Auto-Shopper

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Abstract

The objective of this project is to be able to build a cart that is capable of following the user, during grocery shopping, by the Bluetooth signal sent from the user's phone. This is to create an innovation that forms a more convenient environment while shopping. It also helps prevent the spreading of Covid-19, that could infect the customers by touches through the carts. This reduces the risks of getting Covid-19 infection, while performing an everyday task.

The purpose of this project is to find a way to help with the daily activity like shopping using the Bluetooth iBeacon and RFID. The cart is installed with two Bluetooth devices that find the distance between them and the user's mobile phone using the RSSI or Receive Signal Strength Indicator. It also installed with five ultrasonic sensors to detect the obstacle while moving. If the ultrasonic sensor detects the obstacle, the Bluetooth iBeacon device discovery scanning function will be paused and the obstacle avoiding movement will be commanded. After receiving the command, the wheel that was installed with motors will move according to the function. When the user scans the item with RFID tag to the RFID reader on the cart, the RFID reader will send the data to the database and the application on the user's mobile phone will update the data from the database.

Keywords—Cart, RFID, Arduino, Wi-Fi, Bluetooth, iBeacon, Ultrasonic Sensor, Movement, Tracking

I. Introduction

Shopping for groceries can be hectic, tiresome, and boring. To make it more interesting and a better experience. Sometimes, the user feels like not dragging the trolley from point A to B, thus, we came up with Auto-Shopper. The motivation for this project lies in our broader vision of 'smart-physical shopping'. We realized as a group that (Shopping) is a very dull task that has barely any innovative methods introduced to it.

The challenges that we have faced up until now have been mainly with the overall design of the supermarket and its inner workings. We can introduce a lot more concepts (like AI, and robotic arms) to make it even more interesting and exciting for the user experience.

So basically, a user has an in-built phone application for controlling the trolley and keeping running the total. The cart starts moving when the user is within a certain vicinity of it, with the aid of Bluetooth modules connected to sensors. The user shops for items, and when he/she stops, the cart waits stationary for further movement. When the item is added to the cart, an RFID scanner scans the item's tag to process its description in the application. In the end, this information is outputted in the form of the total price to pay upfront.

Before the hardware aspect, we also built a separate software test case.

Up until now (first draft == 25th Nov), we have finished working with the RFID adding and removing tag data, and User Interface design from the application. Furthermore, we have also completed the Ultrasonic obstruction detection, and 3D printing for hardware materials, and figured out the motor's movement code.

II. Background

We use RFID to detect the products that the user puts into the shopping cart, then send the data to the user interface via Wi-Fi. We also used ultrasonic sensors in collaboration with Bluetooth modules which can detect if the cart is going to be obstructed within a certain range. This will help to avoid collisions with aisles and the customer. The Bluetooth module can aid with detecting the position of the user (with phone) and making sure the cart stays moving within a predetermined proximity between said tools.

III. Project Management

This project was subdivided into two main parts. The first part is calculating the total cost of products and the second part is cart movement. In each part, there are divided tasks.

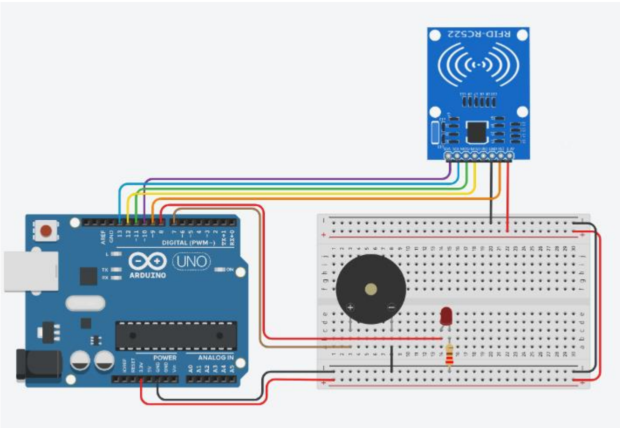
For calculating the total cost of products added to the cart, we use an RFID reader and tags to track each product. Then we Arduino Uno Wi-Fi Rev2 to communicate with an application that displays the list of products and the total cost for the user.

a. Calculating the total cost

Natasha is responsible for the RFID detection part. During the first week (17/10/22 - 23/10/22), we planned to use UHF (Ultra High Frequency) RFID reader to detect the products that get into the cart, so the RFID reader should have long range to be able to detect from all areas in the cart.

