Automated Robot Movement in the Mapped Area Using Fuzzy Logic for Wheel Chair Application

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Abstract. The difficulties of the disabled to move make them unable to live independently. People with disabilities need supporting device to move from place to place. For that, we proposed a solution that can help people with disabilities to move from one room to another automatically. This study aims to create a wheelchair prototype in the form of a wheeled robot as a means to learn the automatic mobilization. The fuzzy logic algorithm was used to determine motion direction based on initial position, ultrasonic sensors reading in avoiding obstacles, infrared sensors reading as a black line reader for the wheeled robot to move smooth and smartphone as a mobile controller. As a result, smartphones with the Android operating system can control the robot using Bluetooth. Here Bluetooth technology can be used to control the robot from a maximum distance of 15 meters. The proposed algorithm was able to work stable for automatic motion determination based on initial position, and also able to modernize the wheelchair movement from one room to another automatically.

1. Introduction

Currently, robotic technology is widely used in the industrial world to undertake the production process. The robot is also used to replace the human work that considered to be difficult and dangerous to humans. We only need to control the robot remotely, and so the jobs can be done more securely and efficiently [1,2].

The use of robots to support daily needs plays a role in the development of information technology. Various forms of the robot had been developed: mobile robot, network robot, robot manipulator (for hand), Humanoid Robot, Legged Robot, Flying Robot (Flying Robot), and Robot In Water (Under Water Robot). The robot has been widely applied in everyday life and used to replace human activities that are considered severe and dangerous [1].

The difficulties of the disabled to move, make them unable to live independently. People with disabilities need tools to move from place to place. For that, we need a solution that can help people with disabilities to move from one room to another automatically.

In 2010 a study was conducted to make micro-mouse robot by using depth-first search algorithm automatically, and the robot was paired with an infrared sensor to follow the black line. Here the robot did not have control and looking only for the path that will pass from one point to another [3].

In 2012 Febriani et al. conducted research to control the robot using a camera sensor that can recognize a predetermined object and follow wherever the object was move. Robot motion control
using image-based random method was used [4]. Previews conducted research to control the robot using a smartphone with Bluetooth media. Robot received commands sent by smartphones such as: forward, backward, right, and left movement [5]. Moreover, furthermore, in 2015 Choudhury researched controlling robots using ultrasound and using the pointbug algorithm. Control of the robot was done using voice command from Google API so that that robot can receive voice message as well [6]. Some previous research also focused on specific location-based control algorithm for example in person locator [7] and crowd mobility simulation [8].

This study was designed to build wheelchair with robotic motion systems in the mapped area with the support of sensor technology and fuzzy logic algorithm.

2. Method
The starting point of the location for this robot first been determined. The input target of this app is the destination location. Sensors are needed as a tool to provide information about surrounding environment to facilitate the movement of robots; We used ultrasonic and infrared sensors that function to transmit information regarding objects that block the movement of robots and infrared sensors as black line readers. Furthermore, the command will be sent using Bluetooth media and processed into commands. The general architecture of the system can be seen in Figure 1.

![Figure 1. General Architecture.](image)

The input of the system was the destination location marked with a blue circle, the starting point of the robot has been determined that be marked with a red circle. The movement of the robot to the location was controlled by using the smartphone so that the robot moves according to the desired destination set by the user. Smartphones connect with robots via Bluetooth media as the process of sending a destination command. The robot will move automatically to the location that has been determined by the user using a smartphone as a robot control system.

Wheelchair robot has embedded a program for determining the predetermined location automatically by using the fuzzy logic algorithm. Fuzzy logic specified one of some destination locations recursively. The robot was then also paired with ultrasonic sensors and infrared sensors. The ultrasonic transducer worked by transmitting a wave and calculating the reflection time of the stream. Ultrasonic sensors worked in a way so that the robot can avoid collisions with objects that are in front of the robot so that the movement to the location goes smoothly without any obstacles. The infrared sensor marked the black line for the robot to move above the black line.

The output expected was the movement of the robot to get to the location desired by the user. Users can control the flow of robots automatically or manually. It aims to modernize the wheelchair system.
automatically from one room to another. Floor plan design for this research can be seen in Figure 2, while schematic diagram for the whole system in this study explained in Figure 3.

![Figure 2. Floor Plan.](image1)

![Figure 3. Schematic Diagram.](image2)

The design form of the system proposed in this study can be seen in Figure 4 which shows steps that users perform on the robot control application and the process done to move the robot to the destination location automatically based on the command given by the user.

Robot control process started when the robot and application on the smartphone have been connected. The connectivity between the two systems was done by utilizing Bluetooth technology as a media liaison between devices.

