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Intelligence Location Detection Line Following Robot using RFID System

Syafiqah Mustaffa[1], Hazli Roslan[1]*, Suhaila Sari[2]

[1]Department of Electrical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, Pagoh, 84600, Johor, MALAYSIA

[2]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Batu Pahat, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: In this era of globalization, the rapid development of science and technology has made Malaysia a country that has a high demand for the manufacturer from our industry. This makes the need of labour increased and it will require a high cost when there has an increase in the number of employees. For an industry that requires human resources to transfer items from one place to another, an equipment that can replace human resources and can work on its own is necessary. Therefore, a device called "Intelligence Location Detection Line Following Robot using RFID system" is designed as an alternative to handle this problem. This equipment operates automatically using several sensors, DC motor and microcontrollers. The sensors used are Infrared Sensor as a movement guide, Ultrasonic Sensor as barrier detector and Radio Frequency Identification (RFID) system as a location detector. While microcontroller used is Arduino as the controller of the entire system and as the connecter for all equipment. This tool operates using a rechargeable battery power supply and moves itself to the charging point when the power is reduced according to the setting set. This equipment can carry a light load and move according to the black line that the user sets as a movement guide. This tool will function as long as the power supply is not disconnected.

Keywords: Automatic Drawer, Infrared Sensor, Ultrasonic Sensor, RFID System

1. Introduction

Malaysia is a country that has a high demand for the manufacturer from our industry. This makes the need of labour increased and it will require a high cost when there has an increase in the number of employees. Many of the industries have shown that many heavy parts have to be relocated to another location, which cannot be achieved without machinery [1]. Therefore, a project named Intelligence

*Corresponding author: hazli@uthm.edu.my

Automatic Driven Drawer are proposed to make a drawer that follow the line to designated place automatically and avoids the obstacle while moving. This project contains three main component that is infrared sensor as movement guide, ultrasonic sensor as barrier detector and Radio Frequency Identification (RFID) system as a location detector.

Infrared sensor Line follower are single-type mobile robots with the ability to follow a line that has a hardwires control circuit on board very precisely [2]. As a result, a robot for line follower is designed for autonomous driving using artificial intelligence [2]. In this previous project, it has design line following robot that carrying medicine to give to the patient whenever they need it and it can reduce the fee for the patient [3]. Therefore, in this project we used infrared sensor to produce a line following robot that follow a black line on a white surface or vice versa.

In Kaiser previous project, it have make a robot that is able to prevent obstacles, to make fast turns and climb bridge and to detect a single target and to transport and carry the object in the correct location [4]. Obstacle avoidance robot is designed to encourage the robot to navigate in an unfamiliar area by preventing collisions [1]. Ultrasonic sensor will sense any obstacles in the path and avoid it to continue the movement of robot. Thus, we also implement some ultrasonic sensor in this project to make it more efficient when avoiding obstacles while moving.

The most important in this project is RFID system as a location detector. Today, Radio Frequency Identification (RFID) has become a business option for cattle identification and Automated Vehicles Identification (AVI) devices [5]. Researchers have suggested in previous project that the technique used in mobile robot navigation to increase the performance of localization using RFID [6]. In RFID system, RFID reader will find and read RFID tag to find the correct location with the instruction given. It will automatically stop when found the right locations. Hence, RFID system is used in this project to track location accurately.

Initially, certain industry faces a difficulty on retrieving certain materials needed by them while working in a factory. They are lack of workers that required to move the drawer which contains their certain needs from one place to another. Thus, it will interrupt their working hours, especially when it needed to be done on time. It will increase the need of worker and the required high cost. Usually, in a factory of working area is a massive place to be walking to and fro. Hence, it will take a long distance to sends the required needs from the drawer and the worker will take a long time to retrieve it. For this reason, this project as far suitable for the workers in a factory to work more efficient by sends and retrieves required needs from the automatic driven drawer from one place to their designated place in the working area. Not only that, the automatic drawer could prevent obstacles from heading towards it as it includes a sensor built upon it. The drawer could withstand a certain amount of load as long as it would not exceed the maximum capacity.

