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"Tec-House" WEBCAM-BASED REMOTE SENSING SYSTEM FOR HOME AND BUILDING SECURITY USING THE HAAR CASCADE METHOD

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A B S T R A C T

A home security system is something that every home owner must pay attention crimes such as burglary often put homeowners at risk. Therefore we need a tool that can bring together automatically remotely to protect the house. The system worked on in this article is a remote sensing system based on webcam. The method used in this sensing system uses the haar cascade classifier method. The results obtained from this remote sensing system are for the implementation of the system on homeowner data sets with 98% results, while for non-home owner image data sets with 96% results. From the results of using a webcam-based remote sensing system using the Haar Cascade Classifier method it can be implemented properly and the average error is 97%. The existence of this Tec-House tool can reduce the crime of theft in a house or building.

INTRODUCTION

Today, with the criminality of crime, society's need for comfort is increasing. As technology develops, more modern security devices and systems are based on more modern technology. Crime, especially robbery and theft, has increased the need for a more efficient and effective security system, especially in this era of Information Technology, a digitally connected security system that can monitor from various places is very important [1]. Figure 1 is a home security remotely.

Figure 1. Remote home security

Biometrics is a technology that uses the characteristics of the human body to distinguish a person from others, such as fingerprints with fingerprint technology, eyes, voice with voice recognition technology, and facial recognition technology. All of these technologies have been widely developed in various applications such as attendance and security systems [2].

The need for a more sophisticated and integrated security system for houses and buildings is very important for everyone to pay attention to before building a house/residential building. In an increasingly insecure situation like today, security is a very important factor for society. Conventional security systems such as the use of locks and CCTV cameras are commonly used, but are less effective in overcoming security problems. Therefore, a more sophisticated and integrated security system is needed that can optimize the monitoring and detection of suspicious events around a house or building [1].

Previous research conducted by Permana & Dwiyono in 2015 on Automatic Door Opening and Closing System About Using Microcontroller-Based Watches. This study discusses a security system that can be controlled using a watch made of an Arduino microcontroller combined using an IR sensor [3]. The system will still work if the watch is worn by someone who is not a resident of the house. Furthermore, in the research conducted by Sehman on the Application of Face Detection with the Eigenface Method on Intelligent Car Security. Facial recognition systems have been used for car security systems. However, the system will only sound an alarm if the detected

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face is not recognized. There is no direct action from the system to secure such as automatically locking the door [4]. Furthermore, in a study conducted by Nazirah Ahmad Zaini et al in 2016 about a remote monitoring system based on a Wi-Fi controlled car using Raspberry PI. The system created discusses a car security system that can be controlled remotely using a Wi-Fi network with a raspberry PI microcontroller [5]. Furthermore, in research conducted by Teddy Mantoro et al in 2018 on the Multi-Face Recognition Process Using the Haar Cascades and Eigenface Methods. The system created discusses the face recognition system using the haar cascade method and the eigenface method [6]. Furthermore, in a study conducted by Ruth Ramya Kalangi et al in 2022 on the Deployment of Haar Cascade Algorithm to Detect Real-Time Faces. The system created discusses the weak classification system used to extract the dominant art of non-human faces based on the histogram of facial skin color [7].

A home security system is something that every home owner must pay attention to. Especially when you have to leave the house uninhabited for work and even for vacation. Homeowners must be worried about burglars, lost jewelry, or the safety of other valuables. Although now almost all housing and apartment complexes have used security facilities, homeowners must remain vigilant and take precautions in their private homes. Digital CCTV monitoring can be seen in Figure 2 below.

Figure 2. Digital CCTV monitoring

In this sophisticated era, security systems are very important given the increasing intensity of crime. In general, people use a security system that is able to record activities in certain corners of the house, including recording incidents of crime, without any early warning. The problem that occurs is that the perpetrators of the crime already know the technicalities of the security system that has been installed which is usually in the form of CCTV, so that the perpetrators of the crime can quickly eliminate the traces of their crime by destroying the recording storage media. Sometimes criminals target homes without a security system, and homes that are rarely passed by the local community. The lack of mobile security or patrol posts further increases the number of crimes that occur in a housing complex [8].

