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COMPARISON OF BACKGROUND SUBTRACTION, SOBEL, ADAPTIVE MOTION DETECTION, FRAME DIFFERENCES, AND ACCUMULATIVE DIFFERENCES IMAGES ON MOTION DETECTION

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Abstract *– Nowadays, digital image processing is not only used to recognize motionless objects but also used to recognize motions objects on video. One use of moving object recognition on video is to detect motion, which implementation can be used on security cameras. Various methods used to detect motion have been developed so that in this research compared some motion detection methods, namely Background Subtraction, Adaptive Motion Detection, Sobel, Frame Differences and Accumulative Differences Images (ADI). Each method has a different level of accuracy. In the background subtraction method, the result obtained 86.1% accuracy in the room and 88.3% outdoors. In the Sobel method, the result of motion detection depends on the lighting conditions of the room being supervised. When the room is in bright condition, the accuracy of the system decreases and when the room is dark, the accuracy of the system increases with an accuracy of 80%. In the adaptive motion detection method, motion can be detected with a condition in camera visibility there is no object that is easy to move. In the frame difference method, testing on RBG image using average computation with a threshold of 35 gives the best value. In the ADI method, the result of accuracy in motion detection reached 95.12%.*

Keywords: *Motion Detection; Background Subtraction; Sobel; Adaptive Motion Detection; Frame Difference; ADI*

INTRODUCTION

Along with the development of an increasingly advanced and modern era, the various acts of crime around us are also increasing. Security becomes one of the most important things to see the many crimes that often occur in the environment. We can not expect the security guard to keep an eye on things at all times.

Therefore, security cameras can be the best solution because it can play an important role as evidence of every crime. By using security cameras, surveillance is not limited to just one object but also to certain areas, both areas where no person is allowed to pass or in areas common to everybody. We have to be careful because in essence, a crime can happen anywhere and anytime (Yamato et al., 2017).

Various studies on motion detection have been widely practiced, among others, Metode Subtraction (Wu et al., 2017) and Algoritma Gaussian Mixture Model (Pratama et al., 2017; Ji and Yu, 2013), Sobel Algoritma (Rahman, 2017; Zhang et al., 2016), Optimal Motion Detection Algorithm (Antonius et al., 2015), Frame Differences (Zul et al., 2015; Wirayuda et al., 2013) and Illumination of Change Detection (Priadana et al., 2017).

Based on the above background, this study compared Background Subtraction, Sobel, Adaptive Motion Detection, Frame Differences and Accumulative Differences Images (ADI) methods to determine the accuracy of the image.

METHODS

In this study, there are several methods that will be compared, following explanation.

Background Subtraction

The designed system is a tool for detecting human movement. Block diagram of security camera system can be seen in Fig. 1. If there is a human movement, then this system will notify the user via email. Users do not need to see the computer screen to monitor the situation at any time. In addition, the user can directly check the location being monitored or ask others to check if there is an intruder so that the crime action can be prevented (Pratama et al., 2017).

Input Section

The web camera will record the state of a location and send the recording to Rasbperry Pi. This web camera has a USB output port (Universal Serial Bus) connected to Raspberry Pi.

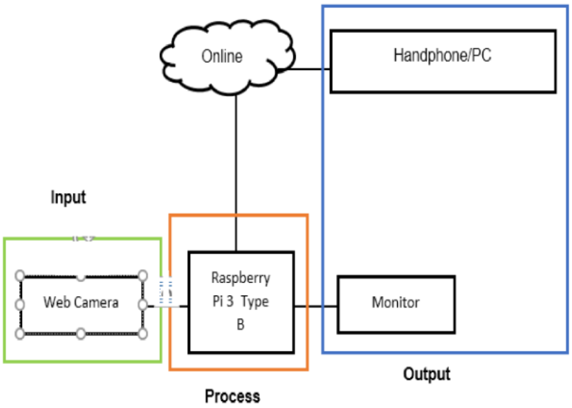


Figure 1. Block System Security Camera Diagram (Pratama et al., 2017)

Processing Section

Raspberry Pi is a component that is responsible for processing. This processing block performs three processes, namely the process of motion detection, human detection and sending notices. The video recorded by the camera will then be processed first by a motion detector. If there is a moving object, then the moving object will be checked again if there are human. If it is detected that the moving object is human, the system will send a notification email.

Raspberry Pi used is type Raspberry Pi 3 Type B. Its motion detection process serves to detect moving objects from video recorded by the camera. Motion detection uses the functionality of the OpenCV library, through the C ++ Application Programming Interface API called cv2.BackgroundSubtractorMOG. The human detection process uses trained classification in the OpenCV library. The human detection used is a function found in the OpenCV library ie cv2.CascadeClassifier.

The function requires a classified file that has been trained to detect a particular object. The file is created in XML (Extensible Markup Language) format found in the OpenCV folder. Human detection has several important parameters, namely image, scale factor, and minNeighbors. The image parameter contains the input image to detect. The scale factor parameter controls how many image sizes are reduced on each image scale. Parameters determine many pixels for sliding show shifts. The process of sending notices to users is sent using email. The email service used is Gmail (google mail).