Since UHF RFID reader is very expensive and have much risk in detecting out of expected range, so in the second week (24/10/22 - 30/10/22), we decided to use HF(High Frequency) RFID Reader instead, and because of the common RFID Reader uses on Arduino is the 13.56MHz MFRC522 module that can only detect in the range of 2-5 cm., so we also decided to change from just putting the products into the cart to tapping the tag on the reader before putting them into the cart. Natasha started the software part on reading the tags' IDs and converting them into hexadecimal numbers for easy to read.

In the third week (31/10/22 - 6/11/22), start working on the hardware part. Also added a buzzer and led to help alert users that the tag has already been read. In picture (a.1) is the circuit design. In this week, the detection is already complete. The reader can read the tags into hexadecimal numbers.



(a.1) Circuit design of RFID detection

In the next week (7/11/22 - 13/11/22), ordered sticker tags for sticking on our products.

In the next week (14/11/22 - 20/11/22), after receiving the tags, Natasha has tested each sticker tag with the reader and store the tags' IDs, after that match each ID with the products' name to show which refers to which product. Also design the circuit to detect both adding and removing products from cart.

In the last week (21/11/22 - 27/11/22), tests on sending data to the UI to calculate the total cost and show product list.

As for the application, it is created by Karnpitcha. The function of the application is to let the user be able to see the current list of products in the cart and the total cost of it. So, this application communicates with RFID via Wi-Fi. The list of the products and the total cost will be updated according to the data which comes from reading RFID tags on products.

We decided to use Arduino Uno Wi-Fi Rev2 for communicating with the RFID because we want to push the data from reading the tags into the database, then the application is getting the real-time data and display it on the UI.

For the application, we wanted it to look unique, modern, and fresh, so we picked purple and blue as our main colors. As for the icon for the application, we use the image of a cart to make it related to our project name. Furthermore, it would be easier for the user to remember the application. The home page of the application displays 'My Cart' at the top, then followed by the list of boxes containing each product's information. The left side of each box shows distinct colors according to the product's category. Next to it is the image of the product and its name. In the middle, it shows the number of items that are present in the cart. On the right, the boxes display the price of the product as you can see in the figure below (a.2).

(a.2) Draft of the application

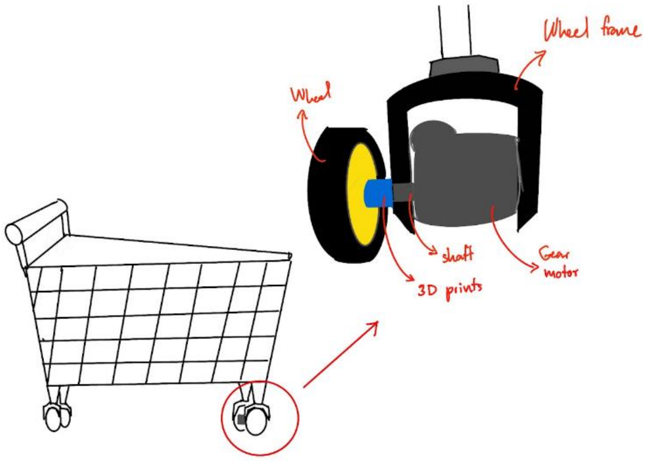
Karnpitcha uses Android Studio and Flutter for coding applications. The application is dynamic as it must fetch the data and update it according to the database.

b. Cart Movement

Chalita is responsible for hardware and cart movement.

