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Outdoor Elderly Tracking System Using Line Tracking Mobile Robot with Bluetooth Communication System

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Abstract: The concept of Smart City provides technology that assist the elderly to practice their normal life indoor, while this research will assist the elderly in the outdoor environment. This research presenting a method for tracking people at outdoor using mobile robot which will be given an outermost path (line tracking) in an enclosed outdoor area. The mobile robot uses 2 IR sensors to detect the designated path and the processor will instruct to control its motion; besides, the mobile robot also consists of the Bluetooth devices in order to detect the tracker device; so that the mobile robot will stop and produce sound when the Bluetooth tracker device is in range. The outdoor tracking mobile robot was designed and developed to detect the presence of the tracker device and provide signal to declare its presence to the user. The design of the mobile robot can be improved further in future so that it can detect the tracker device without using line tracking as well as it can maneuver on an irregular environment.

Keywords: Outdoor Tracking, Mobile robot, Bluetooth, Tracker device, IR Sensor, Arduino Uno, Smart City, Fall detection

1. Introduction

With the latest technology that invented these years, most of the places around the city is bind with the technology which provided by the concept of Smart City [1]. With the evolution of Industry Revolution 4.0, robotic system and Internet of Things (IoT) it is one of the important challenges that need to be faced [2].

Current researches results show a low spread of smart home products rather than security system products. If smart homes technology is widely applied in the country, there is a chance to analyse more of the incidents happened around the country [3]. Thus, it is a good concept to create a safer residential area. Furthermore, the smart home product can be categorized in communication, security, smart devices, cleaning devices and culinary. For example, a person can control his house's light using sound

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recognition, the cleaning devices will clean the house automatically from dirt, communicate and recognize the person outside the house before entering the house, and also locking system without using hardware. For elderly assist, there are country that had invented and implemented the Fall Detection Technology that will inform responsible agent or family members which registered when fall detected in the housing area, and reminder alarm clock which remind dementia elder the task to do for them [4]. But for outdoor, currently there is not much devices that helping the elderly.

For outdoor, elderly need to take a stroll in nearby garden to maintain their health and body without getting devolution. But sometimes, the elderly might get lost and unable to return home as from research elderly that getting lost has not been clearly established [5]. Therefore, to monitor the elderly's health while let them to take a stroll in outdoor will require special tools or devices in order to ensure the safety of the elderly. The elderly people might spend their time lonely at home as other members of the family might be busy working or spending time outside the house for exercising. With the age factor, the elderly memory degraded with time and hence they might forget the ways to return home when they were exercising [6]. The memory downgraded is the most common disease that occurs in the elderly. Thus, in order to make sure that the elderly can live comfortable within the nearby area near their house is to provide an elder care mobile robot with tracking facilities.

The other problem is the wireless communication system which used to communicate between the mobile robot with the device to be tracked. Basically, the wireless communication system is a controller combination with transceiver pair to transmit and receive the control messages without hard-wired connection [7]. There are various types of wireless communication system which are Wi-Fi, Bluetooth, ultrasonic, and also Radio Frequency (RF) to proceed the tracking system. Different communication systems have their range limit for connection. Thus, it is required to determine the wireless communication system that can solve the outdoor tracking system.

The main objectives of this research is to design mobile robot that will lead the user to his item after giving command.

- To design and analyse mobile robot with line-detector sensor and Bluetooth module using Arduino and the path for mobile robot to follow.
- To develop the algorithms for the communication system between mobile robot and the device.
- To analyse the function of the mobile robot.

2. Materials and Method

This section will discuss the different components that have been used and will demonstrate the complete system in detail with block diagram and flowchart.

2.1 Overview of the research

In the proposed research, the mobile robot was built by using Arduino Uno, Bluetooth module HC-05, robot chassis, robot components such as motor, IR sensor, wheels, and using black tape as the path for the mobile robot to do tracking. The overall system block diagram is shown at Figure 1. Basically, the Bluetooth device will be carried by the elderly and the module on mobile robot will try to connect the device while moving according to the path pre-set in the location.

