Autonomous Delivery Robot

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1 Introduction

1.1 Objective

Robot is so called the next generation technology and indeed has been brought to our life in many aspects such as education, military and so on. With the occurrence of robots in varieties of areas, a new revolution is happening in real life since robots have their own advantages – low labor cost and stable working performance. In a word, robots have been part of the society in a deep level but there is still a lot improvements needed to enhance the performance. For example, in the coffee shop in the future, not only does the robot make coffee, but also delivers safely by itself. An autopilot robot that is able to deliver food will save a lot labor cost, but the way to its destination is not always smooth and safe, therefore, a solution is needed to deal with different kinds of special situations and potential obstacles. It is difficult for robots to recognize the surrounding objects and react as it supposed to but failure of avoiding obstacles raises the concern of safety. High performance detection, analysis and controlling systems are capable of decreasing the failure rate. However, it would cost too much to be afford for industrial applications. Due to this reason, delivery robot is still far away to daily life.

Our goal is to find a low-cost solution so that delivery robots becomes applicable in the real life. We will use combinations of 2D lidar and other sensors to lower the cost but keep the functionalities. These sensors will collect data and communicate with processor. After processing the data and calculate the desired actions, the robot will adjust the motor to avoid the obstacles. After dealing with all the problems it encountered, the robot will navigate to the destination in the end.

1.2 Background

YummyFuture has been part of the revolution in food industry by robots and they had a prototype of robot coffee stand which still need improvement in delivery system. Many previous solutions for detection use 3D lidar with camera to recognize the surrounding areas. This solution works well but a 3D lidar costs more than $1000 and need a high-performance processor, making the solution cost too much for industry.

We are going to use 2D lidar about $200 instead to drop the cost significantly. Many other sensors such as sonar and infrared detectors are used to make up the functionality of detection and increase the accuracy. In this way, using the combination of sensors, we can achieve a low-cost solution with an equivalent accuracy of output.

