, a personnel or clinic staff will be assigned to standby throughout the face recognition process to avoid falsification of face input such as placing photographs in front of the camera.

System Testing and Performance. A five-point Likert Scale that was modified to match the system's description was used in the study to evaluate the program. The questions asked from the respondents are as follows:

Q1. The system is programmed in the way that the user would easily understand.
Q2. The proposed system is usable to the user.
Q3. The proposed system is able to solve the common problems resulted from the manual transaction of data.
Q4. The proposed system is user-friendly.
Q5. The proposed system performs the intended function.
Q6. The proposed system is accessible.
Q7. The proposed system quality is good.
Q8. The proposed system runs properly.
Q9. The proposed system's layout and design is appropriate.
Q10. The proposed system meets the satisfaction of the user.
The scale in Table 2 is used to verbally interpret the total responses by computing the mean.

Table 2 Likert scale interpretation

Mean	Verbal Interpretation
1.00-1.79	Uncertain
1.80 – 2.59	Strongly Disagree
2.60 – 3.39	Disagree
3.40 – 4.19	Agree
4.20 – 5.00	Strongly Agree

3.0 RESULTS AND DISCUSSION

Survey. Figure 6 shows the survey responses to the importance of selected information that must be included in the Electronic Medical Record.

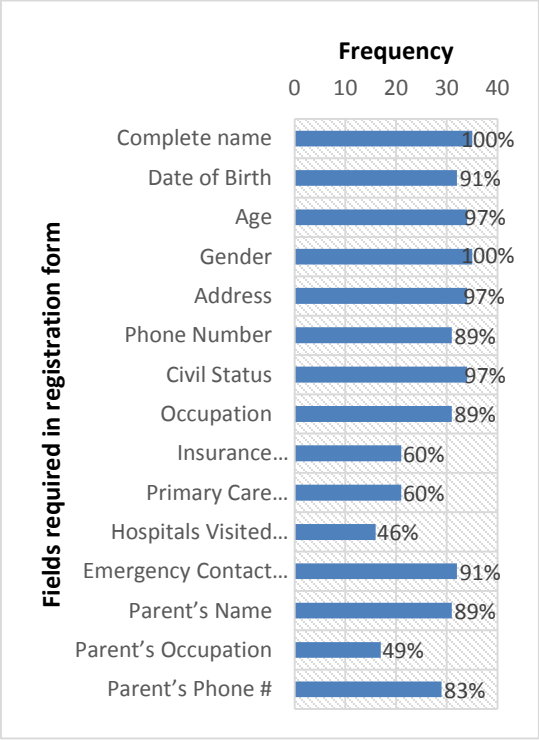


Figure 6 Survey results on information necessary for a new patient registration form in a clinic

User Acceptance Test. Table 3 shows the result of the user assessment testing conducted at selected clinics in Santa Rosa, Laguna. With means between 4.2667 and 4.4000, it can be verbally interpreted that the respondents strongly agreed on the following: 1.) the system was programmed in a way that it can be easily understood, 2.) it is usable to them, 3.) it can solve problems to replace manual transactions of data, 4.) it is user-friendly, 5.) it performs the intended function of storing and retrieving information, 6.) it runs properly, 7.) it has appropriate layout and design, and 8.) it meets the satisfaction of the user. With the mean of 4.0667 and 4.1667, respondents only agree with the following: 1.) the proposed system is accessible and the 2.) system has a good quality.
Based on the computed standard deviation, which are all less than one, it can be established that there was only a minimal variation in the answers of all the respondents.

Table 3 Computed mean of the user acceptance results

Question	Mean	Standard Deviation	Verbal Interpretation
1	4.4000	0.5632	Strongly Agree
2	4.3667	0.4901	Strongly Agree
3	4.2667	0.6397	Strongly Agree
4	4.3667	0.5561	Strongly Agree
5	4.4000	0.5632	Strongly Agree
6	4.0667	0.8277	Agree
7	4.1667	0.8339	Agree
8	4.3000	0.8367	Strongly Agree
9	4.3667	0.4901	Strongly Agree
10	4.3000	0.7944	Strongly Agree

Face Detection Test. As shown in Table 4, all faces captured by the camera have been 100% detected.

Face Recognition Test. Table 5 shows three (3) patients with ten trials each were selected to execute the second test by means of recognizing the faces saved in the database.

Table 4 Face detection testing with 18 registered patients in the database

Patient	Face Detected? (Y/N)
1	Y
2	Y
3	Y
4	Y
5	Y
6	Y
7	Y
8	Y
9	Y
10	Y
11	Y
12	Y
13	Y
14	Y
15	Y
16	Y
17	Y
18	Y

Table 5 Face recognition testing with 18 registered patients in the database

Trial	Face 1 (Patient 1)	Face 2 (Patient 2)	Face 3 (Patient 3)
1	Y	Y	Y
2	Y	Y	Y
3	Y	Y	Y
4	N	Y	Y
5	Y	Y	N
6	Y	Y	Y
7	Y	Y	N
8	N	Y	Y
9	N	Y	Y
10	Y	Y	Y

The face recognition system for EMR significantly recognizes the patients. Patient 1 was recognized 7 times out of 10 trials, patient 2 was recognized 100%, and patient 3 was recognized 8 times out of 10 trials. Errors were caused by uneven lighting of the surrounding and distance from face to camera. It is stated that face recognition could reach 100% efficiency but not always, thus, there is no existing face recognition algorithm that is 100% guaranteed [15]. The lighting should be constant and intense enough to capture the features of an individual's face and to identify the patients correctly. The distance from face to camera varies since the quality of the photo is better if the image is near the camera.

4.0 CONCLUSION

Based on the results of the testing gathered on the study using face recognition system, monitoring and managing of patient medical records can be done using C# programming language with .net Framework 4.0 and EmguCV library. The prototype was built with a web camera mounted on motor servos for mobility. EMR was successfully integrated with face detection and recognition that uses Viola-Jones algorithm and Eigen-faces algorithm. With the use of the Eigen-faces algorithm, an individual's face was recognized. MySQL database was efficiently used to store and retrieve the items including the images, information, and record of the patient being registered. The system can be concluded as user-friendly since it yielded a mean of 4.3667 which can be interpreted as strongly agreed by the respondents. In addition, tests like consistency of matching images and accuracy of the face recognition with electronic medical record have been successfully made. Finally, it can be concluded that the system can be implemented as long as the functionality is guaranteed and related issues are carefully handled.

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