Webcam Application for Classrooms Monitoring

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Abstract. Along with the development of information technology in the security field, the need for technologies that can assist human work in maintaining security is also increasing. One of the efforts in maintaining security is through monitoring of an area, such office area, and educational institution. Monitoring the institutions are necessary to look at the condition of a classroom, which is generally used a monitor screen to display monitoring results that will limit the movement. Therefore, the system design is done to perform monitoring of a classroom on smartphones. In the implementation, the design of the data communications system, hardware and software first then will be analyzing the implementation and testing system including the measurement in it. This system uses web camera (webcam) to monitor classrooms that are connected with raspberry pi via USB port where Raspberry Ethernet/ LAN/ RJ45 port connected to a router. Monitoring location can be done by smartphones without internet as the devices are in the router network coverage.

1. Introduction
Monitoring of an area on a regular basis is quite difficult, especially if the monitoring area has a wide scope as well as offices, shopping centers, and educational institutions. It is to prevent frequent criminal acts in public areas, and in educational institutions, monitoring is also required to monitor the state of a classroom especially during the process of teaching and examination [1].

Direct monitoring without the use of technological progress will be quite difficult considering the time, and when there are other important activities. General use of technology is still limited where the PC monitor screen used as the main media to display the monitoring results can limit the movement [2].

Based on the description above, then this tool is developed for monitoring a classroom with a monitoring process that can be done through mobile devices such as smartphone [3]. Many studies mention that the use of smartphones as a tool provider of information that multi-media provide a positive impact for the user [4-9]. This research designs a classrooms monitoring process that is done by using a webcam that is connected with raspberry pi as a controller to process the data that captured by webcam which will be sent to the android device via wireless local area network using router [10].

2. Design and implementation

2.1. General review
The design is the process of pouring ideas based on the basic theories that support ideas [11]. Figure 1 shows the designing process that is divided into several parts, as follows:

- Specifying the system block diagram;
• Determining how the tools work;
• Designing Hardware;
• Designing Software.

2.2. Block diagram
Figure 1 is a block diagram as a general overview of working system tool created. The workings of this tool start from the system input in the form of a webcam that serves to capture images [12]. Furthermore, the catch of a webcam image in the form of digital images will be processed by raspberry pi control. This control serves as temporary storage of captured image data from the webcam to be accessible via the web server [13]. Furthermore, for the system output to be monitored through the Android mobile device, then made an application that is integrated into android to do the monitoring process.

2.3. Designing hardware
The hardware design is shown in Figure 2, where the webcam is connected to raspberry pi control via USB port, raspberry pi’s source voltage obtained from the USB smartphone adapter/charger. The blower on the schematic above is used to cooling raspberry pi so it will not interfere the performance of the tool. Then to be able to transfer the captured images online, raspberry pi is connected to the router via an ethernet cable so that the captured images can be monitored through any device while still within wireless router range by using a web browser. Direct monitoring can be done through android mobile device through the application of the implementation of software design of this tool. Figure 3 illustrates the implementation results of the hardware design.
2.4. Designing software
This design is done by creating a flowchart to simplify the process of implementation and error analysis when the program created [14]. Flowcharts designed in this application are shown in Figure 4.

![Figure 3. Flowchart overall system.](image)

![Figure 4. Hardware implementation.](image)
To facilitate monitoring, an application is created on the Android device so that monitoring can be done anywhere quite easily (Figure 5). Also, this application is equipped with reloading and capture features to saving the image from the monitoring results.

3. Measurements and analysis

3.1. Measurements and analysis of webcam without a router
Table 1 shows that the image captured by the webcam which is not using the router, has a very small delay of 2 ms, the catch of the webcam when capturing the motion will be immediately visible on the monitor screen that has been connected to the raspberry pi control device.

| No. | Webcam Captured Images | Delay |
|-----|------------------------|-------|
| 1.  | Image (.jpg)           | 2 ms  |
| 2.  | Video (.swf)           | 2 ms  |

3.2. Measurement and analysis of raspberry pi connection with the router
Table 2 shows that the connection between the raspberry pi control with the router used is good. When ping from raspberry pi device against IP router or IP PC connected to the wireless router, the response is obtained quickly enough with 1 ms delay.

| No. | IP Address                | Delay |
|-----|---------------------------|-------|
| 1.  | 192.168.0.1 (Router)      | 1 ms  |
| 2.  | 192.168.0.100 (PC/Laptop) | 0.9 ms |
3.3. Measurement and image quality analysis

Table 3. Results of image delay measurement with a resolution of 200x120 pixel.

| No. | Distance (m) | Delay (s) | 10 fps | 15 fps | 20 fps | 25 fps | 30 fps |
|-----|--------------|-----------|--------|--------|--------|--------|--------|
| 1.  | 5            | 2.07      | 3      | 3.39   | 3.5    | 4.02   |
| 2.  | 10           | 2.17      | 3      | 3.45   | 3.7    | 4.1    |
| 3.  | 15           | 2.4       | 3.3    | 3.7    | 3.98   | 4.2    |
| 4.  | 20           | 3         | 3.72   | 3.87   | 4.32   | 4.89   |

