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Design and Build Audio and Video Streaming on Raspberry Pi-based Reconnaissance Robot for Android

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Abstract

The development of sophisticated technology for human life starts from the development of computerized technology, information and communication technology, and technology in the field of mechanics, especially robotics. Robotics technology is a form of technological change that creates innovations all the time. The purpose of this design was to implement the technology concept of the Raspberry Pi microcontroller in the form of military applications, household chores, industrial areas monitoring, and security maintenance that may cause high dangerous risks without the user going directly to carry out the activities. The method used in developing the concept of merging audio and video followed the MJPEG Streamer and Darkice method. The product was a robot that resembles a car made using wheels that moves in the direction the user wants via an Android control. The communication employs a Raspberry Pi server sent from the robot to Android by displaying a streaming screen on the application. The data obtained are in images and sounds generated from the camera on the robot.

Keywords: Surveillance robot, Streaming, Raspberry Pi, Android

Abstrak

Perkembangan teknologi canggih bagi kehidupan manusia dimulai dari perkembangan teknologi komputerisasi, teknologi informasi dan komunikasi, serta teknologi di bidang mekanika khususnya robotika. Teknologi robotika merupakan salah satu bentuk perubahan teknologi yang selalu menciptakan inovasi. Tujuan dari perancangan ini adalah untuk mengimplementasikan konsep teknologi mikrokontroler Raspberry Pi dalam bentuk aplikasi militer, pekerjaan rumah tangga, pemantauan kawasan industri, dan pemeliharaan keamanan yang dapat menimbulkan risiko bahaya tinggi tanpa pengguna langsung melakukan aktivitas. Metode yang digunakan dalam mengembangkan konsep penggabungan audio dan video mengikuti metode MJPEG Streamer dan Darkice. Produk tersebut berupa robot menyerupai mobil yang dibuat dengan menggunakan roda yang bergerak ke arah yang diinginkan pengguna melalui kontrol Android. Komunikasi menggunakan server Raspberry Pi yang dikirim dari robot ke Android dengan menampilkan layar streaming pada aplikasi. Data yang diperoleh berupa gambar dan suara yang dihasilkan dari kamera pada robot.

Kata-kata kunci: *Robot pengawas, Streaming, Raspberry Pi, Android*

1. Introduction

Technological advancements and innovations have two effects on human existence, spanning from computerized technology to robotics. Information and communication technologies. A human being's attitude or actions determine whether technology has a good or negative influence. Many new technologies have emerged in this more complex era. One of them is in the field of security or the development of old technology, precisely the existence of mobile technology known as robots, a type of technological development implemented to produce new inventions **[1].** One of the beneficial effects of human-powered technology is the advancement of robotics, which is now advancing at a quick pace to aid human activities in various sectors, such as manufacturing, mining, agriculture, security, and even entertainment. Typically, the robots used are surveillance robots intended to monitor risky industrial locations **[2].**

Robots provide several benefits and have become an integral part of contemporary life, as evidenced by the military's use of surveillance robots to conduct impossible tasks directly on humans to monitor dangerous circumstances and situations. However, due to the lack of sound output characteristics, which are equally crucial in the monitoring process, the monitoring system has not yet reached its full potential. Robots have also begun to make inroads into the fields of entertainment and education, as well as household chores **[2][3].** With androids that can be used in addition to being a means of communication, functioning in the media, accessing the internet, we can easily control the state of using an android that has been connected with robot users.

This android uses an app that can see the condition of the place through a camera connected to the Raspberry Pi directly streamed. This app was created by using Android Studio software **[4]**. The design of the robot was developed by implementing IP cameras to monitor the condition of the room, but still using computer devices of which weaknesses are difficult to carry around compared to using android devices. With android, it can monitor the situation directly and continuously without overloading large storage. It can display objects full of data obtained through a Wi-fi connection sent by Raspberry Pi **[5][6].**

Robots can be employed for personal or everyday objectives, such as predicting occurrences and detecting the presence of movement, in addition to monitoring and controlling. The robot system was tested by providing monitoring results in audio and video and testing the robot's control on an android using joystick data from Firebase that

corresponded to its movement in the application [7]. Robots have become an essential device in developing robotics technology, taking human activities, physical tasks, and monitoring using programs to make the device active with commands based on the user [8]. Therefore, it takes development in conducting surveillance by making the robot display audio and video simultaneously in real-time and continuously in audio and video capture. With audio side by side with video, users can maximize the results of monitoring using android apps. From this, it is designed to use a server to stream audio using Caster.Fm and video servers with a Raspberry Pi server.

