Security Camera Implementation System on Smart Home Using Web-Based Frame Difference Methods

Mochamad Faiz[1], Azam Muzakhim Imammuddien[2], Rieke Adriati Wijayanti[3]
[1,2,3]Digital Telecommunication Network Study Program,
Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia
[1]mochamadfaiz391@gmail.com, [2]azam@polinema.ac.id, [3]riekeaw@polinema.ac.id

***Abstract*—The development of technology in the field of security has a big impact on people's lives throughout the world. The security is threatened when there is a burglary in the neighborhood. One of the applications of image processing is the frame difference method, which used comparison of the captured image frame circuit according to time order. Frame difference algorithm applied to grayscale image computing using ESP32-CAM cameras for security cameras. This research was developed with a system that can monitor objects detected in real-time by streaming using a website. The ESP32-CAM camera and the PC have a packet loss value of 4.29% and an average delay of 0.3 seconds so that the images captured by the camera can be well received by the PC. The frame difference method with moving objects is used and detected well during the day due to solar lighting, but at night only depends on luminous objects. This method has the disadvantage that when moving objects inhabit the same field of view, the system will define it as movement so that the frame difference method is not adaptive from changes in the captured area.**

***Keywords*—Color detection, frame difference, smart home**

I. INTRODUCTION

Supervision systems with monitoring cameras have become environmental security standards, such as in office buildings, dormitories, schools, business centers, and even correctional facilities [1]. Utilization of microcontroller and single board computers that have been equipped with Internet of Things (IoT) facilities and multimedia processing capabilities, causing the results of camera monitoring and video processing can be accessed anywhere without the physical limitation of the physical surveillance system with the monitoring camera has become a safety standard for environmental, such as Office buildings, dormitories, schools, business centers, and even correctional facilities [2]. Utilization of microcontrollers and single board computers that are equipped with Internet of Things (IoT) facilities and multimedia processing capabilities, causing the results of camera monitoring and video processing can be accessed anywhere without physical distance restrictions

In its development, image processing is very helpful to solve problems that are often faced by humans in their UMM. Image processing is used for technological purposes, especially in the field of computer vision. Image Processing is an image processing technique from objects [3]. To detect the movement around the house, use a webcam, a and webcam camera as data input. Digital cameras will record objects in the form of humans who move as references and send data to PCs Processing image processing requires accuracy and accuracy of data and knowledge about statistics because this image processing is related to data processing.

One of the applications of image processing is the frame difference method, in the form of a comparison of the captured image frame circuit according to time order. Image series that contains extracted geometry features, and then analyzes [4]. The first frame was called a reference frame and the second frame was called an input frame. Both of them are compared and the value of differences in pixels is determined. Therefore from these problems, in this thesis designing a security camera implementation system for Smart Homes using a web-based frame difference method that works based on the detection of movement through the difference in frame image recorded through the camera [5]. This system operates using the IoT (Internet of Think) method that is connected through a web server that is connected to the input from a webcam.

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II. METHOD

A. Frame Difference

The stages of the research to be carried out in making the Smart Home system with the frame difference method are shown in Fig. 1. and Fig. 2. Frame differences are applied through three stages of the process. The first stage is the process of determining the reference image or background, the second stage is the process of arithmetic operation subtraction, and the last is the threshold [6]. The threshold is an important part of determining the accuracy of the detection of motion. The detected threshold value is inversely proportional to the number of noise. The greater the threshold value in the algorithm time frame difference, the smaller the number of noise detected [7].

The first frame was called a reference frame and the second frame was called an input frame. Both compared the difference in difference in pixels is determined [8]. Optimization can also be done by combining other algorithms into the frame

difference, one of which is the Joint Different. A difference was developed to speed up the Smart Home Pixel Classification process.