Raspberry Pi must be connected to the internet. In this design, Raspberry connected to the internet using a WLAN network. In order to send notifications, users need to have a Gmail account first. The user will receive a notification when the identified object as a human is detected. On the notice, as many as three images and a text will be sent. These three images are identifiable images of humans.

Output Section Sends Notification

The computer screen is displaced to display the GUI (Graphical User Interface) and view real-time video recordings. In the GUI, the user can manage the program, such as selecting the environment conditions where the camera will be installed, set the email address, and activate the program. Mobile functions as a notification recipient. The device will receive notifications in the form of text and recording images when there is a moving object or detected human presence.

Designing Software

The software used is Python version 2.7 and OpenCV version 2.4.11. In OpenCV, there is a library of programming functions that can be directly used to detect motion and detect humans. The flow diagram of the detection test is shown in Fig. 2. The user is required to select the video input to be tested. The video can be a video file with a recorded .avi format or video recording directly through the camera. Before starting the test, the user is required to enter the email address to be used along with the password. Then the user can choose to add a notification recipient by filling in the email address of other recipients. Users may also refuse to add a notification. After that, a notification email can be sent.

The main menu flow diagram is shown in Fig. 4. The first stage is camera initiation, motion detection, human detection, and email settings. This stage provides a variety of parameters needed to record video, detect motion, detect humans from moving objects and send notifications via email. The next stage is the detection of motion and human detection. If a moving object is detected on the video, the program will start the human detection process. If the moving object is human then the notification will be sent to the user.

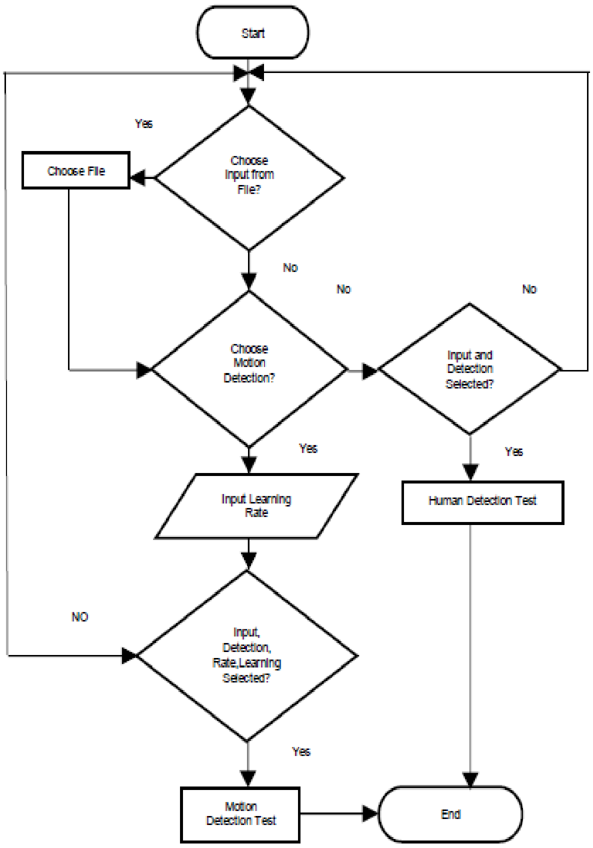


Figure 2. Flow Chart of Motion Detection and Human Detection Test (Pratama et al., 2017)

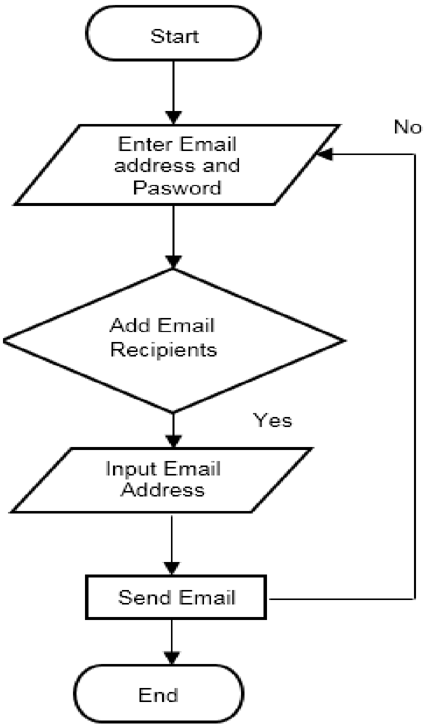


Figure 3. Flow Chart of Notification Delivery Testing (Pratama et al., 2017)