From the explanation of the problems above, it inspires the author to overcome these problems through the "Tec-House" Remote Sensing System Based on Webcam and Raspberry PI 3 for Residential Security. This residential security system utilizes facial recognition technology with the haar cascade classifier method using a Raspberry PI 3 microcontroller as a control system that is triggered by a webcam camera (face recognition sensor) as well as speakers and telegram notifications to homeowners as an output system [21].

So that with this system, remote security for the home owner, no longer worries about the condition of his home from crime or theft.

In this article, the author uses face as a facial recognition technology to be applied to a residential security system. The reason the author uses the face as a recognizable object of the system is because the face is a unique part of each person's body that is difficult to manipulate or copy. However, this article requires a system to detect and recognize each individual's face, which has a pre-saved image sample of each individual with full access to the saved home. The system requires people not to move their faces during the recognition process for accurate readings [23].

In this study, we will explain the design and construction of a remote sensing system based on a webcam. This system uses remote sensing technology that can identify and record suspicious events around houses or buildings remotely [4]. In addition, this system can be accessed online via the internet network, allowing users to monitor the security of homes or buildings remotely. Raspberry Pi 3 is a mini computer that can be used for various purposes such as prototyping, application development, and system development. The Raspberry Pi 3 has the ability to connect and control a wide variety of sensors and devices, including webcams. Therefore, the Raspberry Pi 3 is very suitable to be used as the basis for a webcam-based remote sensing system [5].

The remote sensing system proposed in this study uses digital image processing technology and deep learning to detect suspicious events, such as human or vehicle movements. This system can be set to provide notifications to users when suspicious events are detected. In addition, the remote sensing system proposed in this study is also equipped with automatic video recording and data storage features. With this feature, users can record suspicious events and store the data as evidence or as a reference for further security analysis [6].

With a more sophisticated and integrated security system as proposed in this study, it is hoped that it can provide a sense of security and comfort for the occupants of the house or building. In addition, this system can also help reduce crime rates and make it easier for security officers to monitor the security of the surrounding environment. It is hoped that this article can make users feel safer, the author also uses the haar cascade classifier method to identify or classify faces with the camera and then save them to the SD card, then send notifications to users that someone has entered the house. The haar cascade classifier method identifies a person's face by detecting the face, mouth, nose, right eye and left eye.

METHOD

The data used in this study are image samples taken from webcam camera captures, with several limited aspects, namely: variations in the position of the facial image, distance from the face to the webcam camera and light intensity. For variations in the position of the face, the following positions are carried out: facing forward (frontal), parallel rotation 300 degrees to the

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right, parallel rotation 300 degrees to the left, lifting the chin 150 degrees up, head bowed 150 degrees down, the face captured by the webcam is partially not obstructed by other objects, do not cut much and do not move. For aspects of the face distance to the webcam camera, the ideal distance will be obtained, namely 50cm and 100cm [9].

In this study, a method for detecting human facial images using the Haar Cascade Classifier method will be used. The face is one part of humans that has different characteristics for every human being [10]. In this study, the Haar Cascade Classifier method was used as a method for facial pattern recognition. The following is the process flow of the Haar Cascade Classifier method in Figure 3.