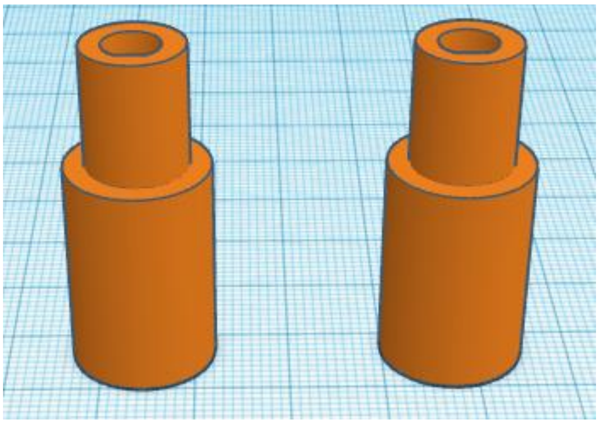
During the first week of the project, or the date of 17/10/22 till 23/10/22, Before working on the project, Chalita would need to have a rough design of what the project is going to look like, to be able to continue with the primary task, for the hardware, the ordering of equipment and the hardware pieces, which takes an average of 4 consecutive days to be delivered. During the time of delivery, the team searched for the parts that could be bought in nearby shops, to speed up the process.

After the first week passed, the second week of the project, or the date of 24/10/22 up until 30/10/22. I worked on assembling the components that have arrived by sketching the design of the cart, there were many questions to ask we during the design, such as how will the motors be able to attach to the wheels, could the motors move a cart that was almost as heavy as 3kg. The design is inserted in the image (b.1) down below. Since the cart was ordered and made from metal, there were not many changes that could be applied except for adapting the design to the cart. Making it the most suitable for the project.



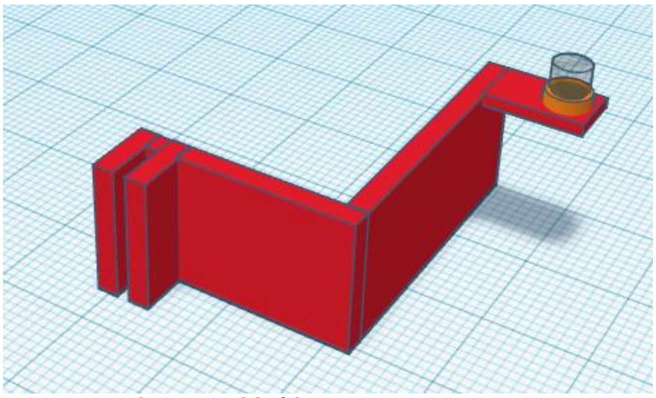
(b.1) design of cart and motor connection

The motor replaced the original wheel position, being contained in the wheel frame instead. This is due to the replacement of the original wheel. The wheel that came with the cart contained bearings and it was almost impossible to remove, making it unsuitable to connect it with the motor, as the shaft would only turn the bearing, but the wheel will stay stationary. Another reason is that the replacement wheel is 1 or 2 centimeters too large for the wheel frame. Causing excessive friction with the wheel is spin, the movement becomes less efficient, and the motor would require more force to move the cart. The image down below is the design of the 3D print that is used to connect the motor and the wheel. One end fits the wheel, and another end fits the adapter.

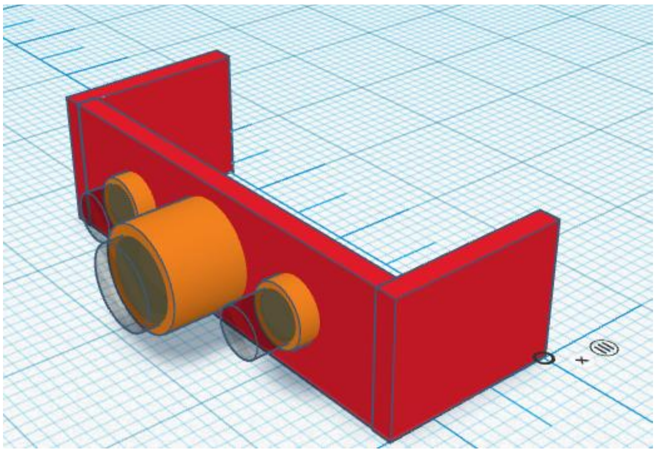


(b.2) design of the first version of the motor and wheel connector

In week 3, the date 31/10/22 to 6/11/22. The 3D design is printed was connected to the cart. However, it lacks support for the motors, the motors tilt when the cart is stationary. This shows an imbalance between the weight of the motors and the wheels. Causing more designs to be created. Such as the motor support. The following picture (b.3) is the 3D model of the motor support. The motor support and the motor also have to be connectors which means that the connector has to be designed, picture (b.4) is the 3D model of the connector.



