Design and Development of Automated Restaurant Service Robot

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Abstract— This project aims at the design and development of the automated restaurant service robot. The robotics technology is replacing human work at a fast pace throughout the world. At restaurants and hotels, the customers face a lot of problems due to manual order processing, unhygienic waiters. Such limitations can be overcome by our design of AUTOMATED RESTAURANT SERVICE ROBOT. It is used for ordering food and beverages. The customer needs to scan the QR code on a particular table. After scanning a mobile application will be opened on his/her smart phone from where he/she can order the food. As the orders will directly display in the kitchen, after food preparations the chef will load the order on the robot & press the table number from which the order was received, then the only task of the robot is to serve the food on that particular table. After receiving the order customer needs to press the received button on the robot then the robot will starts moving towards to the kitchen. These robots are able to carry out the task of serving the food and beverages more effectively and efficiently than a human can do. We use the technique of line follower for the robot to move. Not only to replace the current traditional food serving technique but also for assisting the waiters we ca use these proposed automated restaurant service robot.

Keywords—Automated, Scanning, QR, Line follower,

INTRODUCTION

Restaurant automation means the use of a restaurant management system to automate the major operations of a restaurant establishment. Even in the early 1970s a number of restaurants served food solely through vending machines. These restaurants were called automats or, in Japan, shokkenki. Customers ordered their food directly through the machines. More recently, restaurants are opening that have completely or partially automated their services. These may include: taking orders, preparing food, serving, and billing. A few fully automated restaurants operate without any human intervention whatsoever. Robots are designed to help and sometimes replace human labor (such as waiters and chefs). The automation of restaurants may also allow for the option for greater customization of an order. Robotics companies are designing robots to handle tasks, including serving, interacting, collaborating, and helping. These service robots are intended to coexist with humans and engage in relationships that lead them to a better quality of life in our society. Their constant evolution and the arising of new challenges lead to an update of the existing systems. In the restaurant industry cleanliness, hygiene, proper work, timing, quality are most important. By switching to automation food industry had made fortune and continue doing it mainly due to these reasons- Robots make no mistake. Requires less maintenance and service. Save money as well as human resources. To serve in the restaurants within the time with no mistakes and hygiene the path following (trolley) robot is a great option. In Today’s world there is a continuous need for automation. The objective of this Project is to create automated service robot which will help to reduce human efforts and human contact. Main concept behind this project is to automate the traditional serving system of restaurant.

LITERATURE REVIEW

Research of the Localization of Restaurant Service Robot - Yu Qing-xiao, Yuan Can, Fu Zhuang, Zhao Yan-zheng. [1] This paper designs a restaurant service robot which could be applicable to providing basic service, such as ordering, fetching and sending food, settlement and so on, for the customers in the robot restaurant. In this study, both three landmarks positioning and landmark-based localization algorithms are proposed to localize the mobile robot with rough precision in the restaurant. And Optical Character Recognition (OCR) technology is used to distinguish the unique table number of different landmarks.

Understanding the robotic restaurant experience - Faruk Seyitoğlu, Stanislav Ivanov. [2] The results reveal a model of components of robotic restaurant experience that include six main themes: attraction for kids, robotic system, memorable experience, ambience related attributes, food related attributes (economic value and gastronomic aspects) and deficiencies (in robotic system, in ambience related attributes and in food related attributes).

Line Follower Using Arduino and Its Applications - Md Younus, Pooja Gadekar, Adhiraj Walse. [3] This paper has been designed to build a Line following Robot using IR sensor to follow a designated path which is provided and runs over it. ROBOT has sufficient intelligence to cover the maximum area of space provided. It will move in a particular direction specified by the user to navigate the robot through a black line marked on the white surface. Automatic parking technology has become a popular research topic. Automatic parking technology can complete parking operations safely and quickly without a driver and can improve driving comfort, while greatly reducing the probability of parking accidents.

Dawning of the Age of Robots in Hospitality and Tourism:Challenges for Teaching and Researcht - Murphy, J., C. Hofacker, U. Gretzel. [4] This conceptual paper revisits, refreshes and reinforces a 1984 study that challenged hospitalityeducators to include robotics in their classes and their research. The paper briefly reviews robotics literature, explains three robot categories—industrial, professional service and personal service emphasises the importance of autonomy and human robot interaction, and provides hospitality and tourism examples. This literature review leads to six areas of importance for teaching and research of robotics in hospitality and tourism. The paper gives academics and practitioners a foundation for envisioning the current and future state of robots in hospitality and tourism.

