Utilization of CCTV as a Security System Using YOLOv8 Algorithm (Case Study of Desty Collection Clothing Store)

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***Abstract*—This study aims to prevent crimes such as theft that have occurred in the past, where a former employee committed theft by duplicating the store key. By developing a system that integrates Closed-Circuit Television (CCTV) technology with the You Only Look Once version 8 (YOLOv8) algorithm for real-time human detection. YOLOv8 was chosen for its ability to detect objects with high accuracy and speed. The system sends a signal to the ESP32 module via Firebase when detecting a human presence outside operational hours, activating a buzzer as an alarm. The security mode can be controlled via an application to activate or deactivate the alarm. When the security mode is deactivated, the buzzer will not sound even if a human is detected. The system also records CCTV screenshots upon detecting a human for monitoring and verification purposes. Implementing this system can enhance security with effectiveness, flexibility, and the potential to reduce negative incidents outside the store's operational hours. System testing results showed the ability to detect human presence at lighting levels of 1-2 Lux with an average confidence score of 63,4 percent, and at 54-56 Lux with an average confidence score of 71,6 percent.**

Keywords— Buzzer, CCTV, Internet of Things, Security System, YOLOv8.

I. INTRODUCTION

Closed Circuit Television or CCTV is a system that can monitor an area using a video camera that is placed at a certain point and transmits the signal to a control room so that it can be monitored and record activities in the point area [1]. CCTV is also a security system that is often used in companies, shops, homes and streets to monitor and record activities in the environment. This research is expected to optimize the CCTV function to be better and useful in the security system. CCTV requires high bandwidth and storage because it will transmit a large amount of data [2].

Many people use CCTV to be an option as a security system to monitor activities in a shop, but it cannot stop a person's activity to commit a crime, especially at night no one monitors during the night. This aims to monitor and record all activities that occur in places that have been installed with CCTV cameras [3]. CCTV technology can also be utilized for employee monitoring and security monitoring. If a company is not monitored, it is possible that employees will work outside the targeted standards, causing losses to the company [4].

The number of theft cases that are only recorded by CCTV but are known in the morning. As in the recent case reported by the Jakarta Tribune on June 16, 2023 about "Robbers Break into a Shoe Shop in Koja, While Smoking Take Away Motorbikes to Laptops" [5]. Masa just found out that the rolling door was open so Masa immediately checked his valuables, and the robber was recorded on CCTV when committing his crime. From this there are still some shortcomings of CCTV as an option for a security system in a shop, because someone needs to continue monitoring to find out if there is someone who is doing unwanted activities. So CCTV is needed as a security system so that it can find out or detect someone when no one is monitoring CCTV, when the camera detects someone it will notify the user in real time so that the user can take further action.

Based on the above problems this research was made, by creating a security system using Artificial Intelligence Algorithm YOLOv8 which is applied to the CCTV system to detect human movement when the security mode is activated. If a human is detected, the system will send a notification to the user and the device installed in the user's home even though the store is in a different place from home. The system can also be controlled on the app for security mode.

The working principle of YOLO is to take an image and divide it into SxS grids, within each grid, then extract bounding boxes. For each bounding box, the network outputs class probabilities and adjusts values for the bounding box. Bounding boxes with class probabilities above the threshold are selected and used to detect objects in the image [6]. The limitation of the YOLO algorithm is that it struggles with small objects in the image, for instance, it may have difficulty detecting flocks of birds. This is due to the spatial constraints of the algorithm [7].

This research is expected to optimize the CCTV function

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to be better and useful in security systems as a means to expand the author's knowledge and apply the knowledge that has been obtained, especially in the YOLOv8 Algorithm with the use of CCTV that can detect human presence [8]. A system for sending and receiving human detection notification data on CCTV to users to improve store security outside operating hours. CCTV can be categorized as part of a system that uses technology to monitor and record events in a particular environment. However, CCTV itself is not automatically considered artificial intelligence (AI), unless the system also integrates AI technology for video analysis, object detection, facial recognition, or behavioral analysis.

In short, artificial intelligence (AI) is a field in computer science that focuses on developing computer systems that can perform tasks that typically require human intelligence, such as learning from data, recognizing patterns, making decisions, and solving problems [9]. Artificial intelligence modifies or adapts the computerization of human actions (including the prediction or control of robots), so that they can become more accurate. AI is used to improve security and surveillance with fraud detection, facial recognition, and anomaly analysis systems that can identify potential threats or risks [10].