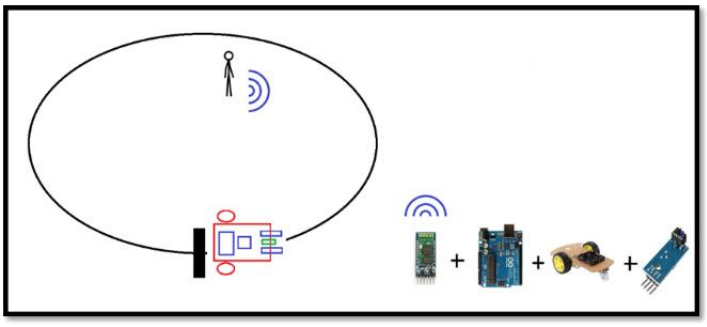

Figure 1: **Overview system block diagram**

2.2 Research flow

The design of the research is started with the hardware design. Firstly, the hardware is design according to the components that required to attach on the robot chassis. Then, the hardware is built up according to the sketch and tested. After testing the stability of the hardware design, the circuit construction is proceeded. Finally, the algorithm for the Arduino is design and upload it to the Arduino to make the prototype worked. Figure 2 below shows the flow of the research.

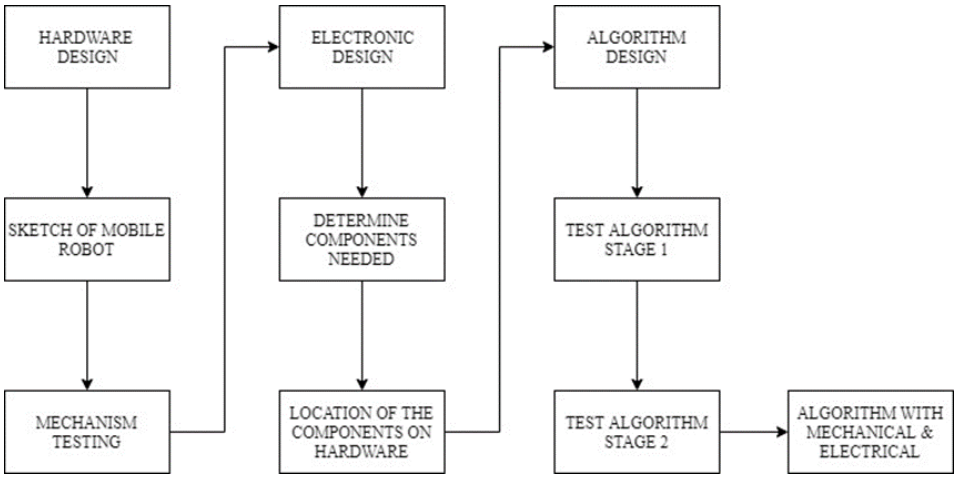

Figure 2: Summary of research flow

2.3 Hardware and components

This section shows the hardware and the components used in order to design and construct the prototype. The processor used is Arduino Uno, L298N motor driver. Besides, the prototype also consists of the HC-05 Bluetooth module in order to detect the presence of the object nearby. The sensor used for this prototype is the IR line sensor module in order to complete the line tracking task. Figure 3 shows the schematic connection of the circuit.

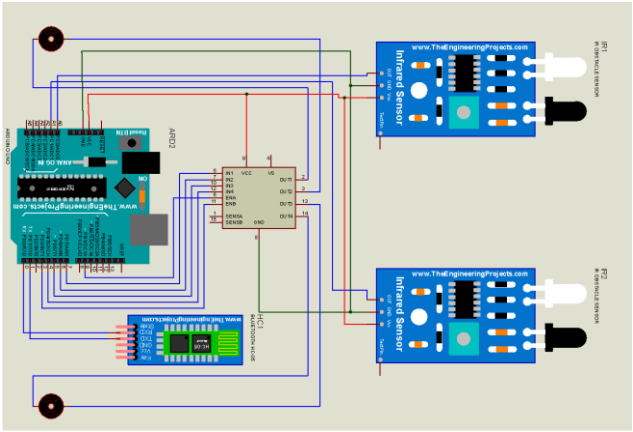

Figure 3: Schematic diagram of the mobile robot

2.3.1 Arduino uno

The Arduino Uno is an ATmega329P based microcontroller board (eight bits). It consists of six analogue pins and 14 digital pins. It can also connected to SPI in order to transmit the data. The flash memory of Arduino Uno is 32KB and the clock speed is 16MHz.

2.3.2 L298N motor module

This driver required 7-12V power supply in order to be activated. It can control two motors according to the different input of ENA, ENB, IN1, IN2, IN3, and IN4. While the 5V port is to provide the power supply to the Arduino card.

