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A Simple Yet Reliable Facial Emotion Detection for Campus Environment

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Abstract*: Nowadays, crime incidents like stealing, fighting and harassment often occur in campus leading to serious consequences. Students do not feel secure to study in campus anymore. Thus, a simple facial emotion detection system using a Raspberry Pi is introduced to help mitigating the issue before getting worse in campus. Two algorithms are used for this project including Haar Cascade and Local Binary Pattern (LBP) algorithms. OpenCV is a library that can be used for image processing. LBP algorithm is used for face detection in OpenCV. When a person enters the specified area, the camera will capture the image and detect the image of the person. Then, a rectangular box appears on the face image of the person. The image is automatically sent to the email. The face detection is enhanced by adding a face alignment. The face alignment is used to detect the location of many points on the face. It recognizes the emotions for each face and gives the confidence score. The value 0 of confidence score is the perfect face recognition. Although the system is simple, it is still reliable to be used in a campus environment.

Keywords: Face alignment, Face detection, Raspberry pi.

I. INTRODUCTION

Many Malaysians concern on the rising crime and violence in the country. Victims have experienced a wide range of emotional and psychological responses. Research into emotional effect of crime incident shows that 73% of crime victims feel fear of victimization [1], 70% of them are very distressed following the burglary and 40% of them are afraid to be alone in their property following the incidents [2].

A Door Control System based on a Smart Camera has been introduced [3]. The system can detect and identify a person by face detection, and then analyze the path trajectory, whether the person intends to access the door or not. However, the system still has disadvantage where it cannot detect efficiently if many people use the same door. Face Recognition based on Embedded System is developed in [4]. The face recognition process is realized only by computers with high performance. The OpenCV facial Haar-like features are used to identify the facial region and the Principal Component Analysis (PCA) is employed for quick extraction of facial features.

Smart Surveillance Monitoring System which uses Raspberry Pi and PIR Sensor [5] exposes the increasing of mobile usage to assist technology for the security system. When motion is detected, the cameras automatically initiate recording and the Raspberry Pi alerts the owner of the possible intrusion. The home security system captures information and transmits it by a 3rd generation (3G) Dongle to a smartphone using web application. The project provides a good security system, but the system does not only detect human motion but also can detect animals and other things. A research by Sandeep *et al.* [6] states that face recognition can be done using Bayesian classifier algorithm. The RFID (Radio-Frequency Identification) and GSM (Global System for Mobile communication) technology are combined to access the locker securely. It senses the vibration sensor and the sensor sends the control signal to the Raspberry Pi processor.

Video recording system has been introduced by using night vision camera with Raspberry Pi [7]. The camera detects object when the object starts moving and records it immediately through Raspberry Pi. The camera detection is applied for object which is not exactly human, but also animal. When the camera detects the object, it does not notify user. The user cannot get real time notification when it is happened.

Biometric security system such as fingerprint and speech technology [8] states that fingerprint is unique to each human because people have different fingerprint. Fingerprint has 5 classes to be recognized which are arch, left loop, right loop, tented arch, and whorl. Every image should be stored clearly in order to recognize a person. The fingerprint technique introduces issues when the person has a broken fingerprint which cannot be detected by the sensor.

Most of the previous systems are expensive and complex to be applied in a class, gallery or hall, so a simple facial emotion detection system is needed. Thus, the aim of this project is to develop a simple system to detect any crimes or violence occur in the campus environment particularly in the class and shop area.

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The owner of the shop or the campus authority will be notified by an email.

II. METHODOLOGY

A Raspberry Pi 3 which has high processing capacity, low price and ability to adapt to different programming modes is used. The device uses Linux as an operating system (OS). Linux has access to many libraries and applications. Raspberry Pi has an Ethernet port allowing us to access and manage a network connection easily, four USB ports to connect devices like a keyboard, mouse, camera, and other devices that connect through a USB port and an HDMI port which gives us an access to the interface of the OS installed [9].