The YOLO algorithm is a real-time object detection algorithm, designed to improve upon existing object detection algorithms. Real-time object detection is becoming a critical component in various applications, including autonomous vehicles, robotics, video surveillance, and augmented reality [11]. Among various object detection algorithms, the YOLO work system stands out for its outstanding balance between speed and accuracy, enabling fast and reliable identification of objects in images. Since its inception, the YOLO family has continuously evolved, with each new version fixing limitations and improving performance from previous versions [12].

The literature review provides a perspective on previous research and potential developments. The first research with the title Designing Algorithm Patterns and Security System Images Using Convolutional Neural Network, where the purpose of this research is to overcome theft and fraud in cultivating shrimp ponds by implementing CCTV for human activity recognition using CNN process rocks and Yolo version 8. The system results show that it can detect human activity sitting, standing, squatting, running. However, the shortcomings of his research are the absence of notification to users when there is suspicious activity [13].

The second research with the title Home Security System Based on Multiface Recognition Using Convolutional Neural Network (CNN) Method. The purpose of this research is to overcome crimes that are now increasing and overcome the security system on CCTV which is still less effective, so research was made to add a home security system with Android-based multiface recognition. If the detected object is not a family member, the system will send a notification to the user's smartphone in the form of name, time and date when the object is identified. The drawback is that the notification is only sent to the smartphone [14].

Then, Designing CCTV based on Wireless Sensor Network with Movement Detection System for Home Security, where the purpose of this research is to create a home security system that utilizes PIR sensors, cameras and ESP32 as CCTV to detect if there is someone's movement, the camera will capture images and send notifications which will get a URL address to get the image. The drawback in this research is that the PIR sensor can detect the movement of animals that are moving and also notifications can be received but it still takes time to take action quickly [15].

II. METHOD

A. System Design

The type of research to be carried out is Research and Development (R&D), which is a method of research and building a tool that is a problem solver with existing methods. This research method is used to produce certain products and test the effectiveness of these products. With the hope that this research can complement the shortcomings of previous research. In this study discusses a security system using the YOLOv8 Algorithm, where a tool or system will be built that keeps a store safe from theft and property damage, especially when outside store operating hours. The research process begins with research design to analysis of research results. The research design begins with a literature review, which involves a literature review of journals, articles, and dissertations related to the importance of human object detection to be processed so that it can be evaluated as a suspicious action or not and then given a notification and buzzer sound.

A block diagram illustrates the basic principles of the system being planned. Each block element in the system has its own function, so by understanding the block diagram overview, the planned system development can be implemented efficiently.

The system will be depicted on a block diagram that explains the work process, as shown in Fig. 1.

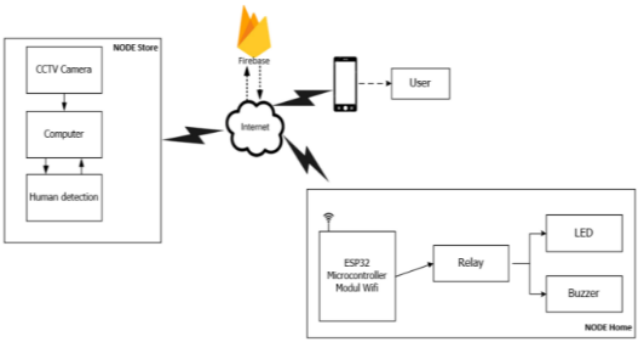


Figure 1. System Block Diagram

CCTV cameras are connected to a laptop via the internet to process the main program, namely the YOLOv8 Algorithm. ESP32 is connected to a Laptop and HP Application via the internet to get data from firebase in order to control the security mode and can send notifications via the internet when a humanknown. The final test point is in the power output section of the wireless charging receiver or that leads to the cellphone USB to find out the voltage output that can be transferred to

charge the cellphone battery. is detected by CCTV using a buzzer, LED and notification on the application.

In the system, if it detects suspicious human actions outside the store's operating hours, the detection data will be sent to the microcontroller and computer via firebase to provide output in the form of notifications on the user's mobile application and buzzer sounds and led lights. Its functions include visualization of system workflows, analysis and design of structures, building mutual understanding among stakeholders, identification of dependencies and relationships, problem solving, system documentation, development team communication, training, performance evaluation, and integration with programming. As an important tool in software development, flowcharts help in designing, understanding, and managing systems more effectively.