2.3.3 HC-05 bluetooth module

The HC-05 Module is required in this research as the mobile robot need to track the presence of the Bluetooth. The six pins of the module is VCC, Ground (GND), Transmitter (TXD), Receiver (RXD), EN, and State pins. The corresponding pin will connect to the Arduino in order to make the Arduino capable to use the Bluetooth communication system.

2.3.4 IR line sensor module

The line sensor module which is used to detect the presence of the line in order for the mobile robot to follow the line. There are four pins which are Vcc, GND, DO, and AO. This module will provide either digital or analogue output when the receiver received the signal transmitted by the transmitter. The 9V battery is required in this prototype construction because of the need of the L298N motor driver. The motor driver required 7-12V input in order to function.

2.3.6 DC motor

The selection of 12V DC motor is because it can provide larger force to move the mobile robot. As the mobile robot may be too heavy to move, therefore using 12V motor can make sure the mobile robot can run smoothly when start to function.

2.4 Software and programming design

The main software will be the Arduino IDE. It is mainly used to program the Arduino Uno processor. Arduino IDE consists of built-in serial monitor which will allow to determine the process of the system to achieve the research objectives.

2.5 Software system algorithm

The System algorithms are classified into two units which are the mobile robot unit and the tracker devices unit. The mobile robot algorithms consist of the sensors algorithm and the movement of the motor while the tracker device is focusing on the data transmit of the Bluetooth signal.

2.5.1 Mobile robot algorithm

The algorithms of the system is start with setting the counter value to 0 at the beginning. Then it detect whether the button is pressed to start the tracking. Next it will start to detect whether bluetooth is in range or counter value is greater and equal to 15000. The reason to use 15000 is that the mobile robot to pass through the black tape one time requires roughly 5000 counts. When both cases have not met, the program will start to control the motor using the left and right sensor readings. If the left and right sensor reads digital '1', the counter value will increase by a digital '1'. When left sensor reads '1' and the other reads '0', the right motor will move forward and vice versa. When both left and right sensor reads '0', both motor move forward. Figure 4 shows the overall algorithms flowchart of the system.

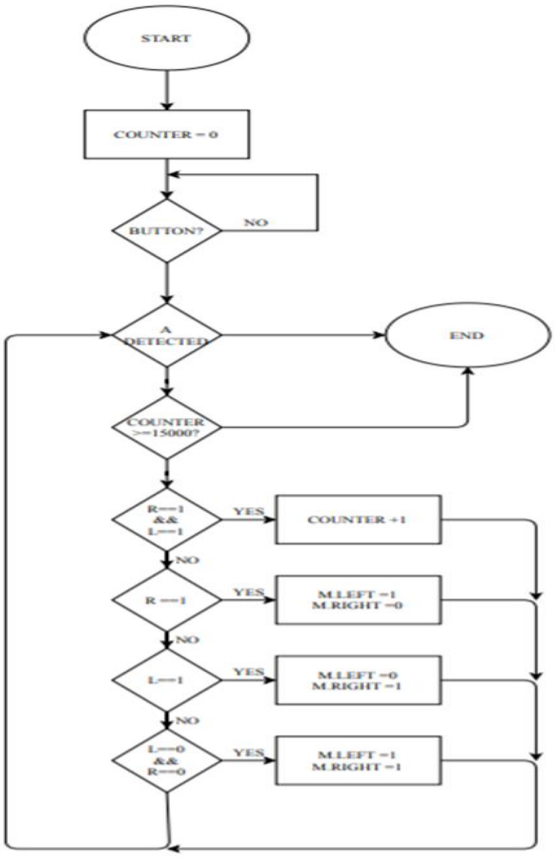

Figure 4: Mobile robot's algorithms flowchart

2.5.2 Tracker device

The Tracker device is a simple connection between Arduino and HC-05 Bluetooth Module. The connection between them only the power supply (Vcc), ground (GND), and the TX-RX connection. The schematic diagram for the Arduino and HC-05. The function of the tracker device is to constantly transmit signal to make sure the HC-05 on the mobile robot can get communicate with it when both

devices are in range. This Tracker devices can be supplied with a 5V Power Bank. There is no code for the tracker device but we need to configure the Bluetooth module in the AT-command mode to make sure the HC-05 for tracker device is selected as Slave mode.

3. Results and Discussions

The results will discuss the hardware that is the robot (mechanical structure and electrical circuit), the mobile Robot Function. The mobile robot motion with IR sensor and the motor motion according to IN1 to IN4 will be discussed as well. The Bluetooth module and path design will be discussed in brief as well different mode of line tracking.

