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Design of Telerobotic system using Bluetooth with Behaviour-based Control Architecture

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Abstract. Telerobotic system is needed in several environments to perform a process in a remote system using a robot. Some peripherals are connected and used in a telerobotic system. Unfortunately, to interconnected the peripherals, control remotely and perform a task entirely in limited time is not easy. It needs a robust control architecture. Several classic and modern control has been attempted. This paper proposed a behavior-based control architecture to control a telerobotic system using Bluetooth. Several experiments have been performed in a real robot. Based on some results, the proposed system able to run a telerobotic system to perform several tasks well.

1. Introduction

The development of robotics at this time the robot can be used for heavy-duty, dangerous, repetitive and dirty work. The use of other robots includes cleaning of toxic waste, underwater exploration and outer space, mining, rescue mission work. In the past, robots were not an option because of the high cost and required trained people to operate it. However, in its development, robots are used in situations and locations that were unthinkable in the past [1]. In recent years, wirelessly controlled robots have been used in search and rescue missions. This robot must be controlled deep into the ruins to search for possible casualties and to transfer important data along with a video to the savior [2].

Telerobotic in recent years have increased use of wireless communications and demand for systems that can easily connect devices for wireless long-distance data transfers worldwide. The software system can be built in three different programming languages and controlled over the internet by using web pages that are protected with username and password to ensure it cannot be hacked. Web pages designed to control robots remotely via the internet by web browsers such as Mozilla Firefox. Robots can be controlled using any device, laptop, mobile or tablet. The main problem in this telerobotic discussion is speed and accuracy.

The problem with communication media is still a significant obstacle to this telerobotic robot where the robotic area of the field can become an obstacle. The problem of distance will significantly affect the speed and accuracy of the robot, the issue of time delay speed and accuracy will be hazardous if doing medical work and rescue mission in dangerous situations. Telerobotic can go into locations that humans cannot, and robots can be strong enough even to lift the car [1]. The problem of inaccurate robot movement is also a constraint resulting from the failure of communication. So that the action of controlled robots from a distance with wireless is not as expected.

Kind of research about telerobotic one of them learns remote control using a remote controller through WLAN. Extinguishing Fire, avoiding obstacles by viewing video display, Robot has a network camera that sends video directly to the remote control. With the robot method can be controlled remotely, can



walk and move autonomously from a certain distance can see the video display on the robot. With data of delay time measurement, screenshot image, connection result, video streaming and useful distance test. To improve security to access robots and data generated by robots, passwords are used in LAN (Local Area Network) and passwords with OTP (One Time Password) for WAN (Wide Area Network).

Robot design, the robot can be operated via Android Smartphone phone. Robot control is done wirelessly with Android Smartphone communication using Bluetooth feature even though the distance is close but more stable. This robot is a camera that connects with Android smartphone to facilitate monitors from a range or in different rooms and locations. To control the device of the whole system by using an Arduino UNO Microcontroller. Bluetooth Module, Smart Phone IP Camera, Module Diver Motor that aims to move the motor. In achieving the task of Arduino Microcontroller is uploaded with a program written using programming language.

2. Method

The design of the required hardware and software will be described in this section by showing the block diagram of the streetlight automation system that will be created and the program flow chart of the method.

2.1. System design

To realize this robot, then the whole system of simulated robot simulation using android smartphone using communication via Bluetooth for motor control and Wi-Fi for video display as in Figure 1.

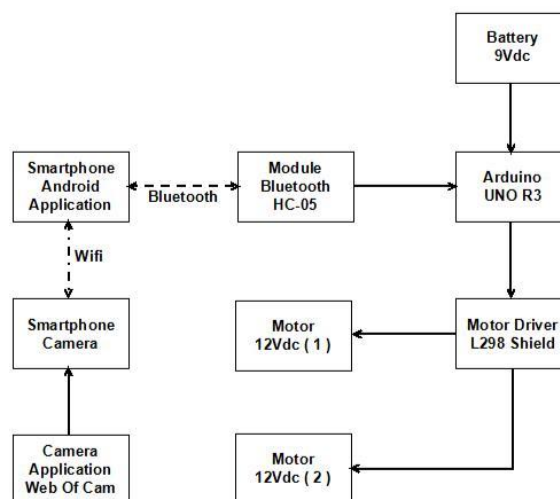


Figure 1. Block Diagram

In concept block diagram according to Figure 1 where smartphone uses Bluetooth connection with module HC-05. Arduino Uno gets 9Vdc power input from the battery, as the microcontroller already in the program receives a connection from HC-05 then the resulting data is fed to the L298 Shield motor Diver to drive the motor 1 and motor 2 for forward, backward, right and left motion.