The main objectives of this project are to design and make a drawer that has an ability to automatically move to a designated place. Furthermore, to improve the capabilities of drawer movement by applying Radio Frequency Identification (RFID) system as location detection. It also to ensure that the drawer can travel safely to the destination during the process and obtain the data.

2. Materials and Methods

The project is inspired by a drawer that have been use manually to carry objects from one place to another. Hence, in this project, it has been improved by making an intelligence drawer robot that can go to a designated place using line following.

2.1 Materials

This robot contained three main component that is infrared sensor, ultrasonic sensor and RFID system. It has used Arduino Mega as a microcontroller board for the input and output pins. It also contained another component that help this robot moves.

- Line Follower

The line follower that used in this project is three TCRT5000 infrared sensor (IR sensor). IR sensor is used as the line detecting sensor in this project. IR sensor consist of IR LED and Photodiode that used to detect line logic. They are arranged next to each other, so that when the light emitted by an IR LED, it will be detected by Photodiode when it reaches a reflective surface.

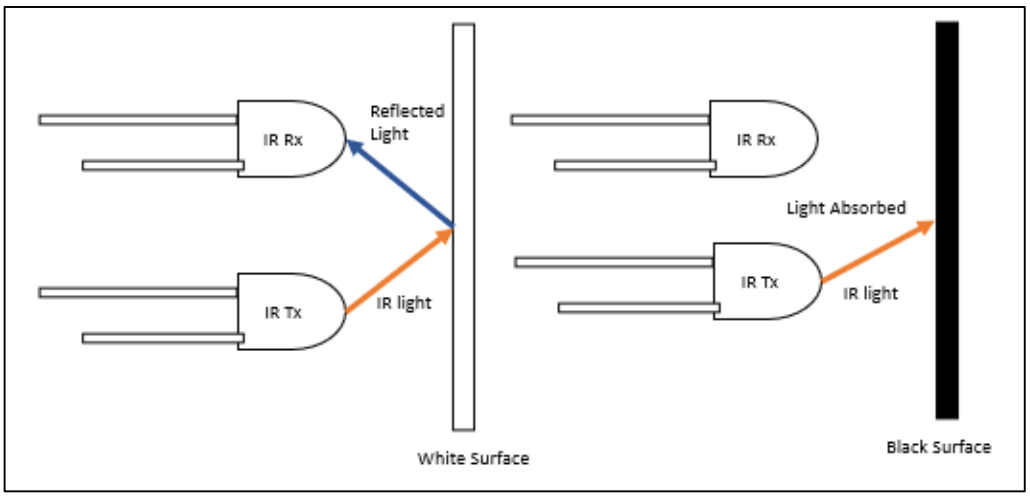

Figure 1: The operations of typical IR sensor

In Figure 1, the infrared light that is emitted by IR LEDs is reflected and detected by the photodiode since its light-colored surface is high. In the case of a low reflection on the black surface, the light is completely absorbed and the photodiode is not reached by the black surface [7]. The IR sensors are arranged next to each other (left, middle, right), so that sensors can cover large area when it starts to move. When the left or right sensor sense the black line, then the project needs to turn left or right. This shift is detected by Arduino Mega and the signal is sends to motor driver accordingly. The left or right side of the robot slows down the motor by PWM while other side of motor is running at normal speed. Arduino Mega tracks the data from both the sensors continuously and turns the robot according to the line it senses.

- Ultrasonic Sensor

At the same time, the ultrasonic sensor will operate simultaneously when the robot starts to move. The ultrasonic sensor is a device which can measure distance with sound waves to an object. The trig pin will send out a sound wave at a specific frequency to detect the obstacle [8]. When the signal reaches the surface, the signal return back and the Echo pin will pick up the signal. The time required by the signal to return back is saved in variable. Then, the time of signal is multiplied by speed of sound and divided by 2 to get the distance of obstacle that shown in Figure 2. In the meantime, the robot will always move forward, and the direction of robot will change when the ultrasonic sensor detect any obstacle in its range.