Design And Implementation of a Service Robot For A Restaurant - L. Acosta,∗ E.J. Gonz´alez, J.N. Rodr´ıguez, A.F. Hamilton, J.A. M´endez, S. Hern´andez,M. Sigut, and G.N. Marichal. [5] This paper presents a highly specialized autonomous robot. The task of the robot is the setting and clearing of tables in a controlled environment. The environment in which the robot will operate, that emulates a restaurant, will be controlled and well known. The first objective of the robot is to navigate around the room to find collectable sites, that is, tables. Once the robot has located a table, its task consists of collecting the different objects located on that table. The robot is designed to identify and collect the following objects: dishes, bottles, glasses, forks, spoons, and knives.

The development of the restaurant service mobile robot with a Laser positioning system - Tzou Jyh-Hwa L. Su Kuo. [6] The first object of this paper is to develop a restaurant service mobile robot. This service mobile robot can transfer dishes in the restaurant. It also can show the customers to the unoccupied table. The service efficiency of the restaurant service can be increased with this service robot. This service mobile robot is equipped with ldquoLaser positioning systemrdquo. The laser positioning system is used for rapid and precise positioning and guidance of the mobile robot. The second object of this paper is to develop an ordering dishes system with wireless network. Customers can order dishes on portable wireless PDA or on the touch screen of the robot. After finishing ordering dishes, the order can be transferred to the kitchen through the wireless network. When the food is finished by the cooker, the service mobile robot can carry the dishes to the customers.

METHODOLOGY

There were many options regarding robot mechanism such as, Optical Character Recognition (OCR) technology, ldquoLaser positioning system , line following fundamental .Optical Character Recognition (OCR) technology: In this technology a unique table number is used to distinguish the different landmarks.(paper1) ldquoLaser positioning: The laser positioning system is used for rapid and precise positioning and guidance of the mobile robot.(paper 6) Line Follower Using Arduino: Line following Robot using IR sensor to follow a designated path which is provided and runs over it. . (Paper 3) Based on feasibility, function, cost, line following mechanism was selected for optimum output. The path following system we have used here is based on IR Sensors.IR sensor is a special type of photo sensor which can detect Dark and Light colours. Generally a black path is made on white surface so the sensor can differentiate between both easily. Pair of IR sensors are used to detect the black line. The robot move forward if both detectors are on white surface. As soon as either of the detector cuts black line robot will move in respective direction.3 ultrasonic sensors are used on different direction of robot to avoid the collision. Ultrasonic sensors will calculate the distance between robot and object and will stop immediately. As soon as the object is moved out of the way the robot will continue to move on the path. A straight line will be used at each table as soon as both sensors go high it will detect certain table. Keypad will be used to feed the table number by the staff. for example: if staff enters table 3 the robot will come across 2 straight lines and will stop at 3rd which means it should stop when both the IR sensors get high 3rd time. For robot to return to its ideal position we will use same logic as soon as rest button is used on the keypad the robot will come across certain number of straight line and stop at its ideal position.

DESIGN AND DEVELOPMENT

Determining the load capacity of robot:

Now taking in consideration about all the tableware that are normally used in restaurants and which going to be carried to table are following-

Product to be carried	Empty weight (per unit) (in grams)	Full weight (with contents) (per unit) (in grams)
Cutlery: 1. Metal spoons 2. Metal folks	1. Metal spoons = 20g 2. Metal folks = 45g	--------(carried empty)
Plates: 1. Appetizer plate 2. Dinner plate	1. Small plates = 476g 2. Big plates = 1000g	---------(carried empty until table)
Main course utensils: 1. Starter 2. Main course(vegetable) 3. Dal	1. Starter bowl= 330g 2. Main course bowl=550g 3. Dal bowl = 686g	1. Starter bowl=493g 2. Maine course bowl= 630g 3. Dal bowl= 850g

CASE 1: (for 6 people)
If the robot carries all the food of 6 people trip 1 for starters plus trip 2 for main course the total weight carried by robot = 1st trip + 2nd trip
For example, if:
1st trip= cutlery + appetizer plates × 6 + starters ×3
= 390+2856+493
= 4725 g = 4.725 kg
Now,
2nd trip= dinner plates + appetizer plates + cutlery + dal × 2 + main course(vegetables) × 3 + rice × 2
=2856+6000+390+(850×2) +(630×3) +(490×3)
= 13822 g = 13.822 kg
Therefore, maximum weight carried for 6 people will be 13.822 kgs.