Using Arduino UNO as the brain of this robot, so in making this robot requires an Arduino Uno. The framework design of this robot uses two wheels with a simple framework that moves freely forward, backward, left and right.

In this design, Arduino is a microcontroller with ATmega 328. In designing this robot use Arduino using an output of PWM (Pulse Width Modulation) as a speed regulator. Shield connection with LM298 shield motor device, power input from battery 9vdc. Arduino has everything needed for designing this robot, easily connect it to a computer with a USB cable. For Arduino programming with computer serial communication as well as data communication between microcontroller with a laptop using Arduino UNO application. Arduino for connection with Bluetooth module HC-05 is also available RX, TX, 5v & GND so easy to operate.

This robot uses a DC motor for driving. DC motor is controlled directly by the microcontroller. The microcontroller voltage is only 5 volts, while the dc motor used in this robot requires 12-volt voltage to work optimally. This motor control circuit called the motor driver (L298 Shield) and two batteries 9 v combined in series with the aim of 9 volts, but the ampere is up.

This motor driver comes with a shield that the output pins are adjusted to the Arduino UNO. So, this circuit can be mounted easily on Arduino UNO without needing soldering and more jumper on IC 298 output pins.

Seen in Figure 2 shows that the base robot is made using plastic acrylic with 1 mm thick for strong from vibration and load of battery, smartphone, and microcontroller.

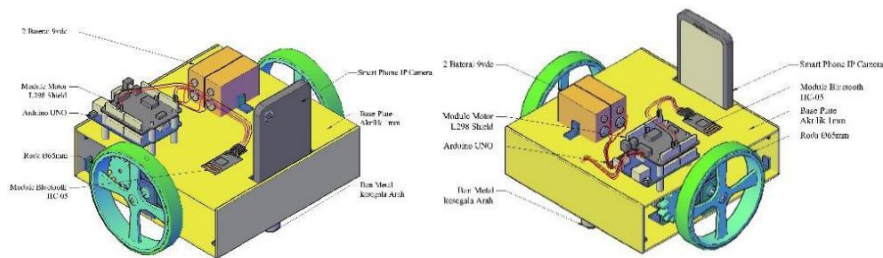


Figure 2. Design the form of robots

2.2. Flowchart

Making this control application cannot be separated from the making of flowchart system where the author hopes by making this flowchart, can simplify and precisely target for making robot, program, and testing to get a result as expected.

As seen in Figure 3 this application starts with Bluetooth connection smartphone with Bluetooth module HC-05 make connection and pairing process by entering password and Wi-Fi connection with LAN or with Peer to peer for IP camera connection. So next can open the inventor application that has been installed on a smartphone, then start to screen to 2 main views.

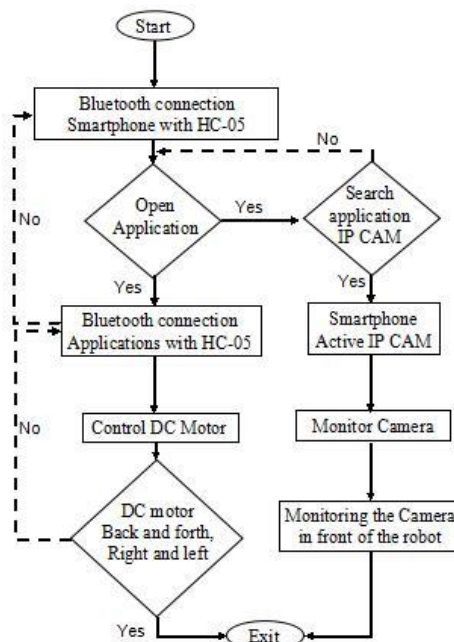


Figure 3. Flowchart robot controller application

In the process of opening this application Bluetooth connection into the form so that the link appears green and IP address that has been in the appropriate input IP camera that is on camera web of cam application that can be downloaded in the app store android. If the Bluetooth and IP camera connection is active then the video display will appear according to the view in front of the robot and dc motor control to advance, backward, right, and left can be done by viewing the picture in front of

the robot, if the application and robot running hope can exit the app or close the app by pressing the exit button.

3. Results and discussion

3.1. System design result

Here are the parts of the design that has been done. Divided into 2 sections namely hardware and software.

After the design and programming are completed, the next step is testing and analyzing the device based on the test point of the series to be recorded. The process of testing there is how many things will be tested. Testing and data collection is done repeatedly to produce data that is really accurate.

