

Design and Performance Evaluation of an Arduino Uno-Based Robot for Automated Food Delivery in Restaurants

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ABSTRACT

The increasing adoption of automation technologies in the hospitality industry provides opportunities to support repetitive restaurant service activities, particularly food delivery. This study aims to design and implement an Arduino Uno-based waiter robot capable of delivering food to designated customer tables based on user input. The developed robot integrates an Arduino Uno as the main controller, an L298N motor driver for DC motor control, DC motors for movement, a push button for destination selection, TCRT5000 sensors for line tracking, an LCD for displaying the selected destination, and a battery as the power source. The robot operates using predefined line-following routes and programmed direction selection at intersections. Experimental results showed that the robot successfully followed the designated routes and delivered food according to the selected destination. The system also demonstrated the capability to deliver food to two customer tables within a single delivery operation. These results demonstrate the feasibility of the proposed Arduino-based waiter robot for supporting basic automated food-delivery tasks in restaurant environments.

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1. INTRODUCTION

The rapid development of robotics and digital technologies has created new opportunities for automating repetitive activities in the hospitality and food-service industries. Service robots are increasingly being explored for tasks such as material transportation, information delivery, and customer assistance, particularly in environments where repetitive operations can be standardized. In the hospitality sector, the adoption of service robots has attracted considerable research attention because robotic systems can support employees in performing routine tasks while providing alternative forms of customer service [1], [2]. A systematic review of service-robot research in the hospitality and tourism sector has also identified service robots as an increasingly important research area, with growing attention to technological capabilities, operational performance, and user-related factors [3]. In restaurant environments, these developments are particularly relevant because transporting food and beverages from the preparation area to customer tables involves repetitive movement that can potentially be automated.

Conventional restaurant operations generally rely on human waiters to transport food and beverages from the preparation area to customers. Although human-based service provides flexibility and direct interaction with customers, repetitive delivery activities can increase employee workload, particularly during periods of high service demand. Robotic systems can provide an alternative mechanism for performing repetitive delivery tasks while allowing human employees to focus on activities that require direct communication, decision-making, and customer interaction. Previous research on food-delivery robots has demonstrated that robot-based delivery represents a distinct service mode that can be evaluated in comparison with human delivery and conventional customer collection in terms of service performance and customer expectations [4]. Furthermore, studies on restaurant service robots have shown that customer acceptance is influenced by factors including perceived safety, interaction quality, perceived usefulness, and attitudes toward robotic services [5]. These findings suggest that the development of a restaurant service robot requires not only an effective movement mechanism but also reliable operation within the physical and social conditions of a restaurant environment.

From an engineering perspective, a mobile service robot requires the integration of locomotion, sensing, and control mechanisms to perform its intended tasks reliably. Obstacle detection is particularly important in restaurant environments because tables, chairs, customers, walls, and other temporary objects may interfere with robot movement. Ultrasonic sensors provide a relatively simple approach for estimating the distance between a robot and surrounding objects and have therefore been widely adopted in mobile-robot applications. For example, an Arduino-based mobile robot equipped with ultrasonic sensing has been developed for autonomous movement and obstacle avoidance [6]. Such an architecture demonstrates the feasibility of implementing basic robotic perception and movement control using a relatively simple microcontroller-based platform. However, the application of these capabilities to an integrated restaurant service robot requires additional consideration of route following, food transportation, and service-task execution.

More sophisticated restaurant service robots have also been developed using advanced navigation technologies. Chen et al. developed a non-contact service robot for fast-food restaurants that incorporated mapping, localization, and navigation to support food-service operations [7]. Such systems demonstrate the feasibility of deploying autonomous robots in complex restaurant environments. However, advanced navigation architectures generally require additional sensing devices, computational resources, and software components, which may increase system complexity and development requirements. For small-scale restaurants, educational laboratories, and prototype-oriented research, a predefined route combined with basic sensing and control may provide a more accessible approach for implementing essential service functions without requiring a fully autonomous navigation architecture.

Despite the growing body of research on restaurant service robots, there remains an opportunity to develop and experimentally evaluate a relatively low-complexity robotic platform that integrates movement control, obstacle detection, and a food-serving mechanism within a single microcontroller-based system. Existing studies have primarily emphasized customer acceptance and service experience [1], [5], comparisons of service modes and service quality [4], or advanced autonomous navigation involving mapping and localization [7]. In contrast, relatively simple Arduino-based mobile robots have generally been investigated in the context of movement control and obstacle avoidance rather than as an integrated platform for restaurant service applications [6]. This gap indicates the need for a practical robotic platform that combines fundamental mobility, sensing, and serving functions and evaluates their performance under a defined restaurant-service scenario.