CASE 2: (for 10 people)
Similarly for 10 people calculating maximum weight that is of 2nd trip = 23439 g
= 23.439 ≈24 kgs

Therefore, the maximum capacity for robot can be estimated or kept is 23.5 kg which can be rounded off to 24 kgs.

Dimension of robot:

Determining the minimum required dimension of tray on which the food will be kept:

Task specification of tray:
Should be able to carry 6 kgs of load.

Area of each tray should be enough to fit in 2 big plates side by side.

Dimensions of tableware that are considered in table:
Dinner plate radius = 133.35 mm = 13.33 cm
Appetizer plate = 88.9 mm = 8.89 cm

Dal serving bowl = 127×88.9 mm = 12.7×8.89cm

Rectangular starter serving plate = 203×127×25.4mm
Now according to the task specification as each tray should have enough area to fit 2 dinner plates kept side by side.
Therefore, area of one dinner plate = πr^2
= π × (13.33)^2
= 558.86 cm^2
So, area of 2 dinner plates = 558.86 + 558.86
= 1117.72 cm^2
Therefore, required radius of tray can be determined by:

$$A = \pi r^2$$
$$1117.72 = \pi \times r^2$$
$$\frac{1117.72}{\pi} = r^2$$
$$\sqrt{\frac{1117.72}{\pi}} = r$$
$$\therefore r = 18.8\ cm$$

Determining height of robot:

Generally, the height of tables that are used in restaurants is between 28 to 32 inches = 711.2 to 812.8 mm

And the chairs used in restaurants have seating height from 18 inches to 23 inches = 457.2 mm to 584mm

Total height of chair that are been used in restaurants is in range 38 inches to 40 inches = 965.2mm to 1016 mm

Now for user comfort and easiness so that he/she does not have to bend more or get up from his place these three heights act as base for determining the placement of trays.

Therefore, by choosing minimum heights and giving more room for tolerances. The maximum height of robot is kept as 1200mm that is 120 cm without tyres.
Distribution is as follows:
The circular base of robot on which all the trays and support bars are going to mounted is of height 150mm and of diameter 452mm and thickness of 5mm as all the circuits are going be mounted inside the base shell.

The first tray should be at seating level or also said as knee level after seating that is 457.2 mm but as tyres will add more height therefore the first tray is placed at 400mm from the lowest point of base.

Second tray will be situated at table counter height or lower than that for comfort of customer and to provide enough room between the trays the space between it is kept 250mm. so second tray is placed at 650mm from the lowest point of base.

The third chair will be placed lower than the total height of chair for comfort and visibility so distance of third tray from lowest point of base is 900mm.

The last tray will be fixed on top support bars to so the distance between third tray and fourth is 200mm.

Force acting on each tray:

As the capacity of each tray is = 6 kgs
Therefore, g = 9.8m/s^2
m = 6kg

$$\therefore F = mg$$
$$= 6 \times 9.8$$
$$= 58.8\ N$$

=

Materials Used:-

1. ABS Plastic- The material that will be used to build the robot is ABS plastic. The reason behind using this material is because we didn't want robot to be bulky and heavy so we are using ABS plastic to make it lightweight. The material should be sturdy and should not deform under load conditions (when food is kept on it). Also ABS plastic have strong resistance to corrosive chemicals and physical impacts.

2. Arduino UNO- Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc

3. IR Sensor- An IR Sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. An IR sensor can measure the heat of an object as well as detects the motion. The working principle of an infrared sensor is similar to the object detection sensor.

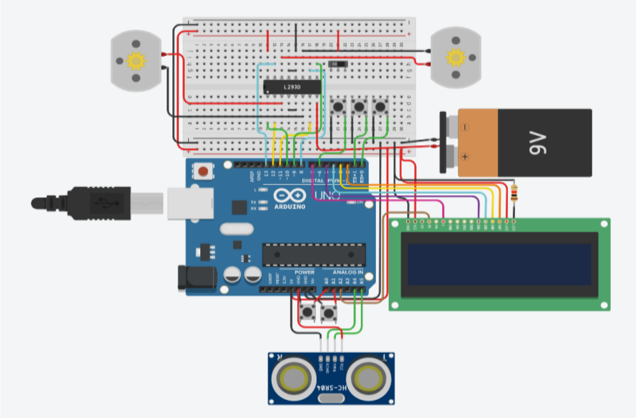
4. Motor Driver- The L293D is a popular 16-Pin Motor Driver IC. As the name suggests it is mainly used to drive motors. A single L293D IC is capable of running two DC motors at the same time; also the direction of these two motors can be controlled independently. So if you have motors which has operating voltage less than 36V and operating current less than 600mA, which are to be controlled by digital circuits like Op-Amp, 555 timers, digital gates or even Microcontrollers like Arduino, PIC, etc.

