Design and Development of an Efficient Food Delivery Remote Operated Vehicle (ROV) for restaurants with Cloud-based Data Management

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Abstract: An autonomous, navigating ROV will move the food within the restaurant environment by avoiding obstacles to ensure that all the orders are delivered on time and in a safe manner. When necessary, it can be operated remotely allowing for agility in dynamic environments. Use of Robotics & Cloud Computing in Food Service Industry allows for improving operational efficiency, and revenue enhancement with better customer satisfaction. In this paper, we present the architecture and implementation of a online food ordering system with Remote Operated Vehicle (ROV) for automatic food delivery inside restaurants. Essentially, it provides an integrated online ordering system for end users to place orders from restaurants or food outlets using the web-based application.

Keywords: *Remote Operated Vehicle (ROV), Cloud-based data management, Smart restaurant systems, Robotics in food service.*

I. INTRODUCTION

The Tremendous innovation in the food service industry is brought about by automation, robotics, and digital technologies. With an ever-increasing need for fast and efficient service in high-paced contexts such as restaurants, innovations like ROVs, and cloud-based systems are becoming indispensable parts of the modernizing machinery. Traditional food delivery in restaurants is highly based on human labor and therefore would be prone to delays, errors, and inefficiencies. An integration of an automated food delivery system with online order management will provide a new approach to increasing both satisfaction of the customers and operational efficiency.

The paper to present the design and development of an online food ordering platform that integrates a Remotely Operated Vehicle (ROV) for autonomous food delivery within restaurants. The key factor is that the solution allows customers to place orders via an online user-friendly interface and directly interfaces with the restaurant's Point of Sale (POS) system. Once ordered, the ROV would move around the restaurant using sensors and obstacle detection to reach the intended table or location to deliver food. The ROV would then be remotely controlled by restaurant staff using a mobile app when manual control would be necessary.

II. RELATEDWORK

Mishra et al. [3] Developed a web application for customers to order through their smartphones. The system is authorized by the kitchen assistant to control the menus of each table and follow each order. It is proposed that a waiter robot be used to deliver ordered goods to a specific table.

Amit et al. [4] Developed a system based on the coordination methods of the following robots that bring an object to a specific table. The menu is provided using the Android phone's loaded mobile application when connected to the Arena's Bluetooth address. The system uses wheel encoders and RF technology to navigate robots to target tables. The table detection wheel encoder method is susceptible to wheel failure.

Shiny et al. [5] designed a robotic waiter system for ordering, serving, and billing. The ordering system

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includes a keypad for order input and an LCD for order display. The order is sent to the kitchen via the WIFI ESP8266 module. The robot has wheel encoders for wheel steps to navigate towards its destination. It also has a proximity sensor to sense the target. The research is confined to the application of wheel encoders susceptible to wheel slippage.

Kamaruzzaman [6] created a prototype robot waiter that gets orders through an Android application and brings from the kitchen (food/drinks up to 600g) to the destination where the request is being sent. The robot moves to the destination through rotary encoders to count the robot's wheel revolution by sensing the wheel steps encoded in the program. The robot has an LCD display, indicating orders and emitting alarms when it reaches its destination. This research focuses on the application of a rotating encoder for target detection sensitive to wheel slip.

Singh et al. [7] designed a robot waiter system with a PID control algorithm to improve navigation to the customer's table. Upon reaching the specified table, the robot will produce a pre-recorded greeting and menu voice message. The guest's reply is recorded through the microphone installed at the front. Upon the completion of the order, the guest will click on the go button installed on the table connected with the RF transceiver module. This research is aimed at the social interaction of the robot with consumers and has no priority to table detection.

Aishwarya et al. [8] This is a system that allows customers to retrieve menus by simply pressing a button on the table, then moving a robot to the client's table by simply following the black line on the ground. At the receiving end, an LED positioned on the button press moves the robot to the destination (customer table), and an LED is placed, which forms a connection between the robot and the table. The robot moves to the table by following the black line, takes the order of the customer, and returns to the kitchen after delivery by following the black line located on the floor. The interference of the LED light with the ambient light affects the robot by precisely identifying the location of the table.