2. Methods

Researchers used the MJPEG Streamer method to display video and Darkice as an audio configuration in this design. When the two configurations were ready to run, the merge was done so that the construction of audio and video was displayed simultaneously. The configuration was implemented on the Raspberry Pi using the Archlinux operating system. Then, it was connected by getting an IP address between the Raspberry Pi and the camera. The configuration of merging between the MJPEG Streamer method for video and Darkice for audio was as follows: using puTTY software with the Archlinux operating system was described when the configuration was successfully marked with the active status of the program. Audio and video configurations are presented in **Figure 1.**

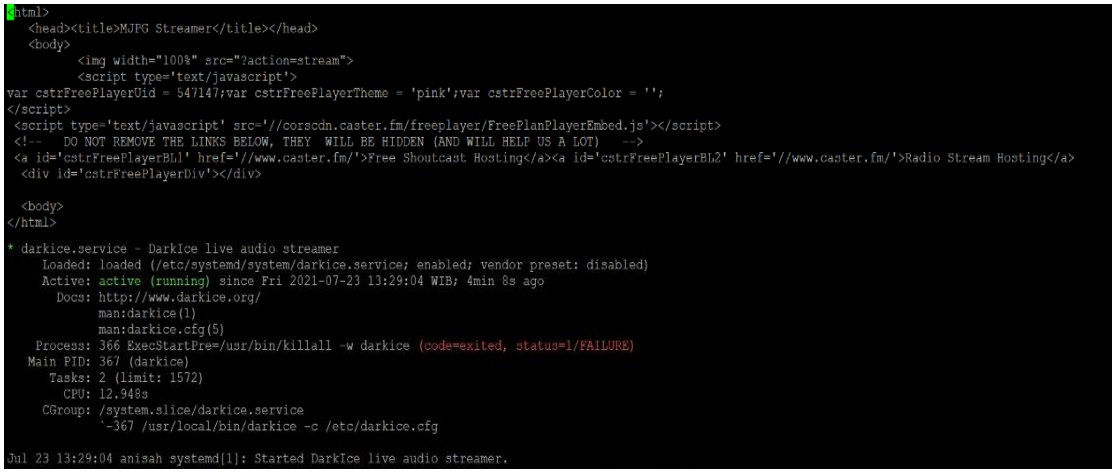

Figure 1. Audio and Video Configuration

a. Hadware Design

The design used two microcontrollers in Arduino Uno and Raspberry Pi that connected each other with several supporting components. It then used a block diagram to give a better understanding of the flow of hardware to the user.

