VOL. 19, NO. 3, 2020, 66-69
www.elektrika.utm.my
ISSN 0128-4428

ELEKTRIKA
Journal of Electrical Engineering

Design and Implementation of an Autonomous Delivery Robot for Restaurant Services

Dele Z. Yanmida[1*], **Sabur A. Alim**[1] and **Abubakar S. Imam**[2]

[1]Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria.
[2]Department of Mechatronics Engineering, Nigerian Defence Academy, Kaduna, Nigeria

[*]Corresponding author: ydelzach@gmail.com, Tel: +2348065906122

Abstract: Technology advancement in the field of robotics has cut through every facet of human endeavours and employed in human environment to assist in performing tasks and making our daily lives more comfortable. Restaurant service is not exempted from this, as recently robots have been employed to carry out tasks including ordering, fetching, delivering & billing, in the restaurant to make service delivery smarter and more efficient. This study addresses the challenges in a traditional restaurant setting by introducing a model delivery robot as a waiter and a wireless system of placing orders. A novel approach of table detection and localization by a mobile robot through the use of RFID in indoor setting was proposed. The study presents a line following robot utilizing a programmed Arduino module to deliver an item (cup of drink up to 300gram weight) from Kitchen to the table from which the request was made by detecting an RFID tag at table (target) location through the onboard RFID reader on the robot. An android application was also developed for placing orders from customer's smartphone to a protoboard (receiver) containing a Bluetooth module placed in the kitchen. The performance of the robot was evaluated to determine the suitability and effectiveness of the table detection and localization with the RFID proposed technique. A promising result was observed with close proximity to target with an average error of 5% recorded.

Keywords: Android Application, Bluetooth Module, Delivery robot, Line following, RFID Tag.

Article History: received 21 August 2020; accepted 6 December 2020; published 26 December 2020.

1. INTRODUCTION

In earlier times, robot applications were confined to industrial and manufacturing processes but in this era, robots have transited from industrial setting to becoming an integral part of our lives. These robots closely interact with humans in everyday environment, rendering services that are tedious and redundant, thereby making our life more comfortable [1].

Robot as waiter is a center of attraction nowadays in restaurant, café, offices as the need to automate tasks ranging from ordering, fetching, serving, billing etc, increases daily to overcome the manual approach. Innovative technologies such as adopting mobile robots, wireless order, billing and call system, automated menu-recommender had been developed in a bid to tackle the challenges in the traditional restaurant settings [2].

This paper addresses this challenge by introducing a model delivery robot developed and implemented to deliver order drink (cup of drink 300gram max) to two tables to emulate a restaurant setting. An RFID approach to table detection and localization by a mobile robot was implemented for the delivery robot in an indoor setting.

2. REVIEW OF RELATED WORK

Mishra et al. [3] introduced a web-based application in which a customer can use his/her smartphone to place their orders. The system is authorized from an attendant in the kitchen to manage the menu from each table and keep track of each order. A waiter robot is suggested and needed to deliver ordered items to the respective table.

Amit et al. [4] developed a system based on the technique of coordinate following robot in order to deliver an item to a particular table. A menu is made available through a mobile app installed on an android phone when connected to the Bluetooth address of the arena. The system employs a wheel encoder and an RF technology to guide the robot to the required table. The wheel encoder technique for table detection is prone to wheel slippage.

Shiny et al. [5] developed a robotic waiter system for ordering, serving and billing. The ordering system consists of a keypad for placing orders and LCD for displaying orders. The order is transferred to the kitchen using the WIFI ESP8266 module. The robot uses wheel encoders for wheel steps to navigates to its target. It is also equipped with a proximity sensor to detect the target. The study is limited to the use of wheel encoder prone to wheel slippage.

Kamaruzzaman [6] developed a prototype waiter robot to receive order-request via an android application and collect(take) food/drink (maximum 600g) from the kitchen to the destination where the request is being made. The robot moves to the location using rotary encoders for counting the robot wheel revolution by measuring the wheel steps encoded in the programming. The robot has an LCD screen to display orders and rings an alarm when it gets to its target. This study is limited to

the use of rotary encoder for target detection which is prone to wheel slippage.

Singh et al. [7] developed a robot waiter system using with PID control algorithm to enhanced navigation to the customer's table. On getting to the designated table, the robot will generate a pre-recorded greeting and menu voice message. Reply of the guest is recorded using the microphone fitted at the front. After completing the order guest will press the go button fitted on the table interfaced with the RF transceiver module. This study is focused on the social interaction of the robot with customers and no emphasis on table detection.