A system was developed by Khan et al. [9] where customers place orders via a keypad with the food menu list and the prizes which are shown through an LCD screen. After the waiter robot takes the order from the customer, it moves to the table location following a black line strip on the ground. When the customer receives his refreshment, the waiter robot returns to the kitchen location. The present study is restricted to the line following to target (table).

Asif et al. [10] Designed a system that allows customers to order by pressing the electronic menu bar connected to the Bluetooth module, and transmits the data to the kitchen at a speed of 9600 bps baud. The robot is equipped with four IR sensors, two sensors on both sides used for counting tables and two other sensors in the middle used for the detection and tracking of white lines. Then the robot waiter transfers the object from the kitchen to the customer's table. In this study, IR transmitters and receivers are used to detect tables that are susceptible to IR errors.

III. METHODOLOGY

- **Main control Unit**
  The main control unit is Arduino Mega. Microcontroller ArduinoMega board - Open source software and hardware for board with 54I/O pins. Arduino Mega is a microcontroller chip that can load programs and execute programs. In this study, Arduino receives inputs from ultrasonic sensors, Wi-Fi modules, and IR sensors to control motors via motor drivers.

- **Wireless order System**
  A wireless system through which the placing of orders from table to kitchen by scanning the QR code present on the table through online platform on a smartphone as seen in Figure 1.

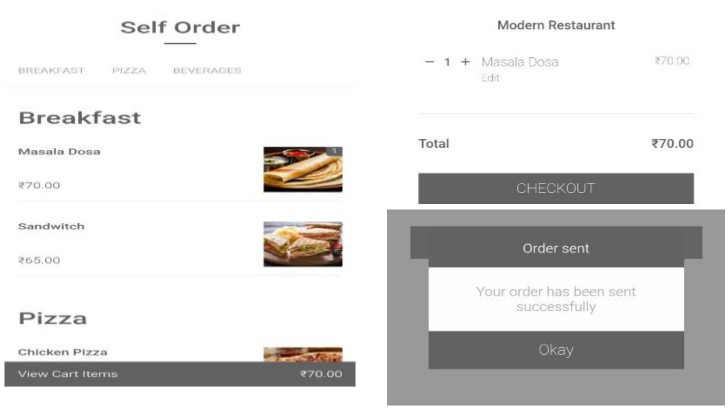

Figure1: Ordering platform.

➢ **Data management**

The ordered data of the particular table through the customers gets recorded on the website with the restaurant operators can access the data and manage the data. Figure 2 displays the orders placed by the customers and Figure 3 displays the total numbers of orders placed throughout the day.

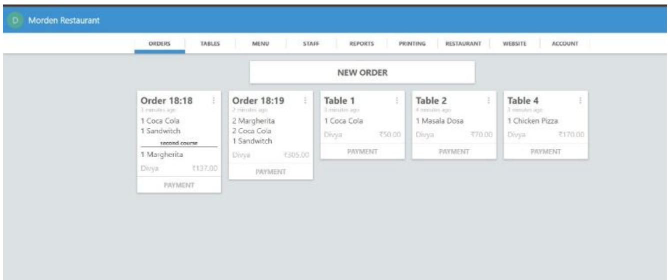

Figure 2: Order Display

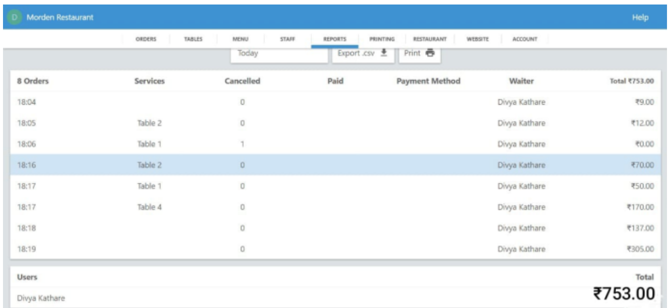

Figure 3: Order Data Display

➢ **Navigation Unit and Detection Unit**

The robot is intended to move from the kitchen to the table area to deliver an order. This goal was accomplished by programming the robot to trace a black line using six IR sensors that detect the line on the floor and to halt at the designated table to deliver the order based on the signals from the IR sensor combination coded in its programming.