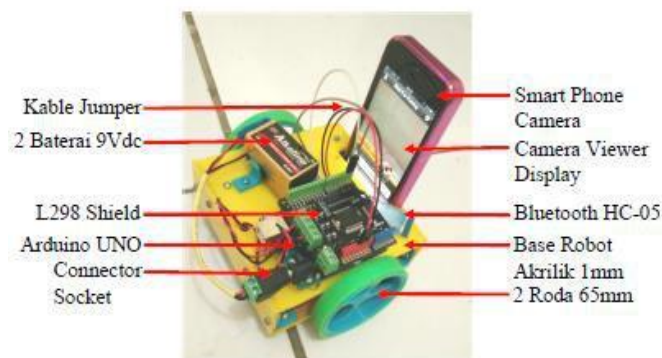


Figure 4. Devices

In testing the mechanical device as in Figure 4 base plate entirely using 1mm plastic acrylic that can withstand the weight of dc Motor, Arduino, Driver l298, Battery and Smart Phone camera. For the main material, wheels use plastic PVC and coated rubber so that one of the wheels does not happen slip that resulted not run straight, for smartphone camera placed in front of a robot with inbox which has been hollow for a smartphone can be installed. For Arduino installation, L298 and HC-05 drivers use the spacer that is positioned on a base plate, and there is jumper cable to connect HC-05 with Arduino and power cable from 9 VDC battery. Smart Phone can configure your phone into a camera or Viewer unit can enter IP address displayed on the camera device to a web browser so that it can see a video display.



Figure 5. Web Application Display of Cam

In Figure 5 the web app display of this camera after downloaded in the App Store and installed on the Android smartphone that will be a viewer or camera. After opening the application, it will show a step 1 and step 2 where the choice Viewer or camera in the design of this application robot into the camera after selecting the camera and the next and the camera with IP Address.

3.2. Experiment result

A test is divided into several parts, namely hardware, and software. Here is a test that has been done.

3.2.1. A communication test

This test aims to find out whether the Bluetooth HC-05 module can communicate with Android, this test is done by giving 5Vdc power on Bluetooth module which then its existence is detected by Android with Bluetooth scan.

Bluetooth detection test by activating the HC-05 module along with Arduino which is connected with a jumper cable and 5 vdc power input for HC-05. Then, current mode Bluetooth on smartphone control or smartphone user after detected HC-05 then select and enter pairing Bluetooth.

After a scan, then at the available device, there will be devices detected by android the Bluetooth module HC-05. Select then there will be pairing dialog box will ask for a pin (default 1234) for pairing with Android and Bluetooth HC-05 has connected with a smartphone.

Table 1. Test Bluetooth connection

No.	Type of test	Expected results	Test results
1.	Turning on Bluetooth connection on Android	Bluetooth is on	Succeed
2.	Turn off the connection Bluetooth on Android	Bluetooth off	Succeed
3.	List displays Bluetooth device pair on Android	List of paired devices	Succeed
4.	Connect Bluetooth connection from the list of paired devices	Connection connected	Succeed
5.	Decide Bluetooth connection from the list of paired devices	Connection lost	Succeed

The results obtained from Bluetooth testing with Bluetooth control distance testing open area and testing in the enclosed space as follows.

3.2.2. A robot movement test

The purpose of testing the system as a whole is to know how the robot moves and communicates through the control of the user. Testing is done by trying the actual buttons on the control app already installed on Android. Each test is done step by step, i.e. forward, backward, turn left, turn right and stop.

Table 2. Trials of Robot movement

No.	Type of Movement	Direction Turn Left Motor	Direction Turn Right Motor	Test Results
1	Advanced	Advanced	Advanced	Succeed
2	Back off	Back off	Back off	Succeed
3	Turn left	Back off	Advanced	Succeed
4	Turn right	Advanced	Back off	Succeed
5	Stop	Stop	Stop	Succeed

From Table 2 test the movement of the robot forward, backward, turn left, turn right and stop by paying attention to the direction of the motor rotation and the right motor. With the result of forwarding direction forward motor rotation direction and forward direction motor rotate forward, backward, reverse direction reverse motor direction and reverse direction motor right backward, command turn left reverse direction motor left and backward direction of motor rotation right forward, command turn right direction turn left motor forward and reverse direction motor right backward, stop command we do experiment with run-first robot then dismiss it with result of rotation direction left motor stop and right motor rotation direction stop, with experiment several times this is taken result overall that robot successfully walk command.

3.2.3. A camera test

Results obtained from the camera test by testing the distance of the open area camera, testing in the closed area and the following camera screenshots.

