Implementation of Line Follower Robot for Food Delivery Robot

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Received: August 21, 2024; **Accepted:** November 27, 2024

***Abstract*— A line follower robot is a robotic system capable of autonomous navigation by following a predefined path using optical sensors. This research focuses on the development of a line follower robot for food delivery in the food and beverage industry, particularly in restaurants, cafes, and eateries. The industry faces challenges such as low service efficiency and long order waiting times, which can lead to customer dissatisfaction. The objective of this research is to build a robot that can enhance service efficiency and overall customer experience. The method used is action research following Kurt Lewin's model, which includes planning, implementation, observation, and reflection stages. The developed robot is equipped with an Arduino Uno, infrared sensors, and other components that allow for high-precision navigation. The research results show that the line follower robot successfully followed the predetermined path and delivered food efficiently. The evaluation indicates that the robot's speed needs to be adjusted according to the load to avoid deviation from the path. This research provides significant contributions to improving operational efficiency and customer satisfaction in the food and beverage industry.**

***Keywords*— robotics, line follower robot, food delivery, arduino**

I. Introduction

A line follower robot is a robotic system capable of autonomous navigation by following a predetermined path or line, usually guided by optical sensors [1]. These robots are designed to move along specific routes, detecting and following lines marked on surfaces [2]. They are widely used in various applications such as agriculture for crop maintenance, educational workshops to enhance students' robotics knowledge, and industrial settings for automated tasks [3]. The robots are typically equipped with sensors like infrared and distance sensors to detect lines and objects, enabling them to make decisions based on the environmental input they receive [4].

The food and beverage industry, particularly in places like restaurants, cafes, and eateries, often faces challenges in improving service efficiency [5]. Long wait times for orders can lead to customer dissatisfaction and reduce restaurant productivity [6]. The line follower robot emerges as a solution to address these challenges by providing an efficient and reliable food delivery system [7]. By incorporating the latest technology in hardware, this research aims to tackle classic issues commonly faced by restaurants, cafes, and eateries, such as long order wait times and uncertainty in food delivery [8]. The primary objective of this research is to build a robot to enhance service efficiency and improve the overall customer experience. In this way, the robot not only becomes a tool for optimizing the daily operations of dining establishments but also serves as a critical element in creating a strong connection between customers and the brand of the dining establishment [9]. This robot is equipped with the latest technology in terms of hardware [10]. From a hardware perspective, this robot has a set of advanced sensors that allow it to navigate with high precision around the dining environment. Additionally, an integrated manipulator enables it to pick up orders with high accuracy and deliver them to customers safely and efficiently [11]. This research makes a significant contribution to improving the operational efficiency of dining establishments while also enhancing the overall customer experience. One of its contributions is its ability to reduce the workload of employees by taking over routine tasks such as order delivery. In this way, employees can focus on other tasks that require human interaction and increase overall productivity. Additionally, this robot also helps reduce order wait times by delivering orders quickly and on time, thereby reducing customer frustration and increasing their satisfaction.

This research not only helps improve the operational efficiency of dining establishments but also creates a better customer experience. With fast and efficient food delivery service, customers can enjoy their meals without having to wait too long. This creates a positive impression on customers and increases their loyalty to the restaurant. Moreover, the seamless interaction with this robot adds its unique element, making the dining experience more enjoyable and memorable for customers [12]. Thus, this research is not just a technological innovation in the food and beverage industry but also a practical and effective solution to enhance service efficiency and improve the overall customer experience. With its ability to reduce employee workload, optimize dining operations, and create a better customer experience, the line follower robot has the potential to become an integral part of the future of the food and beverage industry.

Previous research has highlighted the importance of integrating technology into the food and beverage industry to improve service and customer experience. However, little focus has been placed on developing a food delivery robot prototype that can be implemented in various types of dining establishments. This robot offers a unique contribution in meeting this need [13]. With existing research, this study is expected to provide an effective and innovative solution to improve service efficiency and customer experience in the food and beverage industry as a whole.