➢ **Obstacle Detection Unit**

The delivery robot has an HC-SR04 ultrasonic sensor that helps it identify and steer clear of obstacles in its way. This system relies on ultrasound technology, which measures sonic pulse reflection and the time it takes for the pulse to return, to detect any obstacles ahead and halts until the path is clear before continuing toward its destination.

➢ **Remote control application**

The application is developed to control the robot to perform its delivery task. The operator can control the robot to deliver tasks from the starting position (kitchen) to the end position (table). Figure 5 represents the remote controller of the robot. As shown in the figure 5.

Figure 5: remote control application.

➢ **Implementation Of Delivery Robot**

To execute the design concept, a space with four tables and a kitchen was created to replicate a dining environment. The robot is tasked with delivering an item to the designated table as ordered from the kitchen. Customers submit their orders via the QR code located on their table. This is illustrated in the flow chart shown in Figure 6.

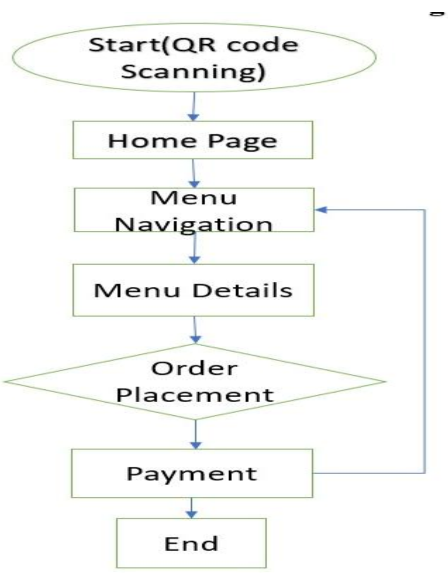

Figure 6: Flow chart of ordering system.

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According to the flowchart, an item is ordered and the food is prepared and loaded onto the robot for delivery to the requested table by following a blackline. When the system encounters an obstacle, it pauses until the obstacle is cleared before continuing to the target. The infrared sensors detect the combination along the path to ensure it takes the shortest route to the destination (Table). The preprogrammed sequence of tags along the path for each table enables us to identify the tag at the table and stop so the order can be collected. Afterward, the system returns to the kitchen, as illustrated in the block diagram in Figure 7.

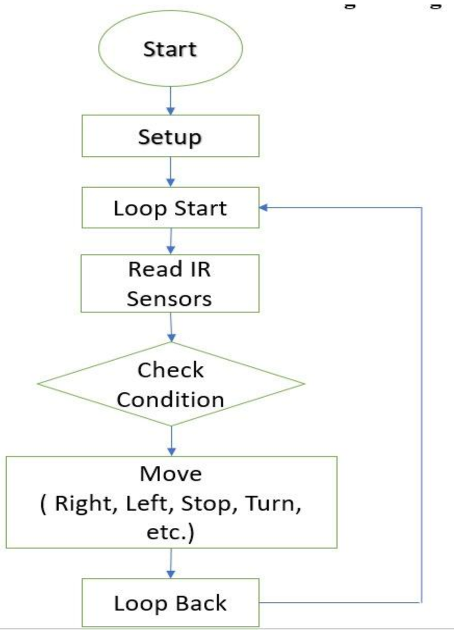

Figure 7: Flow chart of line following.

The PCB circuit diagram necessary for the robot is depicted in Figure 8. Figure 9 presents the completed robot, which includes the Arduino Mega and various sensors along with the PCB circuit. Figure 10 illustrates the robot's path arrangement featuring a kitchen and four tables for showcasing service delivery. Figure 11 displays the design model of the robot intended for item delivery.