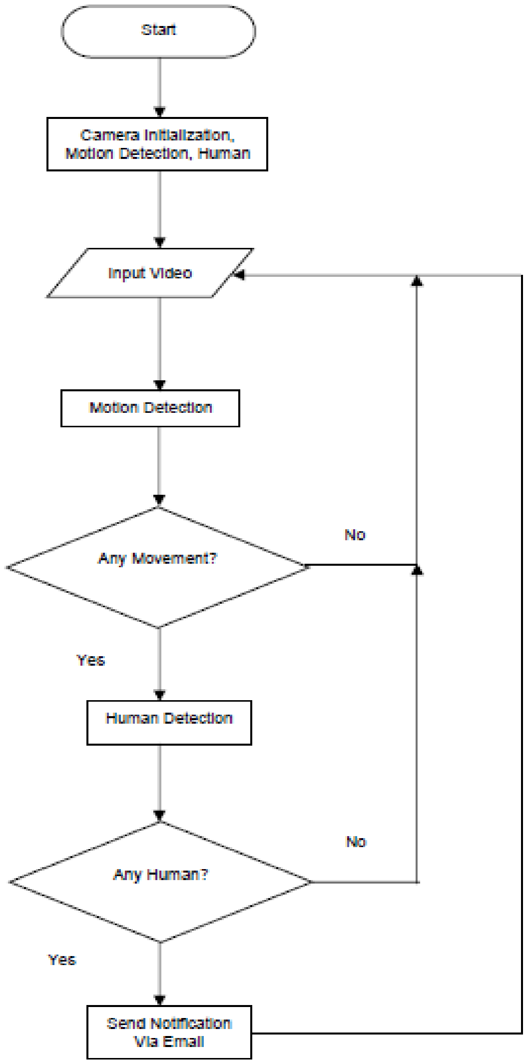


Figure 4. Block Diagram of Security Camera System (Pratama et al., 2017)

Designing Hardware

The hardware that has been assembled needs to be contained in order to be protected from damage. The entire set of contained tools is shown in Fig. 5. On the front, a clear plastic layer is used to protect the camera section. The container is also equipped with a sleeve for wall mounting.

Figure 5. The whole set of tools (Pratama et al., 2017)

Sobel

Sobel's algorithm is the development of Robert's method of using HPF (High Pass Filter) filters that are numbered zero in the buffer. This method uses a principle that can generate HPF that is the principle of Laplacian and Gaussian functions. The advantage of the Sobel algorithm is the ability to reduce the amount of noise before performing edge detection calculations. (Rahman, 2017).

2	1	2	0
0,5	0	0,5	0
1	-0,5	0,5	0
1	0,5	-0,5	-0,5
1	0	2	0
0	0	0	1,5

*	*	*	*
*	*	*	*
*	*	2	*
*	*	*	*
*	*	*	*
*	*	*	*

Figure 6. Sample Example of Sobel Operator Matrix (Rahman, 2017)

Frame difference is a technique used to calculate the absolute value of the difference difference between the background frame and the current frame. Then use thresholding to know the difference between pixel both frame. In general, background subtraction equations can be represented as follows (Rahman, 2017):

$$|I(x,y,t) - I(x,y,t-1)| > Th$$
$$B(x,y) = I(x,y,t-1)$$
$$|\ I(x,y) - B(x,y)\ | > Th \quad (1)$$

Where Th is the threshold value, I (x, y) is the nth current frame, and B (x, y) is the previous frame, which has been initialized as the reference frame or the background frame. Simulation scenarios are designed in such a way that motion detection systems using the Sobel algorithm can produce data that are close to ideal criteria and can be analyzed for performance. The scenario is divided into three conditions, namely the first scenario of bright conditions, the second a dim scenario condition, and the third dark scenario. The results of the simulation will be analyzed its performance using quantitative analysis method.

Adaptive Motion Detective

Adaptive Motion Detection Algorithm is an algorithm in the field of Computer Vision that serves to detect motion in the video by combining two methods, namely Static Template Matching and Dynamic Template Matching methods. This algorithm is made on the basis to obtain a more optimal method of detecting motion where in the previous methods there are still weaknesses that often appear the result of a false positive that is the condition where the system concludes that there is movement but actually nothing (Antonius et al., 2015).

Dynamic and Adaptive Templates Matching is a method developed based on Dynamic Template Matching in order to generate a more accurate method of motion detection of a video. The motion detection stage performed in this method is to take a reference image and then compare the reference image with the next image to find whether there are differences in pixels on the two images then the system takes the pixel coordinates that have the color difference for the next compared to the motion that has been detected at previous iterations of whether the coordinates of the gained motion are the same as the coordinates of the previous movement. Seeing the advantages of Dynamic and Adaptive Template Matching methods compared to Static Template Matching method and Dynamic Template Matching, this research uses motion detection method in the system that will be made to make the system more accurate in detecting motion while testing the reliability of the method in its application.