3.1 Sensor and module

The result of each sensor and module set-up are shown and explained. The sensor and module included are IR Line sensor, L298N motor module, and HC-05 Bluetooth module. The path for the mobile robot to track are also included.

3.1.1 IR sensor

The IR sensor is an important component that is required in order to solve the line tracking system. Basically, the IR sensor is referred to the digital value. When IR sensor is detecting the line, it will produce HIGH digital signal and vice versa. the signal produced is used to control the mobile robot motion. As the IR is sensitive to light, therefore it is required to adjust the sensitivity of the sensor. When both LED on the sensor lighted, which means a Low signal is produce while only one LED lighted, it produces a High signal. The moving direction of the mobile robot is opposite to the sensor detection side. Which means when left sensor detects, the mobile robot will turn right in order to get back to track the line. Table 1 summarise the motion of the mobile robot due to sensor signal.

Table 1: Summary of the mobile robot motion with IR sensor

LEFT sensor	RIGHT sensor	Motion
HIGH	HIGH	Counter up
HIGH	LOW	Turn right
LOW	HIGH	Turn left
LOW	LOW	Go straight

According to the Mobile robot speed, it is required to calculate how many counts when passing through the starting line. From the testing, it shows that to pass through the starting line, it will count up to 4000 – 5000 counts. Accordingly, to make searching for 3 rounds, we need to set the mobile robot to stop when counter is >15000.

3.1.2 L298N motor module

The L298N motor module is used to control the motor motion in order to complete the basic mobile robot system. There are 6 input signals and 4 output signals to control the motor's motion. The inputs are ENA, ENB, IN1, IN2, IN3, IN4, and outputs are A1, A2, B1, B2.

ENA and ENB is used to control the speed of the motor A and B respectively. Motor A is the motor attached at left side and motor B is attached in right side. The value varies from 0 (stop) to 255 (maximum speed). While the IN1 to IN4 is the signal received to control the motor direction. Table 2 shows the summary of the motor motion related to IN1 to IN4. The ENA and ENB are set to 100 when forward, 150 when turning, and 0 when stop.

Table 2: Motor motion according to IN1 to IN4

IN1	IN2	IN3	IN4	Motion
1	0	1	0	Forward
1	0	0	0	Turn right
0	0	1	0	Turn left
0	0	0	0	Stop

3.1.3 Bluetooth module

The Bluetooth module used in this research is HC-05 which can choose to be master or slave. For the module on mobile robot will be master while the module for the tracker is a slave. In order to configure the Bluetooth module to either master or slave, we need to enter the AT Command Mode. Press and hold the button on the module while the power is 'ON'. Then upload an empty code of Arduino into the module and the AT Command Mode is 'ON'.

3.1.4 Path design

The path of the mobile robot was made using the 2.5cm width black tape on white acrylic board (85cm x 60cm). The path does not create according to any scale of a location. The path using a round closed loop in order to make the mobile robot track the path smoothly.

3.2 Result

After configure all the sensors and modules; the mobile robot is assembled together in order to add in the features. The testing part divided in 3 stages, Normal line Tracking, Line Tracking for 3 rounds, and line tracking with Bluetooth system. During this stage, the mobile robot should be able to follow the line smoothly and without cross beyond the path created for tracking. First, it will start when the *reset* button on Arduino is pressed. The mobile robot is then start and the sensor will detect the tape to control the direction of the mobile robot. The mobile robot will move in the snaky motion as the line sensor very sensitive to light, therefore, the sensitivity for the IR sensor and the speed of the mobile robot is adjusted in order to allow smoother movement of the mobile robot. After the sensitivity adjustment, the mobile robot is able to move smoother and continuous along the path. It is noticed that both IR line sensors show low-signal, which mean the mobile robot will start moving forward for the path tracking when the button is pressed. While whe left IR line sensor produces high-signal. Thus, the mobile robot will stop left motor while maintain the right motor rotating forward to adjust back the position to the path. It shows both the IR line sensor produces high signal which will make the mobile robot to stop at the starting point.

Line tracking for 3 Rounds stage, the mobile robot should be able to stop when the mobile robot finish tracking the path for 3 rounds. The path had marked a starting point with wide black tape. Every time the mobile robot passed through the starting point is count as 1 complete round. The counter system is use to determine which rounds is the tracking. the mobile robot is allowed to pass through the starting point with the normal speed and the counter value is obtained from the serial monitor which is roughly 5000 counts per pass. Thus, the limits of the counter are set to 15000 counts before the mobile robot stop.