II. Methods

This research was conducted using the action research method, which means the researcher was directly involved in the design, creation, and implementation of the research outcomes. In carrying out this research, the researcher employed methods, procedures, and concepts that have been proven to be accurate and applicable for producing a product or other conclusions that can be directly accessed by the public. This action research uses Kurt Lewin's model as a reference. According to Kurt Lewin, the stages in action research include four phases: Planning, Acting, Observing, and Reflecting [14].

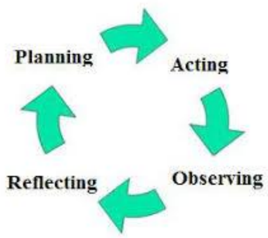

Fig. 1. Stages of Kurt Lewin's Methodology.

A. Planning

The planning stage begins with identifying the problem or objective to be achieved. The robot design process starts by selecting hardware components that meet the needs and specifications. At this stage, the researcher creates an electronic design using Arduino to develop the line follower robot. In this research, Arduino Uno, IR sensors, and other components are used to develop the line follower robot.

B. Acting

This stage involves the implementation of the plan that has been created. Start by building or assembling the robot components according to the designed plan. Program the robot controller according to the algorithm that has been planned to control the robot's movements based on input from the sensors.

C. Observing

After the robot is built and tested, the next step is to observe the robot's behavior during the trials. Observe how the robot reacts to changes in the path, its movement speed, and the accuracy in following the line.

D. Reflecting

The reflection stage is the time to evaluate the observations. This evaluation includes identifying successes, challenges faced, and potential improvements. Critically discuss what has been successful and what needs to be improved in the line follower robot.

III. Results and Discussion

The research results on the implementation of the line follower robot development for food delivery robots can be described as follows:

A. Planning

This stage involves the design and development planning of the line follower robot. It includes identifying the needs and technical specifications that the robot must meet to function effectively as a food delivery robot. During this stage, the research team designed the path scheme that the robot will follow, selected appropriate sensors such as infrared sensors and distance sensors, and determined the necessary hardware and software for controlling the robot. Additionally, the food delivery route within the restaurant or cafe was arranged to ensure that the robot could move efficiently and avoid obstacles.

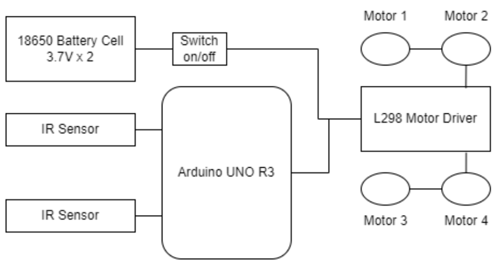

Fig. 2. Block Diagram of Line Follower Robot.

Figure 2 is a visualization of the block diagram for constructing the line follower robot. This block diagram serves as a visual representation of the electronic system and data flow involved in the robot's operation. The block diagram of the line follower robot consists of a Power Supply that provides the necessary electrical power to all components of the robot. Next is the Arduino, which is the brain of the line follower robot, controlling all operations based on input from the sensors. The sensors function to detect the line on the surface that the robot must follow, and the actuators are used to move the robot dynamically. The components and circuits used, as referenced in the block diagram in Figure 2, can be seen in Figure 3.

Journal of Electrical, Electronic, Information, and Communication Technology (JEEICT)
Vol. 06 No. 2, October-2024, Pages 55-58 DOI: https://doi.org/10.20961/jeeict.6.2.92211

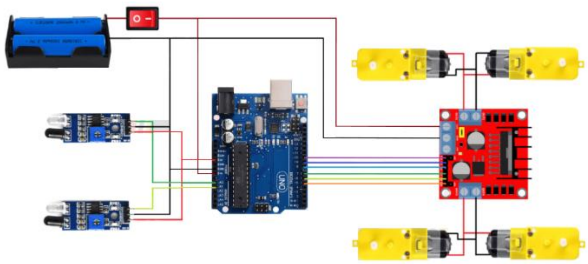

Fig. 3. Circuit Diagram of Line Follower Robot.