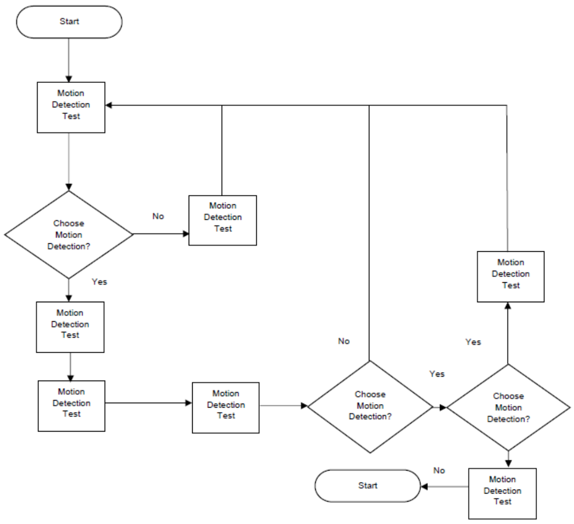


Figure 7. Flowchart Algorithm Dynamic and Adaptive Motion Detection (Antonius et al., 2015)

Frame Differences

Frame differences as the main reference for detecting motion captured through the camera. The frame differences method is combined with various methods and algorithms for the determination of reference drawings and comparison thresholds. This research uses frame differences method to detect motion that is monitored by using IP Camera. Furthermore, reference image determination technique is done by using dynamic template matching method. The reference image used is the image captured at time t-1. Where the image which will detect is marked with the image captured at time t. In general, the process undertaken in motion detection using the frame differences method can be seen in the following points.

1. Capture images from IP Camera. Catching is done in accordance with a certain period of time.
2. Determination of image resolution to be stored in the database. The captured image resolution of the IP Camera is 640 × 480 pixels.
3. Determination of color component of an image. The image color components tested in this research are RGB, Grayscale and YCbCr. RGB color is the original color of the image. While Grayscale image obtained from equation (2).

$$f_o(x,y)=\frac{f_i^R(x,y)+f_i^G(x,y)+f_i^B(x,y)}{3} \quad (2)$$

Where: fo is the value of the grayscale color component, fiR, fiG and fiB is the RGB value of the image. The process of converting RGB image to YCbCr is derived from equation (3):

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.299 & 0.587 & 0.144 \\ -0.1687 & -0.3313 & 0.5 \\ 0.5 & -0.4187 & -0.0183 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (3)$$

Where: Y is the luminance color component, and Cb, Cr is an image color component other than luminance. R, G and B are RGB image color components (Zul et al., 2015).

Accumulative Differences Images

Accumulative Differences Images (ADI) method is comparing image differences in several consecutive frames of video. When compared to a method that only compares the differences between two frames in each process, the ADI method is considered to reduce errors since they are derived from the accumulated value of the movement of some frames. The conventional intensity-based ADI method can work well under constant lighting conditions. The ADI method can also overcome false detection problems from inaccurate image details such as edges and lines (Priadana et al., 2017).

The process of image-change detection in the video that will be carried out in this research includes two subprocesses namely motion detection process with ADI method and image change detection by Illumination Invariant Change Detection method combined with image cropping method to limit the observation area. In this system, there is two motion detection process. The first motion detection process aims to detect motion in the video. The second motion detection process is to detect that the motion is no longer present. After that will be done image detection process combined with cropping method of image where aims to detect image changes in the observed region that has been determined between the reference image with the image after the movement. The results of the image change detection and cropping process of the image will be the basis for determining whether or not the image changes to the video to be inserted into the system. The image change detection system of the video shown in the diagram in Fig. 8.

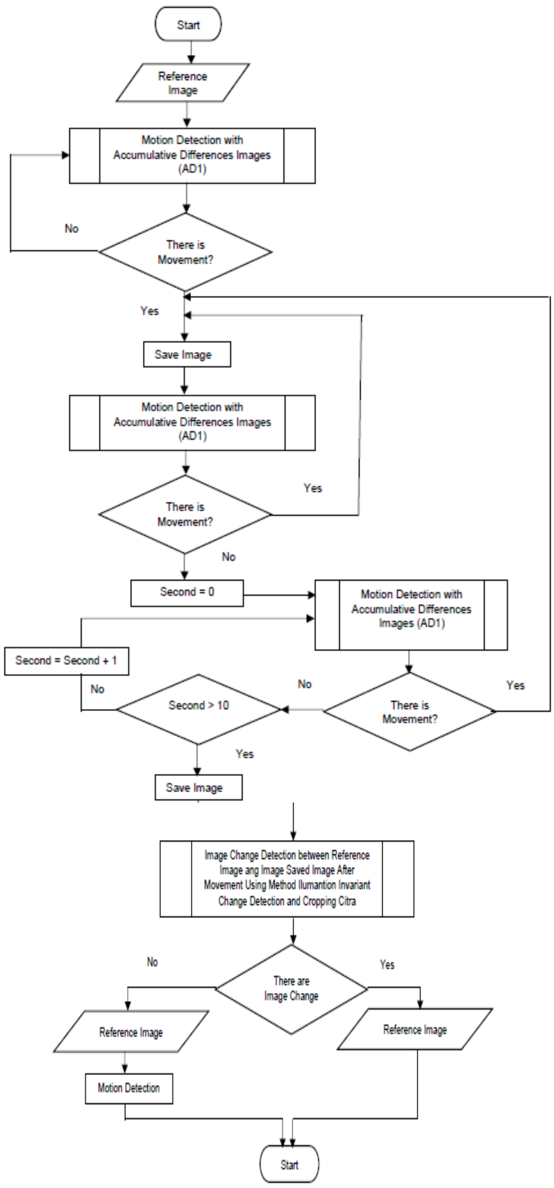


Figure 8. Designing System (Priadana et al., 2017).