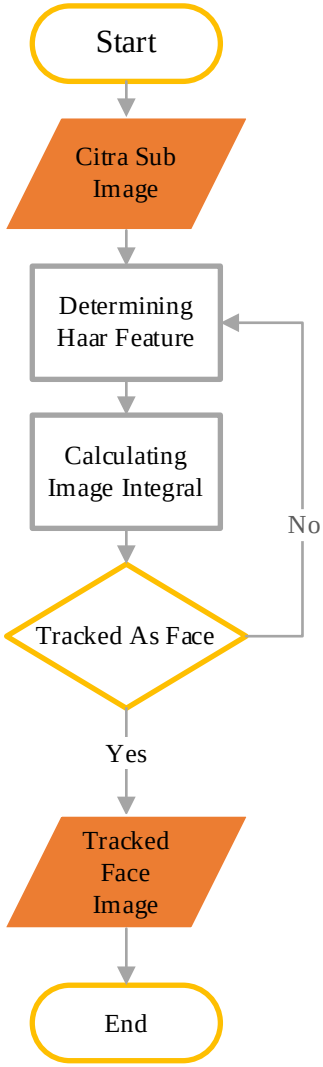

Figure 3. Flowchart of the Haar Cascades Classifier Method

Haar Feature is based on the Haar Wavelet. A Haar wavelet is a single square wave (one high and one low). For two dimensions, one light and one dark. Furthermore, combinations of boxes are used for better detection of visual objects [11]. Each Haar-like feature consists of a combination of black and white boxes as shown in Figure 4 below.

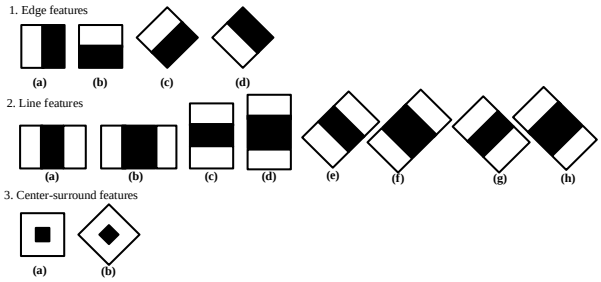

Figure 4. Haar Like Feature

Training Data On Haar

The Haar method requires 2 types of object images in the training process, namely: Positive samples; Contains the image of the object you want to detect. If you want to detect faces, these positive samples contain face images. Negative samples; Contains an image other than the object you want to identify. Negative samples are generally in the form of background images such as walls, landscapes, and others. The resolution for negative samples is recommended to be the same as the camera resolution. The training of the Haar method uses the two types of samples above. The information from the training results is then converted into a statistical model parameter.

The presence of the Haar feature is determined by subtracting the average pixel in the dark area from the average pixel in the bright area. If the value of the difference is above the threshold or threshold, it can be said that the feature exists. The value of the Haar-like feature is the difference between the number of gray level pixel values in the black box area and the white box area, which can be shown in Equation (1).

F(x) = Sum black rectangle – Sum white rectangle (1)

Description: where for the box on the Haar-like feature can be calculated quickly using an "integral image" [12].

Integral Image is used to efficiently determine the presence or absence of hundreds of Haar features in an image and at different scales. In general, such integration means adding small units together. In this case the small units are pixel values. The integral value for each pixel is the sum of all the pixels from top to bottom. Starting from the top left to the bottom right, the whole image can be added up by several integer operations per pixel [13], Figure 5 is an integral image.

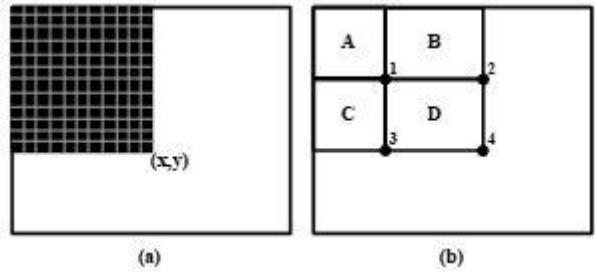

Figure 5. Integral Image

As shown by figure (a) above after integration, the value at the pixel location (x,y) contains the sum of all pixels in the quadrilateral area from the top left to the location (x,y) or the shaded region. In order to get the average pixel value in the rectangular area (shaded area) this can be done simply by

dividing the value at (x,y) by the rectangular area, it can be seen in Equation (2).

$$ii(x,y)= \sum_{x}{}' sx, y' sy\, i(x'y') \quad (2)$$

Description:
ii(x,y) = Integral image at location
x,y i(x',y') = pixel value in original image

To find out the pixel values for some other rectangles, such as the rectangle D in figure (b), it can be done by combining the number of pixels in the area of the rectangle A+B+C+D, minus the number in the rectangles A+B and A+C. plus the number of pixels in A. Where, A+B+C+D is the value of the integral image at location 4, A+B is the value at location 2, A+C is the value at location 3, and A is at location 1 [14]. So the result of D can be computed in Equation (3).

$$D = (A+B+C+D) – (A+B) – (A+C) + A \quad (3)$$

Cascade classifier

Cascade classifier is a chain of stage classifiers, where each stage classifier is used to detect whether in the image sub window there is an object to be detected (object of interest) [15]. Cascade classifier can be seen in Figure 6.

