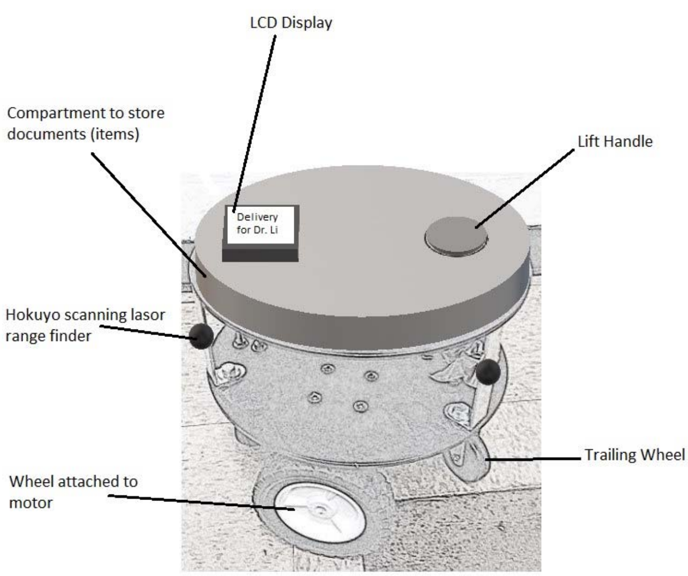
Deliveroid

Solution Design Approaches

To find the best solution to realize the Deliveroid, each team member was tasked with creating an innovative design. This document contains the three designs by members Shelton, Conrad and Jonathan. Each design details how the Deliveroid would be able to semi-autonomously pick up a document from a source office and deliver it to a specified destination.

Design #1 - Shelton



Components in Design #1:

- Previously used “Busboy” robot frame
- LCD Display
- Hokuyo scanning laser range finder
- Encoders for Odometry sensing
- Raspberry Pi
- Wi-Fi Module

Fig 1

The first design of the Deliveroid focuses on achieving the software implementation of the autonomous aspect of the Deliveroid. The physical design is minimal, having the cylindrical frame used by the no longer active Busboy team. It is cylindrical in shape with a total of three wheels. 2 larger wheels towards the front of the bot is motorized and a trailing wheel is also included to enable easy mobility and turning. The items to be transferred are stored in a lift compartment on the top of the bot. This design is pictured in Fig 1 above. The design uses the Robot Operating System (ROS) in order to implement its positioning system and autonomous movement from between offices. Before making the bot available to workers, the ROS navigation stack, scanning laser range finder, odometry sensors and the ROS slam_gmapping is used to create a two-dimensional map of floor. With this technology, the designer is also able to specify points on the 2D map (such as “Professor X’s office”).

Methodology

The Wi-Fi module first enables the bot to connect to the office network. The Raspberry Pi acts as a server and the user is able to connect and send a form to that server by navigating to a webpage. The user submits the pick-up location and the destination using the online form. The system would match the entered pick-up and destination locations with the specified points on the 2D map. ROS rviz and the scanning laser is then used to self-localize the bot and find the necessary path that the bot must follow to arrive at the selected destination (as per user entry in online form). The LCD clearly displays the recipient’s name.

Drawbacks

The design had several drawbacks. One such drawback was the fact that the bot could only do a single delivery at a time. Later on, other designs had several compartments that enabled multiple simultaneous deliveries. Also, using the Robot Operating System can become increasingly difficult. Integrating different sensors with ROS means configuring the inputs of the sensors to fit the manner required by the OS.