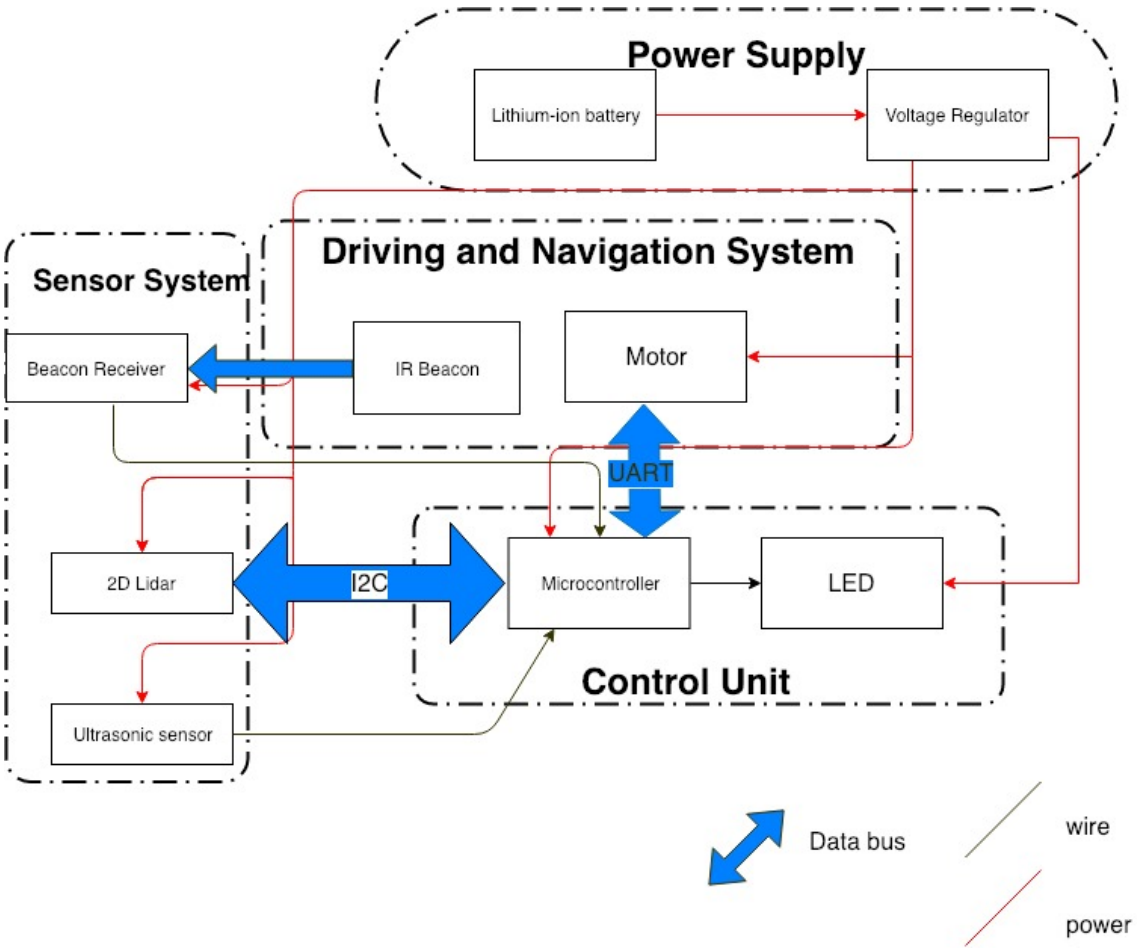
High level Requirements

1. Robot must be able to detect the standing and moving obstacles in its path in 50cm using its sensor and adjust motors correspondingly.
2. Robot must be able to navigate to the destination.
3. Robot must be lost-cost comparing to the existing solutions, the cost should be lowered by $500.

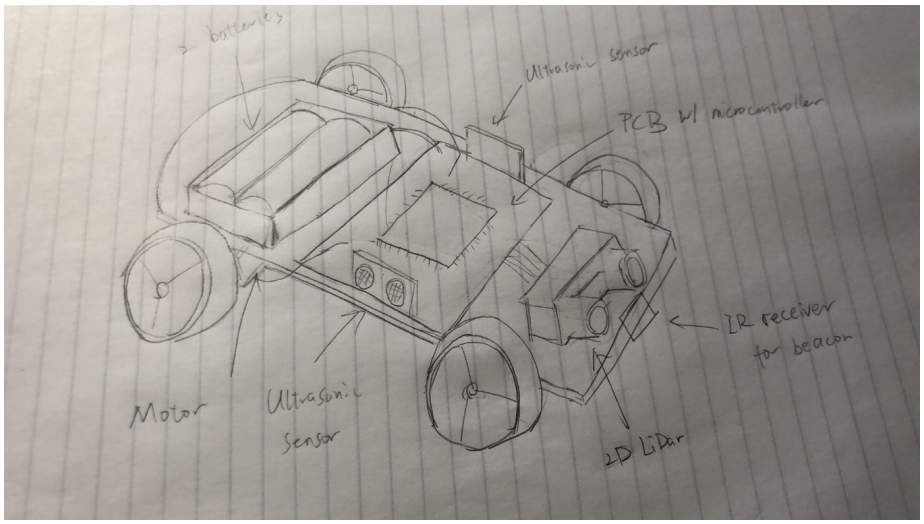
2. Design:

The entire project consists of four functional sections: Power supply system, sensor system, control unit and the driving & navigation system. The power supply is designed for keeping the project working properly including achieving all the expected functions. The sensor system is used for collecting the data from the surrounding areas, especially the potential obstacles. The control unit will be able to analyze all the data collected from all the sensors and make decisions for the driving system to execute. The driving & navigation system is supposed to make the corresponding actions according to the commands received from the control unit, and then make the vehicle approaching the pre-assigned destination.

Block Diagram



Physical Design:



Physical structure description: Our chassis will contain two batteries as DC power supply, two motors, two ultrasonic sensors, a 2D LiDar and an IR receive for beacon, and all

components are connected to the PCB with microcontroller in the middle of the chassis. The motors are installed adjacent to the two rear wheels. Two ultrasonic sensors are on the both sides of the chassis and a 2D LiDar is at the front of the car to detect the potential obstacle. There is also an IR receiver can locate the IR transmitter beacon so that the car can drive towards the destination.

2.1 Power Supply

The power supply is providing all the energy that whole project needs. It consists of two lithium-ion batteries and a voltage regulator.

2.1.2 Voltage regulator

This component is used to generate the corresponding desired voltages that the electronic components in other modules require. It should be providing 5.6~6.4Volts and max current 1A.

Requirement	*Verification*
1. *It should provide voltage in the range of 5.6 ~ 6.4 V and max current 1 A* 2. *The maximum Temperature at maximum current and voltage should be below 140 °C.*	1. *Connect the voltage regulator to two Li-ion battery each providing 3.2 V.* 2. *Measure the open-circuit voltage with a voltmeter, ensuring that it is below 6.4 V.* 3. *Add a resistive load to circuit such that the voltage drop is 5.6 V.* 4. *Ensure the current through the load is below 1 A in series.* 5. *Observe the temperature and ensure it does not exceed 140 °C.*

2.4 Sensors system

The sensors system manages navigation and obstacle detection of the robot, it will send feedback from different sensors (IR, LiDar, Ultrasonic) as data to the control unit.