The system workflow will be described by representing the processes that occur in a system through a flowchart using graphical symbols, as follows:

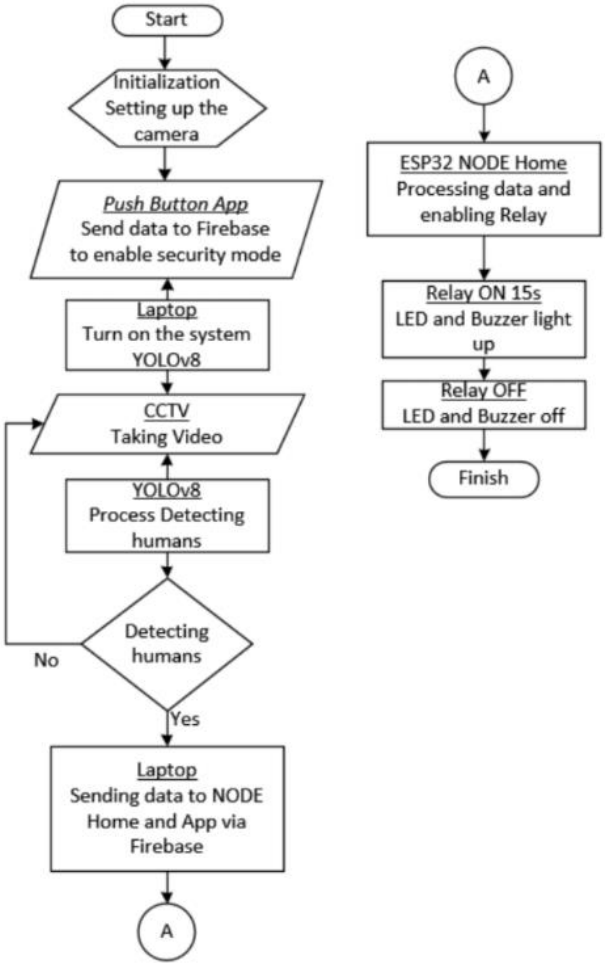


Figure 2. Flowchart System

In Fig. 2, it is explained about the flowchart from starting with Start. After that, the system will run and If the push button on the application is pressed, it will enter security mode and activate the YOLOv8 system on the laptop. CCTV will take pictures and YOLOv8 will process human detection. When the system detects a human according to the time outside the store's operating hours, the system will send data to the user via the Internet to the Mobile Phone Application and the microcontroller in the shop owner's house to process the data to instruct the output to turn on the LED and Buzzer.