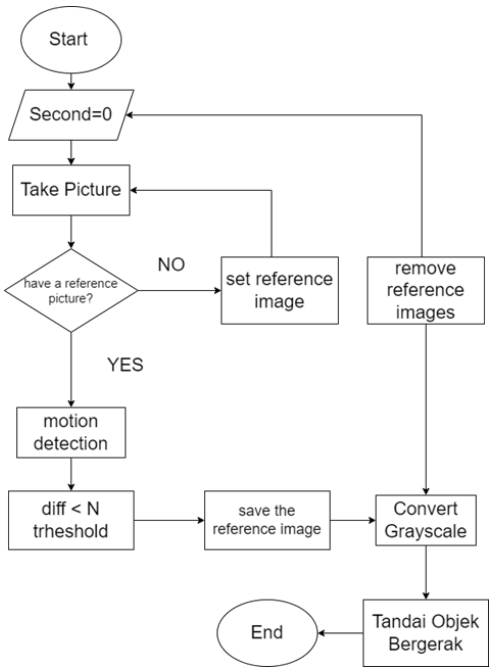


Figure 1. Flowchart Frame Difference

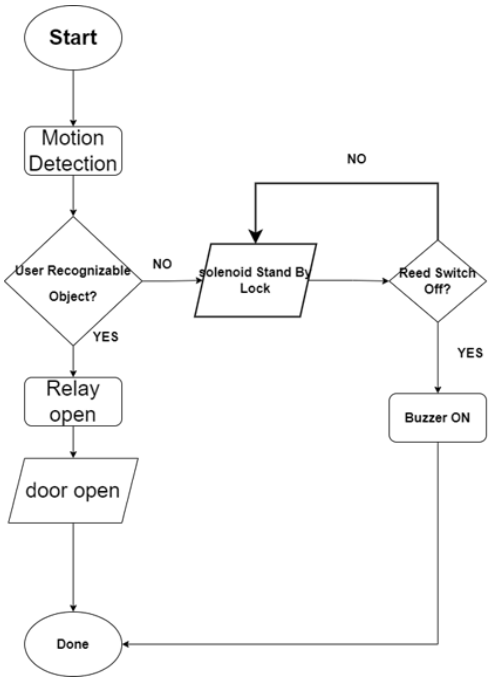


Figure 2. Flowchart System

B. Desain Hardware

The flow diagram of the hardware system design is shown in Fig. 3. The user is the one who operates the system and gets the detection results in the form of video streaming using the internet or server that is used for databases and live cam as input systems [9]. The database is used as a list of user history when registering. The security system usolenoidnoid doorlock as an automatic lock sensor that can be controlled by Arduino, this is used to open the door of the house by moving the servo motorbike as a driver to open and close the solenoid with indications of LED lights for lighting at home that can be controlled automatically by the user.

The buzzer is used as an alarm to indicate a movement that is considered suspicious by the user as a form of security when the ESPCAM32 camera is used for image recording for the detection of movements around the house [10]. Foreign reasons will force the door and then switch as a prevention if there are strangers who are not given access to enter The system will ring the buzzer as an alarm.

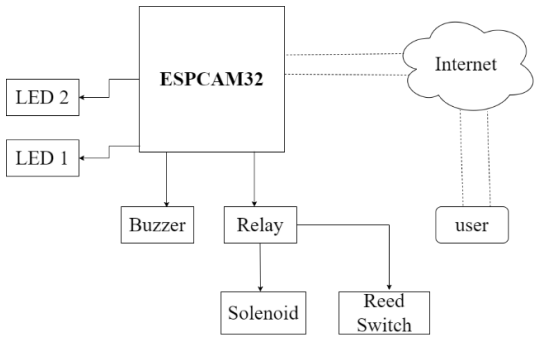


Figure 3. Design Hardware

C. Implementation

The 3D circuit design of the circuit used is shown in Fig. 4. and Fig.5.