The Hardware Design Block Diagram is presented in **Figure 2.**

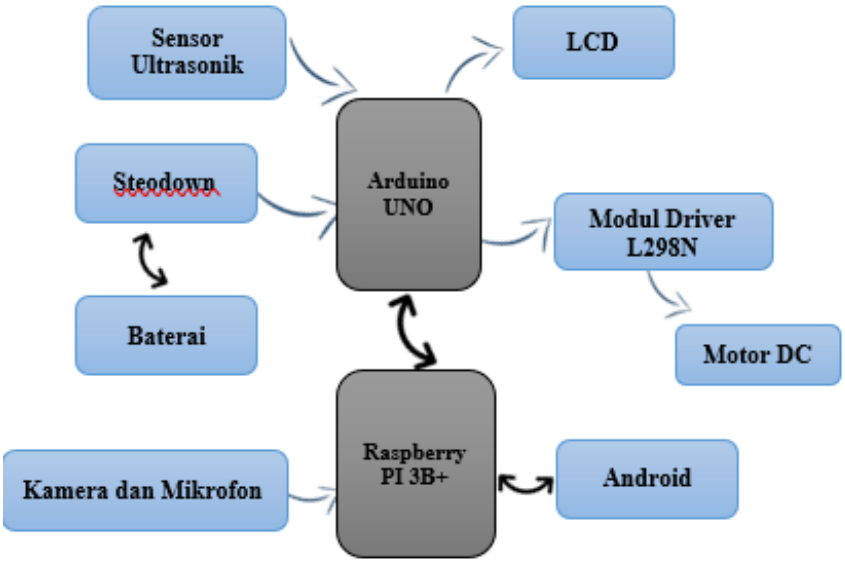

Figure 2. Hardware Design Block Diagram

Figure 2 is a block diagram that explains how the Raspberry Pi functions as a server that sends communication to androids and the Raspberry Pi. For example, camera devices and microphones are configured through commands from Raspberry Pi in the Python language to connect to the internet via Raspberry Pi so that they can display the results in the form of audio and video on Android applications. Supporting components such as ultrasonic sensors, LCD (Liquid Crystal Display), L298N Driver Module are connected to Arduino Uno as command-and-control manager of each supporting element **[9]**, and a battery with a battery voltage of 12 volts as power for the Arduino Uno. The DC motor takes command of the L298N Driver Module connected to the Arduino Uno. Once all the devices and supporting components are connected, they are connected between the Raspberry Pi and Arduino Uno into one unit to communicate with each other with Android commands. In determining the block diagram design, a flowchart is also required, which is the workflow of the device. Hardware Specifications used are presented in **Table 1.**

Table 1. Hardware Specifications Used

No	Hardware	Specifications
1.	Raspberry PI 3B+	1. Processor: Broadcom BCM2837B0, Cortex-A53 SoC 64-bit @ 1.4GHz 2. Memory :1GB LPDDR2 SDRAM 3. Micro SD format for loading operating systems and data storage 4. Input Voltage: 5V/2.5A DC via micro-USB 5V DC connector via GPIO header 5. There are 16 GPIO Pins included with VCC 5V and 3.3V, GND, TX, RX 6. USB and Ethernet connections
2.	Arduino Uno	1. Has 14 PWM digital pins including TX RX, six analog input pins 2. USB connection 3. 16MHz Crystal oscillator, reset button 4. Vcc 5V and 3.3V, GND
3.	Modul Driver L298N	1. Moving the dc motor 2. Has a maximum power of 25W 3. Module Dimensions in 43x43x26 millimeters 4. Voltage for input used 5volt-35volt 5. The output voltage of 2A
4.	Ultrasonic Sensors	1. To determine the distance of the device from objects 2. Can read distance from 2cm to 400 cm 3. Read each angle by 15 degrees 4. The voltage used is 5v 5. 60 ms reading cycle
5.	Camera and Microphone	1. Maximum resolution of 720p camera 2. There is a diagonal field of view of 55 degrees 3. Type of mono microphone with noise-reducing 4. Range of audible distance from a distance of 1.5m 5. USB connection
6.	Stepdown	1. Used to lower the voltage to be stable 2. Dimension module stepdown of 42x20x14mm 3. DC input voltage of 3V-40V [10] 4. The output voltage of 1.5V-35v
7.	LCD *(Liquid Crystal Display)* 16x2	1. Voltage of 5V 2. The working voltage of VCC, GND 3. Dimensions of 80x35x11mm 4. Consists of 2 lines and 16 characters

In **Table 1**, the specification of each hardware used in hardware design explains that each hardware used can be connected into one unit. The specifications results are shown for the hardware used following each capability on the microcontroller and each hardware capability.

With hardware specifications, it was easy to create workflows using flowcharts. The Hardware Flowchart is presented by **Figure 3.**