Aishwarya et al. [8] developed a system in which the customers can take his/her menu through a button simply pressed on the table after which the robot navigates to the customer's table by simply following a black line on the floor. At the receiving end, an LED placed glows on pressing the button which makes the robot drives towards a target (customer's table) also equipped with an LED that glows creating a junction in between the robot and the table. The robot moves to the table by following the black line and takes the order of the customer and returns to the kitchen after delivery following a blackline mapped on the floor. LED glow interference with ambient light affects the robot from accurately locating table location.

Khan et al. [9] developed a system in which a customer place orders through a keypad containing the list of food menu along with the prizes which are displayed via an LCD screen. Upon taking the order from the customer, the robot moves towards the table location by following a black line strip on the floor. As soon as the customer gets his refreshment, the waiter robot goes back towards the kitchen location. This study is limited to line following to target (table).

Asif et al [10] came up with a system that enables the customer to place an order by pressing an electronic menu bar connected to a Bluetooth module to transferred data to the kitchen at a baud rate of 9600 bps. The robot is equipped with Four IR sensors, two of these sensors on the sides were used for table counting, while the other two sensors in the center are for white line detection and following. Then the robot waiter moves the item to the customer's table from the kitchen. This study uses IR transmitter and receiver for table detection which is prone IR errors.

3. DESIGN OF DELIVERY ROBOT

In order to deliver a cup of drink from a source (kitchen) to destination (table) system was developed using an Arduino Mega kit. The robot was design in steps or unit.

3.1 Main control Unit

The main controller unit is the Arduino mega microcontroller. Arduino Mega board is an open source software and hardware with 54 I/O pins. The Arduino Mega has a microcontroller chip that will be loaded with the program and execute the programmed instructions. In this study, Arduino takes input from ultrasonic sensor, RFID tag, Bluetooth module, IR sensors to control the motors through motor driver. Also, LCD and Buzzer receives programmed output instructions from the controller.

3.2 Wireless order System

A wireless system of placing orders from table to kitchen is designed by developing an android app installed on a smartphone as seen in figure 1 (a) and (b).

Figure 1. (a) Android App Setting (b) App layout

An HC-08 Bluetooth module placed in the kitchen receives the order and display on LCD

3.3 Navigation Unit

The robot is desired to navigate from kitchen to table location to deliver an order. This was achieved, the robot was programmed to follow a blackline with three IR sensors to detect blackline on the floor.

3.4 Target (Table) Detection Unit

The robot is able to identify the desired table location through the use of an RC522 RFID reader on the robot to detect a preprogrammed tag placed at table location while navigating on blackline.

3.5 Obstacle Detection Unit

The delivery robot is equipped with HC-SR04 ultrasonic sensor to detect and avoid collision with an obstacle on its path. The system uses an ultrasound sensor based on sonar pulse reflection and time of flight to detect an obstacle on it path, waits for clearance before proceeding to its destination.

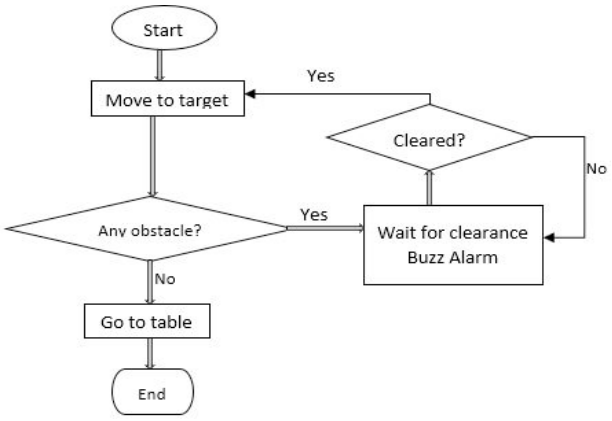

Figure 2. Algorithm (Flowchart) of Obstacle detection

Figure 3 shows the architectural block diagram of communication between the Arduino mega and sensors.

3.6 Scope of Arena Setting for Robot Operation

The model delivery robot was tested in a 2m by 3m arena with two tables and a kitchen (as shown in Figure 6) to emulate a restaurant setting. The system is designed to handle an order at a time.