Design #2 - Conrad

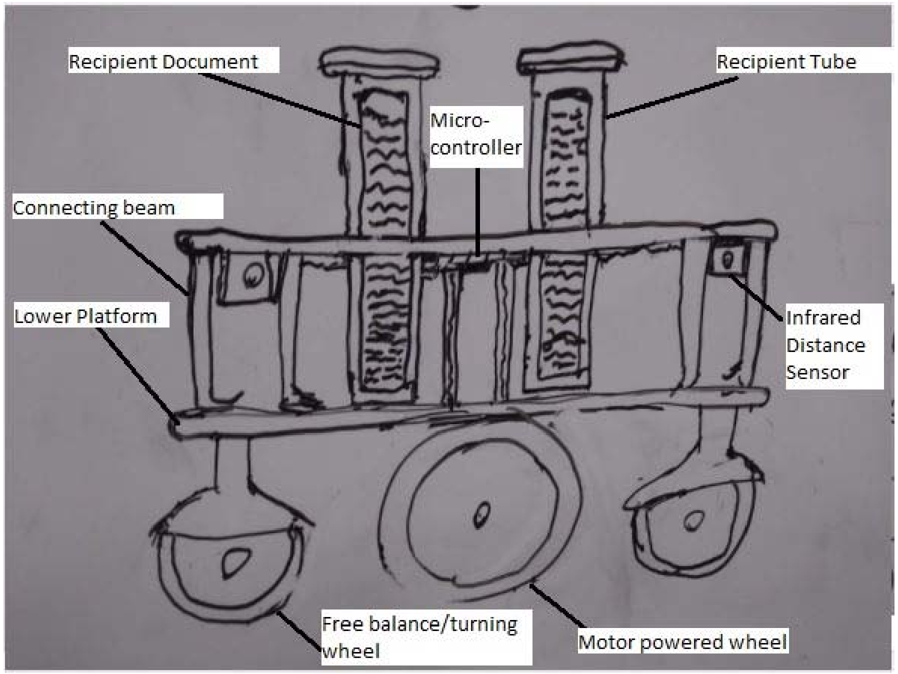


Fig. 2-1

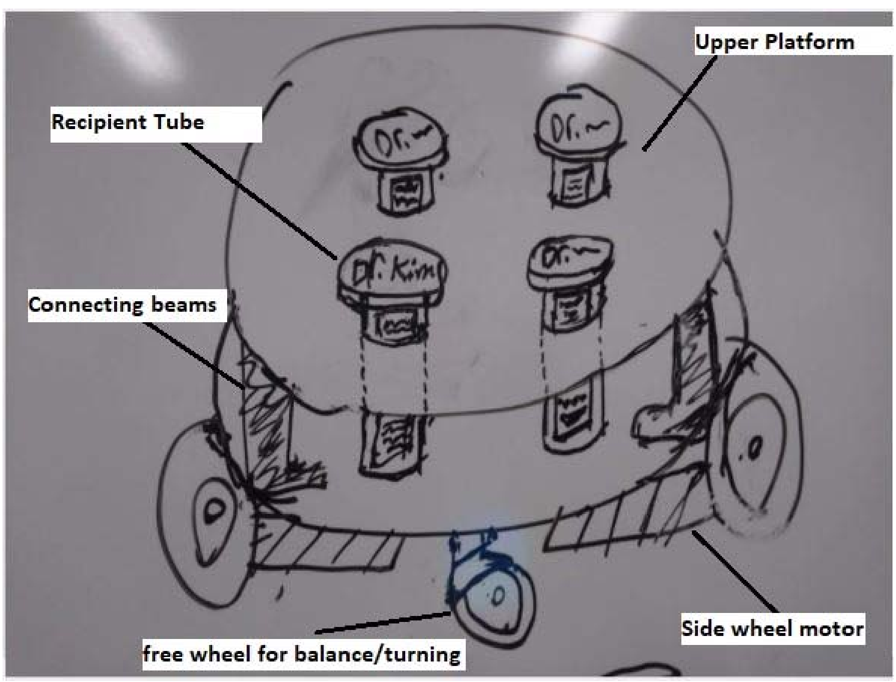


Fig. 2-2

This design builds off of the framework of the “Busbot” project of a previous senior design class.

The adjustments made are shown in Fig. 2-2. Capsule sized holes made in the top platform (4 in this schematic but possibly more in a final product). These holes will allow for the transportation of documents via capsule. These capsules are named for the recipient and are thus easy to identify. Aside from this capsule transppport implementation, the design compared to the Busbot remains largely unchanged. The Drawback of this is that there are only so many predefined recipients that can be had per Deliveroid, using this method. Another drawback is that documents must first be manually folded by the user before transport. In terms of safety, this design keeps its components under it's top platform. In the side view (Fig. 2-1) you can see the microcontroller and IR sensors located under this top platform. You can also see 2 wires connecting the top and bottom plates that have straight lines accompanying them. These are the power lines for the motor powered wheels contained in clear insulated tubing another factor to reinforce safety along with electrostatic immunity. Although not depicted in Fig. 2-1 or 2-2, any wireless communication modules (RFID, Wi-Fi, Bluetooth), would also be attached to the underside of this top platform with power sources possibly under the bottom platform. This design is also cost efficient due to the fact that it merely expands on components that we already have rather than utilizing entirely new ones.