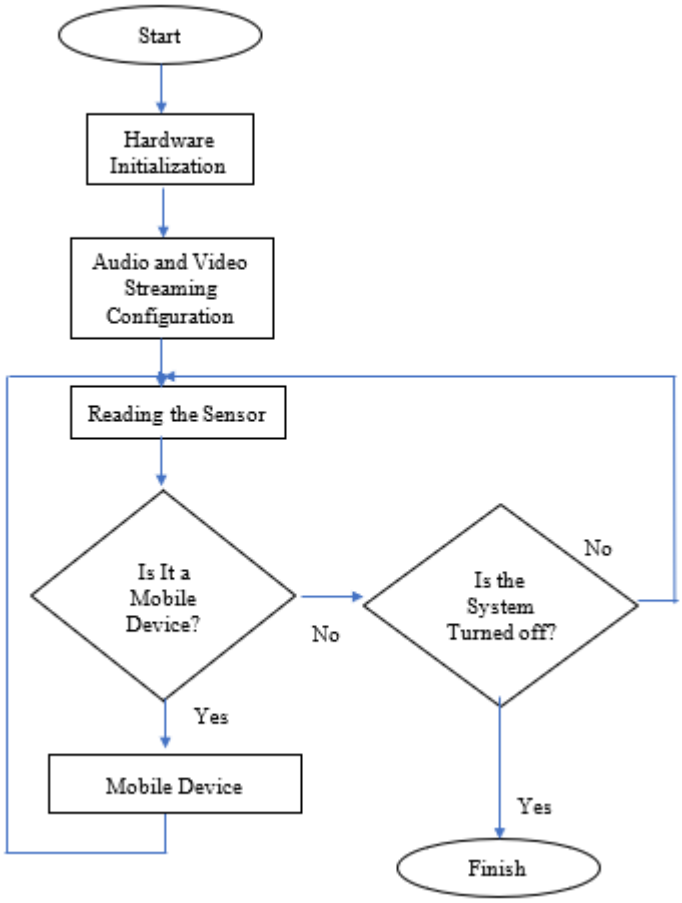

Figure 3. Hardware Flowchart

Figure 3 describes the movement system of hardware to display the results of hardware monitoring that begins with the initial rating or initialization of the hardware system that inputs the audio and video configuration, reads distance data from the sensor to the server, and ensures the robot moves or does not move.

b. Hadware Design

At this stage, software design created a control application for hardware that displayed streaming screens, IP search addresses, joysticks as robot controls, and distances on ultrasonic sensors using Android Studio configured with a flowchart. The Android App Flowchart is presented by **Figure 4.**

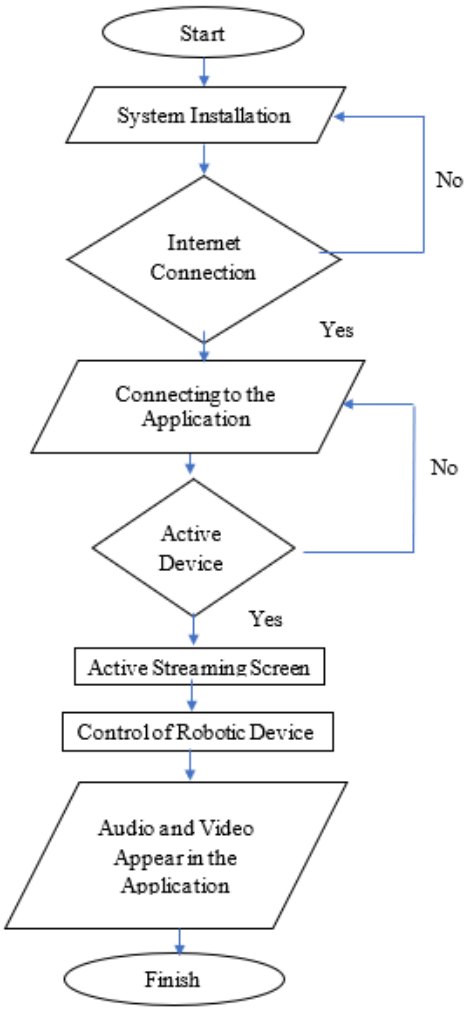

Figure 4. Android App Flowchart

Figure 4 is a flowchart of application development on android. It starts from the login page, and the user ensures the system is installed and has a stable internet connection connecting directly to the application. If it does not, return to ensure the system is installed. When relating to the application and the device is active, the active streaming screen runs, and the joystick movement control functions well. Audio and video can be viewed on the streaming screen in real-time in the app. In supporting Android application creation, additional software is required that can help in generating the desired application. The Supporting Software Specifications Used are presented in **Table 2.**

Table 2. Specifications of Supporting Software Used

No	Software	The scope	Specifications
1	Arduino IDE	Ran a program of all supporting components on the robot	1.6.11 version
2	puTTY	Ran programs on Raspberry PI using the Python language Archlinux operating system [11]	0.74 version
3	VLC Media Player	Played and viewed audio and video quality	3.0.14 version
4	Android Studio	Created a control application that would be used to run robots in Java [12]	4.1.3 version
5	Xampp	Saved website files to localhost hosting called through browser	3.2.4 version
6	WinSCP	Transferred darkice configuration data and MJPEG streamers to puTTY	5.17.10 version Code Based puTTY 0.73+
7	PHP My Admin	Is a free software that managed MySQL administration operations such as databases	5.5.30 version - Cll – MySQL Community server

Table 2 explains the scope of programming in generating the desired android application with some supporting software tailored to the hardware specifications used.