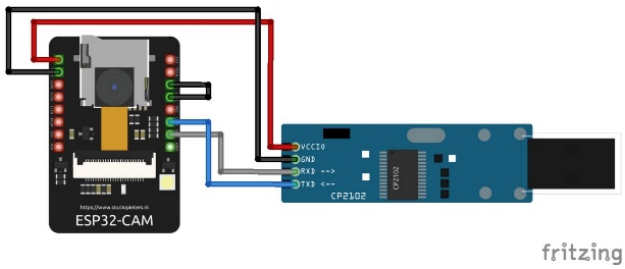


Figure 4. Design 3D Hardware ESP32-CAM

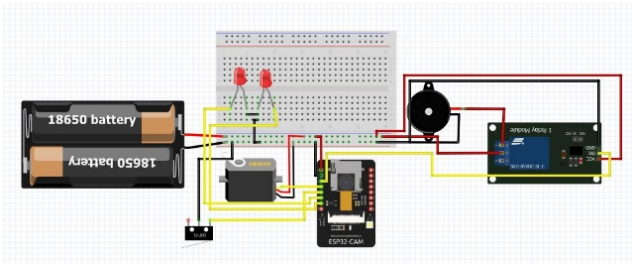


Figure 5. Design Components

USB TTL in the circuit is used for the process of uploading data scripts to the web server. In TX and RX pins enter the Pin Out and UOR which functions as a transfer and receiver process, ground enters the ground pin for grounding and VCC pin as a voltage input. The entire circuit is supplied power supply with 5 volts. Reed Switch or magnetic sensor enters the

input 1 relay pin is used to normalize the closed buzzer into a closed circuit. The solenoid valve is triggered by relay input 2 which is controlled through a web server user [14]. The inside lamp will turn on when the user is allowed to access but the user's lamp will be off and the buzzer sounds if the door is forcibly opened.

III. RESULTS AND DISCUSSION

A. Frame Difference

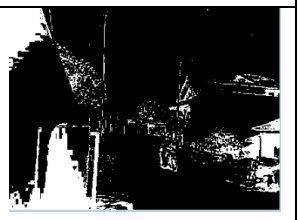
Fig. 6. components of the design result where ESP32 Cam Microcontroller as a camera input to detect motion. The reed switch is used for locking doors in the form of prevention magnets if the door lock solenoid door is forcibly opened. The input is given in the form of two different image files. The first image file input contains the hand movements of a stationary person. While the second image file contains the movement of the hand up in front of the camera. If the results of the two inputs will have different results.

Threshold or threshold influences the test results where the threshold is related to the sensitivity of the camera in detecting objects, the lower the threshold value, the higher the sensitivity of the camera, so that if there is a slight change the camera will detect. Because the nearest light changes are considered movement, it will not be effective if the threshold value is too low. While the higher the threshold, the lower the sensitivity of the camera so that the camera is difficult to detect motion. Therefore, the threshold value is set according to the surrounding circumstances so that the sensitivity of the camera becomes effective. In the first input, a stationary object using clothes that have a light colour pattern so that when the object moves through a dark background image is also not considered movement because the colour of the object and the background are the same.

Figure 6. Electronics Component

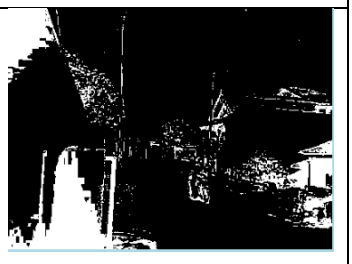
In Table I calling the 3D image change process to 2D then a comparison process is carried out between two different frames and displayed on the image mask tab [6], if there is a difference then the white contour will be displayed if it is no different then the black background will be seen.

TABLE I
PROCESS 3D TO 2D

3D Picture	2D Picture
	

Based on Table I image results are displayed on the image mask tab so that the object can be detected. In the next stage, the results of the frame differential test data can be displayed in Table II until table 4 with the primary basic color selection.

TABLE II
FRAME DIFFERENT

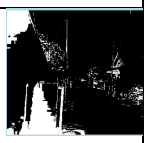
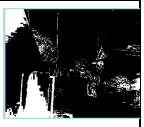
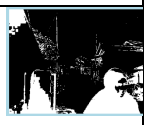
Frame 1	
Frame 2	
Result	

The first frame was called a reference frame and the second frame was called an input frame. Both are compared and the difference in difference in pixels is determined [11].

Optimization can also be done by combining other algorithms into the frame difference, one of which is the Joint Difference. A joint Difference was developed to speed up the Pixel Smart Home classification process.

Output in the form of still objects displayed as home objects due to lighting differences is defined as moving objects due to differences in reference images and subsequent capture images. The effect of lighting can change the shape of the object so that the difference between light and dark in frame 1 and frame 2 is defined as a movement. In the object, obtained object-colored yellow output results are not displayed on the image masking due to the value of the yellow color outside the value of the blue color selection. This shows that in the morning testing the object looks clear because it is assisted by lighting in sunlight.