Fig. 8 shows the steps of image-change detection in the video. Where there are two stages in the system are motion detection and image change detection. At first webcam camera will do image capturing or image acquisition. generated in the image acquisition process will be used for the motion detection process using Accumulative Differences Images (ADI) method with the first step is the acquisition of the image to be performed and used as a reference image. The reference image is an image with no moving objects. The reference image in the RGB color model is converted into a grayscale color model. Computer-connected CCTVs will conduct video acquisition and generate frames of the video sequentially over a period of time. The collection of frames obtained from image acquisition in the RGB color model is converted into a grayscale color model. Some grayscale color images are then compared with reference images using the ADI method resulting in an accumulated value of the difference by the reference image and the image of the acquisition result. The accumulated value is then compared to a threshold value. If the accumulated value of the difference between the reference image and the acquisition image is greater than the threshold then it is stated that there is an object moving in the sequence of the image. If the motion is not detected, the system will again perform image acquisition and motion detection process using ADI method. If the motion is detected, the system will save the image and re-perform the motion detection process using ADI method. If movement is still detected, then the system will repeat the process of storing the image and motion detection process using ADI method.

If the movement is no longer detected for 10 seconds, the system will perform the image acquisition and compare the reference image (reference image either in the form of image image capturing or image obtained from the background modeling process at the time of data collection) with image acquisition result after movement by method Illumination Invariant Change Detection combined with image cropping method that aims to limit the observation area (Priadana et al., 2017).

RESULTS AND DISCUSSION

This section discusses the comparative results of each motion detection method. The input used is several videos of different durations recorded at the rate determined by each method. The following comparison results from the five Methods.

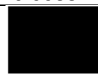
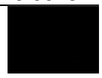
Background Subtraction

The input used is several videos with different durations recorded with frame rate of 24 frames per second. Camera position unchanged on various tests. All tests are conducted on indoor and outdoor conditions during the day. The resolution used is 640 × 480 pixels. The camera is installed at a height of 2.7 m and is located in the corner of the room. The camera's viewing angle is arranged so that people can clearly see the person in that position. Motion detection testing aims to find the appropriate learning rate parameters to be applied to different environmental conditions. The rate of learning is determined based on the frame history. There are 4 variations of frame history to be used, ie 100 frames, 200frame, 300frame, and 400frame. So, the variation of learning rate that will be used is:

History frame = 100
Learning rate = 1 $(riwayat\ frame)$ = 1100 = 0.01
History frame = 200
Learning rate = 1 $(riwayat\ frame)$ = 1200 = 0.005
History frame = 300
Learning rate = 1 $(riwayat\ frame)$ = 1300 = 0.0033
History frame = 400
Learning rate = 1 $(riwayat\ frame)$ = 1400 = 0.0025

The following Table Results Testing motion detection inside and outside the room.

Table 1. Motion Detection Test Results on Indoor Conditions

Number of Frame	Origina l Frame	Mask Foreground Display of Learning Rate Variation			
		0.01	0.05	0.0033	0.0025
1					
117					
137					
700					

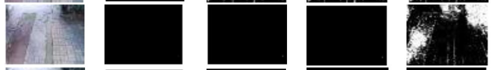
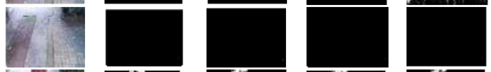
Based on Table 1, it can be seen that the foreground mask of each learning rate has almost equal performance. Each variation of the learning rate is capable of generating a foreground mask that marks the moving object.

Table 2. Test Results of the Influence of Learning Rate Variation on the Number of Frames Processed Under Indoor Conditions

Time (second)	Input (number of frames)	Output (number of frame rate of learning)			
		0.01	0.005	0.0033	0.0025
6	144	39	38	38	38
12	288	58	57	57	57
18	432	129	128	127	125
24	576	200	222	223	219
30	720	234	256	257	253
36	864	259	281	298	309
42	1008	342	366	384	395
48	1152	348	372	390	401
54	1296	465	489	507	519
60	1440	496	518	536	548
66	1584	543	572	591	603

Based on Table 2, there is an increase in the number of output frames as the learning rate becomes smaller. So, the lower the value of the learning rate parameter, the more the number of output frames. In addition, the number of output frames per learning rate will also increase with time. The number of output frames from each of the learning rate parameters is less than the number of input frames. The learning rate parameters for motion detection under indoor conditions are selected by considering the foreground mask view as well as the number of output frames. The foreground mask results show that the lower learning rate parameter tends to produce a better foreground mask (Pratama et al., 2017).

