Handsfree Following Cart

Fall 2021 - ECE 445 Project Proposal

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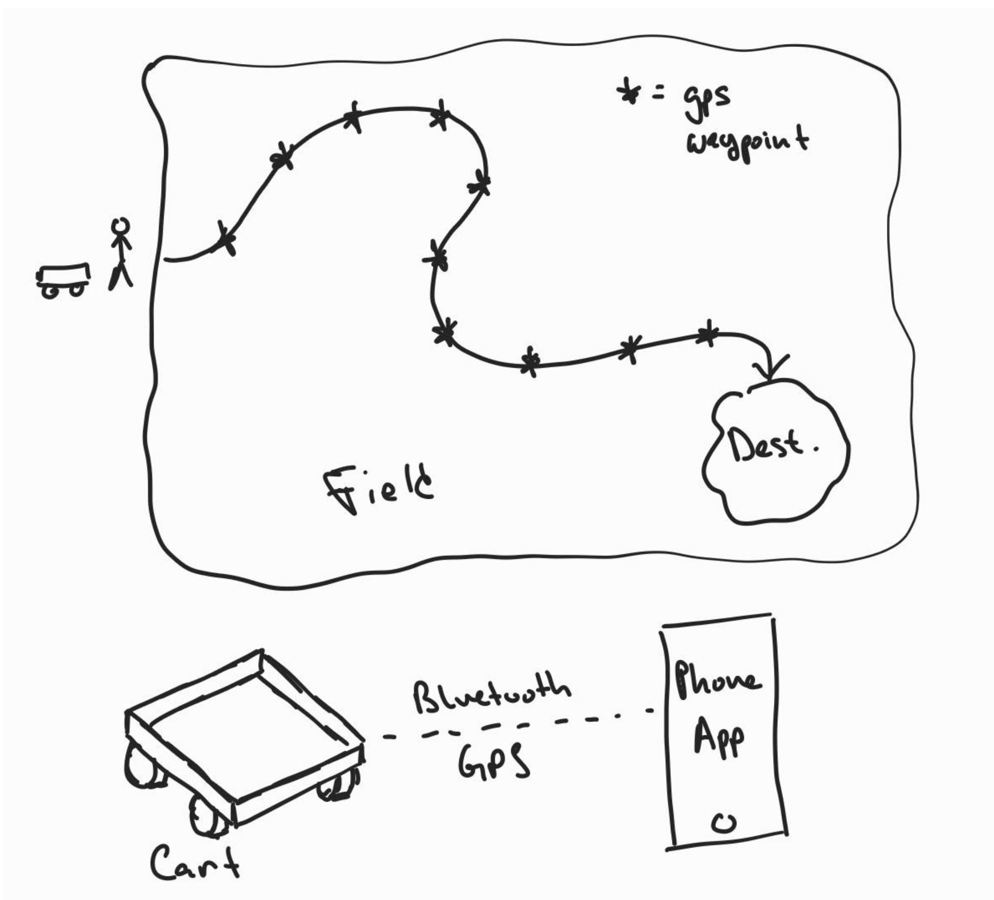
1. Introduction

1.1 Objectives

Maintenance, gardening and custodial duties often result in alot of labor and time wasted in transporting resources between locations. Moving heavy loads often takes multiple trips involving multiple people and thus becomes very inefficient. The Handsfree Following Cart aims to alleviate workers from carrying such loads and to reduce the manpower required for the task. Additionally, it will help to increase safety in the workplace, as elimination of the need to move heavy loads will reduce risk of injury.

Our proposed solution is a cart that will track and follow a person while simultaneously being able to carry a load. The handsfree cart would be able to navigate wherever a person is able to go, including ramps and elevators with enough . To further automate the process, the cart can also follow a predetermined route in an environment that has already been mapped.