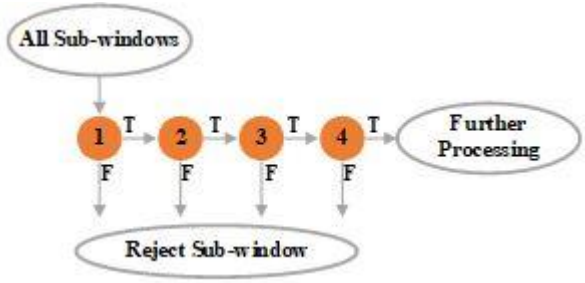

Figure 6. Cascade Classifier

Stage cascade classifier All Sub-window: All image objects, Load: the process of separating face objects, Stage 1,2,3: what types are included in the haar feature Detectface: face detection, Reject Sub-window: Sub-windows that do not include objects [16].

RESULTS AND DISCUSSION

Based on the theoretical basis and the existing problems, the system design in this article must go through several stages. The outline of this research will be described on the road map shown in Figure 7 as shown below.

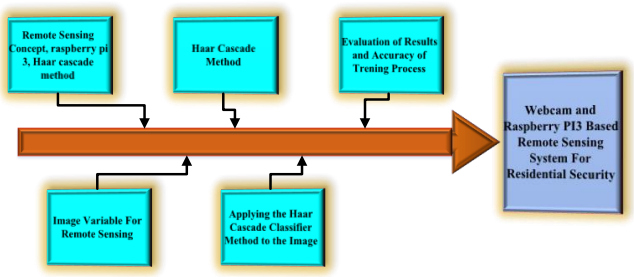

Figure 7. Research Roadmap

The system created in this article aims to produce a Tec-House remote sensing system based on a webcam and raspberry pi3 for residential security. Thus, a system is obtained to secure the house remotely, which later the user of this Tec-House tool can monitor the state of the house and can be notified on the user's cellphone via telegram when someone else enters the residence.

The implementation of remote sensing systems based on webcams and raspberry pi3 for residential security has a device working method. How the device works is shown in Figure 8.

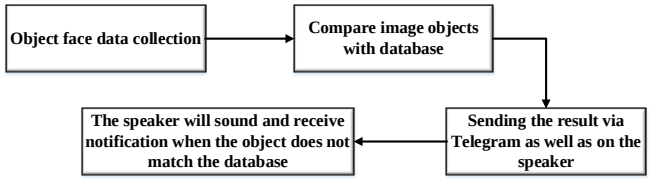

Figure 8. How the Device Works

The collection of data sets of several faces from the owner of the house which will later be carried out by the process of trending the data set to store the data set in the system. Then the system will work when the webcam camera captures an image or face. Then when the face image captured by the webcam camera does not match the data set in the system, the user or home owner will get a notification via telegram and an alarm will sound. This indicates that someone else has entered the house, so that the homeowner can anticipate and know that his house is not safe.

Tec-House remote sensing system will be made by following the design and block diagrams that have been made. Figure 9 is a block diagram of a remote sensing system based on a webcam and raspberry pi3.