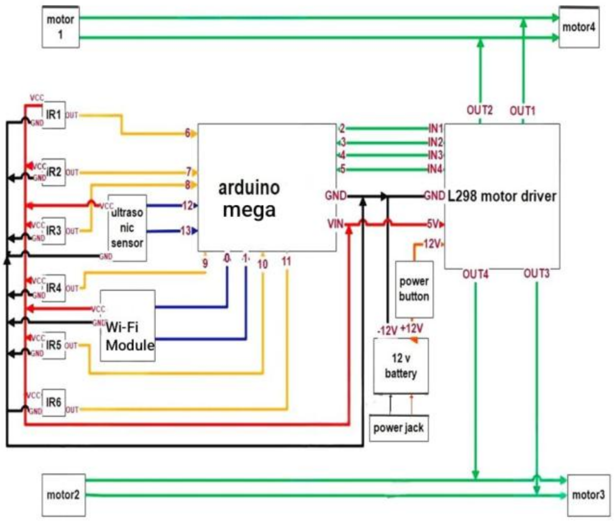

Figure 8: PCB circuit Diagram

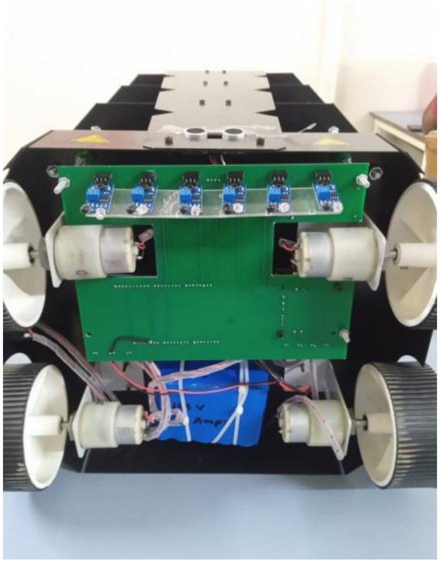

Figure 9: Assembly of components with a robot.

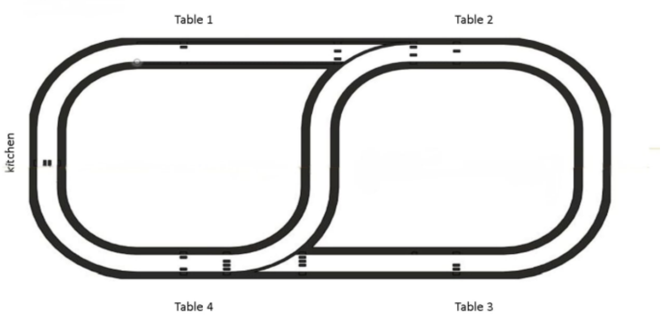

Figure 10: Robot Path.

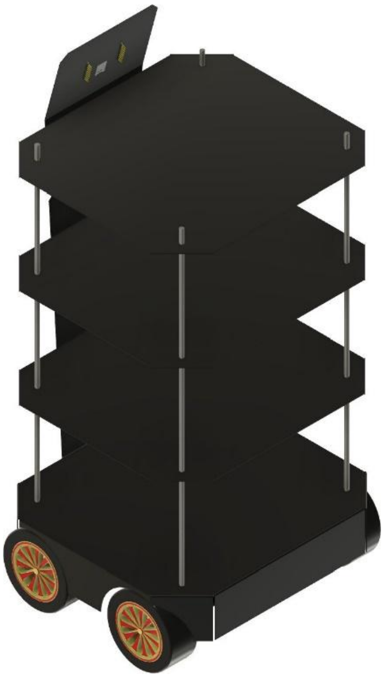

Figure 11: Robot model

The calculations required for the robot model to carry out the task with maximum payload capacity are done by applying external force on the model. Here, the design model weight is 8kg.