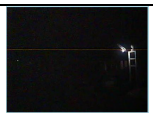
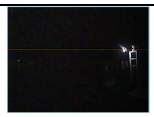
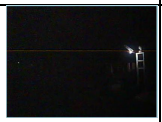
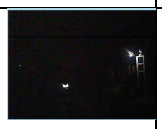
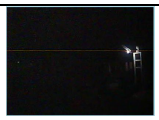
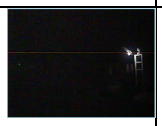
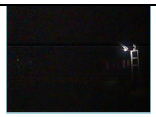
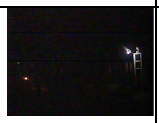
TABLE III
COLOR SELECTION AT 1.00 PM

No	Object	Frame 1	Frame 2	Result
1.	Stationary objects			
2	Moving Object			
3	Blue Color Selection			
4	Yellow color selection			
5	Red color selection			

Testing in Table III with daytime conditions obtained optimal lighting of sunlight right above the camera so that the data collection process and the movement detection process using frame differences become clearer [12]. The process of detection with objects at a long distance produces a very small difference process due to the resolution of ESP32-Cam 480p compared to objects that are closer to the object becomes clear because the object is near the camera. However, this method still has problems when objects come and statically remain in the camera display. Objects (humans) enter the field of view and are detected correctly. However, it is still detected as a moving object in the next table. It can be seen that the system is not adaptive to change in the captured area.

Testing in Table III with daylight conditions obtained optimal illumination of sunlight just above the camera so that the process of data capture and motion detection process using frame difference becomes clearer. The process of detection with objects at a long distance produces a very small difference due to the resolution of the ESP32-CAM 480p compared to objects closer to the object becoming clear because the object is near the camera. However, this method still has a problem when the object comes and statically stays in the camera view [13]. The object (human) enters the field of view and is well-detected. However, it is still detected as a moving object in the next table. This indicates that the frame difference method is not adaptive to changes in the captured area.

TABLE IV
COLOR SELECTION AT 7.00 PM

No	Object	Frame 1	Frame 2	Result
1.	Stationary objects			
2	Moving Object			
3	Blue Color Selection			
4	Yellow Color Selection			
5	Red color selection			

Based on Table IV testing in dark conditions, obtained objects detected are radiant objects. The light released by the object is detected as a movement because there is a difference in Frame 1 and Frame images 2. Conditions of ESP-32CAM Camera Specifications are not equipped with infrared features so that at night the camera can not detect objects with minimal light [14]. Based on the test results in Table IV it was found that there was an input image with the first image of a low brightness condition, low contrast, and low quality obtained output image results were not very clear due to minimal

lighting. In the red, blue, and yellow selection testing the best results were obtained in day conditions, this was due to some conditions of the influence of lighting changes in the detection process providing better quality on video streaming but gave a heavier burden on eSP-32cam so that the delay was longer to The process of shooting references and input frame 2 images for the output frame difference process if the quality is lower the delay value becomes shorter and the load on the ESP32-Cam is lighter so that it makes it easy to detect the frame difference.

With dim light conditions obtained objects are not detected to the maximum due to less illumination and small objects make the detection process less clear because it is blocked by a larger object. Objects walking in front of a camera with long visibility are disguised by other objects. The system focuses on a larger object with the difference in light of the lamp and the environment being detected as motion. This shows that lighting greatly affects the detection process captured by the camera because the lack of light will be defined as a moving object so that the detection is focused on a larger object [15].