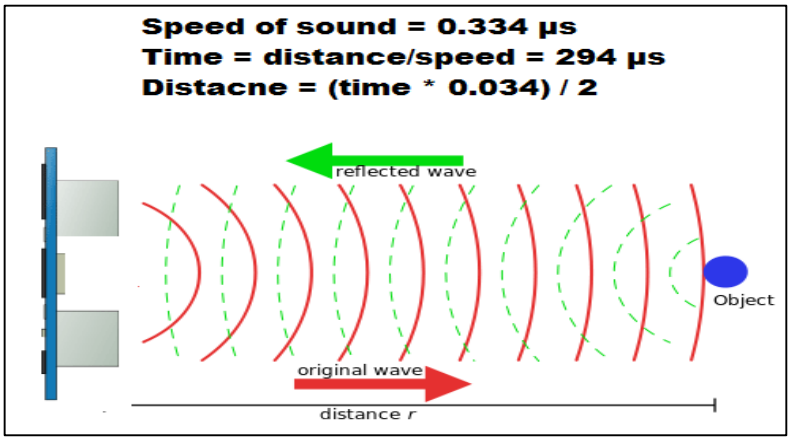

Figure 2: Ultrasonic Sensor formula

- Radio Frequency Identification (RFID) system

In addition, this circuit contain a Radio Frequency Identification (RFID) kit that used to call the robot to the designated place when the button is push. RFID is a type of communication between a transmitter (transponder or tag) and a receiver (reader) [9]. The RFID tag has a chip and an antenna. A chip can store a unique serial number or other data based on type of the tag. The information is transmitting from the chip to the reader by antenna which is attached to the microchip. While RFID reader communicate with the tag using its own antenna and without a direct line of sight that depend on radio frequency and type of tag.

- Motors and Wheels

The DC motors have been used in the circuit for the proper movement of the device and beaver wheel is mounted at the front of the robot line. The caster wheel allows the robot to travel in either direction quickly. The motor driver controls dc motors in the end side of the robot. And the device needs a small 6-12 V power supply that can be supplied as a battery.

2.2 Method

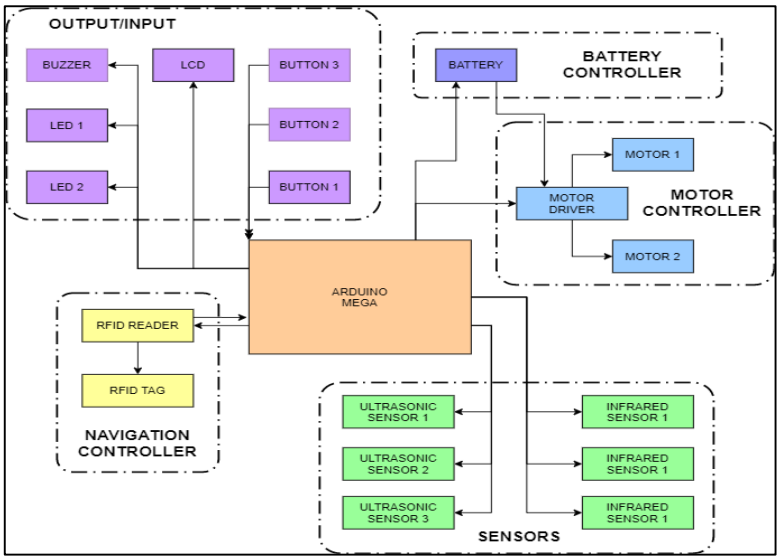

Figure 3: Block diagram of the system

There are five parts in this block diagram (Figure 3) that is output/input, battery controller, motor controller, sensors and navigation controller. Infrared sensor and ultrasonic sensor are located at sensors part. It works when light from IR LED bits the opposite surface and it reflects back to the photodiode. Then, the signal is sent to microcontroller or the main circuit to make a decision according to the

algorithm. While ultrasonic sensor works when the sensor head encounters the sound wave and receives the wave from the target reflected back. It also measures the time between the emission and reception by measuring the distance to the destination [10]. Next is navigation controller, it contains RFID system that is RFID reader and tag. RFID reader will detect the tag and send the data back to microcontroller to the next step. The simplest RFID tag consists of two parts that is an antenna for signal transmission and reception and an RFID chip for the storage and additional details of the tag [11]. Output/input have two parts, for input we have three buttons and for output, we have buzzer, two LED and an LCD. Besides, we have battery controller that contain 12 V battery to connect to Arduino Mega and motor driver to provide the power supply. Lastly, motor controller that contain motor driver and two dc motor. Motor driver is used to move left and right dc motor.