Table 4. Results of image delay measurement with a resolution of 260x180 pixel.

| No. | Distance (m) | Delay (s) | 10 fps | 15 fps | 20 fps | 25 fps | 30 fps |
|-----|--------------|-----------|--------|--------|--------|--------|--------|
| 1.  | 5            | 2.97      | 3.21   | 3.45   | 4.05   | 4.32   |
| 2.  | 10           | 2.98      | 3.43   | 3.87   | 4.45   | 4.89   |
| 3.  | 15           | 3.34      | 3.65   | 4.01   | 4.67   | 5      |
| 4.  | 20           | 3.65      | 3.77   | 4.23   | 4.88   | 5.21   |

Table 5. Results of image delay measurement with a resolution of 320x240 pixel.

| No. | Distance (m) | Delay (s) | 10 fps | 15 fps | 20 fps | 25 fps | 30 fps |
|-----|--------------|-----------|--------|--------|--------|--------|--------|
| 1.  | 5            | 4.1       | 4.3    | 4.35   | 4.45   | 4.4    |
| 2.  | 10           | 4.23      | 4.45   | 4.65   | 4.76   | 4.87   |
| 3.  | 15           | 4.56      | 4.58   | 5.02   | 5.02   | 5.54   |
| 4.  | 20           | 5.67      | 5.88   | 5.9    | 6.01   | 7.62   |

Measurement in this section is done to find out whether good or bad image quality, also whether far and near distance will affect the delay at the time of sending the result of catching webcam image. The results seen from Tables 3, 4 and 5 show that video image resolution can affect the amount of speed in data processing, the larger video image resolution the delay required for image processing will be greater. It is because at the resolution of large video images there are more pixels. On the results also obtained, the greater the frame rate then the lapse (delay) will be greater. It is because the video with a large frame rate means the number of frames produced every second is also getting bigger. Distance factor of the measurement also affect, the greater the distance then the lapse (delay) will be even greater [15].

3.4. Measurement and analysis of system resistance to motion

Measurements in this section are performed to test the system’s durability, how long the raspberry pi control can survive when the number of motion images captured by the webcam, because when the absence of motion, images or video will not be stored. At this measurement, the resolution of the webcam captured images is set 320x240 pixels.

Table 6. The results of measurements of system resistance to motion with bitrate 400000.

| No. | Fps size | File size (kB) | System time duration |
|-----|----------|----------------|----------------------|
| 1.  | 10       | 105.3          | 864000 seconds       |
| 2.  | 15       | 167            | 540000 seconds       |
| 3.  | 20       | 169.7          | 540000 seconds       |
| 4.  | 25       | 170.7          | 540000 seconds       |
| 5.  | 30       | 176.3          | 540000 seconds       |
Table 7. Results of system resistance to motion with bitrate 500000.

| No. | Fps Size | File size (kB) | System time duration |
|-----|----------|----------------|----------------------|
| 1.  | 10       | 140.7          | 68400 seconds        |
| 2.  | 15       | 153            | 61200 seconds        |
| 3.  | 20       | 196.7          | 46800 seconds        |
| 4.  | 25       | 233            | 39600 seconds        |
| 5.  | 30       | 259            | 36000 seconds        |

Table 8. Results of system resistance to motion with bitrate 600000.

| No. | Fps Size | File Size (kB) | System time duration |
|-----|----------|----------------|----------------------|
| 1.  | 10       | 142            | 68400 seconds        |
| 2.  | 15       | 167            | 57600 seconds        |
| 3.  | 20       | 213            | 43200 seconds        |
| 4.  | 25       | 253.7          | 36000 seconds        |
| 5.  | 30       | 261.2          | 36000 seconds        |

The results in Tables 6, 7 and 8 show that if the frame rate and bitrate are bigger, then the data size also increases [16]. This can affect the resilience of raspberry pi control system because the size of memory SD card that used on raspberry pi control is 11 GB, so the length of recording time process is limited, and before reaching the limit of maximum at a certain time, raspberry pi must delete image files and webcam-captured videos.

4. Conclusions and suggestions

From several experiments done, the speed at transferring video images from raspberry pi control to other devices via a router depends on the amount of resolution, frame rate, bit rate, the distance between the transmitters and the state, in which the system is used whether there are many obstructions or not. The larger resolution, frame rate, and bitrate set, then the delay will also be greater. The last thing is the greater distance between transmitter and receiver then the process of sending the image will be longer.

For further development tools, it is suggested that webcam captured can be accessed online by operator’s network, so the access distance for monitoring is unlimited as long as there is a data network. The webcam can move automatically at a wider angle to monitor the entire contents of a classroom. The process of recording video, as well as streaming audio and applications on Android for more than one webcam.

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