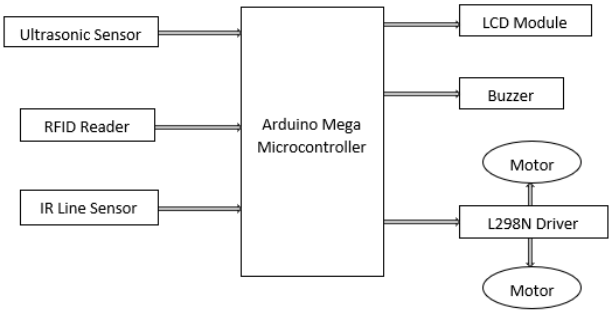

Figure 3. Block diagram of sensors and actuators of robot

4. IMPLEMENTATION OF DELIVERY ROBOT

In order to implement the design concept, an arena consisting of two tables and kitchen was set up to mimic a restaurant setting. The robot is to deliver an item (water or juice) to the request table as received in the kitchen. As the customer places his/her order through the app, the order is received via the Bluetooth module and LCD placed in the kitchen. The kitchen attendant placed the item on the robot after which it navigates to the destination table by following the blackline. The RFID reader beneath the robot detects the tag at the table location. The LCD on the robot display order information to the customer while the buzzer gives alarm signal. Fig. 4 shows the flowchart of operating process of delivery robot.

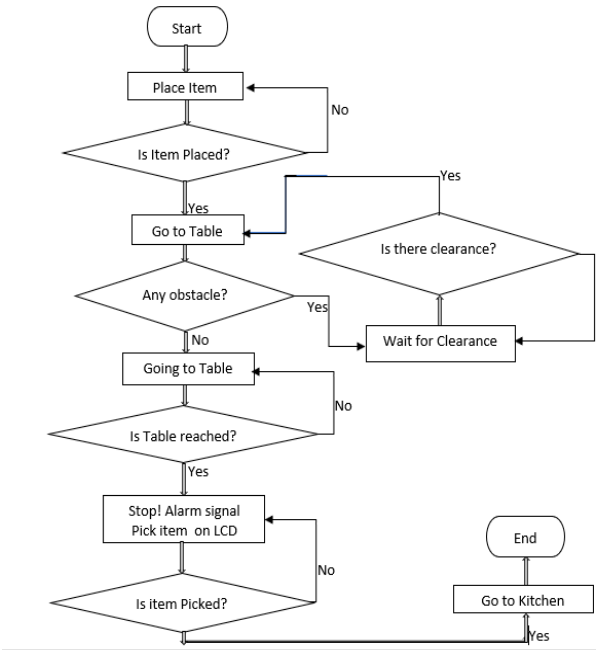

Figure 4: Flowchart of Operating process

From the flowchart, an item is placed on the robot to deliver to a table of request by following a blackline to the table. When the system encounters an obstacle, it waits and give an alarm signal for clearance before proceeding to target. The RID reader scan and detects the tag at table and stop for order to be picked. The system returns to the kitchen afterwards.

Figure 5 shows the assembled robot with Aruino Mega and other sensors. Figure 6 shows the arena setup with kitchen and two tables to demonstrate service delivery. Figure 7 shows the reciever's end at kitchen with HC-08 bluetooth module, buzzer and LCD for receiving orders. Figure 8 shows robot taking order to a table of request.