In Figure 4, it shows the flowchart of the system includes a phase checking and a phase initialization. In the flowchart above, it is necessary to check battery level before proceed to another process in the system. In the checking phase, the system will check the battery level of the drawer to make sure it will be sufficient to complete the task for a long period of time. If the battery level is sufficient, the drawer will proceed to the initialize and begin the process to send the equipment. However, if the battery level is under critical level, it will automatically be going back to the main station and start to charge the battery itself.

In the initializing phase, the motor will begin to rotate and move to the designated place. The LCD, LED and buzzer will turn automatically turn on. The LCD will display the battery level and the destination of the drawer. There is two type that is red LED and green LED to show either the drawer is available or not. Besides, the buzzer use to make a sound when it is move from one place to another place. When the robot starts to move, IR sensor will detect the line to make sure that the robot reach the destination. The robot also will begin to detect all the surrounding obstacles using the ultrasonic sensor. There are 3 ultrasonic sensors used to make sure that the robot can avoid the obstacle. The ultrasonic will choose the right path either right, mid, left and back side that can be used to avoid the obstacle.

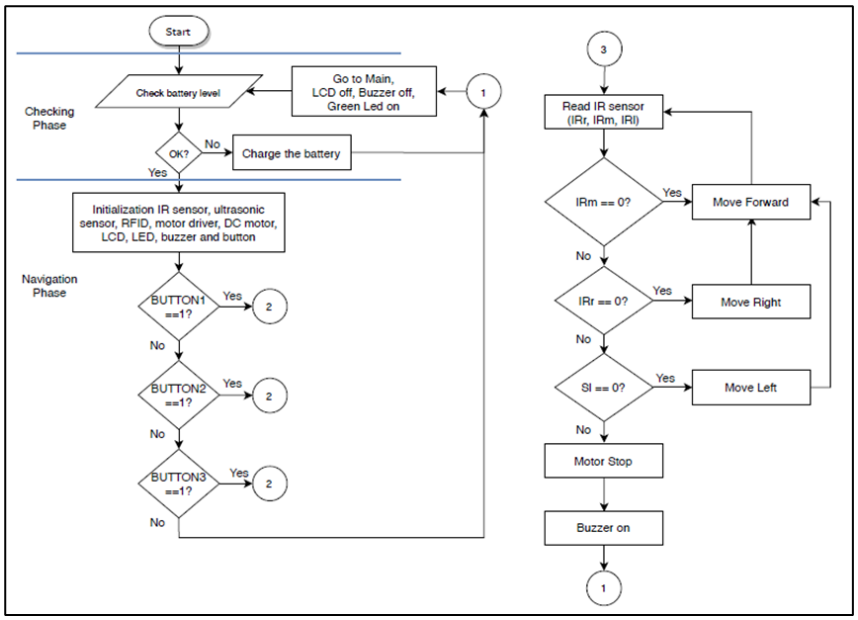

Figure 4: Flowchart of the system

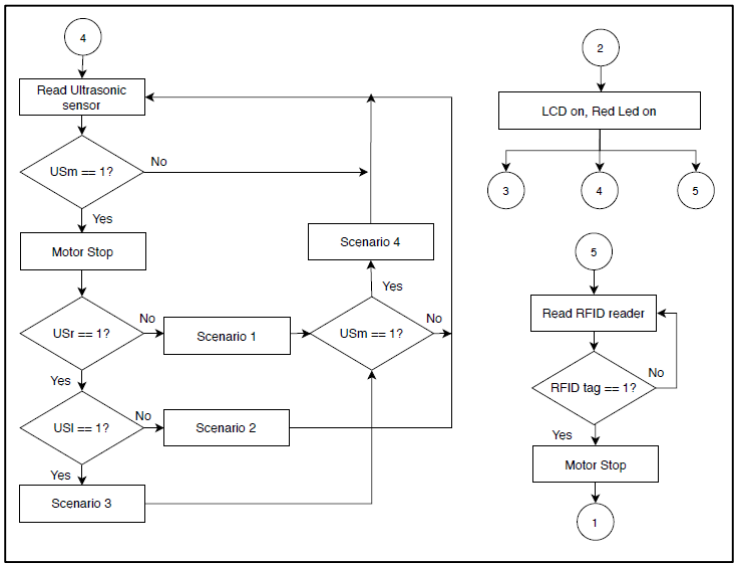

Figure 4: Flowchart of the system (continue)

3. Results and Discussion

The complete structure of drawer robot that move automatically to designated place is shown in Figure 5 for the front view and Figure 6 for the top view of the robot. This is the final prototype of the drawer robot.

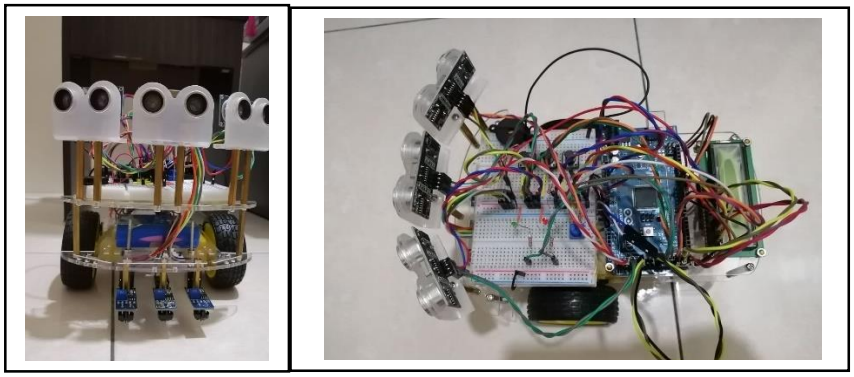

Figure 5: Front view

Figure 6: Top view