The control that can be done on the robot application of this location control was:
1. Automatic movement.
   This process is done by giving the command to the robot to move automatically to the location that has been addressed and mapped.
2. Manually-controlled movement.
   In this process, the application can perform the control manually. This process is done by giving orders to the robot to move manually with the command forward, backward, right, and left.

2.1. System Design Analysis
To analyze the system we designed, here we use process diagram which shows process chain in the application and robot control in both automatic and manual movement.

![Figure 4. Controlling Process Diagram.](image3)

The robot control process to get the wheelchair robot to a location using this Android app was as follows:
1. Users pair-to-pair android with robot device using Bluetooth.
2. In this pair-to-pair process, the user inputs the Bluetooth code of the robot device on the smartphone.
3. The Bluetooth code sent by Android smartphone will be processed by ATmega8 to be customized and to connect to each other.
4. If the code sent users using the smartphone accordingly, then the smartphone and robot device will be connected.
5. Once connected, the user can control the robot to get to a location automatically or manually using the smartphone.
6. Users use the app to control the movement of the robot. The control performed by the user is the movement automatically and manually.
7. In this control, there are two types of utilization of signals used, namely, analog signals and digital signals. Analog signals are used in the process of pairing between Bluetooth from smartphones and robots, while the digital signal is used in the output produced by ATmega8.

2.2. System Flowchart
A system flowchart is a chart showing the workflow of what was being done by the system as a whole as well as the procedures used in its operation (Figure 5). The stages of the system on the robot according to the flowchart are:
1. When the system powered the device will detect all devices connected to it. Such as Bluetooth, infrared sensors, and ultrasonic sensors.
2. After all, devices were detected, the system will wait for the pairing command performed by the user using the smartphone.
3. If the pairing process were successful, then the robot device and smartphone would be connected.
4. If the pairing process failed, the system would prompt the user to enter the device code correctly one more time.

This process ensures the robot device with the smartphone to be connected.

![Flowchart Connectivity Between a Smartphone and Wheelchair Robot](image)

Figure 5. Flowchart connectivity between a smartphone and wheelchaired robot.
After smartphones and robot devices were connected, the user can control the robot to get to a location that has been mapped both manually and automatically using applications that have been installed on the smartphone.

The steps to control the robot explained in Figure 6 were as follows:
1. Enter the bot control app on the smartphone.
2. Perform a pair-to-pair device and smartphone.
3. Once the smartphone and devices are connected, the next process is to enter the robot control menu to get to the mapped location.
4. The control was done by the user is to control the robot automatically and manually to go to a location that has been mapped.
5. In the process of automatic movement, the system used a fuzzy logic algorithm to determine the direction of motion based on the initial position.
6. In the manual control process, commands from the smartphone, i.e., right, left, forward, backward were given.

![Flowchart system for controlling wheel chaired robot automatically and manually.](image)

**Figure 6.** Flowchart system for controlling wheel chaired robot automatically and manually.

### 3. Results and Discussions

A set of system testing was done to find out the ability of the robot to move automatically or manually in the mapped area. In this test, we focused on the accuracy of the system in determining the space to be addressed. Also, testing also took into account the performance of devices attached to the robot. The plot was mounted on the robot as one of the most important parts because the attached device
captured data that was processed by ATmega8 for the robot to move appropriately. In testing the performance of this system to analyze the transmission, voltage is divided into two variations of distance that is five voltages, (± 5) voltages. The prototype was designed to test the performance of the system using the power coming from the installed battery.

The results of the processing done by the robot device and its effect on the robot system were shown in Table 1. To test the effectiveness of robotic movement, then the testing device was done based on location. Taking into account the position of the test to calculate a good position when the robot arrived and went to the specific location set by the user, as for the test results can be seen in Table 2.

| No | Devices         | Sent Voltage | Sent Voltage (±5) |
|----|----------------|--------------|------------------|
| 1  | Ultrasonic Sensor | Good        | Not Good         |
| 2  | Infrared Sensor  | Good        | Not Good         |
| 3  | Bluetooth       | Good        | Not Good         |
| 4  | Servo Motor     | Good        | Not Good         |

### Table 2. Performance Testing.

| No | Destination | End Position |
|----|-------------|--------------|
| 1  | Room #1     | Good         |
| 2  | Room #2     | Good         |
| 3  | Room #3     | Good         |
| 4  | Room #4     | Good         |

### 4. Conclusions

Smartphones with the Android operating system can control the robot using Bluetooth. Here Bluetooth technology can be used to control the robot from a maximum distance of 15 meters. Controller ATmega8 must obtain current and voltage supply from the appropriate battery so that the sensors and wheels can work properly. The robot in several testing success fully arrived at a specified location in a favorable position as set by the user. Automation of robot movement for disabilities to a location has been developed to modernize the wheelchair system.

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