A smart building security system with intelligent face detection and recognition

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Abstract. The security system is the most important application that protects several threats from inside and outside of an organization. The purposes of several security building applications such as the system will know criminals, disgruntled former employees enter the workplace, and enabling building security to work proactively for ensuring that associates and customers are safe from harm. By implementing face detection and recognition of the security system, video surveillance in the building can be improved by upgrading the system of video surveillance with artificial intelligence. The aim of the research is to develop the face detection and recognition in the security system in the building with recognizing human faces and image capture to the cloud storage. The result shows that the video will stream and recognize human faces whether the person is authorized or unauthorized in the system image using Raspberry Pi 3. For analysis purpose, the image captured and stored from the two type of cloud storage namely Cloudinary and Dropbox had been analyzed. Based on the analysis, the image captured and stored into Dropbox cloud storage give the best performance features which gained more 75% of quality images.

1. Introduction

Nowadays, people spend 80 percent of their lives inside buildings [1] such as office buildings, schools, hospitals and homes. The Internet of Things (IoT) offers innovative, smart building solutions to meet these goals for safer and cheaper than the old system uses such closed-circuit television (CCTV) and less power use that can prevent overloaded current power. The creation of this system has grown in developed countries such as the United Kingdom where most every building has an image processing system where the intruder's face will be captured through cameras and the system will go through to the police system.

To enhance the security level of the Internet of Things (IoT) devices, the smart building with intelligence system has been designed for specific purposes such as which system when someone comes into the building and the camera will capture the object's image and then send the object's image in the cloud. The research has been done in home security system [2], face recognition IoT system [3] and an implementation of Raspberry Pi application [4],[5] where the project has been using the Raspberry Pi board in the application and face recognition system based on OpenCV [6]. In [4], live video streaming system using raspberry pie with cloud server is proposed which including video capture module, video compression module and video streaming module using Linux operating system.

Based on issue of fire breaks out at police HQ department of Bukit Aman in 2015 [7], the building has no security system for storing data information permanently because the building used closed...
circuit television (CCTV) using Network Video Recorder in server room which the data storage may be changed or deleted by someone who is not responsible for protecting criminal data information. In that case, there are no critical criminal investigation documents in the building instead of the criminal investigation department in the other level of the building. By creating the security of face detection and recognition with cloud system, the smart building system can be implemented in front of the door of department for capturing the image of person whether authorized or unauthorized according to references [8] - [24] so the sensor will detect every face for transmitting image processing to the cloud system which the investigator can check the person who entered the building on the cloud.

Therefore, the aim of the research is to develop the smart building security system with intelligent face detection and recognition with the aid of the cloud system in real time using Haar-Cascade method and histogram of oriented gradients. The camera sensor and the raspberry pi board established the Internet of Things (IoT) application system using Dropbox cloud storage implementation. The project used the raspberry pi 3 in model B+ concept to operate the whole system. Furthermore, a connection is needed between Logitech USB webcam with 5 Megapixel and Raspberry pi 3 model B+ using html web page, python programming language and OpenCV based on Linux operating system. For analysis purpose, the image captured and stored from the two type of cloud storage namely Cloudinary and Dropbox will be analyzed.

2. Research Methodology

Figure 1 shows the block diagram of the project. The system is divided into two parts; hardware and software design. In the hardware part, the camera sensor will detect and recognize the presence of human whether the person is authorized or unauthorized in the system using the raspberry pi 3. While in the software design part, the project will be interfaced with html and cloud storage platform on the system using Dropbox.

![Figure 1. Block Diagram of the System.](image)

The person will be allowed to enter the building with authorization by the system. However, the person who enter the building without authorization by the system can be considered as an intruder. The image captured will store directly to the Dropbox Cloud Storage when the system detects the presence of human.

2.1. Hardware Design

The system has a camera sensor which Logitech model webcam for face detection and recognition connected to the USB port of Raspberry pi 3 model B+ concept to interface with html and Dropbox as a data platform. The Raspberry pi connected to the router by using a network cable to configure the network on raspberry pi before raspberry pi can be used as wireless. In addition, Raspberry pi has been using the Raspbian stretch as an operating system that is stored in a 32 GB microSD card. As we can see in Figure 2, it shows the connection between the Logitech webcam, screen monitor and Raspberry pi 3 model B+ have been set up in hardware implementation.
2.2. Software Design

OpenCV stands for Open Source Computer Vision Library, which has C++, C, and Python interfaces, running on Windows, Linux, Android and Mac. In this project, the system uses OpenCV in version 3 which is up-to-date compared to the lower version of OpenCV.

Haar Cascade is a face detection algorithm used to identify faces, pedestrians, objects and facial expressions in an image. In Haar-Cascade, the algorithm is provided with several numbers of positive images which are faces of different persons at different backgrounds and negative images which are images that do not face but can be anything else like tree and grass. The feature selection is done along with the classifier training using Adaboost and Integral images. The Adaboost classifier is retrained the algorithm iteratively by choosing the training set based on the accuracy of previous training. There are several stages as related to Figure 3 and Figure 4 for this project where this project has been using Haar cascade approach method using OpenCV version 3 and python programming language in version 3.5 to process the computer vision and image processing in this project.