3.1 Results

In the result part, the data taken is to know the efficiency of the drawer, location detection using RFID system, movement of drawer using infrared sensor and movement of drawer avoiding obstacles. For the first experiment, the drawer is placed at the main point and the button is pressed, then it will automatically move to the designated place. It is to test the efficiency of drawer for every location. For location detection using Radio Frequency Identification (RFID) system, the experiment is to test the RFID system either it can stop at the required place when RFID reader detect the RFID tag while it moving. The component used for this experiment is RFID, Arduino mega, lcd and motor driver. The result for location detection using RFID system is show in Table 1. Next experiment is the movement of drawer using infrared sensor is observe the movement of robot using line follower either it can reach the right destination. It involves infrared sensor, Arduino mega and motor driver for the component part. The movement of drawer using infrared sensor result is shown in Table 2. For the last experiment is to detect an obstacle that placed in the middle line to test the movement of the drawer pass through the obstacles. This experiment used ultrasonic sensor, infrared sensor, Arduino mega and motor driver. The result shown in Figure 7.

Table 1: Location detection using RFID

Location	RFID tag	Time taken to read the tag (s)
A	E7BE3D19	0.55
		0.39
		0.12
B	E7F8C019	0.30
		0.26
		0.10
C	D79A1719	0.45
		0.24
		0.15

Table 2: Movement of drawer using infrared sensor

Left IR Sensor	Middle IR Sensor	Right IR Sensor	Motor movement	Time taken (s)
On	Off	Off	Left	10
			Left	9.2
			Left	9
On	On	Off	Left	9
			Left	10
			Left	8
Off	Off	On	Right	9
			Right	9.5
			Right	7
Off	On	On	Right	8
			Right	8.5
			Right	9
Off	On	Off	Forward	5
			Forward	6.5
			Forward	7
On	On	On	Stop	10
			Stop	9.6
			Stop	9.1
Off	Off	Off	Backward	6
			Backward	7