(b.3) 3D model of the motor-support version.1



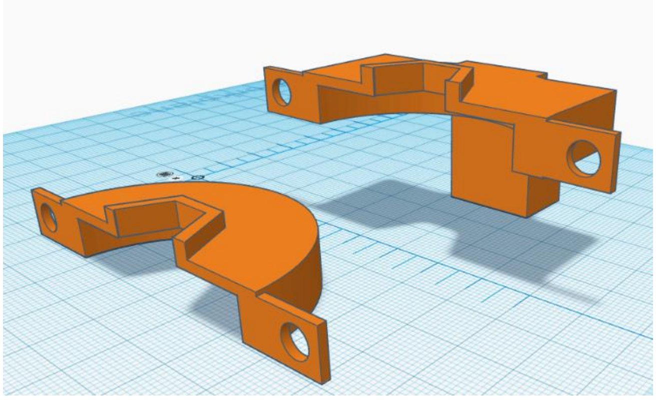
(b.4) 3D model of the motor support and motor connector

After being applied to the wheels and connecting the motors and wheels to the cart, the object with the cart has the appearance of the picture (b.5) below. After being put on a test, applying weights causes the support to break.

(b.5) The first picture of the cart

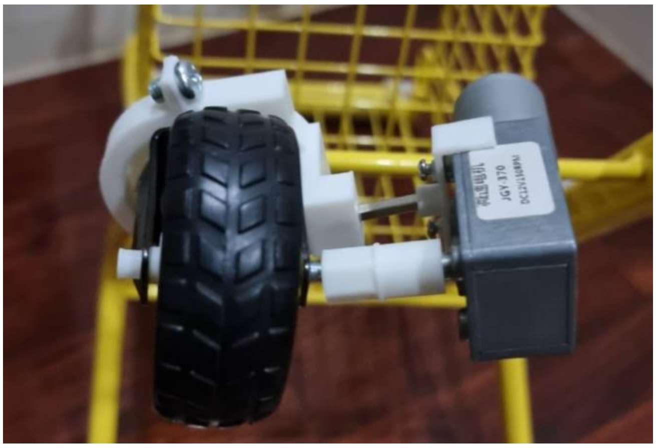
This situation forced Chalita to change its design of it to be more stable and calculate a better weight distribution.

In week 4, the date of 7/11/22 until 13/11/22, the redesign was made. The model of the support have to be more stable and be able to balance the weight distribution better than the deign before. Meaning that that the design will be more complicated than the previous design. The designs are as implemented in the picture below (b.6) The wheel is also now positioned in the wheel frame.



(b.6) is a new design of the motor support which surround the whole wheel frame.

In the week 5, the prints is complete and every prints is assembled with the carts and motors. The picture below (b.6) demonstrated the idea of the assembling of the pieces.



(b.6) the last model of the cart.

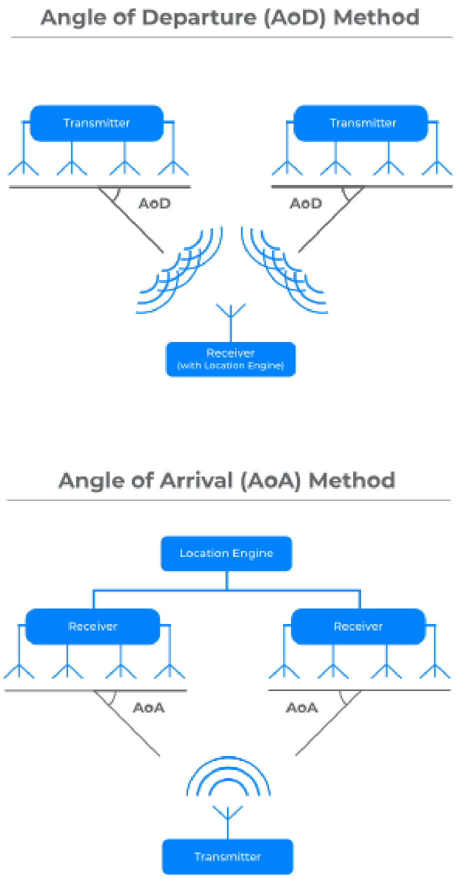
In the week 6, we focused on the testing of the model and assembling every features together.