Based on Table IV testing in dark conditions, the detected object is luminous. The light emitted by the object is detected as a movement because there is a difference in the image of frame 1 and frame 2. Condition ESP-32cam camera specifications are not equipped with infrared features so at night the camera can not detect objects with minimal light. Based on the test results in Table III to table IV obtained frame difference method runs well in the afternoon and morning, but in the afternoon and evening light received little so that the detected object is less clear, frame difference method works by comparison between the two different frames obtained output by the algorithm designed to run well and effectively

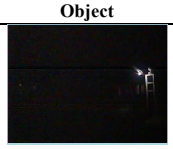
B. Smart Home

The first part is the input of the system where in that section there is a camera module that functions as a movement detection. The input section is the process of recording the image of the movement recorded by the camera. The second part is image processing which was successfully recorded by the camera to be recognized by a predetermined method. The method is programmed on OpenCV using the JavaScript programming language by utilizing the OpenCV library. The third part is the output or output produced from the processing of human images in the second part. The output results are in the form of decision-making on whether the door will open or remain locked [15] .

The image identified by the camera will be processed by the system for decision-making on whether the key will be locked or unlocked. If the user succeeds in recognizing the identified form, then the decision-making for the door lock system is open/unlock. Conversely, if the user cannot recognize the object being caught, the door lock system will be locked/locked.

The first part is the input of the system where in that section there is a camera module that functions as a movement detection. The input section is the process of recording the image of the movement recorded by the camera. The second part is image processing which was successfully recorded by the camera to be recognized by a predetermined method. The method is programmed on OpenCV using the JavaScript programming language by utilizing the OpenCV library. The third part is the output or output produced from the processing of human images in the second part. The output results are in the form of decision-making on whether the door will open or remain locked [15] .

TABLE V
TESTING SMART HOME

No	Object	Button	Solenoid	Buzzer	LED
1.		False	False	off	on
2.		True	True	off	on
3.		True	True	off	on
4.		False	False	on	on
5.		False	False	off	off
6.		False	False	off	off
7.		False	False	on	on

The first part is the input of the system where in that section there is a camera module that functions as a movement detection. The input section is the process of recording the image of the movement recorded by the camera. The second part is image processing which was successfully recorded by the camera to be recognized by a predetermined method. The method is programmed on OpenCV using the JavaScript programming language by utilizing the OpenCV library. The third part is the output or output produced from the processing of human images in the second part. The output results are in

the form of decision-making on whether the door will open or remain locked [15] .

The image identified by the camera will be processed by the system for decision-making on whether the key will be locked or unlocked. If the user succeeds in recognizing the identified form, then the decision-making for the door lock system is open/unlock. Conversely, if the user cannot recognize the object being caught, the door lock system will be locked/locked. Along with the decision making by the user that the door lock will open or remain locked [16], if the door is still locked and forced to open by the object is not recognized then the reed switch will turn on and transfer the buzzer to turn on, but conversely if the user recognizes the object identified it will be given access entry And the LED lights up.

C. QoS

Quality of service is a measurement that shows the quality of network data packages. Qos aims to help users increase productivity by ensuring that users get reliable performance from a network-based application. In this measurement, the author uses one parameter, namely the delay.

TABLE VI
TESTING SMART HOME

Receive Times (s)	Deliver Time (s)	Delay (s)
0	0.000173	0.000173
0.000173	0.00714	0.006967
0.00714	0.013011	0.005871
0.013011	0.013164	0.000153
0.013164	0.026194	0.01303
0.026194	0.031053	0.004859
0.031053	0.031193	0.00014
0.031193	0.041705	0.010512
0.041705	0.041705	0
0.041705	0.041839	0.000134
0.041839	0.042561	0.000722
0.042561	0.050435	0.007874
0.050435	0.625746	0.575311
0.625746	0.664077	0.038331
0.664077	0.664505	0.000428
0.664505	0.665246	0.000741
0.665246	0.685017	0.019771
0.685017	0.696899	0.011882
0.696899	0.697178	0.000279
Average Delay		0.035435

Delay is the time needed by the data to travel from origin to destination. Delay can be influenced by distance, physical media, congestion, or long processing time. Network performance based on Tiphon standards. Based on Table IV the average delay measurement results of 0.3 seconds that indicate the index is very good for the frame difference algorithm process but a high loss package value makes the video streaming process unstable.