3. Results and Discussion

a. Result

1) Robot Hardware Design Results

These are the overall hardware design results connected to each other using supporting hardware tailored to the capability specifications of the Raspberry PI and Arduino Uno microcontrollers. The result resembles a toy car that has four wheels as a tool for the movement of the robot. The Overall Robot View is presented in **Figure 5**.

Figure 5. Overall Robot View

Figure 5 shows the physical form of the robot as a whole from the design of robot hardware that has been designed following the position that allows the robot to function appropriately. This robot had installed all the devices and components and are ready to work. The robot had a size of 20cmx10cmx7cm divided into two parts: the top and the bottom. The entire device in the robot could be configured with a circuit scheme to determine the position of the component connected with the microcontroller to perfect the robot so that it moved following the commands of the program created. The Overall Series Scheme is presented in **Figure 5**.

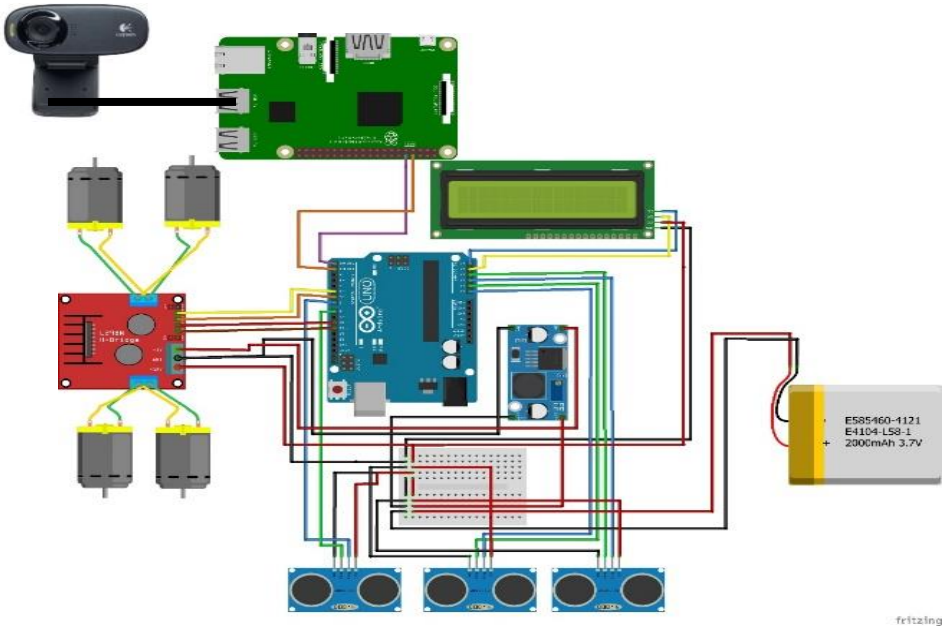

Figure 6. Whole Series Scheme

Figure 6 is a series scheme that explains the overall device and supporting components in the robot. The ultrasonic sensor in this design has a role as a distance control between the robot and the surrounding objects to avoid collisions and make sure that the robot moves well. In this design, we used three ultrasonic sensors to see the distance from the front, right, and left sides. The Liquid Crystal Display displayed the degree of rotation sent from the joystick on the android app and indicated that the robot is active.

The L298N Driver Module serves as the drive and adjusts the rotation speed of the DC motor. Judging from the datasheet, the IC had a large current supply capability of 4A. Usually, the greater the current passed by the IC, the greater the heat. The Stepdown in this design was used to hold the amount of voltage, not to change the output. When the overall design was successfully connected with the android application and moved using a joystick, the

movement of the robot was obtained. The results of the Robot Movement Design are presented in **Table 3.**

Table 3. Results of Robot Movement Design

Command	DC Motor Condition	Data Joystick	Result
Stop	All Motor Stop No Movement	0^o	successful
Forward	Motor Moving Forward	0^o -180^o	successful
Backward	Motor Moving in The Direction of The Rear	180^0 – 360^o	successful
Turn Right	Right Motor backward, Left Motor Forward	0^o -90^o	successful
Turn Left	Left Motor backward, Right Motor Forward	90^o -180^o	successful