2.4.1 LiDar

Requirement	*Verification*

1. *It must emit laser in range 0-30m with accuracy +/- 10cm at distances greater than 1m and +/- 2.5cm at distance less than 1m.* 2. *It must be powered by voltage 4.75-5V with current 105mA in idle mode and 130mA in working mode.*	1. *Connect the lidar to a power supply and resistive load, ensure the input voltage is in the range of 4.75-5V.* 2. *Change the current in series to 105mA and ensure the lidar is in idle mode.* 3. *Ensure lidar is in working mode with current of 130 mA in series.* 4. *Put laser sensors at distance at 1m and 30 m to ensure the working range.* 5. *In the range of 1m – 30m, move laser sensor 10 cm backwards and forwards, and check the output of lidar to ensure the accuracy.* 6. *In the range of 0m – 1m, move laser sensor 2.5 cm backwards and forwards, and check the output of lidar to ensure the accuracy.*

2.4.2 Ultrasonic sensors

HC-SR04 is chosen to be our ultrasonic sensors. They will be put on the side of the chassis to check surroundings and measure distance of close obstacles. These sensors basically support the 2D-LiDar in the sensor systems so that the robot is able to make right decision on turning left or right while encounter obstacle in front of it.

Requirement	*Verification*
1. *It must work under 4.5-5V DC power and current below 2mA Requirement* 2. *It must detect obstacle in range from 5cm to 20m with resolution 1cm.*	1. *Connect the Ultrasonic sensor to a power supply and resistive load, ensure the input voltage is in the range of 4.5-5V.*

	2. *Ensure the maximum current is below 2mA in series.* 3. *Put an obstacle at distance of 5 cm and 20 m to ensure the detection range.* 4. *Move the obstacle 1cm, 10cm and 1m to ensure the resolution of output is 1cm.*

2.5 Tolerance Analysis

Since our original purpose was to use 2D lidar along with other sensors to achieve 3D detections, there must be many limitations existing in some specific situations. Then the tolerance for the sensor system might be the major potential problem in our project. The sensitivity for the lidar and the ultrasonic sensors to get information from the obstacles will also has to be set a particular level. For example, since we are using 2D lidar and multiple ultrasonic sensors to detect the obstacles and the landforms, then we have to set a threshold value to define if a slope is ok for the vehicle to pass by or not, the angle of the slope we expected that the vehicle will be capable to take over will be below 10°.

3 Ethics and Safety

This project is pitched by Yummy Future because they want to find out a low-cost solution for the delivery system. After finished our project, we will share the outcomes with them to improve their understanding. This action is an implementation of #5 of the IEEE code of Ethics, “to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems” [1]. We would like to share our outcome with anyone who is looking to improve their robots.

We are open to accept all criticisms with regarding to the delivery robot and in case it has defects or necessary improvement, we are willing to work on it to adjust. We designed our

robots to have many replaceable parts so that we could improve it by placing more suitable parts. This is described in #7 of IEEE code of Ethics, “to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others” [1].

The most common ethics issue of robotics is that robots may hurt people’s health and property because of its failure of reacting properly. It is possible that a delivery robot navigates at a high speed and hit people or their property. This goes against #9 of the IEEE code of Ethics, "to avoid injuring others, their property, reputation, or employment by false or malicious action." [1]. During the process of designing our robot, we have carefully examined the design and make sure the ethics codes are followed. There is no harmful parts such as piercing parts in the structure of our robot, which prevents the potential hazard. In this way, the action of robot is more human-friendly.

Malicious actions that will hurt people are our biggest concern of safety and we have tried to prevent it by applying the solutions mentioned above. There is a safety standard ANSI/RIA R15.06-2012 for the industrial robot and many of the terms are relevant to our robot. For example, there is one standard that says, “Incidental contact between robot and person will not result in harm to person” and “Power and force limiting” [2]. Our design has carefully followed these standards by removing dangerous parts and adjusting speed. This delivery robot is designed to serve people, and should never have safety hazard. If there is any accident occurred because of our robot, we would accept the responsibility honestly and improve accordingly.

Reference

[1] Ieee.org, "IEEE Code of Ethics", 2019. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 07- Feb- 2019].

[2]robotics.org,“ANSI/RIA-R15.06”,2019.[Online].Available: https://www.robotics.org/robotics-standards. [Accessed: 07- Feb- 2019].