Autonomous Golf

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1. Introduction

1.1 Objective

From a practical standpoint, the biggest obstacle in golf is transportation of the golf bag. The two most popular modes of bag transportation are putting it on a golf cart and driving the cart around the course or putting the bag on a pushcart and pushing it around the course. The problem with these is that golf carts cannot be driven anywhere on a course, forcing golfers to drive the cart to one location, and then walk some distance to their ball and then back to the cart. Pushcarts do not have this issue, but also require the golfer to physically push them around the course. Many golfers like to walk without pushing or carrying the bag. The most popular solution to this problem is to hire a caddie to carry the bag, which can cost upwards of $60 per round and is only available at certain country clubs.

Our goal is to create an affordable autonomous pushcart that can be taken to any course. This allows the golfer to simply walk the course and have their clubs follow behind them.

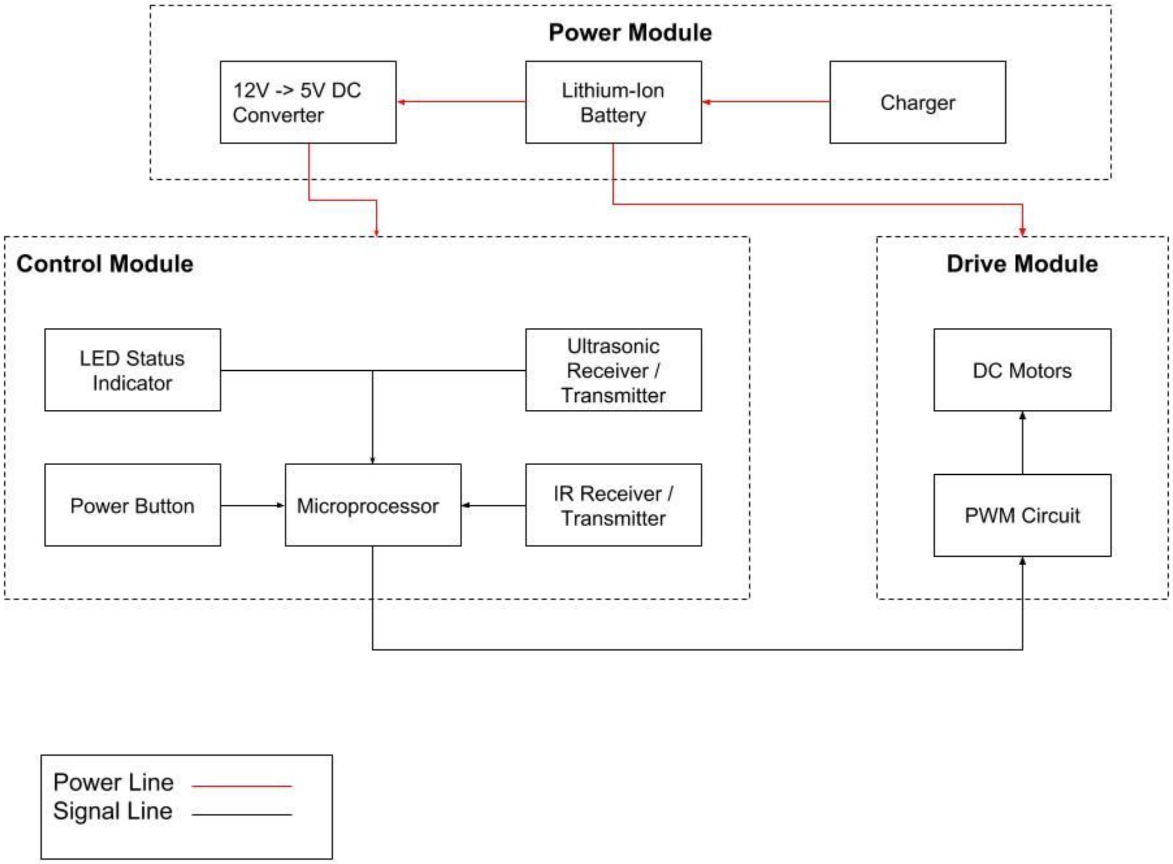
1.2 Background

Current implementations of autonomous pushcarts are expensive ($1500+) and do not avoid obstacles [1]. Our device will be much cheaper to produce and will also avoid obstacles such as trees and other golfers.

1.3 High-level requirements list

- Cart must follow the golfer at a comfortable distance
- Cart must avoid obstacles
- Pushcart must have a pause and run feature
- Pushcart must cost less than $500

2. Design



Our cart will require three sections for proper operation: a power module, a drive module, and a control module. The power module ensures that the device can run for an entire round of golf and that the drive module has access to reliable and accurate power to drive the cart. The drive module moves the cart efficiently and allows for navigation of sharp turns and moderate grade hills. The control module ensures that the device properly follows the golfer and avoids obstacles.

2.1 Power Module

A power supply will be required to drive the DC motors which will give the cart its mobility. The power supply will also be used to power the microprocessor and circuit components. The battery will have a nominal voltage of 12V which will provide power directly to the motors. A 12V to 5V step down converter will be used to obtain the appropriate voltage to power the microprocessor and circuit components.

2.1.1 DC Converter

The DC converter steps the voltage down from the level of the battery (12v) to the level required by the control module (5v).

Requirement: Must step voltage down from 12v to 5v without overcurrent to circuit components.

2.1.2 Lithium-Ion Battery

The Lithium-Ion battery is the energy storage for the device. This battery must be able to store enough energy so that the power module can provide the control and drive modules with sufficient voltage and power throughout a round of golf.

Requirement: Battery life must be adequate to play an 18-hole round of golf with at least 15% charge remaining.