Design 3: Jonathan

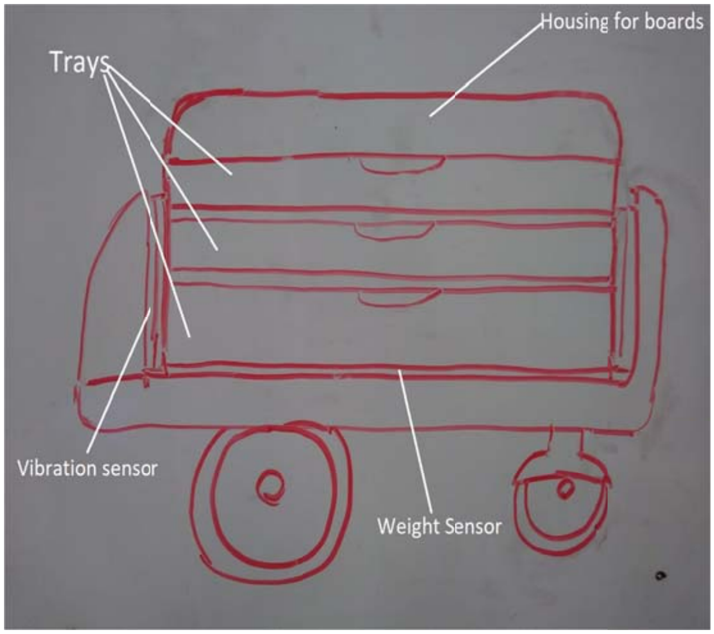


Fig 3-1

This design is based on a moving shelf. It can be simplified into two major components which is the shelving portion and the transport portion. There are three wheels that move and guide the device where 2 larger 6 inch wheels are powered by motors and the other wheel in the back is freely rotating. This setup allows for the best maneuverability compared to a 4 wheeled design and it allows for tighter angles of turning. There is a weight sensor attached at the bottom of the trays which allows us to measure the load and keep speed relatively constant. There is a vibration sensor at the front so that when there is impact the device comes to a halt. A housing at the top protects the electronic components from interference and makes the design sightly. The design also implements infrared sensors on every side as well as one facing at a 45 degree angle downward at the front so the device can discern if there is change in elevation. An RFID tag reader encased at the front allows the guidance of the robot at key places and when delivering trays are also lit to indicate which is for the recipient.

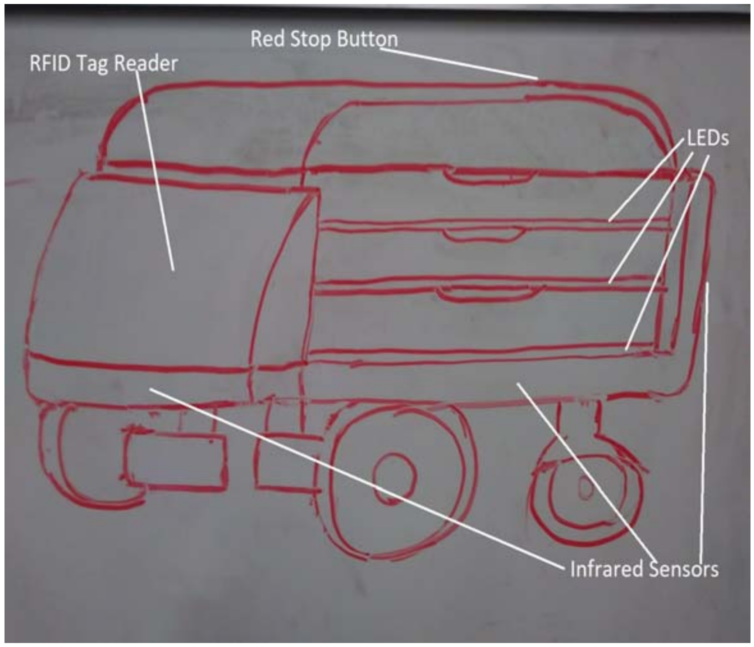


Fig 3-2

Safety wise the device will be machined so that edges are round and a button at the top clearly labeled will allow for emergency manual shutoff if needed.