A Pi Camera Module V 2.1 is used to capture the images or videos, then the images or videos are converted into an OpenCV (Open Source Computer Vision) object. The object goes through image processing and face detection. OpenCV has its own face recognizer algorithms such as Eigenfaces, Fisherfaces, and local binary patterns histograms.

The Raspberry Pi uses a Raspbian operating system which applies python as the main language. Besides that, Python's syntax is easy to learn, readability, object-oriented programming and it is free. Fig. 1 shows a basic process flow of a face recognition system.

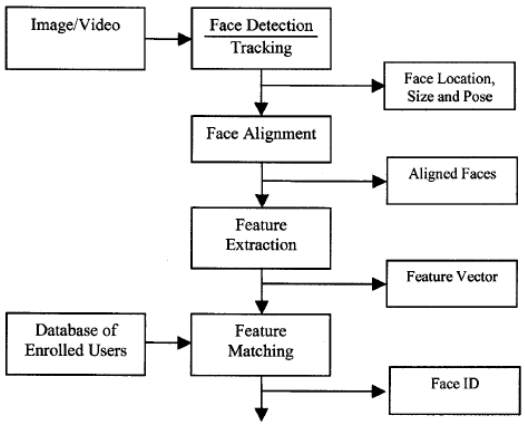


Fig. 1. Basic face detection system

Image or video is taken from the camera before going through face detection. All faces are extracted and passed for the face alignment system. Face detection provides a coarse estimation of location and scale of each detected face. Face alignment gives more accurate localization and normalization of detected faces. The location of eye, nose, lips and other visual features are extracted. The distances and angles between these points are calculated and compare it to the target face and reference faces. Then, the image undergoes feature extraction to provide effective information to distinguish faces of different people. An algorithm is used in order to find the easiest way to detect and recognize a human face. There are many proposed algorithms such as eigenface method, fisherface method and local binary pattern histograms (LBPH) method [10]. Each algorithm has its own characteristics in terms of strength and weakness. Eigenface method is chosen to address this problem as it is widely known to solve the face recognition system. There are three interesting databases which are AT&T face database (acronym), Yale face database A and extended Yale face database B [11]. Here, two face databases are used: AT&T face database and Yale face database.

A. AT&T face database

This database contains ten different images of each of 40 distinct subjects [12]. All images are taken at different times and lighting. Facial expression and facial details are varied. The facial expression refers to open or closed eyes or smiling or not smiling while facial details refer to the faces with glasses or not as shown in Fig. 2

Fig. 2. Face Database data

B. Yale face database A

The database is more appropriate dataset for initial experiments where it consists of 15 people each with 11 grayscale images [11]. The images are varied in terms of light conditions, facial expression and facial details.

In the face detection process, the Haar Cascade is applied to detect the object in the image. The cascade function is an example of machine learning which is used to train for positive and negative images. Haar Cascade is applied to detect eye, frontal face, full body, license plate, upper body and others. Haar features consist of three features such as edge, line and four-rectangle features. Each feature has a single value, obtained by subtracting the sum of pixels under white rectangle from the sum of pixels under black rectangle as shown in Fig. 3 [4, 11].

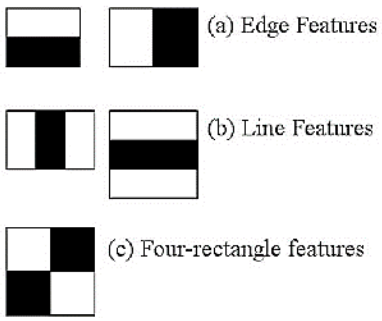


Fig. 3. Haar Cascade feature [11]

All features are applied to all training images in order to find the best threshold which classifies the faces to positive and negative.

Haar cascade detection is used in OpenCV which contains many pre-trained classifiers for face, eyes, smile and others.

