Robotic waiter for Restaurants

ECE 445 Project Proposal

Project #26
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1. Introduction

1.1 Objective

Today, the shortage of manpower has become a huge conundrum for business owners, especially in the food and beverage industry. Even with the deployment of good chefs and experienced managers, restaurants tend to run into a chaos with insufficient servers. Therefore, a quick solution may be to have servers carrying heavier loads to increase efficiency. However, this solution quickly worsen as servers become fatigue and hence, unable to continue working.

Due to the fact that the main duties of servers are to fetch dishes from the kitchen to the customers, we propose to utilize an army of robots for this task. With the help of robots, the problem can be eliminated as robots can continue working tirelessly. Also, as servers are required to be trained, part-time workers tend to contribute to a wastage of resource. Furthermore as part-time workers have irregular schedules, restaurant owners may find themselves having less staff at a critical times. Consequently, to cope with a sudden surge of customers during festive seasons or the weekends, more robots can be deployed instead of having to hire more temporary staffs.

Since the whole system is computer-controlled, these robot servers will be able to place themselves in strategic locations and to have them go through optimized routes. Thus with the implementation of robot to aid the moving and carrying of heavy loads, business owners can shift their concentration into solving other problems.

1.2 Background

The research to optimize restaurant operations has been extensive. Therefore, robots have been used and is currently used in the market to cut cost and increase efficiency. In the China's northeastern Zhejiang province, a restaurant has deployed robotic waiters, each costs more than $9,400. [1]With the region's minimum monthly wage of $300, it may require some time for the restaurant to come to a breakeven. However, in long term, the restaurant may find itself saving money from the employment of less waiters.

In contrast, business owners in the USA may require less time than in China to come to a breakeven. This may be due to the much higher minimum wage. For example, with the D.C's minimum wage of $11.50, this translates to approximately $1,000 per month for every server a restaurant employs.

Therefore, within a year, restaurant owners are guaranteed to save money with the assumption that no maintenance are required for the robot in that duration.

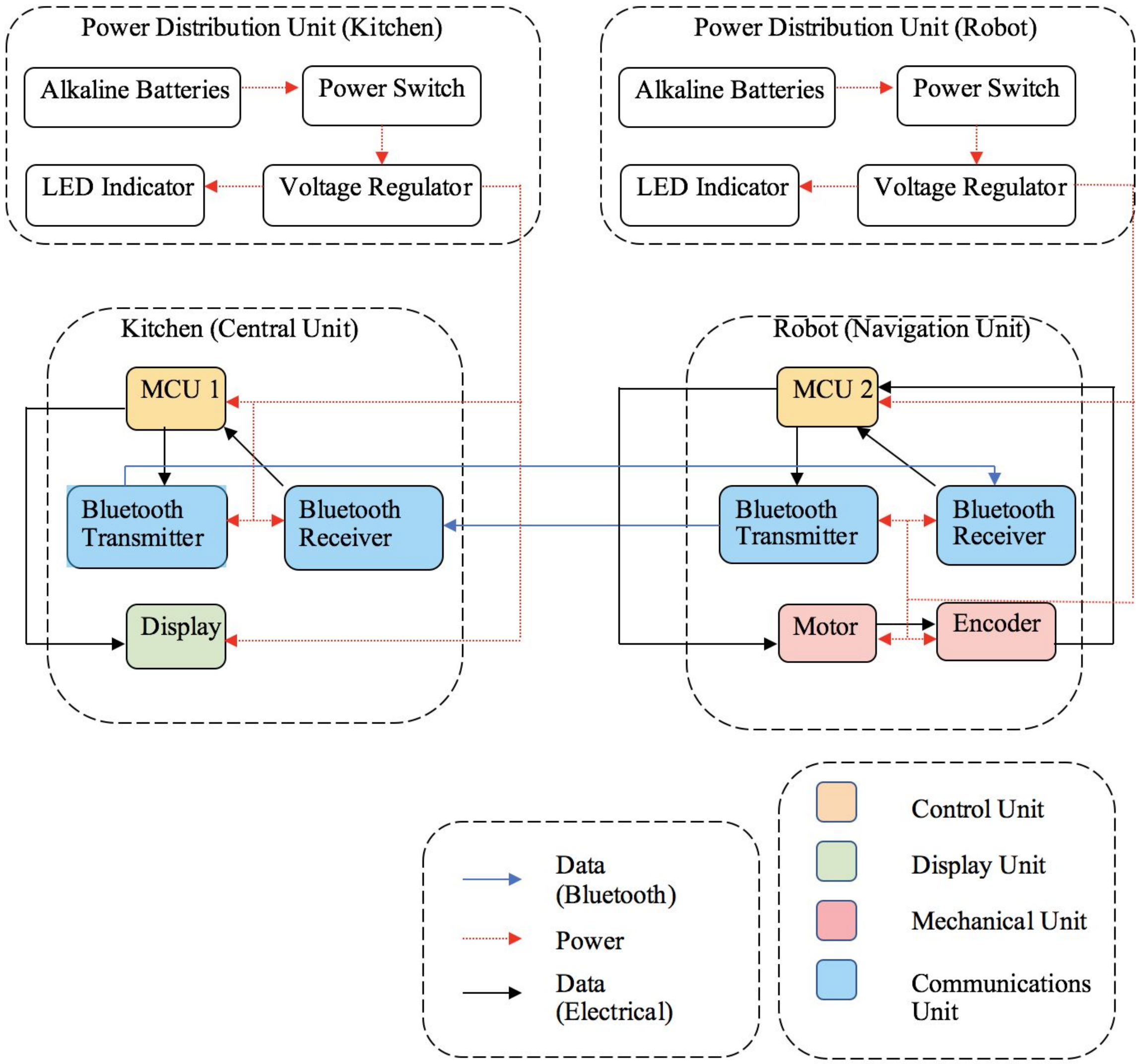
With the account of current robots costing at least $1000, we propose to reduce the costs of robots. In real applications, since the cost of our robots are much lower, it will be relatively easy to increase the number of working robots per unit area.