This design is not the most cost efficient one due to the need for materials to build housing and the extra additional components to give the device awareness of its surroundings. However, this design is more geared towards a more user friendly interface as well as allowing for practicality when transporting items, allowing it to be loaded for up to 3 destinations at once. The design uses a 2D pre programmed map, infrared and RFID in order to find its positioning. There is a massive 54 pin Arduino Mega board that handles all of the sensors and a Texas Instruments board to handle the motors separately. The device will communicate through a wifi shield to the internet so the delivery request can be set and carried out.

Pros & Cons of top two Designs:

Design #2:

Pros	Cons
Size: Small and Compact	Load: Only can transport small amount items
Papers are transported in protective capsules	Capsules cannot transport non-foldable items, Like envelops
Currently in possession of frame	Frame does not accommodate paper shape
Deliverables are clearly labeled	Extra work for user to gently roll document and insert in capsule

Table 1

Design #3:

Pros	Cons
Size: Small	Costs more to manufacture as it requires more parts/components.
Easy insertion for sending and easy retrieval with automatic sliding drawers	Additional microcontroller connections and power consumption
Load: Can carry a large amount of items or a single large item (laptop).	Items must be flat in shape in order to fit into drawers
Weight sensor to limit load to set amount	Additional programming of microcontroller needed for more components
LEDs and LCD allow for superior aesthetics	

Table 2

Design Matrix:

	Cost	Aesthetics	Size	Practicality	Efficiency	Total Score
Weight	4	3	1	2	5	
Design 2	4	2	4	3	3	
Aggr. Score	16	6	4	6	15	47
Design 3	2	3	4	4	5	
Aggr. Score	8	9	4	8	25	54

Table 3

Category Breakdown:

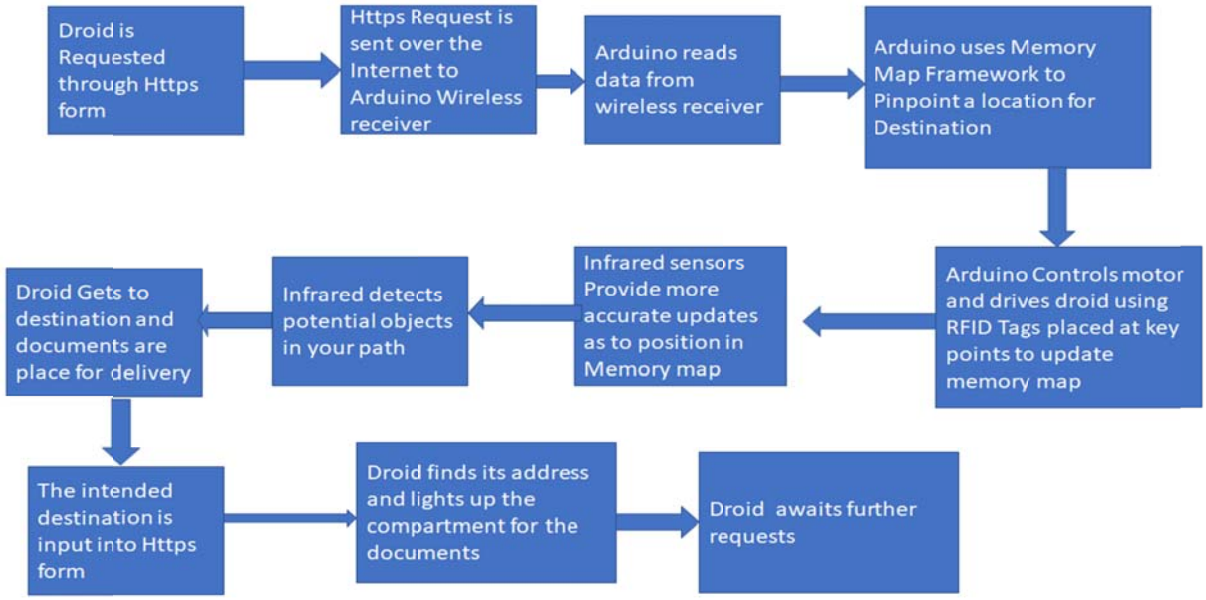
- **Efficiency(5):** A measure of how quickly and routinely the proposed design would be able to carry out its delivery functions. This is highest priority as the objective of the Deliveroid is to eliminate the hassle and time of transporting documents.
- **Cost(4):** A measure of how expensive it will be to assemble the design; with 5 being the cheapest and 1 being the most expensive. Should our device become a good on the market, it will need to be cheap to make when entering the mass production stage.