In this paper, frontal face detection is used and the required extensible markup language (XML) classifiers are loaded into the OpenCV. The automated notifications are sent through Gmail service with Python script. A python script that uses the smtplib native library is created. First, the application to access Gmail account needs to be allowed. The Raspberry Pi can image easily over the Gmail. Then, the python script named mail.py is applied. The email's address and the password for that email are declared. Default email is the email that we want to declare for the Raspberry pi to be used. This default email will send the notification image to another email address. Password for the email is given for the Raspberry Pi to log in. Then 'to Email' represents the email that we want to send. The received email should be the email that we always check. After that, the email address for the 'to be notified person' is included. With the script, we can automate email task easily without worrying about low-level implementation. The developed system also provides live streaming system so that we can monitor the place through phones or laptops. To execute the live streaming, the Internet protocol (IP) address for the Raspberry Pi is used by typing 'ifconfig' in the terminal. Then we store the code into the python script name 'mail.py'. The IP address of the Raspberry Pi is written into the browser to show the live video from the Pi camera.

Data consists of face images are stored for the real time experiment. We apply the database by using 7 images of the total images to test face recognition algorithm. The individual has different facial expressions like happy, sad, normal, angry, sleepy, with glasses and wink. Ten individuals are collected for the face database.

III. RESULT & DISCUSSION

Face detection method is developed based on many criteria such as a face has two eyes which are symmetric to each other, a nose and a mouth. Human skin colour is used to be an effective feature for face detection. Different people have different types of skin colour, and each part of face has its own colour's characteristic. Texture of the face is different from the other objects. H. P. Graf *et al.* [13] develops a method that infers the presence of a face through the identification of face-like textures. Every step of face detection is shown in Fig. 4. The image taken from the pi camera is resized to the specific area of detection. This is important because the huge image size takes longer time to process compared to small image size. Then the image undergoes contrast stretching where the RGB colour is changed to black and white form. In the image, there are many different patterns of colour appear in the image which is transformed to integral image. In the integral image, only the white colour represents the face while other part is represented by black colour. Green box indicates the human's face that is detected. The pi camera frame for face detection with green box is shown in Fig. 5.

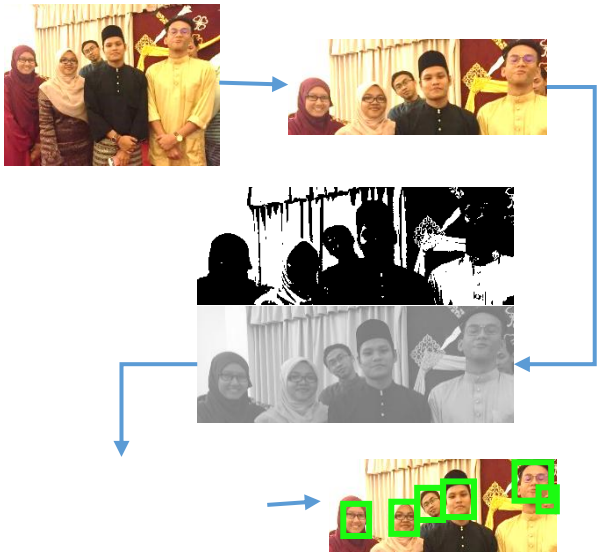


Fig. 4. Face Detection process

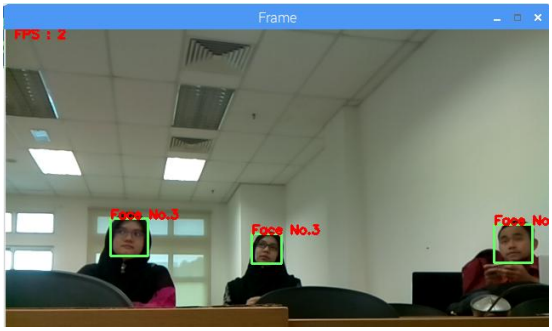


Fig. 5. Pi Camera frame for face detection with green box

When the face is detected by the Pi camera, the camera sends the image of the person through email. The email address and password for the host are set in the python script. Simple Mail Transfer Protocol (SMTP) server is used for this method. The receiver's email has been set in the code in order to receive updated image. New Python script named mail.py was created for this email setup. The email's notification is shown in Fig. 6. The image was sent automatically when the camera detects the face. The time for each picture to be sent to the user's email is set in order to tackle the large number of emails for each submitted images. Furthermore, the live stream video can be viewed through the HTML as shown in Fig. 7.