The contribution of this study is the development and integration of a mobile robotic platform that combines route-following movement, obstacle detection, motor control, and a food-serving mechanism using an Arduino Uno as the central controller. The contribution is not attributed to the use of the Arduino Uno itself, which is a widely used microcontroller platform, but rather to the integration and implementation of these robotic functions into a single service-oriented platform. The proposed system focuses on essential restaurant-serving tasks using a relatively simple control architecture, thereby providing a practical prototype for investigating the feasibility of robotic assistance in repetitive food-delivery activities.

Accordingly, this study aims to design, develop, and experimentally evaluate an Arduino Uno-based service robot for restaurant food-delivery automation. The evaluation focuses on movement performance, obstacle-detection capability, food-serving performance, and the overall success rate of the intended service task. These evaluations are intended to provide empirical evidence regarding the operational feasibility of the proposed robotic platform and to establish a technical basis for further development toward more autonomous and intelligent restaurant service robots.

Theoretical foundation

Line Follower Robot

A line follower robot is a robot that moves automatically following a guide in the form of a line. With the sensor on the robot, the principle of the line follower robot is to read the line by looking at the dark color

difference on the given floor. The line that is usually used is a black line with a white background and vice versa. [2]

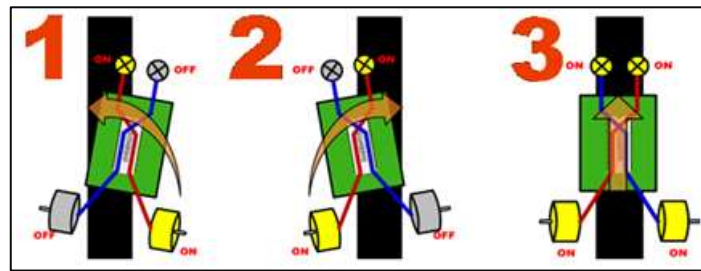


Figure 1 Working Principle of line follower Robot

Arduino Uno microcontroller

Arduino Uno is a microcontroller board that has a total of 32 pins, using an ATmega328p chip, 16 MHz crystal oscillator, ICSP header, reset button, power jack, USB cable. To run the Arduino microcontroller, you can connect the USB cable from the microcontroller to the computer or you can also connect it using an adapter from AC to DC or by using a battery to run the existing microcontroller.

Driver L298N

Motor drivers are devices used to control DC motors. The function of the DC motor driver is to control the direction of rotation of the controlled DC motor. There are several types of motor drivers with different ICs including L298, LMD18200, L293D, etc. Basically, every IC used is an H-bridge circuit, either H-bridge mosfet or H-bridge transistor. Examples of H-bridge transistor circuits are the DC motor driver L293D and also L298N. (Jaya, 2016)

DC Motor

A DC motor is a device that can convert electrical energy into movement or kinetic energy. DC motors produce a number of revolutions per minute or commonly called RPM (Revolutions Per Minute). DC motors can rotate counterclockwise or clockwise if the polarity of the electricity given to the DC motor is reversed. [2]

TCRT 5000 Photodiode Sensor

The sensor on the line follower robot functions to read or detect the path that will be traveled by the line follower robot. The robot path detection sensor is made of LED and photodiode. LED functions to emit light. The light emitted by the LED if it hits a white surface it will be reflected and received by the photodiode and vice versa if the light emitted by the LED hits a black surface it will be absorbed by the black color and not reflected back. [3]

Push Button

Push button switch (tomobol press switch) is a device that functions as a connector or breaker of electric current that works with an unlock system. Push button also functions to send signals to the microcontroller. [2]

LCD 16x2

LCD (Liquid Crystal Display) 16x2 is an electronic component that functions to display the desired data. The characteristics of the 16x2 LCD are that the 16x2 LCD can display 16 characters on the top row and 16 characters on the bottom row, for that the total characters that can be displayed by the 16x2 LCD are 32 characters.

2. METHODS

The research method used in this research is the experimental research method. Which in this method is to find causal data in a process through experiments to find out how to design an arduino uno-based waiter robot.