2.1.3 Charger

The charger is used to recharge the Lithium-Ion battery. The battery will be charged via an IC and will be able to charge the battery to full within 12 hours. A li-ion charging cycle consists of constant-current quick charge at high current to a certain voltage followed by a trickle charge to the voltage spec listed on the battery (12v).

Requirement: Must be able to complete a full charge within 12 hours.

2.2 Drive Module

The drive module will be responsible for providing acceleration and steering capability to the cart. It will consist of 2 DC motors, one for each rear wheel.

2.2.1 DC Motor

The DC motor physically turns the wheels of the pushcart.

Requirement: Must be powerful enough able to handle 20 degree inclines and be able to reach a sustainable top ground speed of 6 mph.

2.2.2 PWM Circuit

The PWM circuit will consist of 2 high-power MOSFETs. The output of the battery will be connected to the drain, while the DC motor lead will be connected to source. The microprocessor will provide voltage to the drain to facilitate the PWM.

Requirement: Maximum current draw must not exceed 80% of MOSFET rated tolerance.

2.3 Control Module

The control module is responsible for sending proper signals to the motors to follow the golfer and avoid obstacles without user input.

2.3.1 Microprocessor

The microprocessor will be an ARM Cortex M-4. It will be responsible for reading all sensor data streams and processing the collected data. It will also manage the run-pause feature and setting the corresponding LED status indicator. It will also be responsible for providing PWM signals to independently control the rotation speed of each wheel.

2.3.2 LED Status Indicator

The LED status indicator will be responsible for displaying the state of the system. There will be two LEDs. One LED will indicate if the system is on. The other LED will indicate whether the cart is in the run state and will be off when the cart is in the pause state.

2.3.3 Run-Pause Button

The run-pause button toggles the carts movement.

Requirement: Must immediately stop both motors when paused, and immediately start when run. Must maintain tracking of user in pause state.

2.3.4 Power Button

The power button turns the device on and off.

Requirement: Must immediately stop both motors on the cart when pressed.

2.3.5 Ultrasonic Transmitter/Receiver

The ultrasonic transmitter/receiver will detect obstacles near the cart to provide collision avoidance.

Requirement: Must sense objects in a 1 meter radius for avoidance.

2.3.6 IR Receiver/Transmitter

The infrared transmitter emits infrared from the golfer to be captured by the multiple receivers on the cart. Varying intensity measured between each receiver will be used to calculate the position of the golfer. The microprocessor analog-to-digital converter will be used to translate the analog intensity to digital format.

Requirement: Transmitters must be precise enough to calculate the golfer's position with enough accuracy to follow the golfer.

2.4 Risk Analysis

The IR sensor array poses the greatest risk to the completion of our project. The sensors must function at a very high level for successful production of a final product.

Without proper IR sensing it will not be possible for the control module to locate the golfer. This is most likely to happen the distance between the golfer and the cart becomes large enough to the point that the variance of the intensities received by each receiver approaches the measurement precision limit of the receivers. The sensors must also provide data at high enough of a granularity that accurate calculations are possible.

Even with the sensors functioning as intended, it will take a lot of experimentation to determine the appropriate location of the sensors to yield the best results. It is important that the system does not lose track of the user at any point, so a wide number of potential scenarios will need to be considered. For example, if a user walks in a way where an obstacle such as a tree comes between the cart and the user the cart must be able to maintain its ability to correctly follow.

It will also only be in the later stages of product design that we will be able to verify that our experimental functionality tests translate to success in the field. For these reasons, we have identified the IR sensor as the largest risk.

3. Safety and Ethics

Potential hazards and overall safety are a concern in our design process as this is noted in the IEEE Code of Ethics, #1: “to hold paramount the safety, health, and welfare of the public” [2]. As designers, we must ensure that this code is upheld by minimizing potential hazards associated with our device and informing end users of these hazards. We will include safety literature outlining potential hazards with our device.

There are a few potential safety hazards with our device. The most notable is a runaway pushcart, which could potentially run into a person if some sort failure arises in the control module. We plan to mitigate this by handling error cases very carefully in our software and having a kill switch on the cart. We will also physically limit the speed of the device to a brisk walking pace (around 5 mph) so that in the case of a collision, damage is minimal.

Another risk are fire/explosion cases with Li-ion batteries [3], as one of these will be our power source. We will avoid such cases by installing a battery with the proper specifications for our use case and having electrical components that do not allow battery discharge at an unsafe level.

Another safety concern is electrical failure due to moisture, since golf courses can often be wet in the morning or during rainy weather. We will avoid water damage to our circuit by constructing an adequate housing for electrical components and thoroughly insulating wires and components outside of this housing. Our device will not be waterproof in cases of submersion, but will be able to operate in rainy weather.

The other ethics concern with our device is to adhere to the IEEE Code of Ethics #3, “to be honest and realistic in stating claims or estimates based on available data” by being realistic about the capabilities of our device. Overselling the device or embellishing features it would not align with this code and can be tempting to do at times, as this is seen in many consumer product descriptions. Even in a regulated market such pharmaceutical sales, more than half of evaluated products make misleading claims [4].

References

[1] Current market product:
https://www.sunrisegolfcarts.com/CaddyTrek-p/FTR-BBCRR2.htm?gclid=EAIaIQobChMItdWNz7rI3QIVCrnACh1RzQniEAQYASABEgK_PfD_BwE

[2] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available:
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[3] R. Long, M. Kahn, C. Mikolajczak. "Fire Protection Engineering". [Online].Available:
https://www.sfpe.org/page/2012_Q4_2/Lithium-Ion-Battery-Hazards.htm. [Accessed 19- Sep- 2-18].

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