1.3 High-level requirements

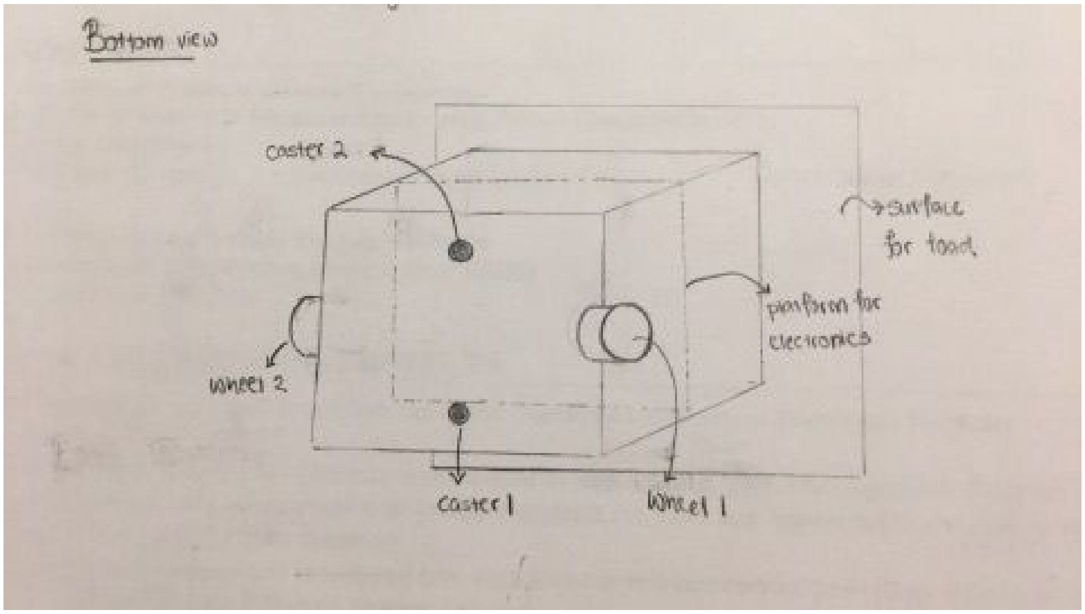
1. Send information from the kitchen's MCU (MCU1) to the robot's MCU (MCU2) and vice versa.
2. Given a destination, the robot is able to calculate and navigate a path to its final destination.
3. MCU1 is able to display the list of tables our robot is serving to on the LED display.