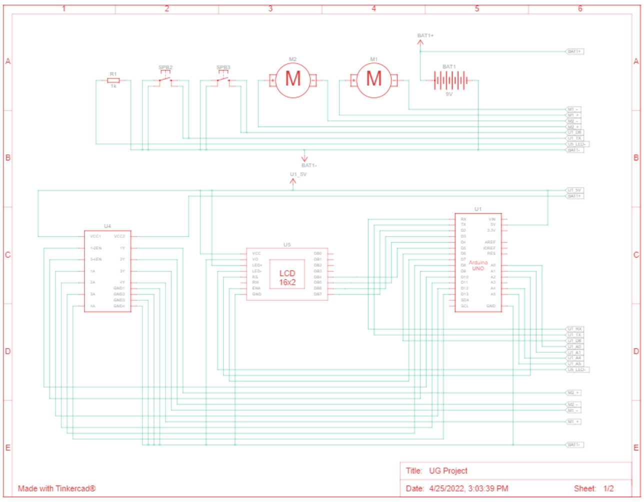
5. Caster Wheel- A caster (or castor) is a non-driven wheel that is designed to be attached to the bottom of a larger object (the "vehicle") to enable that object to be moved. Caster is used to provide support and motion in required direction.

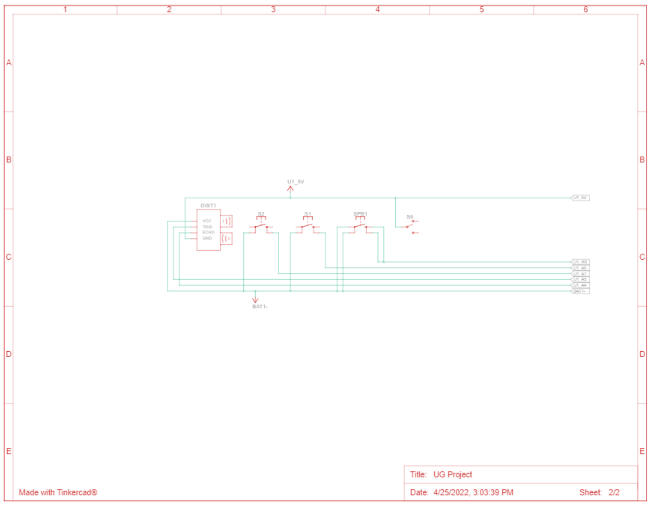
6. Ultrasonic Sensor- An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. This sensor is used for finding obstacle and avoid those.

7. Motor selection:-
Total weight= 32kg
Wheel diameter=60mm
Weight on each driving wheel= 16kg
So,
torque required = F x r = 160 x 30 = 4800 N/mm = 4.8 N/m
Motor RPM = 50
Power = Torque x RPM = 4.8 x 50 = 240 W

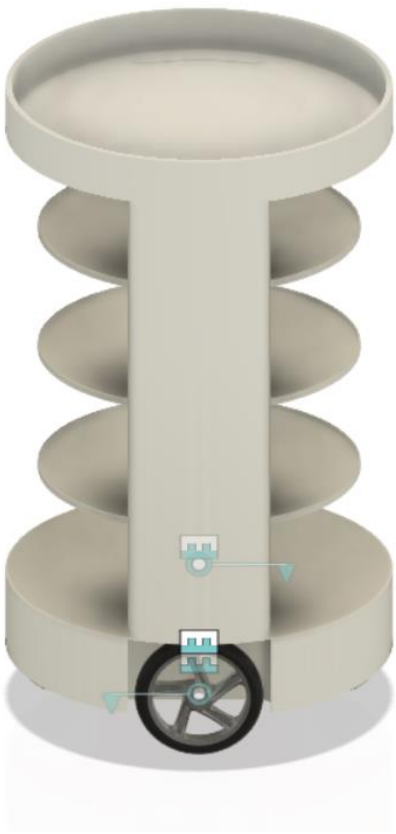
Electric circuit and connections:-
Arduino UNO is used as microcontroller. Two IR sensors are present to detect black line and guide the robot through the working space. It is also equipped with an ultrasonic sensor for obstacle detection, if any obstacle is present on the path the robot will stop. A 16x2 LCD is also provided to display current table and delivery table no. L298N motor driver is used to control speed and direction of motors. To enter the table number push buttons are given there is an increment button a decrement button and a start button.