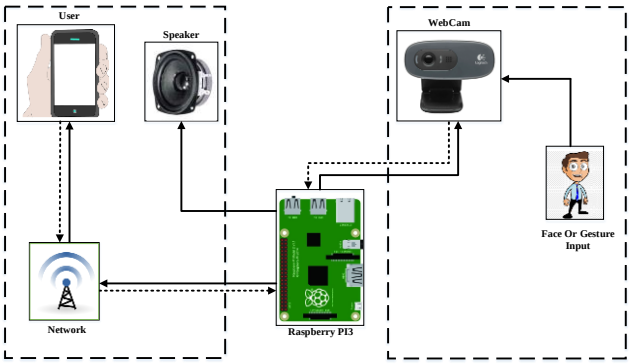

Figure 9. Block Diagram System

In this article it is implemented as a Raspbeery Pi3 microcontroller in a remote sensing system, with the help of a webcam as the main sensor in capturing images or faces, which will then be classified in the system which will then proceed to the process of giving notifications to users or home owners.

The first test is to enter a collection of data into the system in the form of photos or facial images taken directly by integrating a webcam camera on the Raspberry Pi3. The training process will be carried out on the image or face data set. Figure 10 is a collection of facial data from homeowners. Figure 11 is a collection of images from various photographs of faces that are

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not homeowners. This can be taken from pictures on the internet or photos of other people's faces who are not homeowners.

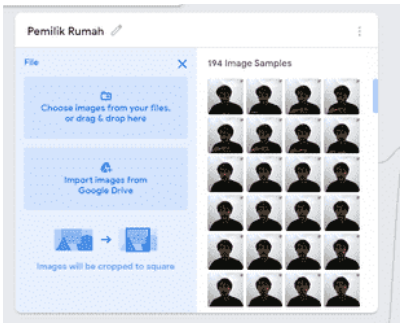

Figure 10. Face Set Data Collection From Home Owners

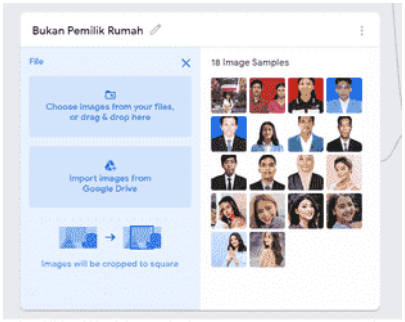

Figure 11. Collection of Face Set Data from Non-Home Owners

The next test is a trending process on the image or face data set that has been entered into the system data base. This test is carried out to determine the accuracy of the data set collected with the system integration of the raspberry pi3, so that later the implementation of the system runs smoothly without any technical interference from the tool (hardware). The results of the trending process are, with the data set of the homeowner's face in the trending process with 98% results being detected by the homeowner. Meanwhile, the trending process with facial data set is not the owner of the house in the trending process with 96% results being detected as not the owner of the house. From the results of the trending testing of the webcam and raspberry pi3-based remote sensing system, it gets great accuracy and deserves to be implemented or implemented into hardware which can later help secure homes from crime or theft. Figure 12 is the result of trending facial data sets from homeowners. Figure 13 is the result of trending data sets for non-homeowners.

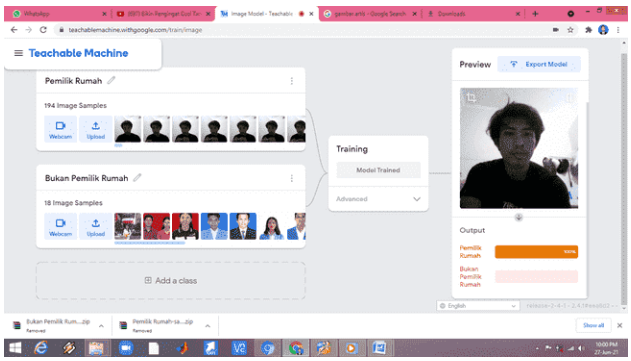

Figure 12. Dataset Trending Results from Home Owners

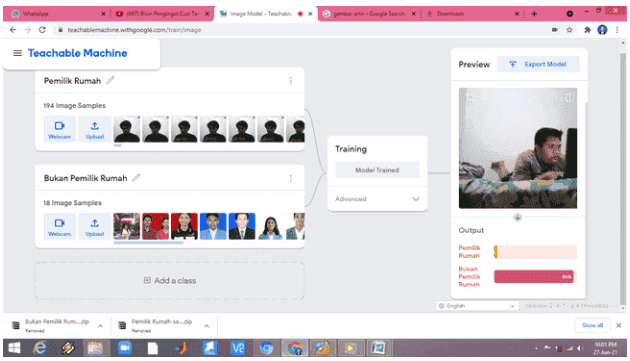

Figure 13. Dataset Trending Results from Non-Home Owners

From the results in Figure 13 above, it can be seen that the percentage of success is quite large, at an average of 96%. So this home and building safety device can be implemented to become a tool or a finished product. So that the public and users of these products can be assisted in controlling or securing their homes or buildings remotely.