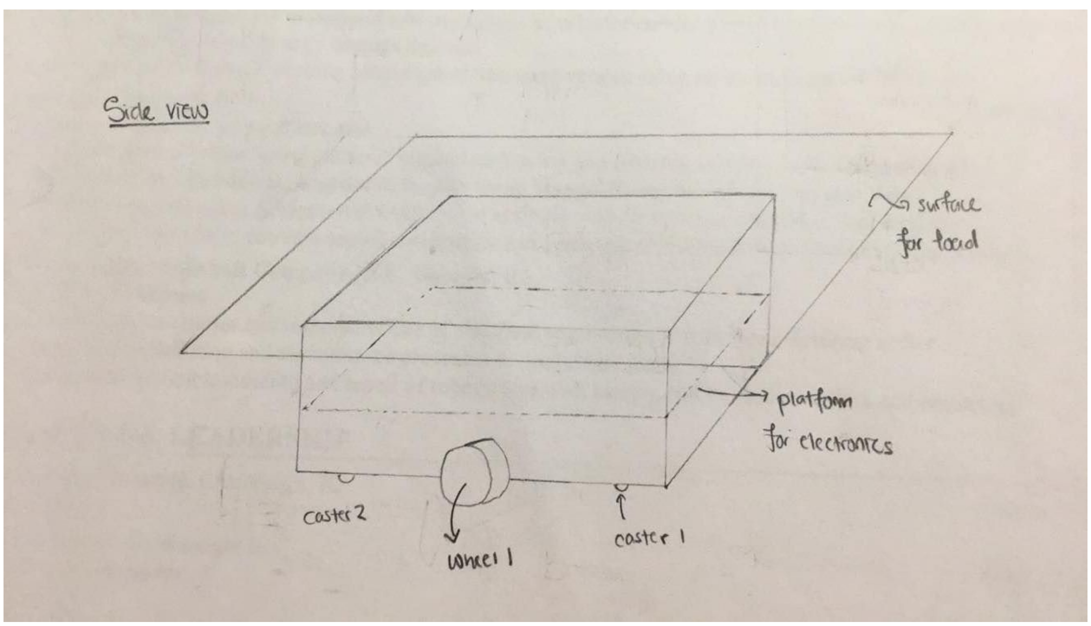
2. Design and Requirements

2.1 Design Block Diagram



2.2 Physical Design





2.3 Power Distribution Unit

The power distribution unit will be responsible to power up the devices for any time it is needed.

2.3.1 Alkaline Battery

A 9V 560 mAh will be used as the main power source. Alkaline batteries are used because they do not require any special disposal method and they are among the cheapest option[2]. However, the downside of alkaline batteries are that they have very high internal resistance and thus, reduces their runtime. Therefore, we may require several batteries on standby. Besides that, misuse of power from the battery may cause damage or failure to our components and thus, protective circuits are required to reduce the probability of such events.

Requirement 1: the battery must provide enough voltage for each part. For robot, it must provide voltage of at least 5.5 to 6V. For kitchen unit, it must provide voltage of at least 3V.

2.3.2 Power Switch

Power Switch turns on or off the power supply from battery to voltage regulator.

2.3.3 Voltage Regulator

This circuit supplies stable DC voltage to other units. For robot part, the Voltage Regulator has to provide voltage at least 5 V and current of at least 1.2A. For the kitchen unit, the voltage regulator has to supply display screen. It has to provide voltage 2.5 to 3V.

Requirement 1: The voltage regulator must provide 5 V from the battery.
Requirement 2: Must maintain temperature of chip below 150°C at a peak current draw of 1.2A.

2.3.4 LED Indicator

The LED indicator will be used to provide operating status of the robot to people around it.

Requirement 1: Have a light viewable from at least 40° viewing area

2.4 Control Unit

The control unit will be responsible in receiving and processing of data.

2.4.1 MCU1 (in kitchen)

This MCU will be inside the kitchen. It will send out instructions to the robots on its next destination. It will also be connected to a LED display that will display the tables, our robot is currently "serving".

Requirement 1: Able to connect to bluetooth transmitter/receiver
Requirement 2: Able to connect to LED display

2.4.2 MCU2 (in robot)

This MCU will be inside the robot. It will serve 2 purposes. One of them would be to connect with the Bluetooth transmitter and receiver unit (inside the robot) and gather instructions from the MCU in the kitchen on where to go next. It would use that information to calculate the path it should take to reach its destination.

The other purpose is to gather data from the encoders that are connected to the motors and ensure that the robot moves the correct distance and at the velocity we want to.

Requirement 1: Able to connect to bluetooth transmitter/receiver
Requirement 2: Sufficient memory to run simple graph-search algorithms to identify path to take

2.5 Communication Unit

The communication unit will be responsible for the conveying of information from the control unit to the respective components.