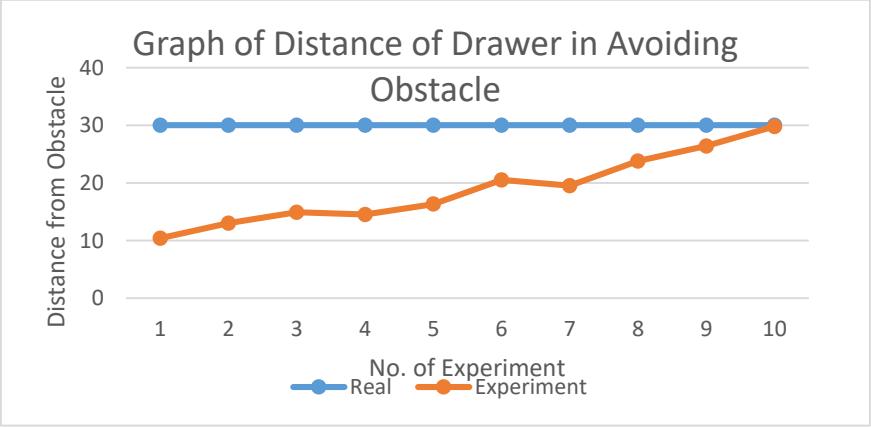

Figure 7: Graph of Distance of drawer in avoiding obstacle

In experiment 1, from observation, the robot able to reach the designated place when the button is pushed. When button 1 is pressed, the robot automatically moves to location A, button 2 will go to location B and button 3 will go to location C. It automatically moves and every sensor start detect and transfers data to Arduino give instruction to other components. It finally reaches the correct destinations according to the button pressed. Otherwise, the drawer will stop at different location from the button.

Besides that, for the experiment movement of drawer using RFID system and infrared sensor have high percentage of succeed. This experiment is to test the capability of that component while the robot is move. In movement of drawer using RFID system, it shows the time taken for RFID reader to read the RFID tag. The result shows some improvement for it to detect three different location. However, the movement of drawer using Infrared Sensor also shows the improvement from different type of movement either it turns left, right, forward, backward or stop. It can make a turn smoothly without any delay and it can reduce time for drawer to reach the destination.

Lastly, the experiment to test is the movement of drawer avoiding obstacles. At first, the drawer slowed at detection an obstacle from 30 cm and almost hit the obstacles. Then, it gradually starts to detect the obstacles in range 20 cm to 30 cm. It helps to avoid obstacles and continue move to reach the destination.

4. Conclusion

Based on the result in the experiment, the automated drawer robot will be able to reach the destination easily according to the result and discussion. This is because the robot is design to move automatically to three different location and it can reach to destination safe and faster. Besides that, based on the experiment that use to test the movement of drawer using RFID system and infrared sensor, the findings are as expected. RFID system will read the tags and recognize it either it is the correct place to stop. It takes a few second for the RFID reader to detect the tag while the robot moving and it may cause the time taken increase. While infrared sensor will automatically detect the black line and move forward according to the line. Even it is a bit slow while taking a corner or turn, it still can finish it until reach the destination. It uses to make a move sharply when there is more than one infrared sensor that detect black line. Lastly is about the movement of drawer to avoid obstacles using ultrasonic sensor. The drawer able to detect the distance from obstacle to drawer in the range of 10 cm to 30 cm. It still able to avoid the obstacle even it almost closes to below 10 cm.

In this project, all the objectives that were set at the beginning were achieved. The robot able to move automatically to designated place when the button is pressed. Therefore, the objective to make a drawer that has an ability to automatically move to a designated place is achieved. Next is to improve the capabilities of drawer movement using Radio Frequency Identification (RFID) system is achieve because the drawer robot is able to use the RFID system to detect location using unique identification card including another main component that is infrared sensor. Lastly, it can obtain the data needed for the purpose of research and system improvement is achieve and collected in result and discussion.