![Figure 2. Schematic Diagram of Project.](image)

![Figure 3. How Haar Cascade Works [25].](image)
The algorithm used in the face recognition on video streaming is Haar Cascades algorithm. This algorithm is used for pre-trained images on OpenCV platform. Haar Cascade approach method comes with a trainer as well as a detector and already contains man pre-trained classifiers such as a face, eyes and smile. Haar Cascade files are stored in OpenCV folder and basically a classifier which used to detect particular objects from the source. Haar cascade is designed by OpenCV to detect the frontal face and capable of detecting features from the source. Haar Cascade is a machine learning algorithm used to identify objects in image or video. Before pre-trained an image, the system needs to build a dataset first so that the system can recognize faces in the dataset and encode them into 128-d vectors on each image using Histogram of Oriented Gradients (HOG) as a detection method.

Figure 5 shows the flow of proposed system. Based on figure 5, the face recognition system have been implemented using raspberry pi 3 with the Logitech USB camera can stream the video on the website while the system also can store an image of the presence of human directly to Dropbox cloud storage. The system needs WiFi connection by applying a private network in order to run the system. After the system successfully connected to WiFi, the user needs to insert a username and password correctly due to the project has been encrypted for system security.

Next, the user can choose either face recognition on video frame or face detection direct to the Dropbox cloud storage. If the user chooses face recognition, the video stream of face recognition will display on video frame which can recognize the face’s staff of the building with the staff names displayed on a video frame. Besides, the system also cannot detect suspicious person by displaying "Unknown" on video frame so that the user can identify a suspicious person in the building. However, if the user chooses face detection with Dropbox, the system will automatically capture the image and send to the Dropbox storage when the system detected the presence of a human. The analysis of cloud storage between Cloudinary and Dropbox has been done in order to obtain the best result resolution of image captured.

**Figure 4.** Haar Cascade Training Function [25].
3. Results and Discussion
Figure 6 shows the comparison image from Cloudinary and Dropbox cloud storage. The percentage of an image features from Dropbox and Cloudinary are tabulated in the Table 1. With the same resolution of an image; 640 x 480, the quality image from Dropbox is higher at 81 % of lighting compare to image from Cloudinary that only recorded 79% of lighting. In term of light fixture, image from Cloudinary only display at 74% compared to image from Dropbox that recorded 76% display on light fixture of an image.
Figure 6. Comparison image captured from Cloud Storage (a) Cloudinary, (b) Dropbox

Table 1. Image Quality Analysis between Cloudinary and Dropbox.

|                  | Cloudinary | Dropbox |
|------------------|------------|---------|
| Lighting (%)     | 79         | 81      |
| Light Fixture (%)| 74         | 76      |

According to table 1, the analysis showed that the image stored from Dropbox give the best performance features. Therefore, Dropbox cloud storage is applied to the system running on the web server. The main page of the system which encrypted by inserting a username and password for system are shown in Figure 7.

Figure 7. HTML Login Page.
Figure 8 displays the web page of application system which encrypted by the username and password in order for user allowed to enter the system by clicking the button on web page either face recognition or face detection with Dropbox for displaying a video frame of the application.

The video frame after clicking on the button of face recognition are shown in figure 9. The video frame can recognize human names which registered on dataset using Haar Cascade method and the other person that not authorized, automatically the system will display ‘Unknown’. To exit the video frame, the system needs to press ‘Q’ on keyboard.

Figure 9: Video Frame of Face Recognition.
Raspberry pi can detect sensitively with motion or the presence of human which the system will capture the presence of human only when the raspberry pi detected as can be seen in figure 10 and the image captured will directly store on Dropbox cloud storage. This project can reduce the usage of storage because the system will only store the image when it has a movement in front of the camera.

**Table 2.** Accuracy Percentages and Elapsed Time between Cloudinary and Dropbox Image.

|                     | Cloudinary | Dropbox |
|---------------------|------------|---------|
| Accuracy (%)        | 85.3       | 93.5    |
| Elapsed Time (s)    | 10.23      | 5.54    |

Furthermore, Table 2 shows the comparison of accuracy percentage and elapsed time between Cloudinary and Dropbox image in face detection and recognition. The result shows Dropbox image obtained the higher accuracy with 93.5% compared to Cloudinary image with only recorded 85.3% of accuracy. In term of time, the Dropbox image also recorded the faster time with 5.54 seconds compared to Cloudinary image which only obtained 10.23 seconds. Therefore, it is proved that the Dropbox image gives the best accuracy and fastest time in face detection and recognition.

4. **Conclusion**

The video streaming based on the web server using Linux Operating System is successfully developed. The system has been implemented with low-cost, portability and easy to maintain and upgrade. The server periodically obtains video recognition from the camera through the private network such as the video streaming transmitted from camera to the server. Therefore, the real time video streaming with intelligent face detection and recognition based on the web server give the better performance and more secure than the video surveillance due to the limitation of video surveillance which is not provide human recognition on the system. For future works, the system will upgrade face recognition system algorithm using machine learning or deep learning method and the WIFI connection will change to public network access.

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