- **Aesthetics(3):** A measure of aesthetically pleasing the design is. This is important when considering the current status of the art. Most successful Autonomous robots not only accomplish their object efficiently but also do so with a design that is appealing.
- **Practicality(2):** A measure of the Ease of use of the design. It also raises the question of "would an actual person incorporate such a design into their life" This is lower in priority as we suspect that most of those who would obtain a Deliveroid have done so, as the idea of having stacks of important documents transferred not by hand is very practical.
- **Size(1):** A not too important literal measurement of the size of the design. We feel that size does not matter too much as long as the designs aesthetics are able to have it be distinguishable in an office setting.

Top Design choice (Design #3) reasoning:

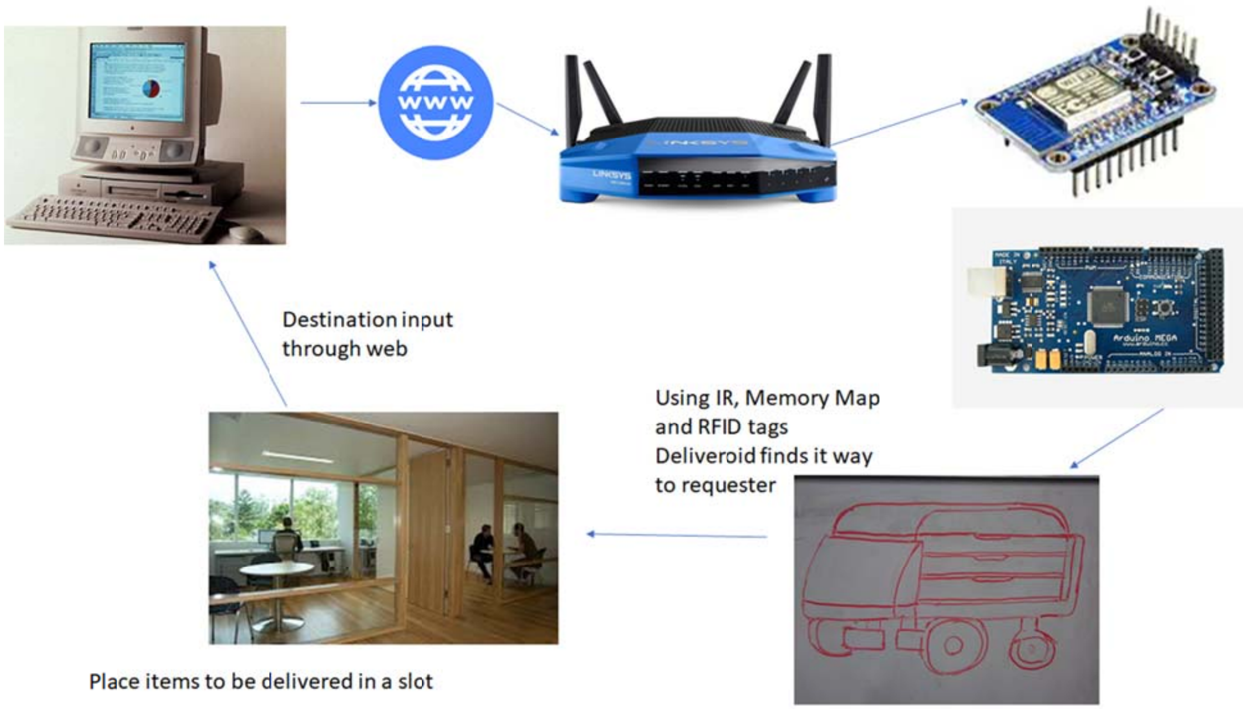
As seen in Table 3 above, using the design matrix, Design #3 came out on top with a score of 54 beating Design #2's score of 47. For this reason, the team chose to move forward with Design #3 as the top design.

Software Operation Overview:



This diagram depicts the process by which the robot will potentially be interfaced with by a user and how it uses the information to go to a specific loading point and then find its way to the intended destination. It is all done through the internet which means it requires a simple web server to process input data from users.

Hardware Overview:



Here is a look at some of the physical components necessary to carry out the process described in the software perspective. The list of components include a PC, wireless router with internet access, an arduino mega with a wifi shield, Infrared sensors, weight sensors, vibration sensor, RFID tag reader, trays with frame, motors and wheels as well as motor driver control board, LEDs to make tray indication easier and a Texas Instruments board to drive the motor control board allowing for entry of a competition.