Table 3. Camera test

No.	Type of test	Expected results	Test results
1.	Connect	Camera connected	Succeed
2.	IP camera with smartphone control	(Visible images around the robot)	
	Creating connection with	Any network changes	Succeed
	LAN & P2P camera IP with	need to connect again	
	smartphone monitor control	(visible images around the robot)	

Based on Table 3 results obtained from camera testing, wifi communications connect IP camera with smartphone control and make a connection with LAN & P2P. But from the results of this test, the camera can be connected by showing images around the robot.

Table 4. Closed area camera test

No.	Distance test	Test results
1.	10 meter	The camera works fine
2.	20 meter	The camera serves disjointed
3.	>20 meter	Camera connection disconnected The camera is off

Based on Table 4 the results obtained in 10 times camera testing in this closed area using LAN modem bolt with separated between the robot outside the room and smartphone control in the room, Wi-Fi camera communications can only reach approximately 20 m. But from the results of this test, more than 20 m camera connection disconnected and the camera off.

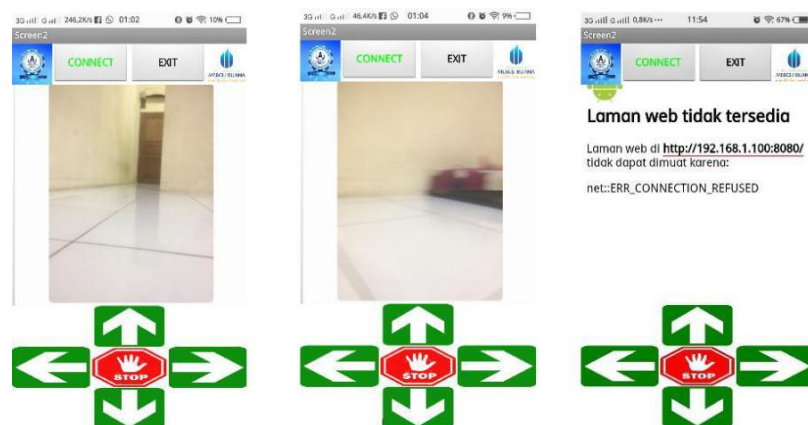


Figure 6. Display on smartphone control

From the screenshot on the camera control or camera user seen in Figure 6 visible display on the Bluetooth, a button has been connected. For previous camera connections activate the camera on the existing smartphone on the robot by using apps that can be downloaded in the Appstore, on the smartphone control or user enter the camera IP address in the Inventor MIT2 application URL after it is reinstalled on the smartphone control or user and shown in the application with the results of the camera shows the video display in front of the robot clearly.

From the screenshot on the camera control or camera user seen in Figure 6 visible display on the Bluetooth, a button has been connected. For the camera, connection shows the video display in front of the robot suffered a blur and the video stopped with blur display due to delay disturbance. This delay disruption impacted the video display and not real-time video caused the robot to hit the front of the object because it is not visible, the screenshot in Figure 6 testing the happening of this delay is done in the closed area.

From the screenshot on the camera control or camera user seen in Figure 6 visible display on the Bluetooth, a button has been connected. For the camera does not appear on the display because the IP address that has been input on the application inventor MIT is not connected with the camera smartphone. Screenshot in Figure 6 testing occurs the problem of not combined smartphone control with a modem and smartphone that resulted in not showing the video only show the IP address that is input to the URL of MIT inventor application.

4. Conclusion

This robot can move well to the left, right, forward, back and stop. Robot control can be done using an Android smartphone. Communication between Android and Arduino UNO using Bluetooth with HC-05 with Bluetooth control result in an open area, Bluetooth communication can only reach 30 m, while Bluetooth control in a closed area is separated between an outdoor robot and smartphone control indoors, can just reach approximately 10 m. The camera uses Wi-Fi communications connecting the IP camera with the control smartphone and making connections with LAN & P2P cameras can be connected by showing images around the robot. The camera in this open area uses LAN modem bolt, and Wi-Fi communication camera can only reach 40 m. While the camera in a closed area separated between the robot outside the room and smartphone control in the room, Wi-Fi camera communications can only reach 20 m. All smart android testing is successful and iPhone only uses iOS version, upgradable to iOS 9.2 does not work with iPhone iOS control smartphone iOS version upgradable to iOS 9.2 can just be camera just. For camera web of cam application that can be downloaded from Appstore can connect more than 1 smartphone. A device on a smartphone Bluetooth connection can connect more than one smartphone, while Bluetooth application MIT Inventor Bluetooth connection already installed on a smartphone cannot connect with more than one smartphone.

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