IV. CONCLUSION

The frame difference algorithm applied to grayscale image computing using an ESP32-CAM camera for security cameras can work properly. ESP32-CAM and PC cameras has a Packet Loss value of 4.29% and an average delay of 0.3 seconds so that the image captured by the camera can be well received by the PC. Smart Home Security Systems Integrated features in the Difference Frame Algorithm run 100%. The Frame Difference method integrated with Smart Home based on the Arduino IDE Open source with the solenoid door lock, buzzer, and LED. The system is controlled through the website in one Wi-Fi network running well. The Frame Difference method with moving objects entering the field of view is well detected during the day due to solar exposure, but at night it only depends on luminous objects. This method has the disadvantage that when a moving object inhabits the same field of view, the system will define it as motion so that the Frame Difference method is not adaptive to changes in the captured area.

REFERENCES

[1] Herdianto, "Perancangan Smart Home dengan Konsep Internet of Things (IoT) Berbasis Smartphone", Jurnal Ilmiah Core IT: Community Research Information Technology, vol. 6.2, 2018.

[2] Pella, S. I. (2021). ”Rancang Bangun dan Analisa Unjuk Kerja Sistem Pengawasan dengan Frame Rate Dinamis Berdasarkan Deteksi Pergerakan”, Media Elektro Journal, 8-14.

[3] D. R. Tadjudin, Ridho, "Implementasi Mobilenetv2 Dan Frame Difference Untuk Penentuan Kecepatan Kendaraan", Jurnal Ilmiah Teknologi Infomasi Terapan, vol. 7.3, pp. 193-204, 2021.

[4] D. H. R. L. Husein A. M, "Motion detect application with frame difference method on a surveillance Camera", Journal of Physics: Conference Serie, vol. 1230, p. 1, 2019.

[5] R. A. Nadafa, "Home security against human intrusion using Raspberry Pi", Procedia Computer Science 167, pp. 1811-1820, 2020.

[6] Yuha, R. A., & Harahap, M, ”Deteksi Gerakan pada Kamera CCTV dengan Algoritma Frame Difference dan Frame Substraction”, In SEMINAR NASIONAL APTIKOM (SEMNASTIK) 2019 (pp. 503-511).

[7] M. F. Khalid, "Human Movement Detection Dengan Accumulative Differences Image", TEKNIMEDIA: Teknologi Informasi dan Multimedia, pp. 1-7, 2020.

[8] Thohari, A. N. A., & Ramadhani, R. D. (2019). ”Sistem Pengawasan Berbasis Deteksi Gerak Menggunakan Single Board Computer”, Jurnal Nasional Teknik Elektro dan Teknologi Informasi, 8(1), 1-6.

[9] Xu, J., Xiong, Z., & Hu, X, "Frame Difference-Based Temporal Loss for Video Stylization", 2021.
[10] R. T. D. Rosmala, "Implementasi Mobilenetv2 dan Frame Difference untuk Penentuan Kecepatan Kendaraan," Jurnal Ilmiah Informasi Terapan, vol. 7, 2021.
[11] Widyanindito, A., & Hanuranto, A. T. (2021). ”Aplikasi Smart Home Untuk Sistem Kendali Peralatan Elektronik Dan Monitoring Rumah Berbasis Android”, Proceedings of Engineering, 8(5).
[12] Artono, B., & Susanto, F. (2018). ”Wireless smart home system menggunakan internet of things”, Jurnal Teknologi Informasi Dan Terapan, 5(1), 17-24.
[13] Wahyudi, R., & Edidas, E. (2022). ”Perancang dan Pembuatan Sistem Keamanan Rumah Berbasis Internet of Things Menggunakan ESP32-CAM”, Jurnal Pendidikan Tambusai, 6(1), 1135-1141.
[14] Al Hakim, A. L., Maulana, I., Wafa, I., & Yulianti, Y. (2021). ”Perancangan Aplikasi Inventaris Gudang Menggunakan Bahasa Program PHP dan Database MySQL Berbasis WEB”, Jurnal Teknologi Sistem Informasi dan Aplikasi, 4(1), 7-13.
[15] Lin, J., Ma, X., Lin, S. C., Yang, J. H., Pradeep, R., & Nogueira, R. (2021, July). ”Pyserini: A Python toolkit for reproducible information retrieval research with sparse and dense representations”, In Proceedings of the 44th International ACM SIGIR Conference on Research and Development in Information Retrieval (pp. 2356-2362).