1.2 Background

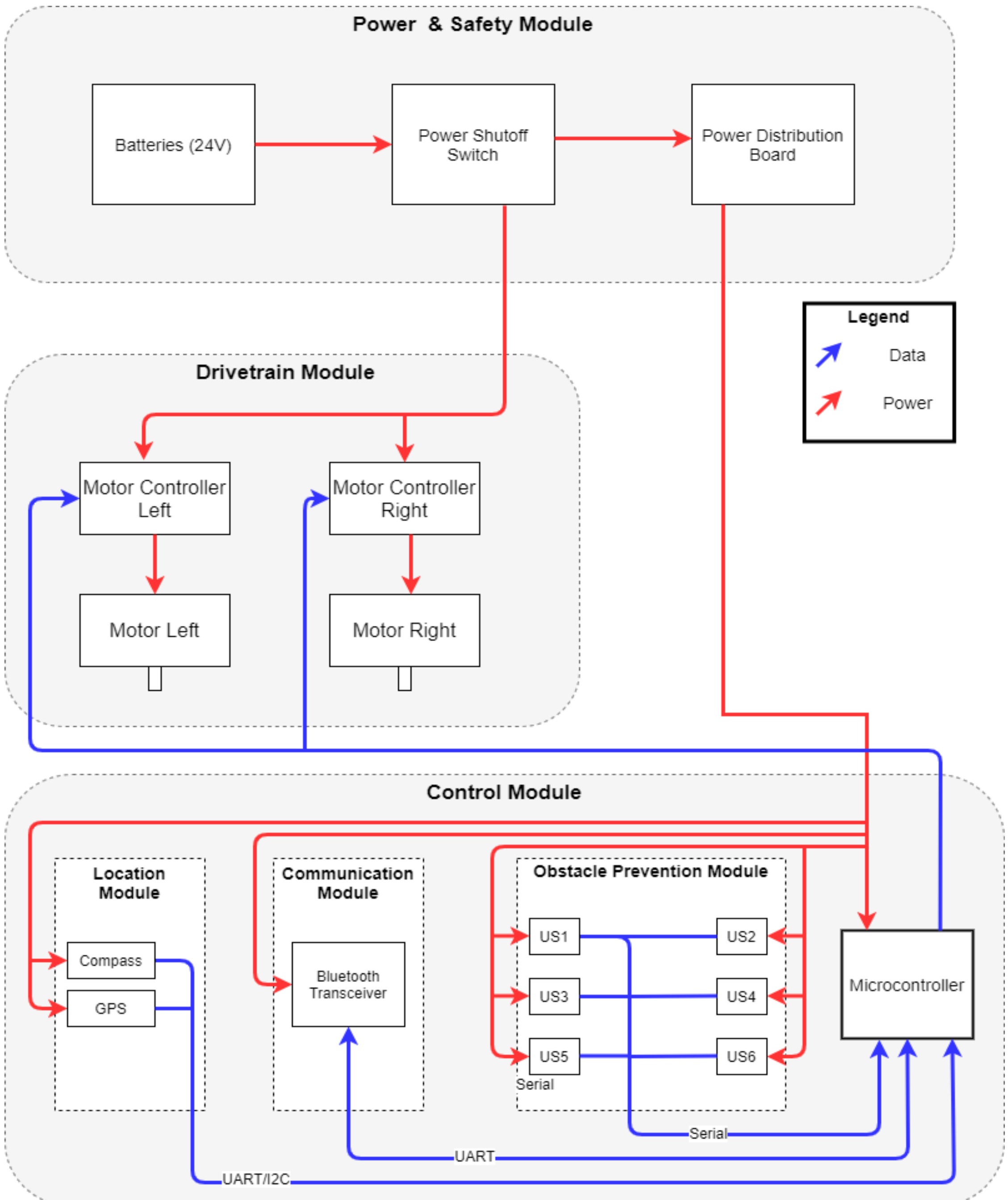
There are existing tools that allow workers to transport heavy loads when necessary, such as wheelbarrows, heavy duty dollies and hand trucks. However these are all tools that require manpower to operate and pose safety hazards and increase risk of injury in the work environment. Another factor to take into requirement is transporting and loading of such tools. An automated tool that is both able to carry loads and is mobile would eliminate all of these hazards and inconveniences in the work environment and can be marketed as such. It would also be able to navigate up a ramp into a vehicle, making it easy to transport.

1.3 High-level Requirements

- Must be able to move 150-200 pounds of material without any external assistance.
- Follow users/preset GPS points at a safe distance at up to 8mph while avoiding collisions that cause damage to cart or to property.
- In case of failure, alert the user if within range and also flash lights on cart for a visual alert.

2. Design

2.1 Block Diagram



2.2 Block Descriptions

2.2.1 Power Subsystem

- Lead acid batteries will provide the power and voltage necessary for the control module, drivetrain module, lights and anything else added. The batteries will provide the power for the motor controllers, which will control the motor speed.
- Batteries:
    - 24V batteries provide power to all components. The power consumption value will be used to determine the capacity of the battery.
- Power Shutoff Switch:
    - Input power will go through a switch which will be used to shut off power to the cart or to be used in case of emergency.
- Power Distribution Board:
    - The power distribution board will take in 24V from the batteries and then step them down to the appropriate voltages (5V, 3.3V) needed for each sensor and microcontroller.

2.2.2 Drivetrain Subsystem

- The Drivetrain module is where the motor controllers take input data from the microcontroller and send power to the motors in order to drive them at the right direction and speed.
- Motor Controller:
    - The motor controller will receive power from the batteries and input signal from the microcontroller in order to drive the motor at the right rpm (based on wheel size and gearbox reduction for speed calculations)
- Motors:
    - The motors will receive voltage from the controller determining what direction they spin and at what speed. These will be DC motors that are typically used in wheelchairs and other robotics applications.