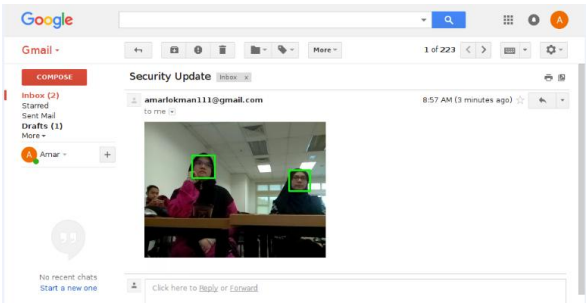


Fig. 6. Email notification for each face detection

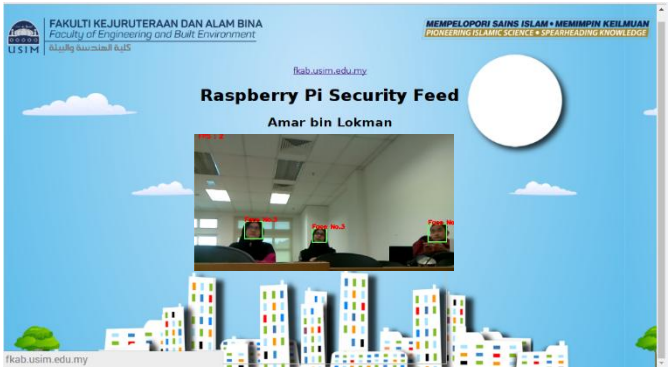
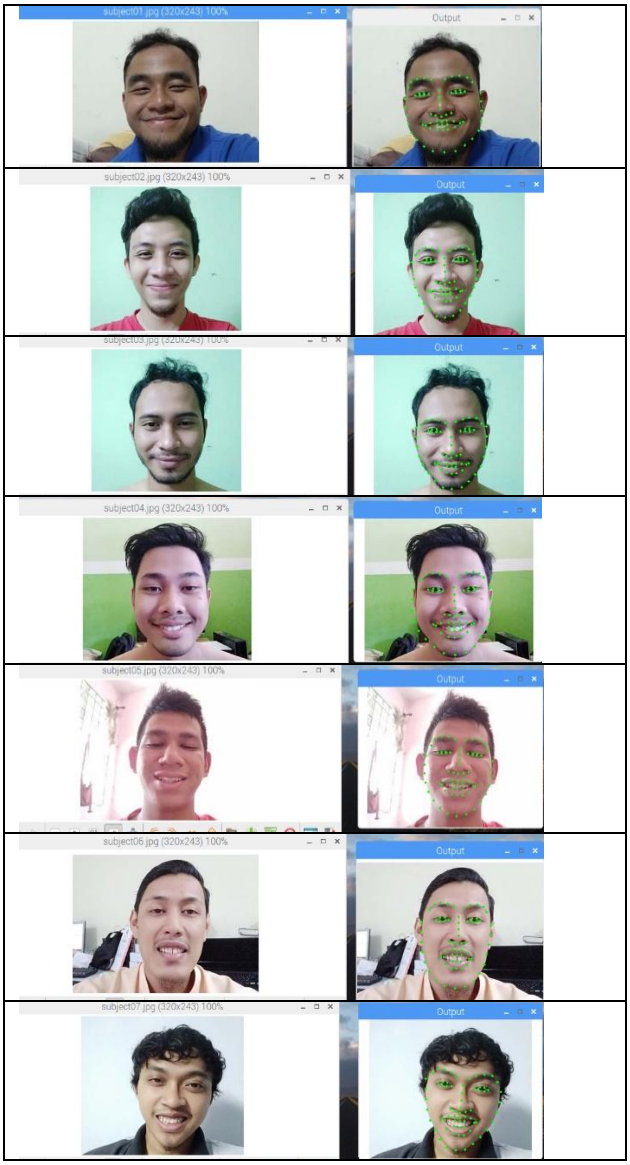