2.5.1 Bluetooth Transmitter in kitchen (central unit)

This transmitter can send the signals from MCU1 to robot's MCU2. It sends only one location of table to MCU2 one time, then it goes to idle mode. Only when MCU1 receives 'complete' message from robot, it sends the second location to MCU2.

Requirement 1: this bluetooth transmitter can transmit data to relatively long distance. The range should be longer than 10 meters.[3]

2.5.2 Bluetooth Receiver in kitchen(central unit)

This receiver receive the signals from MCU2. It can receive different signals from MCU2, such as robot locations, ‘complete’ message, etc.

Requirement 1: this bluetooth receiver can receive data from relatively long distance. The range should be longer than 10 meters.

2.5.3 Bluetooth Transmitter in Robot (navigation unit)

This Transmitter can send the signals from MCU2 to MCU1. It sends robots’ current location when the robot is turned on or finish its move task. It sends ‘complete’ message to MCU1 to finish move task. It also sends poll to MCU1 to ask for next location.

Requirement 1: this bluetooth transmitter can transmit data to relatively long distance. The range should be longer than 10 meters.

2.5.4 Bluetooth Transmitter in Robot(navigation unit)

This receiver can receive signals from MCU1. It receives the location of table from MCU1 and send the location to MCU2 for calculating.

Requirement 1: this bluetooth receiver can receive data from relatively long distance. The range should be longer than 10 meters.

2.6 Mechanical Unit

The mechanical unit is responsible for the movement of the robot according to the instruction from the control unit.

2.6.1 Motor

The motors on the robot is a bipolar stepper motor. It can provide relative strong power for robot and be as cheap as possible. We use two motors on the robot. Each of the motor is connected with a wheel on the robot. So motor can control the direction of robot by rotating wheels in opposite direction. The motor require about 3 to 5 V voltage and about 0.6 A current. [4]

Requirement 1: the motors can provide enough power to carry about 5kg weight object.
Requirement 2: the motor can rotate the wheel both clockwise and anticlockwise.

2.6.2 Encoder

The encoder will be connected to the motors. It will be used to calibrate the wheels to a speed we are comfortable with as well as calculate the distance the robot has moved (using number of rotations of the wheel).

Requirement 1: Able to get rotational data from the motors driving the wheels

2.7 Display Unit

The display unit is responsible for the displaying of the tasks of the robot.

2.7.1 Display

The display on the robot will be a LED display.

2.8 Risk Analysis

There are a couple major risk factors in our project. The first one is the effectiveness of the bluetooth transmission and receiver system. This transmission system will allow signals to be sent from tables to the main MCU in the kitchen and send instructions from the MCU in the kitchen to the robot. Thus if there is a breakdown in this communication, it will majorly derail our project. So we intend to prototype a simpler version of this and confirm that we are able to send messages across correctly.

The other risk factor is in the navigation of our robot. If the robot successfully gets an instruction from the main MCU in the kitchen, it has to be able to identify its location, calculate the root to its next destination, move towards it and stop correctly. The risk factor here is regarding the precise movement of our robot. If our robot does not stop correctly, that could build up and result in a bigger error if the robot has multiple turns to its destination. This could even result in, the robot not reaching its destination and maybe even colliding with another table. To avoid this, we plan on calibrating the robot such that its calculations are precise and it stops at the correct place.

3. Ethics & Safety

We don't have too many safety risks in this project. One of the safety concerns is that we will have a power system on the robot which we need to regulate. We will likely use alkaline batteries which are generally safe but we need to design the power circuit properly so ill-fated incidents will not occur. This acts according to IEEE Code of Ethics Conduct #1 [6].

Also looking at IEEE Code of Ethics Conduct #9, we need to ensure the robot's navigation is not harmful to humans around it. To ensure that, we plan on controlling the speed of the robot to a fairly slow pace - slower than humans' walking speed. If somehow, the speed crosses a certain range that we deem risky, we will have some circuit breakers or safety measures that will completely stop power to the robot so that it does not harm anyone by moving extremely rapidly.

Despite designing a robot that is supposed to replace human workers, we have kept IEEE Code of Ethics Conduct #5 in mind. We believe that our project, in the long term, would help improve people's lives and advance modern technologies.

4. References

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[3] “Wi-Fi Direct vs. Bluetooth 4.0: A Battle for Supermacy,” PCWorld, 2010. [Online]. Available: https://www.pcworld.com/article/208778/ Wi_Fi_Direct_vs_Bluetooth_4_0_A_Battle_for_Supremacy.html [Accessed: Feb. 7 2018]

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