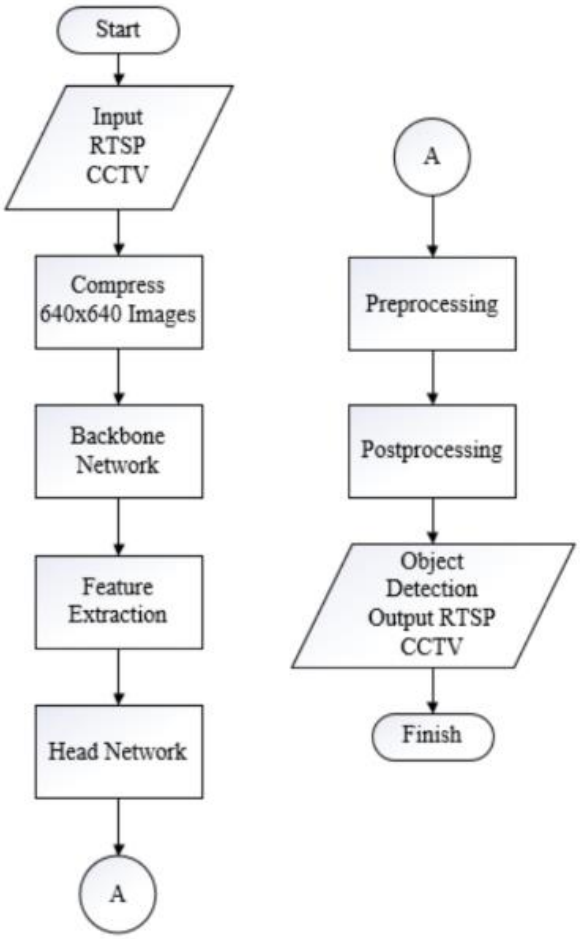


Figure 3. Flowchart Human Detection

Explanation of the human detection flowchart in Fig. 3, starting from the RTSP input used to enter images on CCTV. Then, compress the image according to the training model that the image is resized by 640x640. Backbone Network is used to extract features from images. Then, it extracts important features such as edges, textures, and patterns. The important features of the image are extracted by the backbone network. This Head Network determines the type of object and the position of the object in the image. PreProcessing stage the image is converted into a tensor, normalized and transferred to the CPU/GPU device. Next, postprocessing is filtered to only detect the class of people. Then, the system produces an output in the form of object detection from the CCTV RTSP video stream. The final result of the object detection process is displayed or stored. It includes information about the location and type of object detected in the video stream from CCTV.

There is also a flowchart of the YOLO stages, shown in Fig. 4 which illustrates the flow of the object detection process using YOLOv8, starting with image preprocessing, dividing the image into an S x S grid, and predicting the bounding box. After going through the convolutional layer and Intersection over Union (IOU) calculation, the prediction results are forwarded to the Non-Maximum Suppression step. Loss calculation is performed and if the loss value has converged, the detection process continues to the result evaluation stage. If it has not converged, the process returns to the image division step. This flow ends after the detection result evaluation is performed.

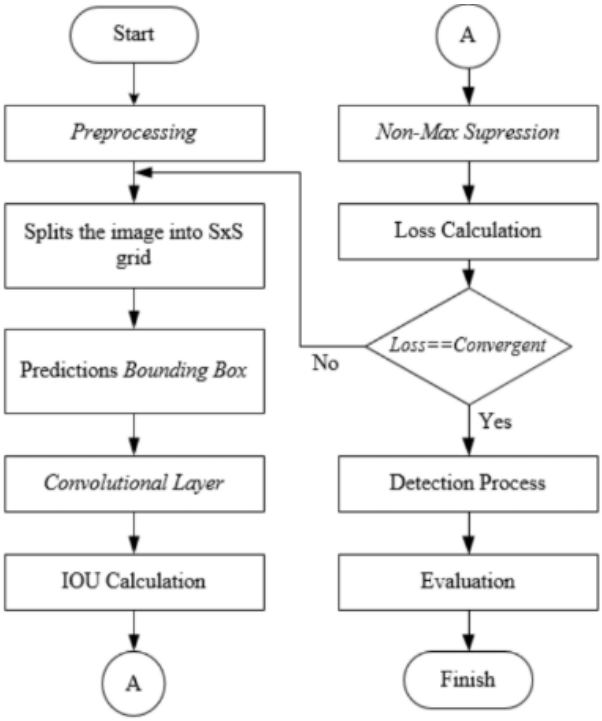


Figure 4. Flowchart YOLO

B. Hardware System Design

The hardware design of a component has an integral role in the successful implementation of the project. Design optimized hardware to perform specific tasks with high efficiency, such as in compute-intensive AI, simulation, or big data processing.

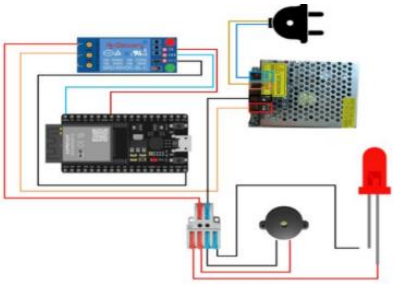


Figure 5. Hardware system design

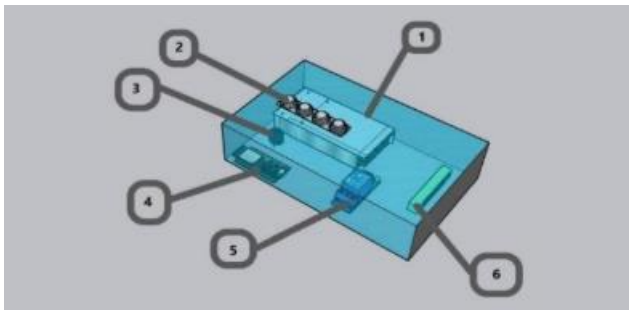


Figure 6. Node 1 hardware design

To support the design of hardware, an overall design system is made as shown above. Fig. 5 and Fig. 6 show the system circuit consisting of the ESP32 as the main controller, relays to control devices and a power supply to provide the necessary voltage. The relay is connected to digital pin 19 and GND on the ESP32, while the power supply converts the AC voltage into DC for the ESP32 and other components. LEDs are used as status indicators with the anode connected to the splitter terminal of the relay and the cathode to the -V of the power supply, while buzzers as alarms or sound indicators are connected to the splitter terminal and -v of the power supply. This system allows the control of electronic devices with visual and audio feedback indicated by LEDs and buzzer.