Figure 3 shows the main circuit of the line follower robot, consisting of the robotic components defined previously through the block diagram visualization. The power supply component consists of two 18650 Battery Cells (3.7V) used to provide power to the Arduino and other components. The Arduino component used is the Arduino Uno R3, which takes input from the infrared sensors to detect the line and sends control signals to the motor driver. The sensors used are two IR Sensors (Infrared Sensors), which send data about the line's position to the Arduino. The actuators consist of an L298 Motor Driver and four DC Gear Motors with wheels. The L298 module receives signals from the Arduino and controls the DC Gear Motors according to those signals. An additional component, the On/Off Switch, is used to activate and deactivate the robot.

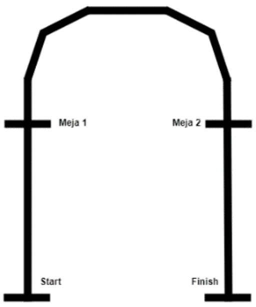

Fig. 4. Robot Path.

Since the line follower robot is designed to follow a line, a path is necessary to guide the robot's direction. Figure 4 shows the path used as a reference for the robot's direction. There are four points on the path: the start, which is the point where the robot begins delivering food; Table 1/Table 2, which are the destination tables where the robot delivers food; and the finish, which is the final point after the robot has delivered the food.

B. Acting

After the planning stage, the next step is to implement the development of the food delivery line follower robot. Below is the appearance of the robot as a result of the Acting phase.

Fig. 5. Appearance of the Food Delivery Line Follower Robot.

Figure 5 shows the final appearance of the food delivery line follower robot. The robotic components are housed between the chassis and the food storage rack. However, the battery component, stored in a battery holder, is placed under the robot's chassis to make it easy to remove and install the battery according to its power needs. The food rack itself consists of two levels, capable of delivering two meals simultaneously.

The main configuration of the Arduino uses the C++ programming language. The differential drive concept is used as the method for turning by adjusting the speed or direction of each wheel. Below is the differential drive configuration used:

1) Moving Forward

To make the robot move forward, both the left and right wheels must rotate forward at the same speed. This ensures that the robot moves straight ahead without veering to the left or right. When both wheels rotate forward at the same speed, the robot will move straight forward.

2) Turning Left

To make the robot turn left, the right wheel must rotate forward while the left wheel rotates backward (this causes the robot to rotate in place with the pivot point around the left wheel).

3) Turning Right

To maket he robot turn right, the left wheel must rotatae forward while the right wheel rotates backward (this causes the robot to rotate in place with the pivot point around the right wheel).

4) Stopping

To stop the robot, both the left and right wheels must stop rotating. This means that no power is sent to the drive motors, so the robot will stop moving.

C. Observing

The results of the robot's implementation and testing on the provided path show that the line follower robot can follow the line and stop at the designated table as intended. However, the robot's configuration, especially its speed, needs attention. If the robot moves too quickly, it may deviate from the path. On the other hand, if the robot moves too slowly, it may struggle to move forward or turn due to the food load. Therefore, adjusting the robot's speed based on its load is crucial.

D. Reflecting

The line follower robot developed for the food delivery case study performed well. The robot could follow the line and stop at the correct table. For improvements or further development of the line follower robot, additional sensors, such as ultrasonic sensors for distance measurement, could be integrated. IoT implementation could also be considered for further development to determine the destination table more flexibly.

IV. Conclusion

This research successfully developed and implemented a line follower robot for food delivery using an action research method based on Kurt Lewin's model. The developed robot was able to follow a line and stop at the designated table, demonstrating that the sensor and control systems used functioned effectively. The results of this research indicate that the robot's speed adjustment is crucial to ensure that the robot stays on the designated path and can efficiently carry the food load. However, this research has some limitations, such as the need for precise speed adjustment based on the robot's load and the potential for path deviation at high speeds. For future research, it is recommended to add ultrasonic sensors for better distance detection and to integrate IoT technology to enhance the robot's flexibility and performance in determining table destinations. This research makes a significant contribution to the development of efficient and reliable food delivery robots, with wide potential applications in the food and beverage industry.

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