Line tracking with Bluetooth stage, the mobile robot will stop when the Bluetooth devices is in range. Due to the non-actual path design, the Bluetooth device is power off when the mobile robot start. After that, to simulate the situation, the Bluetooth device is then plugged with the power supply as the presence of the devices. When the Bluetooth device started to send signal and received by the mobile robot, the mobile robot is not stop immediately but after a few seconds to process the signal and control the movement. The mobile robot stops not at the starting point of the path because the HC-05 module

had detected the tracker device. Thus, the mobile robot will stop immediately when the tracker device is in range.

3.3 Discussion and Analysis

Besides of the solved problems, there are still having some difficulties from hardware and software which currently ignored in this research due to the limitation. The difficulties are when there are obstacles on the path, and the surface for the mobile robot to move around. The function of the mobile robot will be summarized in Table 3.

Table 3: Summary of mobile robot function

No	Function description	Status
1.	Line tracking	Achieved
2.	Bluetooth system	Achieved
3.	Maximum searching round =3	Achieved
4.	Path for mobile robot	Achieved
5.	Mobile robot speed	Average
6.	Obstacles avoidance	Not achieved
7.	Different surface of the ground	Not achieved

The function of mobile robot in this research is shown in Table 3. For function 1 to 4 is the objective and limitation. The mobile robot had successfully completed the line tracking function with Bluetooth system to detect the tracker device. For function 5, the mobile robot speed is set to average speed which increase the mobile robot accuracy in detecting the Bluetooth tracker device. Moreover, the function 6 and 7 mentioned is in the scope and limitation which are not included in this research. Thus, regardless the function, it can be said that the mobile robot in this research had been successfully achieved the objective. However, this research can still be improved by modifying the features of the mobile robot to achieve the obstacles avoidance features and suitable for different kinds of ground surface.

4. Conclusion

The objectives which are the design of the line tracking mobile robot with Bluetooth communication system and the path for the mobile robot to track, the algorithm for the communication system between mobile robot and tracker devices, and the analyze of the function of mobile robot.

For the line tracking mobile robot, the structure of the mobile robot had been assembled together and the algorithm is applied to the processor in order to perform the line tracking function. The line tracking function working slightly bad as the mobile robot does some snaking motion during the turning. In spite of that, the task is considered completed. Then for the Bluetooth system in the research, the Bluetooth module is attached to the mobile robot to improve its performance. The algorithm is then added with the Bluetooth function in order to stop the mobile robot when it detects a target. As a limitation, the range of Bluetooth cannot be reduced and due to the lack of space to perform this function, therefore a demo version of the path is created and the tracker devices was turned to simulate the situation of tracker device in range.

Nevertheless, from the scope of the research that mentioned earlier; there are maximum searching rounds as it might have happened where the tracker device is in range but missed out connection. Therefore, to make sure the system can be search completely, this research had limited the maximum search for the device for 3 rounds. To make sure the mobile robot will stop after searching 3 rounds, the algorithms is then modified with the counter system to count how many times the starting point had been passed. As the value of the counter is approximated in each pass, but sometime the value might not accurate which will make the searching round to extend. Thus, after a few times of trial and error,

the value of the counts is set to 5000 counts to prevent the mobile robot to continue searching after the 3rd round is completed.

4.1 Future development

As there are few limitations in pro research ject which are no obstacle assumed on the path and the path surface condition is not considered. Therefore, the feature of the mobile robot can be still improved. For the obstacle on the path, the obstacle avoidance function can be added. This function is created by using an ultrasonic sensor to detect the front obstacle distance. When the distance with obstacle is close, the mobile robot will off path and return to the path with an algorithm. While for the path surface condition, it is required to upgrade the hardware specification of the mobile robot. The wheels of the mobile robot can be replaced with higher power motor to drive the caterpillar tracks to improve the grips of wheels on different surfaces.

From the hardware side, the line tracking sensor used in the research is very sensitive to light, thus it should be making a cover to block unstable light intensity of surrounding environment to maintain the sensitivity. Besides, the electronics part is exposed to surrounding environment, therefore it should be improved with the cover to prevent the dirt damaged the hardware part. Regardless the limitations, this pro research ject can be considered as functionable to solve the situation of tracking elderly person outdoor and allows the elderly person to exercising outdoor without being lost. Hope this research can be further improve in the future to make it suitable to overcome more situations.

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