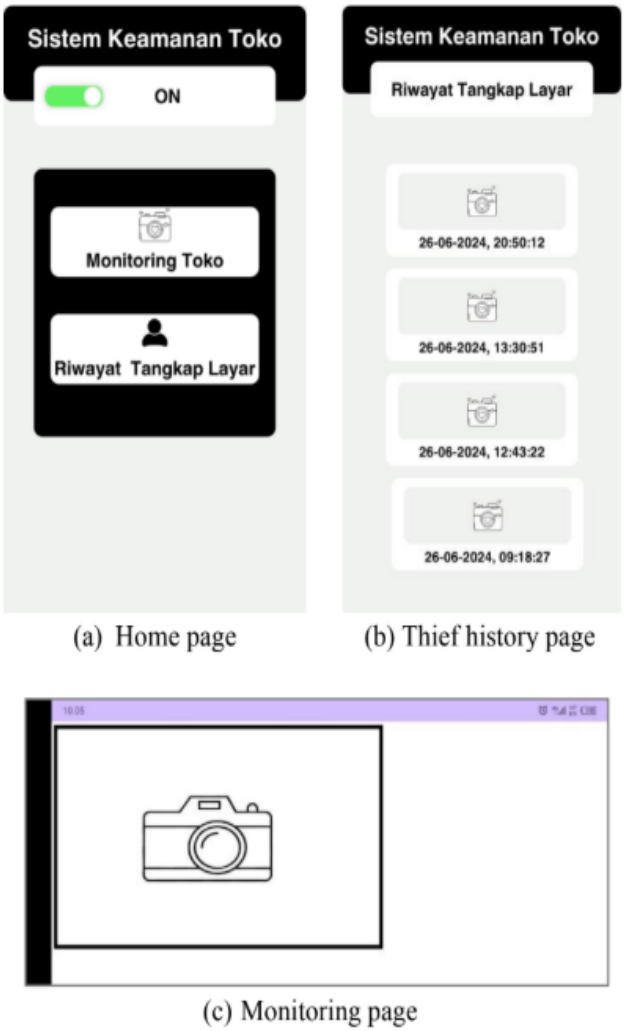
Figure 6. Design of hardware installation

As shown in Fig. 7 is the installation design of the monitoring device. This series of components and sensors is designed to be a tool that has a function according to its purpose. Where, this tool will be implemented in a shop owner's house in order to be aware of the buzzer alarm notification and CCTV will be to capture human object identification images will be placed in the store as both are the testing ground. The description of the placement of CCTV cameras to obtain human detection in figure 8:

Figure 8. Layout of CCTV camera placement

C. *Software System Design*

In this software design, a picture of the application that has been connected to the device used in this study is drawn. In the application there are several features, namely the main page, the button to activate the security mode, the monitoring page and the detected screen capture history results.



(a) Home page (b) Thief history page

(c) Monitoring page

Figure 9. Application design

Fig. 9 explains to conduct research testing of tools that have been designed and built in accordance with system design and mechanical design, it is necessary to record images and videos from CCTV cameras that detect or identify human objects precisely according to the pattern of provisions to assess the quality, performance, or characteristics of a product or system during the testing process. The testing parameters of this tool are the percentage accuracy of the YOLOv8 Algorithm testing to detect humans based on lighting, the ability of the tool to send and receive human detection notification data on CCTV to users, the level of compatibility of data displayed in the application with the database.

III. RESULTS AND DISCUSSION

A. *System Design Results*

The sensor circuit design is placed in a protective box, to keep the device system connection properly installed.

Figure 10. Hardware implementation

Figure 11. Cicuit in panel box

In Fig. 10 and Fig. 11 of the hardware implementation results with the panel box, it consists of an adapter that functions to provide power to various components including esp32 as a microcontroller, relays to switch the flow of electricity to the output components, buzzers as notification alarms and also leds to provide signs.The block diagram of measuring DC input at test point 1 and DC output on the secondary side at test point 4 shown in the Figure 3.1.