After simulating the application of the tool, this research will test the realization of the tool on the hardware that has been made. The goal is to find out how feasible and in accordance with the readiness of the tool for the simulation that has been carried out. Figure 14 is a form of hardware and source code contained in Raspybery PI3.

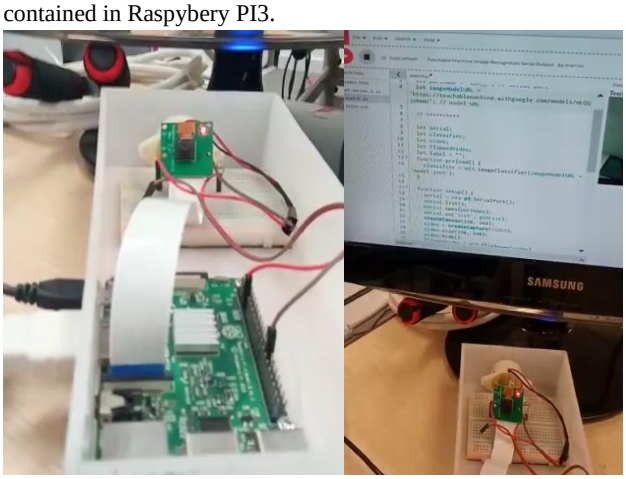

Figure 14. Tec-Hous Hardware Realization and Source Code Display

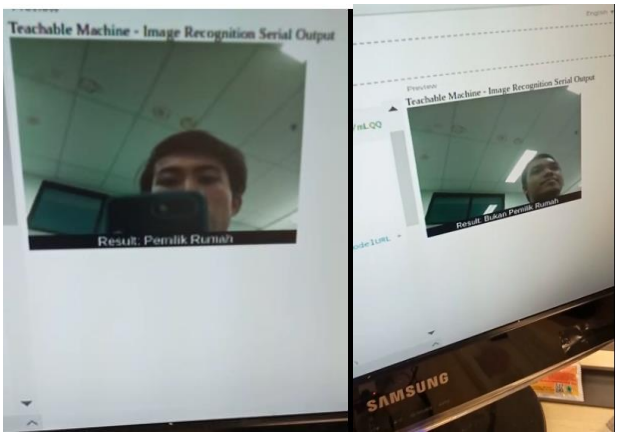

Figure 15. Trial of using Tec-house tools

Next, a trial was carried out using Tec-Hous products by placing faces in front of the installed camera and seeing whether the results were in accordance with the simulations carried out. Figure 15 is an experiment using the Tec-House tool.

From the results of the experiments that have been carried out, the hardware testing is in accordance with the simulation that has been carried out, that is, the home owner can be detected as desired, while those who are not homeowners, the results are clearly visible on the screen results that the face is not the homeowner. Response speed of acceptance of the results issued accuracy reaches an average of 95% success.

CONCLUSIONS

In accordance with the results of the implementation and analysis that has been carried out on the webcam-based Tec-House remote sensing system through the haar cascade classifier method can be used and applied to simulate the actual system. In the experiments that have been carried out, it can be concluded that the use of the haar cascade classifier method in taking pictures or objects which are then forwarded through the raspberry pi3 has the ability to distinguish home owner data sets and non-home owner data sets with an accuracy above 90%. The application of this system helps the community to protect their homes remotely, and can provide notifications via telegram to anticipate crime or theft at their homes. The results of testing the data collection of images or faces of homeowners and non-homeowners have high accuracy, so they are very suitable and very appropriate for use in webcam-based remote home security with remote sensing systems.

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