Ahmad is responsible for the hardware, Bluetooth and Ultrasonic

For the first project progress report (18th to 24th October), since hardware would arrive 3-4 weeks later, we had to prepare software and theory beforehand. I, Ahmad, researched on different types of Bluetooth methods and which would be most suitable. For the second project report (24th to 10th November), Ahmad worked with how the BLE methods would be applied to the cart itself, with Thanakin (software part). From (10th Nov to 25th), I figured out the ultrasonic sensor design on top of the cart and wrote all the software code for 2 test cases of ultrasonic sensors to be expanded to the final number of 5, in total. Currently, Thanakin and Ahmad are still working on Object Obstruction.

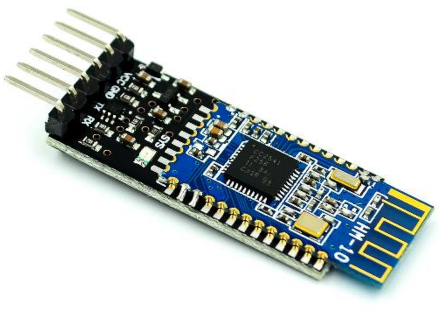
Thanakin is responsible for the software, iBeacon phone detection

In the first week, Thanakin had to find a theory that could be applied to the project, which would detect the distance between a BLE device and a mobile phone. At first, Thanakin found a technique called AoA (Angle of Arrival) and AoD (Angle of Departure), which calculates the angle of the two BLE devices to the phone that could be used to find out the distance.



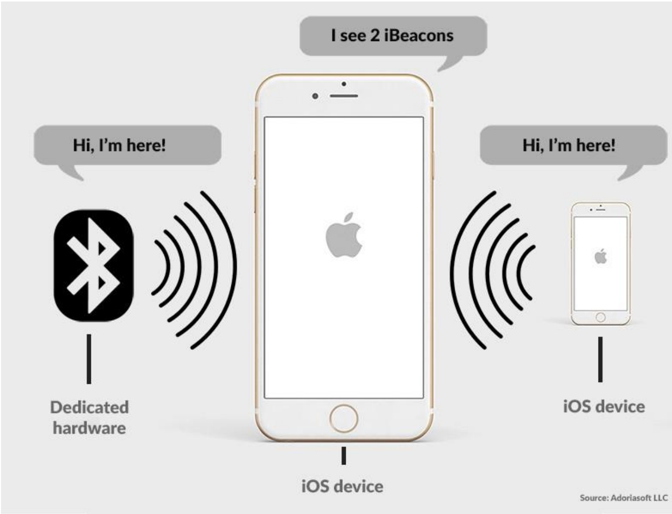
(b.7) the AoA (Angle of Arrival) and AoD (Angle of Departure) method

In the second week, we asked the professor to borrow the HM-10, the used Bluetooth device, to test out the theory. However, there was some problem with the device that Thanakin could not find the AoA or AOD function.



(b.8) HM-10 (the Bluetooth device)

In the third week, Thanakin had to find other methods which, in the end, was the iBeacon method that could give out the RSSI value (Receive Signal Strength Indicator) and use it to find the distance of the user's mobile phone even though the accuracy was unfortunately low.



(b.9) iBeacon technology

https://miro.medium.com/max/800/0*EcGYx_z8SbwFQMJ9.jpg

In the fourth week, Thanakin tried to apply the iBeacon theory into the Arduino. But the problems occurred, when sending the AT+NAME command to one of the HM-10 its response was ERROR and when trying to send the AT+DISI? command to start the iBeacon device discovery scan, there was no response at all. The reason was the firmware used by the BLE module that does not support the iBeacon system.