B. *Software Implementation Results*

The display is an application designed to monitor and present the results of the human detection process implemented in the security system. This interface provides detailed information, including the date, month, and year when the data is generated and recorded by the system, as well as the most recent processing time at which the data is handled and updated. In addition, the display presents visual evidence in the form of captured screenshots of the detected individual, which may indicate a suspected intruder or thief. These images are automatically stored and displayed to support monitoring and

post-event analysis. The application display is illustrated in the following Fig. 12.

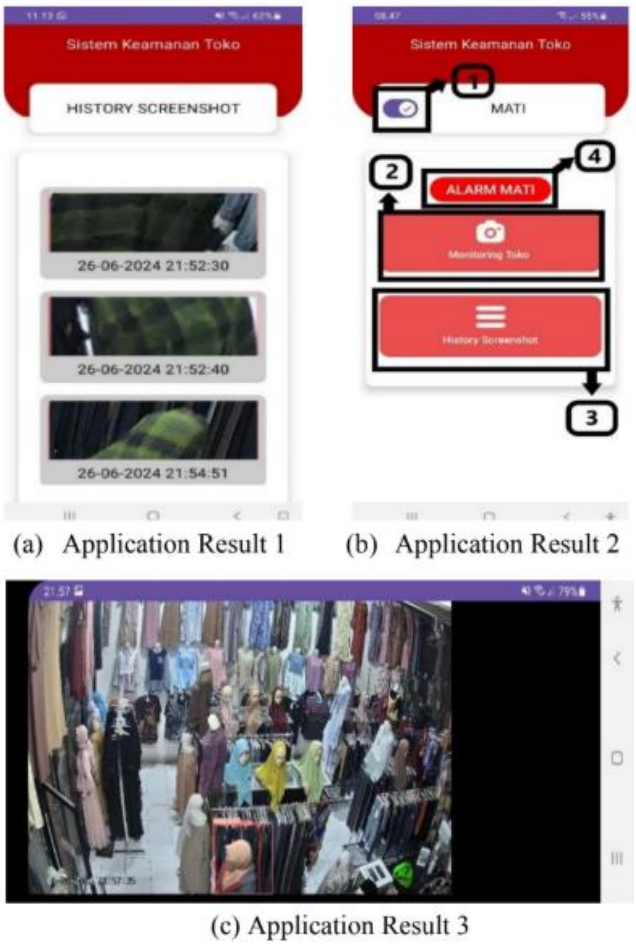


Figure 12. Application implementation results

The description of Application Result 2 is: 1. Button to disable security mode or turn on security mode 2. To monitor if a human is detected 3. Screenshot history from CCTV if a human is detected In Fig. 12, shows the results of the implementation of the store monitoring application using a web view. In this picture, you can see a live view from inside the store taken through a CCTV camera. The image shows various parts of the store. The application displays human detection by adding a bounding box. This implementation allows real-time monitoring of in-store activities through devices connected to the application.

C. Test Results of Human Detection Accuracy

Human detection system accuracy testing is the process of measuring how well the system can recognize the presence of humans in an image or video.

It involves a series of evaluation steps aimed at ensuring that the system can identify humans with a high degree of accuracy and minimal errors. The following are the results of testing the accuracy of the human detection system based on light parameters:

1) Testing Human Detection Using 3 lamps (54-56 Lux)

The detection system test with artificial lighting can be used to simulate certain light conditions consistently in a test environment such as the following using 3 lamps (54 -56 Lux).

Figure 13. Detection system test results using 3 lamps

Fig. 13 is the result of processing data taken using 3 lights. It can be seen that the system successfully detects humans, the results are analyzed to evaluate how well the human detection system can function in various light conditions, the percentage is 86% and 75% with bright light.

When using three lights, the illumination level is in the range of 54-56 Lux. Under these conditions, the system can detect human presence with an accuracy of 70-86% and operates smoothly.

2) Testing Human Detection Using CCTV Lamps (0-2 Lux)

Test the human detection system in various lighting conditions that may occur in the real environment, such as low lighting conditions at night that only utilize the light of CCTV lights, it is a little dark in detection as follows:

Figure 14. Test results of detection system using CCTV lights

In Fig. 14 is the result of human detection that can be said to be successfully detected by the system, but when only using lighting from CCTV, the lighting level is in the range of 0-2 Lux. Under these conditions, the system can detect the presence of humans with an accuracy of around 42-70% and

detection is only limited to the area covered by lighting, which is only in the front row of doors.