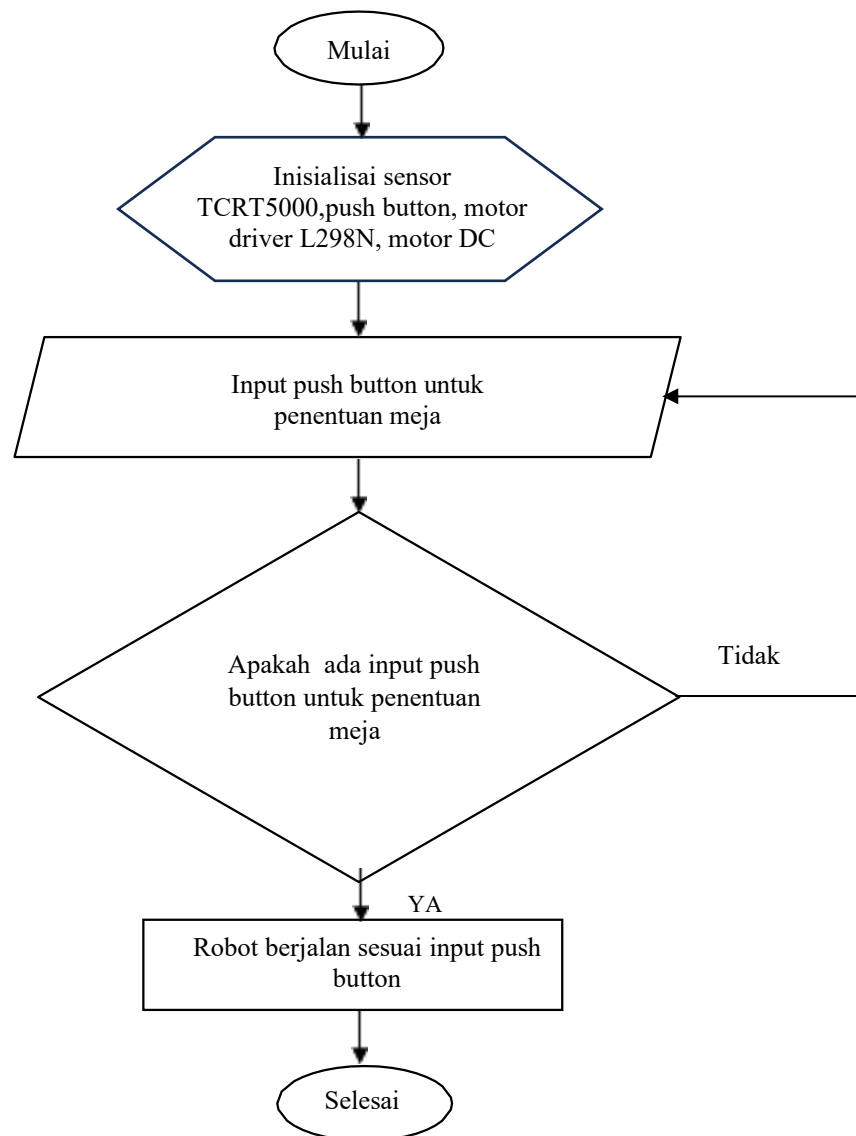


Figure 2 Research Flowchart

3. RESULTS AND DISCUSSION

In this study, there are several tests taken, namely testing the robot waiter path, testing the robot with push button input on the LCD menu, testing the robot as a whole.

3.1 Path testing of the waiter robot

Path testing of the waiter robot will be carried out to test each intersection that the robot will pass through.

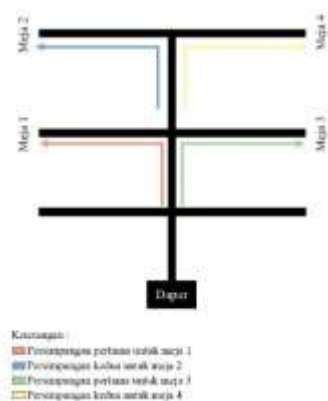


Figure 3 Robot intersection path

The second intersection for table 1, the robot will turn towards the left and the third intersection for table 2, the robot will turn towards the left and for the second intersection of table 3, the robot will turn towards the right and for the third intersection of table 4, the robot will turn towards the right.

3.2 Testing the Robot with Push Button Inputs on the LCD menu

The result of this research is that the robot can deliver food according to the push button input on the LCD menu.

Table 1 Testing Results of Push Button Inputs in the LCD menu on Table Determination

Inputan Push Button pada menu LCD		Meja Tujuan	Keterangan
Inputan Push Button		Meja 1	Berhasil
		Meja 2	Berhasil
		Meja 3	Berhasil
		Meja 4	Berhasil
		Meja 1 ke Meja 2	Berhasil
		Meja 1 ke Meja 3	Berhasil
		Meja 1 ke Meja 4	Berhasil
		Meja 2 ke Meja 3	Berhasil
		Meja 2 ke Meja 4	Berhasil
		Meja 3 ke Meja 4	Berhasil

3.3 Overall Robot Testing

Testing the robot system as a whole is to see the success of the system design made. Testing this waiter robot system to determine the performance of all existing components is able to work and can produce the output as desired. In testing the robot as a whole, there are three tests, where the first test of the robot will deliver food to table 4, the second test of the robot will deliver table 1 food to table 3, and the third test of the robot will deliver food to table 1 and after that table 4.