Table 3 describes the position of the joystick rotation according to the movement used by the controls on the android. The table shows that in the command section, the stop, by the DC motor condition, resulted in "successful". Similarly, the forward, turn right, and turn left commands are according to the motor's condition and the joystick data set. The results of ultrasonic sensor readings or distance sensors are presented in **Table 4.**

Table 4. Ultrasonic Sensor or Distance Sensor Reading Results

Sensor 1	Sensor 2	Sensor 3	Robot Direction
10 cm	10 cm	10 cm	Stop
20 cm	20 cm	20 cm	Rotate Left
30 cm	30 cm	30 cm	According to Control Orders
>30 cm	>30cm	>30cm	According to Control Orders

Table 4. describes the readings of the distance sensor or ultrasonic sensor that set. When an object is in front of the robot within 10 cm, the robot stops and returns to the initial system setting of joystick rotation of 0 degrees. At a distance of 20 cm, when an object is in front of the robot, it rotates to the left. At a distance of more than 30 cm, without a barrier in front of the robot, it moves back according to the control command in the android application.

2) Android Software or App Design Results

The android application design is used to monitor the state of the condition where the robot is located with the display of the streaming screen, the address for IP searches of connected cameras. With this application, the user can efficiently perform monitoring of the robot placed in the desired place. Robot movement adapted to joystick control in apps on android.

Figure 7. Joystick display and streaming screen

Figure 7 displays the results of the design of an android application. It shows a part of the streaming screen showing video and audio from the creation of the robot and the joystick used to control the robot according to the joystick data in Table 3 to find out the quality of the streaming results viewed using the VLC Media Player application. Quality Results from Audio and Video are presented in **Figure 8.**

Figure 8. Quality Results from Audio and Video

Figure 8 displays data from the VLC Media Player app to see the specifications and quality of audio and video. From the results of checking through the application, it appears that the resolution of the video was 640x640, and there was no buffering that resulted in slow and inappropriate video playback in the video shooting. The test results of the audio data had a sample rate, which was an essential explanation in the sense that it was easy to record every second repeatedly and continuously.

The most common sample rates were 44.1k, 48k, and 96k Hz. The higher the sample rate, the larger the audio file size. The data obtained from the audio results on the robot was 44.1k Hz. At a bitrate of 32kb/s, which was a constant bitrate (CBR), if any audio is played, it remains the same rate and does not affect the sound production in the crowd.

b. Discussion

The Raspberry Pi-based surveillance robot with android app control was designed to work according to the control commands of the application with the internet network as the communication between the android user and the robot. The control app allowed the user to perform back and forth, right-left turn, speed setting, and stop positions. This control command worked by sliding the joystick along the x and y axes. The x-axis was a right-left turn command, while the y-axis was a back-and-forth command. Joystick 360^{o} where 0^{o}-90^{o} shows were turning right, and 90^{o}-180^{o} turning left, 0^{o}-360^{o} Return to the starting point to use back and forth movement, when connecting to the Raspberry Pi. The control app also armed itself with a streaming screen to operate video and audio data captured by the camera. From the results elaborated in the results section, it is known that the configuration between audio and video could be realized without delay and the robot displayed the data simultaneously through the internet connection sent from the android via Raspberry PI and vice versa.

The resulting data was in the form of videos in Mp4 format stored in android applications. This design found configurations for audio and video merging that had never previously been simultaneously included. Previous research has shown that audio is done on a computer to broadcast sound and not display images or videos. The configuration produced in this design was simple and easy to understand and had developed into innovation in adding higher sound quality in the absence of noise. This configuration used the Archlinux operating system. In using this operating system, it is necessary to be careful when installing the Archlinux so that there is no communication failure between the audio and video configurations. Similarly, the configuration of merging between Raspberry PI and Arduino Uno into one whole series and retrieving data simultaneously.

4. Conclusion

From the overall tool design results, both from hardware and software design, Raspberry Pi-based surveillance robots with android control, it can be concluded that obtaining data in the

form of audio and video through communication from the Raspberry Pi can be realized. Robots can be moved in any direction and not just focus on a single spot. The speed of the robot is at 100m/s via Arduino Uno software. A camera will display the results in video and audio data connected to the android application directly from the robot. These test results obtained the surveillance robot's performance in hazardous areas that do not allow the user to descend directly to the place. Audio and video data will be stored continuously on Android via Raspberry Pi.

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