amazon carry

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Introduction

What is amazon carry?

Amazon Carry is a personal grocery cart that follows a customer while they shop at a grocery store.

Purpose

The product is designed to carry groceries for the convenience of a typical grocery shopper with the focus in assisting those with disabilities, or small children.

Target Market

We plan to deploy Amazon Carry in major physical grocery chains The convenience Amazon Carry offers complements the benefit of inspecting goods in-store. According to a 2018 study by Adeptmind, primary benefit of in-store grocery shopping is being able to look and feel an item. Making this process easier through Amazon Carry is profitable for the grocery chains.

Our secondary target audience is Amazon Go and its users to further streamline the shopping experience; Amazon Go already removes the checkout process. Currently, there is no comparable product being sold in the market.

Project Description

Users connect to the cart by a web interface. The data from the VCSEL (vertical-cavity surface-emitting laser) sensor and deep-learning enabled camera detects the user and track the user at a default distance of 2ft. The distance and directional data from these subsystems determine motor movement. The Mecanum wheel is capable of omnidirectional movement and in-place rotation. The hosted website also enables manual control, live feedback, customization, and emergency stop.

System

The Amazon Carry consists of multiple peripherals transferring data in real-time [Figure 1].

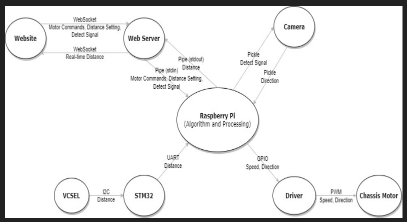

Figure 1: Block diagram of the Amazon Carry system

Components

Sensor

The VCSEL sensor emits a laser to detect the distance between the user and the cart [Figure 2].

- I2C communication between VCSEL sensor and STM32 with drivers to match the data format of the VL53L0X chip.
- UART communication between STM32F4 to Raspberry Pi with baud rate of 4800 bits per second for responsive update.

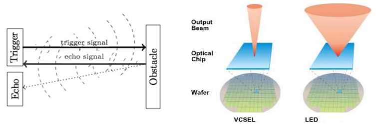

Figure 2: Distance sensors use trigger and echo signal to determine the time of flight between the chip and the object, which translates to distance. VCSEL sensor's wafer emits a narrower output beam that increase data accuracy compared to other distance sensors.

Machine Learning

The PiCamera detects and tracks the user using the OpenCV library, which functions using deep learning modules [Figure 3].

- The user is represented as a box.
- The average of the x-coordinates are used to determine where the user is relative to the camera screen.
- If the average x-coordinate is off-centered, the cart adjusts itself, so the user is re-centered in the camera screen.

Motor

There are four 12-watt motors, each driving a Mecanum wheel.

- A Mecanum wheel is composed of rollers which allow for precise movement in all cardinal directions [Figure 3].
- L298N H-bridge drivers interfaces the motors with the Pi.
- The speed of each wheel is determined by the duty cycle of the pulse-width modulation (PWM) signal.

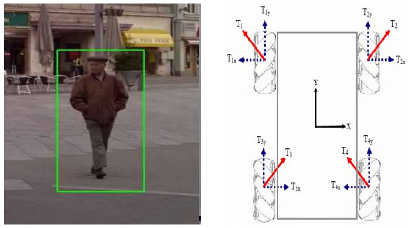

Figure 3: [Left] User being detected by OpenCV detection/tracking modules. [Right] Basic operating principle of Mecanum drive.

Figure 4: The layout of all the web interface pages. [Top] Main page sends a cue to the Raspberry Pi when "Detect" button is pressed. [Left] Debugging Console page will display data related to Amazon Carry. [Right] Manual Control page allows a remote functionality.

Web Interface

Web interface allows the user to communicate to Amazon Carry through any web browser. It can provide real-time data for users like distance, connectivity, and time. It also allows a customization to adjust distance between the user and Amazon Carry [Figure 4].

- Web Server (Node.js)
- Website (React.js, React Bootstrap, CSS)
- Protocols (WebSocket)

Impact and Consequences

Social

Amazon Carry's automation features improve the in-store grocery shopping experience. Amazon Carry affects those who are weak, disabled, or occupied by freeing the hands of the customers.

Economic

Amazon Carry will increase foot traffic in physical grocery stores because it addresses needs of the customers. We can extend the scope of Amazon Carry to warehousing to improve inventory management for future proofing.

Cost

LG prototyped CLOi Cart (similar in concept to Amazon Carry but includes additional features like voice recognition). We expect its price to be ~$1,000 due to advanced manufacturing. Amazon Carry is cost effective at ~$250 due to the focused set of features.

Safety

Amazon Carry has an emergency stop feature on the web interface in case of malfunction. With the current prototype, Amazon Carry occasionally moves unexpectedly because of the limitations of the camera. Regarding environmental safety, Amazon Carry uses a LiPo battery and power bank, which is standard. It is built mostly from wooden material, so minimal manufacturing pollution exists.

Result

Capabilities

Amazon Carry is a smart shopping cart [Figure 5].

- Detect a user after cueing through the web interface.
- Adjust position and angle based on user movement and track.
- Provide full manual control via web interface in case user needs control of the cart.
- Carry multiple grocery items.

Shortcomings and Potential Improvements

Amazon Carry only has collision prevention in the front.

- Mount additional VCSEL or ultrasonic sensors on the I2C bus to detect obstacles in all directions.
- Conduct more usability testing to account for edge cases.

Amazon Carry lacks feedback when it loses track of the user.

- Add screen and algorithms to handle unexpected behavior.

The chassis suffers delayed movements due to weight imbalance.

- Change the chassis design with weight distribution in mind.

Future Implementations

- Enable Bluetooth or Wi-Fi features for large scale deployment.
- Integrate weight and item scanning sensors for more features.
- Design a device-specific convolution neural network to adapt to the grocery store environment and user actions.

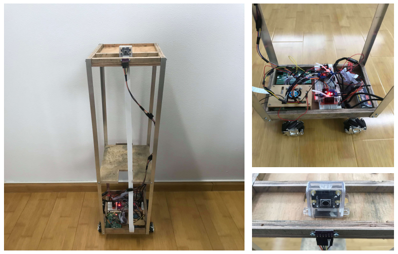

Figure 5: Image of Amazon Carry with fully integrated sensor, machine learning, motor, and web interface components.

Conclusion

Through the Capstone Project, we learned how to program the Raspberry Pi and STM32 microcontroller to automate and control a shopping cart. We became familiar with PWM to be able to control the chassis, communication protocols to obtain VCSEL sensor data, machine learning to implement object detection and tracking, and web interface design to enable human computer interaction.