Table 3. Results of Motion Detection Tests with Learning Rate Parameters in Outdoor Conditions

Number of Frame	Original Frame	Mask Foreground Display of Learning Rate Variation			
		0.01	0.05	0.0033	0.0025
20					
50					
150					
200					
450					
470					

Based on Table 3, it can be seen that there is a fairly obvious difference from the results of motion detection with different learning rate parameters. At the beginning of time when no moving object, all learning rates will assume there is a moving object. The background should be marked in black because there is no moving object. The pace of learning will update the background after some time. Each learning pace has a different time in updating the background. This difference occurs because the greater the rate of learning, the less the number of frame history required to process the background at the beginning of time. In the Background Subtraction method obtained the result of accuracy reached 86.1% indoors and 88.3% outdoors (Pratama et al., 2017).

Table 4. F1 Score Test Results

Place of Video	Threshold	Condition	Number of Samples	PPV	TPR	F1 Score
Indoor	130	Bright	100	0.95	0.80	0.86
Indoor	130	Dim	100	0.96	0.60	0.73
indoor	130	Dark	100	0.98	0.82	0.89
Outdoor	130	Morning	100	0.97	0.80	0.87
Outdoor	130	Day	100	0.89	0.80	0.84
outdoor	130	Afternoon	100	0.98	0.71	0.82

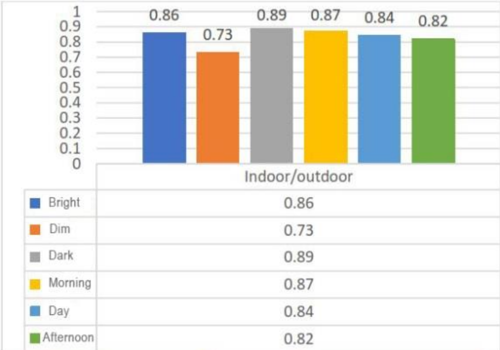
Table 5. Test Results of the Percentage Correct Classification

Place of Video	Threshold	Condition	Number of Samples	TP	FP	TN	PCC (%)
Indoor	130	Bright	100	150	7	100	85
Indoor	130	Dim	100	102	4	100	74
indoor	130	Dark	100	105	2	100	89
Outdoor	130	Morning	100	139	4	100	86
Outdoor	130	Day	100	92	11	100	85
outdoor	130	Afternoon	100	106	2	100	82

Sobel

From the simulation results obtained from several experiments as follows (Rahman, 2017):

Table 4 shows the test results F1 score all experimental conditions. From the above test results, obtained value F1 score ≤ 80% in bright and dim conditions, and F1 score ≥80% when the dark conditions. It can be concluded that to get a good performance should be done in a dark place.



Gambar 9. F1 Result Score (Rahman, 2017)

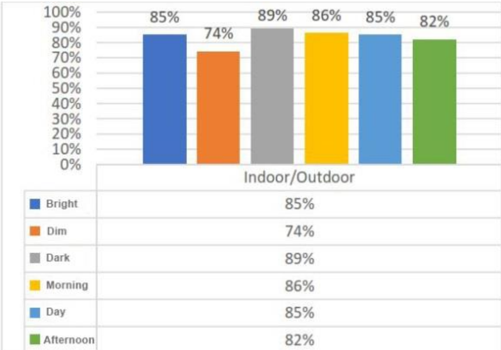


Figure 10. The Percentage Correct Classification (Rahman, 2017)

Table 5 shows the results of PCC testing or system accuracy. The best is obtained in dark conditions, which is 80%. From the above test results, it can be seen that the number of TP pixels and the lower the number of FN pixels will improve the accuracy result. It can be concluded that to obtain high accuracy results, the thing to do is increase the number of TP pixels and reduce the number of FN pixels by way of monitoring in places with low lighting levels.

Adaptive Motion Detection

Adaptive Motion Detection method where first the program performs differencing frame process to find the difference between the last two frame images (Antonius et al., 2015). Against the two Fig. 11a and 11b are then processed differencing frames to produce a new image showing any pixel in the image that there is a change in value or can be said to move.

Figure 11. Two Images that Will be Processed with Differencing Frame (Antonius et al., 2015)

After the process of differencing frames done then the next frame process differencing in Fig. 12 of the process is processed by the process of thresholding to find any pixels whose value exceeds the threshold limit. The pixels whose value exceeds the threshold limit will be 1 and are white while the pixels whose value is below the threshold will be 0 and are black as shown in Fig. 13.

Figure 12. Image Frame Differencing Process Results (Antonius et al., 2015)

Figure 13. Image Thresholding Process Result (Antonius et al., 2015)

If the number of white pixels in the threshold image is 0.1% to 40% of the image, the system will state that there is movement in the image and then look for the outermost coordinates and the number of white pixels in the binary image to determine the area of motion. From the coordinates obtained, it will be drawn a square red line as in Fig. 14 which represents the area of motion.