3) Testing Results Detection of More than 1 Human

Multiple human detection testing refers to evaluating how well the detection system can recognize and mark the presence of multiple humans in an image or video. Test human detection systems under various conditions should be able to recognize and distinguish between various human instances that may overlap or be adjacent. Review the test results to evaluate the system's ability to detect more than one human accurately and consistently. Identify weaknesses and potentials for model improvement in the face of multi- object detection challenges.

Figure 15. Test results of human detection system more than 1

Based on Fig. 15, it can be seen that detection using lighting from CCTV is able to detect two people at once. However, detection is not always consistent when there are many people because objects overlap or are not fully detected. Light-based human detection testing is an evaluation process to determine how well a human detection system can operate under different light conditions. Different lighting can affect the quality of the images or videos analyzed, which can affect the system's ability to detect humans accurately.

D. Test Results of Security System Accuracy

Security system accuracy testing is a crucial process for evaluating the effectiveness of a security system in detecting, identifying, and responding to potential security threats or incidents.

The primary objective of this testing is to ensure that the system operates with a high level of reliability and accuracy under various environmental conditions and security scenarios. Accuracy testing involves assessing the system's ability to correctly detect authorized and unauthorized individuals while minimizing false positives and false negatives. In addition, this process evaluates the consistency of system performance in different lighting conditions, camera angles, distances, and levels of environmental noise.

By conducting systematic accuracy testing, the overall robustness and reliability of the security system can be measured, providing insight into its readiness for real-world deployment and its capability to support effective surveillance and decision-making.

1) Safety Mode OFF Condition

This test is carried out when the security system is off to ensure that the system is as expected.

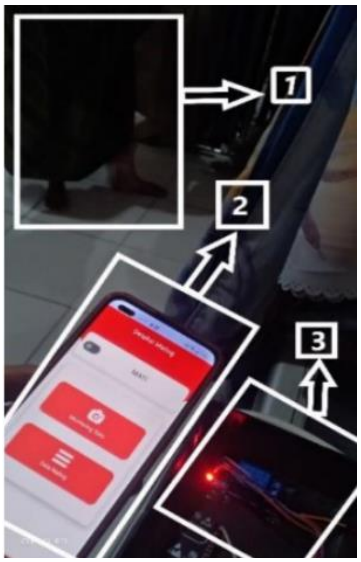


Figure 16. Security system accuracy testing off mode

Description in the Fig. 16 is (1) Humans who enter the CCTV range and are detected as burglars, (2) The application is off security mode, (3) The green relay indicator light is not on because the security mode is off.

2) Safety Mode ON Condition

This test is performed when the security system is on to ensure that the system is as expected.

Figure 17. Security system accuracy testing on mode

Description in the Fig. 17 is (1) Humans who enter the CCTV range and are detected as burglars, (2) The application is ON security mode, (3) The green relay indicator light is on

because the security mode is ON. The buzzer will activate when the green indicator light from the relay is on. Through careful and comprehensive testing, it can be ensured that the system is able to provide effective and reliable protection against security threats that may occur in a store or residential operational environment.

E. Test Results of Latency

Latency or delay is the time it takes for data to travel from the origin to the destination. Some of the factors that affect delay include physical distance, transmission medium, network congestion, and the duration of the process required.

Delay in computer networks can be categorized into four main types: processing delay (delay due to data processing), queuing delay (delay due to queuing at routers or switches), transmission delay (delay due to sending bits to the transmission medium), and propagation delay (delay due to signal travel time in the transmission medium). The standard delay value can be referred to in the following Table I

TABLE I
LATENCY (DELAY)

Latency Category	Latency Measure	Index
Very Good	<150 ms	4
Good	150 s/d 300 ms	3
Medium	300 s/d 450 ms	2
Bad	>450 ms	1

Latency refers to the delay in transmitting data such as the time required to perform I/O operations, such as writing or reading data from input or output devices such as components and external devices. There is an Equation (1) to measure latency in this study as follows:

$$\text{Average delay} = \frac{\text{Total Delay}}{\text{Total Packet Received}} \quad (1)$$