Considering the achievement of the goals of this review, there are some limiting factors that can be changed so that the automatic drawer robot can operate in its most optimal state. In order to increase the drawer robot efficiency, the first suggestion is to add more Infrared sensor. Since the drawer was only able to detect the line follower in certain area, it is suitable to add some Infrared sensor to make it more efficient. However, by adding some Ultrasonic sensor can reach a much greater areas to detect the obstacles while the drawer is moving so that it can avoid any obstacles more efficiently. Finally, we can use automatic drawer by changing to wireless connection, so that we can control the movement of robots remotely.

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References

[1] A. Attar, A. Ansari, A. Desai, S. Khan, and D. Sonawale, "Line Follower And Obstacle Avoidance Bot Using Arduino," no. 4, pp. 18–21, 2017.

[2] Ramshetty. K. S., "Android Based Autonomous Coloured Line Follower Robot," *Int. J. Res. Eng. Technol.*, vol. 03, no. 15, pp. 368–373, 2014, doi: 10.15623/ijret.2014.0315072.

[3] X. Wang, S. H. Kim, C. Chen, L. Chen, H. He, and L. Qian, "Development and Applications of Line Following Robot Based Health Care Management System," *ACS Appl. Mater. Interfaces*, vol. 7, no. 27, pp. 14785–14792, 2015.

[4] F. Kaiser, S. Islam, W. Imran, K. H. Khan, and K. M. A. Islam, "Line follower robot: Fabrication and accuracy measurement by data acquisition," *1st Int. Conf. Electr. Eng. Inf. Commun. Technol. ICEEICT 2014*, pp. 1–6, 2014, doi: 10.1109/ICEEICT.2014.6919137.

[5] L. P. Chuan, A. Johari, M. H. A. Wahab, D. M. Nor, N. S. A. M. Taujuddin, and M. E. Ayob, "An RFID warehouse robot," *2007 Int. Conf. Intell. Adv. Syst. ICIAS 2007*, pp. 451–456, 2007, doi: 10.1109/ICIAS.2007.4658428.

[6] B. Ilias, R. Nagarajan, M. Murugappan, K. Helmy, A. S. Awang Omar, and M. A. Abdul Rahman, "Hospital nurse following robot: Hardware development and sensor integration," *Int. J. Med. Eng. Inform.*, vol. 6, no. 1, pp. 1–13, 2014, doi: 10.1504/IJMEI.2014.058521.

[7] M. Engin and D. Engin, "Path planning of line follower robot," *EDERC 2012 - Proc. 5th Eur. DSP Educ. Res. Conf.*, pp. 1–5, 2012, doi: 10.1109/EDERC.2012.6532213.

[8] Y. Jin, S. Li, J. Li, H. Sun, and Y. Wu, "Design of an Intelligent Active Obstacle Avoidance Car Based on Rotating Ultrasonic Sensors," *8th Annu. IEEE Int. Conf. Cyber Technol. Autom. Control Intell. Syst. CYBER 2018*, pp. 753–757, 2019, doi: 10.1109/CYBER.2018.8688326.

[9] J. H. Teng, K. Y. Hsiao, S. W. Luan, R. C. Leou, and S. Y. Chan, "RFID-based autonomous mobile car," *IEEE Int. Conf. Ind. Informatics*, pp. 417–422, 2010, doi: 10.1109/INDIN.2010.5549708.

[10] D. S. Vidhya Delicia Perlin Rebelo, M. D. Cecilia Jane, S. Linford William Fernandes, and M. Clarissa Joella Costa, "Obstacle Detection using Ultrasonic Sensors," *IJIRST-International J. Innov. Res. Sci. Technol.*, vol. 2, no. 11, pp. 316–320, 2016, [Online]. Available: www.ijirst.org.

[11] G. Liu, W. Yu, and Y. Liu, "Resource management with RFID technology in automatic warehouse system," *IEEE Int. Conf. Intell. Robot. Syst.*, pp. 3706–3711, 2006, doi: 10.1109/IROS.2006.281750.