Figure 4 Testing the Robot on the Path

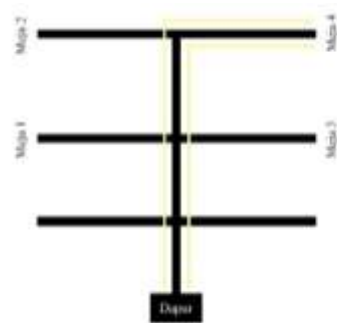
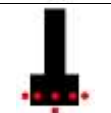


Figure 5 Food delivery route from kitchen to table 4

In testing food delivery from the kitchen to table 4, the results can be seen in table 2 with the robot passing through the intersection of existing paths.

Table 2 Sensor test results on kitchen-to-table line 4

Meja	Nama Jalur	Rute	Pembacaan Sensor pada Jalur	Aksi RLF	Keterangan
4	Persimpangan pertama	1		Jalan Lurus	Berhasil
	Persimpangan kedua	2		Jalan Lurus	Berhasil
	Persimpangan ketiga	3		Belok Kanan	Berhasil
	Persimpangan ketiga	4		Belok Kiri	Berhasil

Persimpangan kedua	5		Jalan Lurus	Berhasil
Persimpangan pertama	6		Jalan Lurus	Berhasil
Finish	7		Putar Balik dan Berhenti	Berhasil

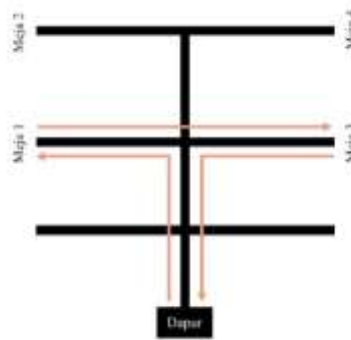
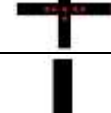


Figure 6 Food delivery route from kitchen, table 1 to table 3

In testing food delivery from the kitchen, table 1 to table 3, the results can be seen in table 3 with the robot passing through the intersection of existing paths.

Table 3 Sensor test results on the kitchen line, table 1 to table 3

Meja	Nama Jalur	Rute	Pembacaan Sensor pada Jalur	Aksi RLF	Keterangan
1 ke 3	Persimpangan pertama	1		Jalan Lurus	Berhasil
	Persimpangan kedua	2		Belok Kiri	Berhasil
	Persimpangan kedua	3		Jalan Lurus	Berhasil
	Persimpangan kedua	4		Belok Kiri	Berhasil
	Persimpangan pertama	5		Jalan Lurus	Berhasil
	Finish	6		Putar Balik dan Berhenti	Berhasil

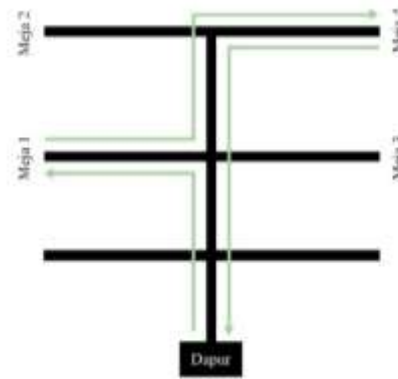


Figure 7 Food delivery route from kitchen, table 1 to table 4

In testing food delivery from the kitchen, table 1 to table 3, the results can be seen in table 3 with the robot passing through the intersection of existing paths.

Table 4 Sensor test results on the kitchen line, table 1 to table 4

Meja	Nama Jalur	Rute	Pembacaan Sensor pada Jalur	Aksi RLF	Keterangan
1 ke 4	Persimpangan pertama	1		Jalan Lurus	Berhasil
	Persimpangan kedua	2		Belok Kiri	Berhasil
	Persimpangan kedua	3		Belok Kiri	Berhasil
	Persimpangan ketiga	4		Belok Kanan	Berhasil
	Persimpangan ketiga	5		Belok Kiri	Berhasil
	Persimpangan kedua	6		Jalan Lurus	Berhasil
	Persimpangan pertama	7		Jalan Lurus	Berhasil
	Finish	8		Putar Balik dan Berhenti	Berhasil

4. CONCLUSION

This study successfully developed an Arduino Uno-based restaurant service robot for automated food-delivery tasks. The experimental results showed that the robot could follow predefined paths, select the appropriate direction at intersections, and determine the destination table based on user input through the push-button and LCD interface. The robot turned left for Tables 1 and 2 and right for Tables 3 and 4, demonstrating the functionality of the programmed route-control mechanism. These results confirm the feasibility of using a simple Arduino-based control architecture for basic restaurant service automation. The current system is limited to predefined routes and basic movement control. Future development should focus on improving obstacle detection, navigation reliability, automatic return-to-base functionality, and quantitative performance evaluation under more complex restaurant conditions.

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