TABLE I I
DELAY MEASUREMENT RESULTS

	Time	Time 2	Time 1	Delay
9	0.252166	1.263528	0.252166	1.011362
18	1.263528	2.272294	1.263528	1.008766
27	2.272294	3.293305	2.272294	1.021011
36	3.293305	4.310114	3.293305	1.016809
45	4.310114	5.323401	4.310114	1.013287
54	5.323401	6.334235	5.323401	1.010834
63	6.334235	7.340395	6.334235	1.00616
72	7.340395	8.352309	7.340395	1.011914
81	8.352309	9.36087	8.352309	1.008561
90	9.36087	10.36884	9.36087	1.00797
99	10.36884	11.37794	10.36884	1.009104
108	11.37794	12.39136	11.37794	1.013416
117	12.39136	13.40074	12.39136	1.009378
126	13.40074	14.42848	13.40074	1.027741
135	14.42848	15.44302	14.42848	1.014538
144	15.44302	16,45509	15.44302	1.012077
153	16.45509	17.47047	16.45509	1.015379
162	17.47047	18.47915	17.47047	1.008675
171	18.47915	19.48841	18.47915	1.009257
180	19.48841	20.50358	19.48841	1.015177
189	20.50358	21.51323	20.50358	1.009644
198	21.51323	22.52055	21.51323	1.007327
207	22.52055	23.54149	22.52055	1.02094
216	23.54149	24.55248	23.54149	1.010983
234	25.56788	26.57843	25.56788	1.010546
243	26.57843	27.59139	26.57843	1.012958
252	27.59139	28.59878	27.59139	1.007395
261	28.59878	29.61144	28.59878	1.012658
270	29.61144	30.62008	29.61144	1.008636
279	30.62008	31.62783	30.62008	1.00775
288	31.62783	32.6348	31.62783	1.006974
297	32.6348	33.65049	32.6348	1.015693
306	33.65049	34.65802	33.65049	1.00753
315	34.65802	35.66816	34.65802	1.010134
324	35.66816	36.68357	35.66816	1.015408
333	36.68357	37.69611	36.68357	1.012548
342	37.69611	38.70434	37.69611	1.008229
351	38.70434	39.71715	38.70434	1.012808
360	39.71715	40.72877	39.71715	1.011616
365	40.72877	41.73416	40.72877	1.005397
378	41.73416	42.74252	41.73416	1.008356
388	42.74252	43.7483	42.74252	1.005776
396	43.7483	44.75659	43.7483	1.008293
404	44.75659	45.76411	44.75659	1.007523
415	45.76411	46.77732	45.76411	1.013211
423	46.77732	47.7917	46.77732	1.01438
432	47.7917	48.81189	47.7917	1.020189
		Total Delay		48.55973
		Average Delay		0.112407s = 112.24 ms

From the calculation results (Table II), a delay value of 112.4 ms was obtained. Referring to the figure above, it

shows that the results of the calculation of the delay value are included in the good category because the delay value is small so that the delay in sending data is also minimal.

$$\text{Average delay} = \frac{48.559726}{432} = 0.112406\ s$$

$$= 112.406\ ms$$

Latency is often measured in units of time, such as milliseconds (ms) or microseconds (µs), depending on the level of speed and responsiveness required by the application or system. Latency reduction is a major focus in many systems, especially in real-time applications and network communications where fast response is critical.

In general, whether or not latency is good depends on the context of use and the specifics of the application. The accepted latency standards can vary from application to application, and what is considered good in one context may not be enough for another context that requires a faster response. Therefore, latency evaluation should always be considered based on the specific needs and expectations of the user or application in question.

IV. CONCLUSION

Implementation of CCTV Utilization as a Security System using the YOLOv8 algorithm at the Desty Collection Clothing Store can be used to find out if there are humans outside working hours by detecting humans using 54-56 Lux getting an average confidence of 71.6%. Then, the YOLOv8 algorithm used in this human detector uses its own data set so it requires labeling and training. The accuracy of the human detection system requires a minimum light coverage of 2 lux to be able to detect humans with an average confidence of 63.4%. Data transmission from the computer to ESP32 through the database when there is a human buzzer will automatically turn on through the relay, the relay gets a command from the human detection results. Application ON and OFF security mode runs smoothly, if off then the relay will not receive a command to turn on the buzzer. Then, the author gave suggestions based on the tests that have been carried out in maintaining the security system of a store so that theft does not occur so that this research project can be developed more perfectly.

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