Figure 14. Final Results Image (Antonius et al., 2015)

Frame Difference

There are several factors that influence the result of motion detection through IP Camera. These factors are image resolution, reference image determination technique, image color component and threshold value determination. In this section an analysis related to image resolution of the frame differences method is performed. Image types used are RGB, Grayscale and YCbCr imagery. The second analysis is the determination of the type of color components captured from the IP Camera. The analyzes are aligned with the best and adaptive threshold determination with a variety of environmental conditions (Zul et al., 2015).

The Effect of Threshold and the Influence of Image Resolution

This study was conducted to compare the keisien correlation between threshold and various resolution images. The standard image generated by IP Camera has a resolution of 640x480 pixels. Benchmarking is done using 4 image resolutions. These resolutions include 640x40 pixels, 512 × 384 pixels, 384 × 288 pixels, 256 × 192 pixels and the last 128 × 96 pixels. The threshold used is worth from 5 to 80 by using multiples of 5. Correlation test is done by using product moment Pearson correlation analysis. The effect of correlation coefficient value is translated based on the range of values that are defined in the following tables.

Table 6. Effect of Correlation Coefficient

Coefficient	Effect
-1.0 to -0.5 or 1.0 to 0.5	Significant
-0.5 to -0.3 or 0.3 to 0.5	Quite significant
-0.3 to -0.1 or 0.1 to 0.3	Low
-0.1 to 0.1	Very low

Table 7 explains that the correlation coefficient values obtained ranged between 0.75 and 0.78. The value means that the threshold has a significant effect on the comparative image results for various image sizes. Negative correlation coefficient indicates that the smaller the threshold value used, the larger the captured pixels will be greater. If the pixel value of the captured difference is very high, then the amount of noise captured from the comparison will also be high.

Table 7. Correlation of Threshold with Image RGB and Grayscale Resolution

No	Size of Image (pixels)	Image Type	
		RGB Coeficient Correlation	Grayscale Coefficient Correlation
1	640 x 480	-0.7786	-0.7876
2	512 x 384	-0.7798	-0.7713
3	384 x 288	-0.7779	-0.7695
4	256 x 192	-0.7732	-0.7652
5	128 x 96	-0.7653	-0.757

Detection using RGB and YCbCr Imagery

This test uses 50 pairs of samples of data captured in different places and conditions. The reference image used is the image captured at time t-1. In addition, there will also be the most adaptive threshold determination with all the conditions captured by the IP Camera. A comparison is done by looking at the percentage value of each comparative result of 50 data samples. The comparative results are analyzed with the aim of producing comparative status information. The status is detected or not detected. The result of comparison of detection using RGB and YCbCr image can be seen in Table 7.

Based on the comparison done then get the best threshold values for various frame differences method algorithm using RGB and YCbCr image. The best threshold value can be seen in Table 8. Based on the comparison graph, the low percentage of the resulting threshold value 5 occurs because of the high noise generated. So the sensitivity level of detection becomes very high. Sometimes the algorithm detects the movement of the image, while the reality does not occur movement. This can happen because of the effects of lighting captured by IP cameras.

Table 8. Detection of Various Threshold Value

Threshold Value	Detection Percentage			
	RGB	RGB Mean	YCbCr	CbCr
5	0	6	18	76
10	28	64	72	88
15	72	86	86	66
20	86	94	90	42
25	90	94	86	24
30	92	94	82	22
35	96	98	86	18
40	92	90	84	10
45	90	92	76	8
50	88	88	6	2
55	88	88	72	2
60	88	86	66	2
65	84	86	60	0
70	80	78	52	0
75	80	78	48	0
80	2	70	40	0

Table 9. The Best Threshold Value for 50 Sample Data

Algorithm based on Image	The best Threshold	Percentage
RGB	35	96%
RGB Mean	35	98%
YCbCr	20	90%
CbCr	20	88%

Figure 15. Comparison the Best Value (Zul et al., 2015)

Accumulative Differences Images

This test is done by selecting the simulation video file to be tested, determining the threshold, and running the system by pressing the process button. To know the success of the system to detect motion is to see the information of motion detection results that will be displayed by the system. The detected information is displayed based on the range of motion change events. Starting from the detection of movement until no longer detected the movement will be counted as one movement. To determine the best threshold value is done by experiment by selecting several threshold values and comparing the results. The threshold value to be tested is the threshold value that will be compared with the value of the difference between the two frames. The experimental results for determining the threshold value to be used are listed in Table 10 (Priadana et al., 2017).

The predefined threshold value will affect the result of motion detection. The smaller the threshold value specified, the difference between the two frame pixels obtained by the system will be greater. If the difference between the two frames obtained by the system is greater, then the accumulated value will increase so it will increase the possibility of the system to detect the movement. Conversely, the greater the value of the threshold is determined then the difference between the two frame pixels obtained by the system will be smaller.