In the fifth week, Thanakin worked on Bluetooth with the iBeacon method to find the mobile phone distance. By using two Bluetooth, the angle of the mobile phone can be found. Finally with the distance and angle, the cart movement could be planned out and send the function to the cart motor.

In the sixth week, Thanakin combined Bluetooth with the ultrasonic that Ahmad had been working on. When the Bluetooth iBeacon detects the user's mobile in a distance, it will send the command to the motor to move to the user until it reaches a range. However, if the ultrasonic detects the obstacle near the cart, it will stop the Bluetooth function and start the obstacle avoiding function instead.

c. Gantt chart for project timeline

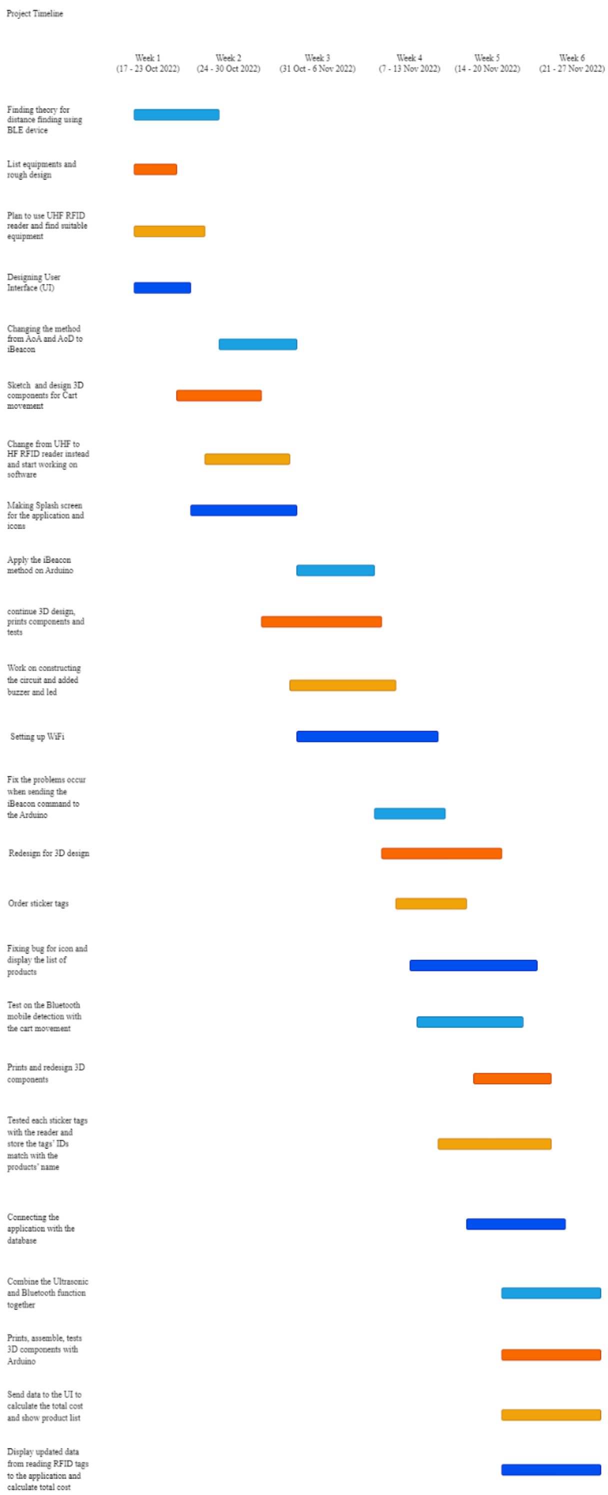
IV. Conclusion

In conclusion, the project is successfully made, however, there were many obstacles, leading to the parts that makes the project not completely perfect.

The RFID-HF is able to read the tags' ID into hexadecimal number, then convert into each specific products data and send to the application.

The Bluetooth software is accomplished by reading the RSSI (Receive Signal Strength Indicator) using the iBeacon technology. Using it to find the distance and angle between two Bluetooth devices and the user's mobile phone.

Furthermore, the application is successfully programmed to draw the data from the database to display the list of products for the current user.



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