2.2.3 Control Subsystem

- Microcontroller:
    - Takes in data sent from gps, bluetooth, and ultrasonic sensors to determine where the cart will go and sends signals to the motor controller. It will also be used to compute the path to take and remember the waypoints to follow.
- Ultrasonic Sensors:
    - Will send sounds waves to determine any change in distances and will relay that information to the microcontroller to prevent obstacle collision

- Bluetooth Transceiver

        - Will establish communication between a user's phone and the cart. Will receive GPS points of the user and also the input commands that set which mode the cart is operating in.
- Location system:
    - Compass
        - Will be utilized to find the cart's orientation and will then follow the user in a much more efficient manner.
    - GPS Module:
        - Will compare the location of the cart to the location of the user to compute the driving signals for the motors in order to follow users or waypoints.

2.2.4 Mobile Application

- Phone Application:
    - The application will use the device's GPS and bluetooth to send location data to the cart controller. If the cart is stuck, it will use the app to alert the user.
    - The application will also have an enable/disable feature that allows the user to choose whether or not to follow the user or to navigate a predetermined route.
    - Apart from a physical killswitch, the option will also be available on the app.

2.3 Block Requirements

Module/Subsystem		Requirements
Power & Safety System	Batteries	1. Provide ample input power to use the cart under normal conditions for up to 30 minutes. 2. Input voltage between 24 to 27 volts 3. Hardcase, non-spillable
	Power Shutoff Switch	1. Hard wired to the input power source to cut off power to all subsystems. 2. Rated for 2x the max current of the whole system. 3. Easily accessible by the user
	Power Distribution Board	1. Step down the input voltages to: a. 5V +/- 0.2V b. 3.6V +/- 0.2V c. 3.3V +/- 0.1V
Drivetrain Subsystem	Motor Controllers	1. Rated for up to 60A under stall conditions 2. Control the rpm with a tolerance of +/- 3 rpm
	Motors	1. DC motor with enough power to start moving a max load of up to 200 pounds. 2. Output shaft compatible with standard wheels hubs without any need for custom adapters 3. Shaft must be able to spin both directions
Control Subsystem	Compass	1. Tells the system the direction of the cart with an accuracy of 1-2 degrees. 2. Updates faster than 60Hz 3. I2C communication
	GPS Module	1. Establish the current position of the cart outdoors within a 2 meter accuracy 2. Must update faster than 10Hz 3. UART communication
	Bluetooth Transceiver	1. Send and receive data between the cart and a phone within 30ft 2. UART or I2C communication
	Ultrasonic Sensors	1. Range of up to 7 meters 2. Accuracy greater than 3 cm

		3. Wave direction of up 45 degrees or greater
	Microcontroller	1. Must be able to receive data from all the above sensors and modules and send data to certain modules 2. Must be able to compute a path direction given new points within 2 seconds. 3. Must be able to store gps waypoints in memory for cart to follow 4. Must be able to notify user if it notices an error or be able to change LED color to notify user of cart status

2.4 Risk Analysis

The subsystem with the highest risk and difficulty would be the Control Subsystem. It is the highest risk because, being the control center of the project, a single failure could lead to system wide failure. And an imperfect implementation could have cascading negative effects throughout the rest of the system. It is also the highest difficulty because it not only has to collect and manage data from different sources, it is also the decision making center that tells the other subsystems what to do. Furthermore, we have to build in safety systems to prevent the cart from moving without any information and will need to ensure that the operation is safe at all times and the user is notified of any system failures either through the phone application or the lights on the cart. We also will have an easily accessible shutoff switch to kill power to the cart.

3. Ethics & Safety

The ultimate goal of this project is to improve productivity and safety in the relevant workplaces. With this in mind, we need to take into consideration the possible risks that the automated cart will pose in a work environment, such as what actions will be taken in the event that a human being obstructs its path or when collision with an obstacle could result in injury. Thus, we must uphold #1 of the IEEE code of Ethics, which is ‘to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to promptly disclose factors that might endanger the public or the environment,’ [1] and also #9 in the code - ‘to avoid injuring others, their property, reputation, or employment by false or malicious actions, rumors or any other verbal or physical abuses.’ [1]

We aim to have the cart moving at a top speed of 7-8 miles an hour, double the average walking speed, and so it must be ensured that the cart is able to recognize positive and negative obstacles and react accordingly, so as to eliminate the chance of colliding with a worker. The event of a worker accidentally walking into the cart is also a consideration, and so we cannot have any sharp objects protruding from the cart.

Throughout the course of the project, we will be very open-minded in respect to taking criticisms and suggestions to improve upon design and execution, and will give due credit to the individual(s) that give us assistance. Thus, we will adhere to #5 of the IEEE code of Ethics, which is to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest and realistic in stating claims or estimates based on available data, and to properly credit the contributions of others.’ [1]

4. References

[1] Ieee.org. (2020). IEEE Code of Ethics. [online] Available at:
https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed 16 Sep. 2021].