Fig. 7. Live video through HTML

The facial emotion detection is developed using facial landmark. Facial landmark is used to localize and represent salient regions of the face which are eyes, eyebrows, nose, mouth and jawline. It labels and identifies key facial attributes in an image. Each trained image output is shown in the Fig. 8. There are 10 subjects and the subjects are counted from 1 to 9 (from above). Subject 9 shows the normal face result because the confidence score is 0.0 (Fig. 9). It means the expression face in subject 9 is like the trained image. The rest of confidence scores for each subject are shown in Fig. 9.



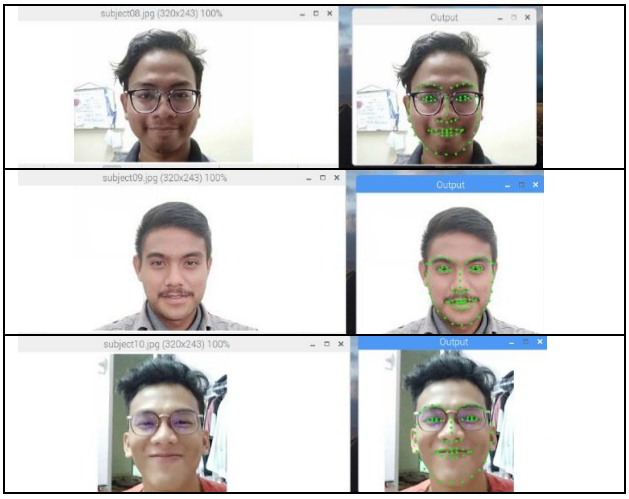


Fig. 8. Facial landmark for each trained image

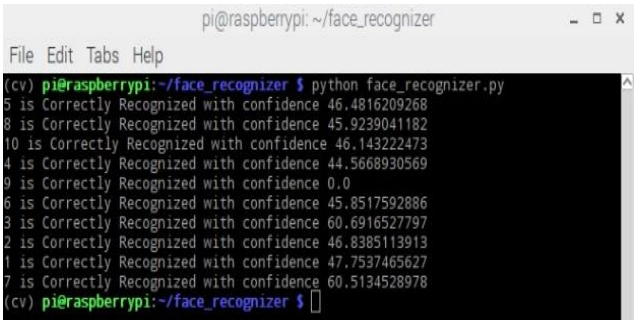


Fig. 9. Normal face result

After the facial emotion is detected, the image will be sent to the user's email automatically and promptly received. Users can also do research what is happening in the region by viewing live videos on the web. In this way, users can avoid any suspicious movements in the area.

IV. CONCLUSION

In conclusion, we develop a simple facial emotion detection, designed to detect any crimes including theft, violence and harassment. Previously, the security alarm is used on campus for protection against theft or property damage. The security alarm system is used to alert the people about theft, but it takes more time for us to solve theft issue.

The developed tracking system can be adapted to Internet of Things (IoT) which can be applied by mobile phones. The facial emotion detection system is used to calculate confidence scores for each of the different emotions. Each confidence score is different for each emotion. Score confidence with 0.0 is a perfect face recognition. The facial emotion detection is very useful not only in the campus but also in the office. We can identify people emotion based on this system. The system can be upgraded using 2D and 3D models. The 3D model offers a promising solution to the problems faced by 2D images and life models.

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