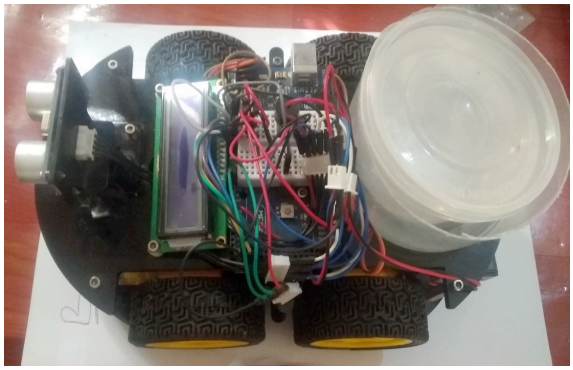

Figure 5. A complete Assemly of the robot

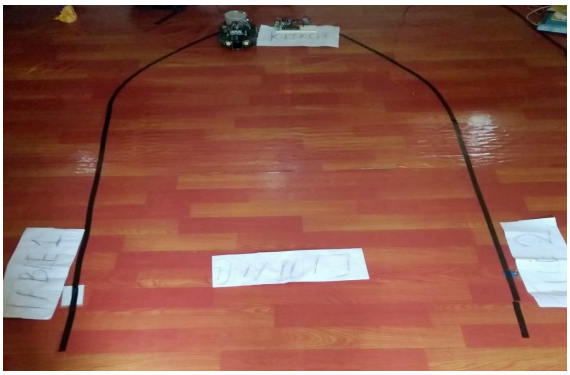

Figure 6. Floor Setting for robot operation

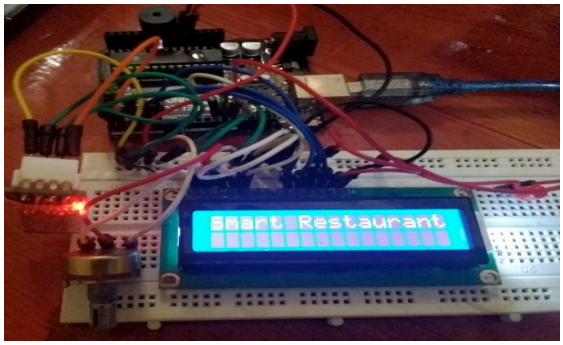

Figure 7. Protoboard reciever's end at Kitchen

Figure 8. Robot going to table to deliver Order

4.1 Experiments and Results

An experiment was conducted to evaluate the accuracy of the RFID reader placed under the robot to detect a tag at table location. The table was fixed at a known marked location 300cm from the kitchen. The robot moved from kitchen by following blackline to a table. The robot detects an RFID tag at table location. The offshoot distance from table location was measured. The error computed as shown in table 1.

Table 1. Table (Target) detection Test with robot

Test	Expected Distance from Kitchen	Robot distance from Kitchen	Offshoot Distance (Error)	% Error
Test 1	300cm	306.20cm	6.20cm	6.2%
Test 2	300cm	303.70cm	3.70cm	3.7%
Test 3	300cm	304.80cm	4.80cm	4.8%
Test 4	300cm	306.70cm	6.70cm	6.7%
Test 5	300cm	304.20cm	4.20cm	4.2%

Mean Absolute error (MAE)

$= (6.2+3.7+4.8+6.7+4.2)/5 = 5.12\%$

The average percentage error noticed in the system is 5%.

4.2 Discussion

The receiver end at the kitchen is capable of taking a particular order at a time while the robot delivers the order to the required table. The system cannot handle multiple order and delivery but can be solved in future works. This system detect it target location (table) by reading the tag at location through the RFID reader installed on the robot. This approach to table detection proves effective (5% error) for indoor system and suitable for restaurant settings.

4.3 Limitations and recommendation of the design:

- Low computation power of the Arduino Mega was used in the system, a robust microcontroller is suggested to improve RFID tag detection accuracy.
- Limited to two tables with request and delivery to a table at a time, expansion in task handling and structural design for more weight carrying capacity is recommended in future works.

5. CONCLUSION

Service robots are increasingly becoming an integral part of our daily lives as they help to automate task thereby improving our lifestyle. The study addresses the need to automate restaurant services. The robot was designed and tested to deliver an order from point A to point B by navigating from Kitchen to table location through the path provided. The results from experiments were evaluated and found to be encouraging. The work presented here demonstrate the possibility of having robots as waiters in restaurant. The system can also be used in offices, health care, as elderly assistants and lots more.

REFERENCES

[1] T. Jhy-Hwa, L. Su kuo and Wu-Feng. “Development of the restaurant service mobile robot with a Laser positioning system” 27th Chinese control conference. Pp 662-666, July, 2008.

[2] Zhu Bing, Xu-yan Zhou, Tan Bin, Peng Xu-Ge, “Research and design of restaurant service in wireless call system,” in Artificial Intelligence and Education (ICAIE), 2010 International Conference, Hangzhou, China, Oct 29-30, 2010, pp.437-440.

[3] N. Mishra, D. Goyal and A. Sharma “Automation in Restaurant: Ordering to Robots in Restaurants via Smart ordering system”, International Journal of Converging Technologies and Management (IJCTM), vol. 4, 2018.

[4] K. Amit, A. Akshay, I. Faisal, and M. Abdulahi. “Advance serving Robot for Restaurant” International Journal of Engineering, Science and Computing (IJESC). Vol. 6, 2016.

[5] J. Shiny, V. Nanthagopal and R. Raguram. “Automation of Restaurant,” IJARE*IE*, pp.1532–1539, 2017.

[6] T. Kamruzzaman, “Design and Implementation of a Robotic technique-based Waiter”. International Conference of Electrical Information and Communication Technology, pp. 7–9, 2017.

[7] A. Singh, N. Malik and K. Pratiba. “Serving Robot New Generation Electronic Waiter,” presented at the IJESC, pp 3763–3766, 2016.

[8] R. Aishwarya, M. Rawat and N. Chandra, “Wireless Coordinate following Robot for Restaurants,” International Journal of Advance Research and development, pp 33-36, 2018.

[9] Z. Khan, C. Paper and K. Buice “Waiter Robor – Solution to Restaurant Automation” International Journal of Engineering Science and Computing. 2015.

[10] M. Asif, M. Sabeel, Mujeeb-ur-Rahman, Z. H. Khan, “Waiter Robot, Solution to Restaurant Automation” MDSRC - 2015 Proceedings, 14-15 November, 2015.