Therefore the calculation for Pay Load Capacity is given below:
Force = Design model weight (m) x Gravity
Force = 8 x 9.81
Force = 78.48N ≈ 8 kg.
Therefore the maximum payload capacity of the robot is up to 8 kg.
The FEA analysis required for the robot model is carried out by considering the payload capacity of the robot is shown in below figure 12for stress analysis and Figure 13 for strain analysis.

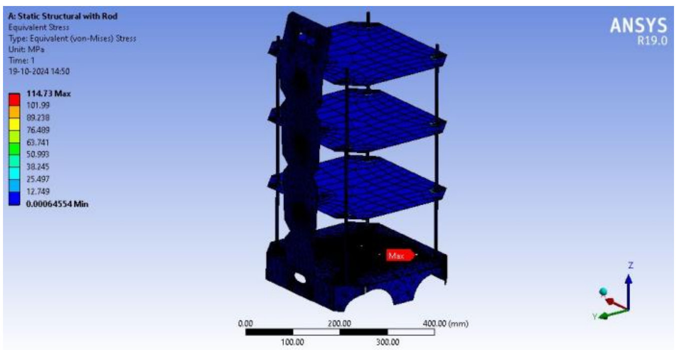

Figure 12: Stress Analysis.

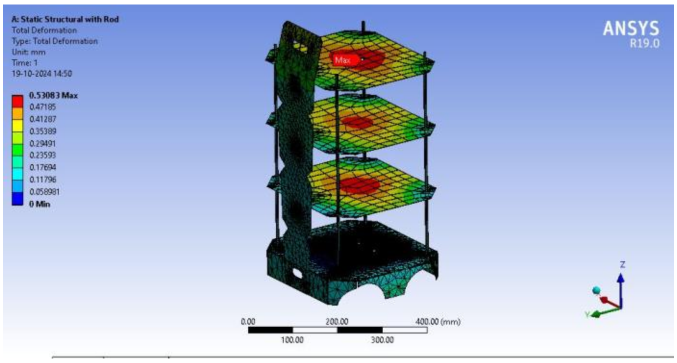

Figure 13: Strain Analysis.

IV. RESULT

The research paper describes the design, development, and deployment of an intelligent autonomous food delivery system that combines QR code-based online ordering with a Remote Operated Vehicle (ROV) for smooth in-restaurant food delivery. The system was tested stringently in a mock restaurant environment, and notable results were obtained. The QR code scanning system enabled customers to effortlessly place orders through a smartphone, which were sent directly to the kitchen through a cloud-based data management system. This eradicated errors in order-taking manually and minimized wait times. The ROV, which was provisioned with six IR sensors, provided excellent precision in line-following navigation, staying within black paths on the ground that were previously defined to arrive at specific tables. In addition, the HC-SR04 ultrasonic sensor provided real-time obstacle detection and avoidance to facilitate safe movement in dynamic environments. The structural integrity of the robot was also confirmed using Finite Element Analysis (FEA), verifying its capacity to support a maximum payload of 8 kg, which is ideal for carrying several dishes. The cloud platform offered restaurant employees a central dashboard for order tracking, data analysis, and operations management, thus boosting total efficiency. Figure 11 shows the successful delivery of coffee and water bottle delivery.

Figure 14: Result output of the robot.

V.CONCLUSION

The research finds that the combined system is an effective solution to typical restaurant problems like delays in service, human mistakes, and sanitation issues by streamlining order processing and delivery through automation. The synergy between QR technology, autonomous robots, and cloud computing not only enhances customer satisfaction but also maximizes restaurant efficiency. Potential future additions would involve AI-based dynamic pathfinding to handle dense crowds, increased payload capacities for bulk orders, and voice interface modules to create an enhanced interactive experience for customers. The study emphasizes the viability of applying such systems to real-life restaurant environments to support the increased uptake of smart restaurant technologies. This innovation is an important step toward the future of automated food services, weighing efficiency, reliability, and convenience of use.

VI. REFERENCES

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