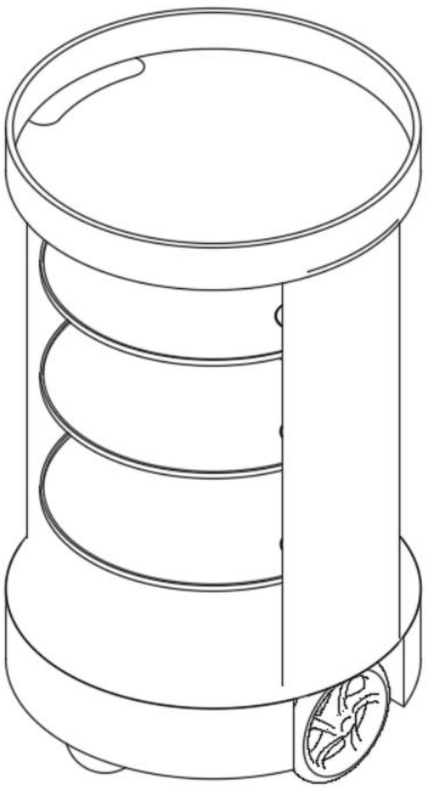






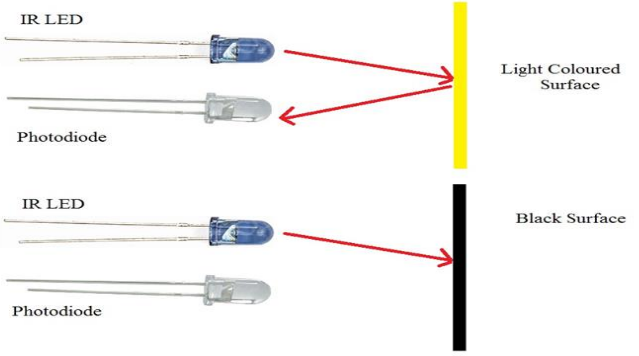
Design and Schematic diagram:-

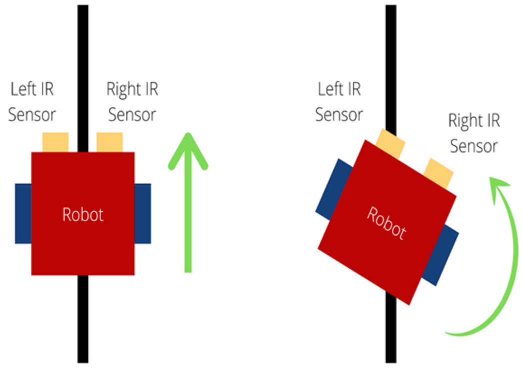




WORKING

The robot will start from loading station in kitchen where a worker will load the ordered food on to the robot trays and enter the respective table number. Then robot will move through restaurant floor and follow a pre-defined path. The path is designed and mapped in such a way that near each table a perpendicular line to the path is given, when robot reaches to this point both IR sensors will detect black line and this event will be used as a counter. A variable will increment in program and when this variable is equal to the pre-set table number the robot will stop and the customer will pick up the order. After the order is picked up message will be displayed to press a button and when it is pressed the robot will return back to kitchen. The variable will get incremented each time robot passes though perpendicular black line and then after it covers all tables it returns back to kitchen and this process will repeat.





CONCLUSION

Robots have become very popular and are being used in almost every sector, people have started accepting robots as a part of their lives because it not only makes getting work easier but also the amount of time required is less. Restaurants have also used robots to perform various tasks but most of them are expensive, so we are developing a solution that is cost effective and performs efficiently. As cost has become a major factor but our design of restaurant robot is cost efficient since we have used the concept of line follower to make the robot move. The design used is very compact and comfortable and can be used in any restaurant. Our aim is not to replace human labor completely rather use robots to assist them. Our robot is a very useful solution to all types of restaurants (with minimal changes in table arrangements) and in future it can be enhanced more.

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