Table 10. Experiment Results with Different Threshold on Motion Detection

The Best Threshold	Detected or No	Note
1	No	No motion detected because the motion level is less than 1
0.5	No	No motion detected because the motion level is less than 0.5
0.1	Detected	No motion detected because the motion level is less than 0.1
0.05	Detected	No motion detected because the motion level is less than 0.05
0.03	Detected	No motion detected because the motion level is less than 0.03
0.02	Detected	No motion detected because the motion level is less than 0.02
0.01	Detected	No motion detected because the motion level is less than 0.01
0.005	Detected	No motion detected because the motion level is less than 0.005

$$NilaiThresholdDeteksiGerak = \frac{0.03 + 0.05}{2} = 0.04 \quad (4)$$

From the test results in Table 10, it can be concluded that the movement can be detected if the threshold value ranges from 0.01 to 0.005, but the exact value for determining the movement is 0.03 to 0.05. If the threshold value is smaller than 0.02, smaller changes such as changes in illumination and shadow will also be detected as a movement. Thus, the collected threshold value to be used is calculated by equation 4 (Priadana et al., 2017).

Then it can be determined the exact threshold value to detect motion on the image change detection system in this video is 0.04. The experimental results performed on fourteen simulation video data both containing and which do not contain wallpapers will be the basis of precision calculation, recall and accuracy of motion detection where performed with a predetermined threshold value of the previous calculation are shown in Table 11.

Table 11. Accuracy of Experiment Results on Motion Detection

No	Video File	Duration	A	B	C	D	E	F	G	H
1	05.40-NoVan.avi	01.02	4	5	4	5	4	5	0	0
2	05.43-Van.avi	01.05	2	3	1	2	1	2	1	0
3	10.08-NoVan.avi	00.45	3	4	2	3	2	3	1	0
4	10.11-Van.avi	00.59	3	4	2	3	2	3	1	0
5	10.58-NoVan.avi	01.00	4	5	4	5	4	5	0	0
6	11.01-Van.avi	01.00	1	2	1	2	1	2	0	0
7	12.07-NoVan.avi	00.42	3	4	3	4	3	4	0	0
8	12.09-Van.avi	01.03	1	2	1	2	1	2	0	0
9	15.49-NoVan.avi	00.50	3	4	3	4	3	4	0	0
10	15.51-Van.avi	01.00	1	2	1	2	1	2	0	0
11	17.50-NoVan.avi	00.52	3	4	3	4	3	4	0	0
12	17.54-Van.avi	00.55	2	3	1	2	1	2	1	0
13	21.00-NoVan.avi	00.46	3	4	3	4	3	4	0	0
14	21.28-Van.avi	01.07	1	2	1	2	1	2	0	0
	Total		34	48	30	44	30	44	4	0

Note:
A = Number of motion detection by system
B = No amount of motion detected by the system
C = Number of motion should be
D = Number of undetected motion should be
E = Number of motion detection equal (true positive)
F = No motion detectable amount equal (true negative)
G = False is positive
H = False negative

According to the movement correctly detected by the system using the ADI method, testing can be performed using precision, recall, and accurate calculations. With evaluation, the result of calculation of precision and recall from motion detection stage got precision value equal to 88.24% and 100% recall value. Accuracy value obtained from motion detection of 95.12%.

Comparison Methods Analysis

Each method has the same function but what distinguishes it is the supporting method used. Here is an explanation of the results of the analysis of the five methods.

In the background subtraction method, the Gaussian Mixture Model algorithm is used to detect motion in moving and silent background conditions. The input used is several videos with different durations recorded with frame rate of 24 frames per second. Accuracy results which obtained by this method is 86.1% indoors and 88.3% outdoors.

In the Sobel method, there is an advantage of being able to reduce the amount of noise before performing edge detection. In the Sobel method, the detection results depend on the lighting conditions of the controlled room. When the room is in bright condition, the accuracy of the system decreases and when the room is dark, the accuracy of the system increases up to 80% in the dark room.

In Adaptive motion detection method, this method detects movement by combining 2 methods namely Static Template Matching method and Dynamic Template Matching. Both of these methods are needed to obtain optimal results, which do not cause False Positive. This method is able to detect the movement that occurs in the camera's visibility well when placed inside and outside the room provided that in camera visibility there is no object moving constantly.

In Frame Difference Method, Dynamic Template Matching method is used for reference image determination. Based on the test results, testing on RBG image using average computation with a threshold of 35 gives the best value.

In the Accumulative Differences Images method, this method has the advantage of reducing error because it is taken from the accumulated value of the movement of some frames. For the accuracy result obtained from this method is reach 95.12%.

CONCLUSION

Based on the results of the discussion and analysis discussed earlier, it can be concluded as follows. Each method has its own advantages and produces different accuracy. In Background Subtraction method, the average accuracy of human detection result on indoor condition is 86,1% and outdoor condition is 88,3%. In the Sobel method, the accuracy results in dark conditions reached 80%. In the Adaptive Motion Detection method, the movement can be detected if still within the camera's visibility in the absence of a moving object constantly. In the frame difference method, testing on RBG image using average computation with threshold 35 gives the best test value. In ADI method, the result of accuracy in motion detection reached 95.12%. So based on the accuracy of several methods compared, the highest accuracy results are in the ADI method and the lowest accuracy results are found in the Sobel method.

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