Laser Tag Droid

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ECE 445 Project Proposal

1. Introduction

1.1 Objective

Our proposed project is to design, build, and test a remote control laser tag droid that allows users to engage in exciting physical and computer gameplay. When switched into autonomous mode the droid will be able to search for, identify, and engage opponent droids automatically. This will create a fun laser tag experience whether you are playing solo or with a group. It will be a wheeled vehicle with the mobility to move around quickly and maneuver easily. The droids will be controllable wirelessly via an iOS app which allows users to play the game. (Note that we are only building one droid for this semester project.)

1.2 Background

Over the past 5 to 10 years, the market for remote control toys of all types has expanded dramatically. With the technology steadily becoming less expensive and more accessible, these toys have gotten a huge amount of exposure and have gained in popularity with consumers of almost every age. However, most products in this category are simple models of cars, planes, or helicopters that are only meant to be driven or flown around and nothing more. A relatively small number of RC toys take advantage of their potential to be used as (or in) games. Typically if there is a game or competition involving RC toys, it consists only of racing. However, many people are naturally competitive and would prefer something more dynamic than simply driving or flying. One example of a very popular type of RC competition are battlebots. The drawback to these competitions is the inevitable and significant damage that the vehicles suffer. Therefore, we believe that an alternative non-destructive type of RC competition such as laser tag would be very popular with consumers. Laser tag bots have been implemented in several ways already. Some have been bipedal walking robots, and some have been built with a simple wheeled car design. Still others have been implemented using flying quadcopters [5]. Even with these, however, there are drawbacks. Flying vehicles are somewhat hard to control and slightly dangerous, and bipedal or wheeled designs are often rather slow and unexciting. Our design will attempt to remedy these negative factors and add unique functionality that would make for a successful product.

1.3 High level Requirements

- The droid will have an autonomous target seeking mode, in which it will move around on its own looking for targets.
- The droid will have a player-controllable mode, in which its movement and firing can be controlled by a user with a mobile phone app.
- The droid will be powered by a standard 7.4V LiPo hobby battery.

2. Design

2.1 Block Diagram

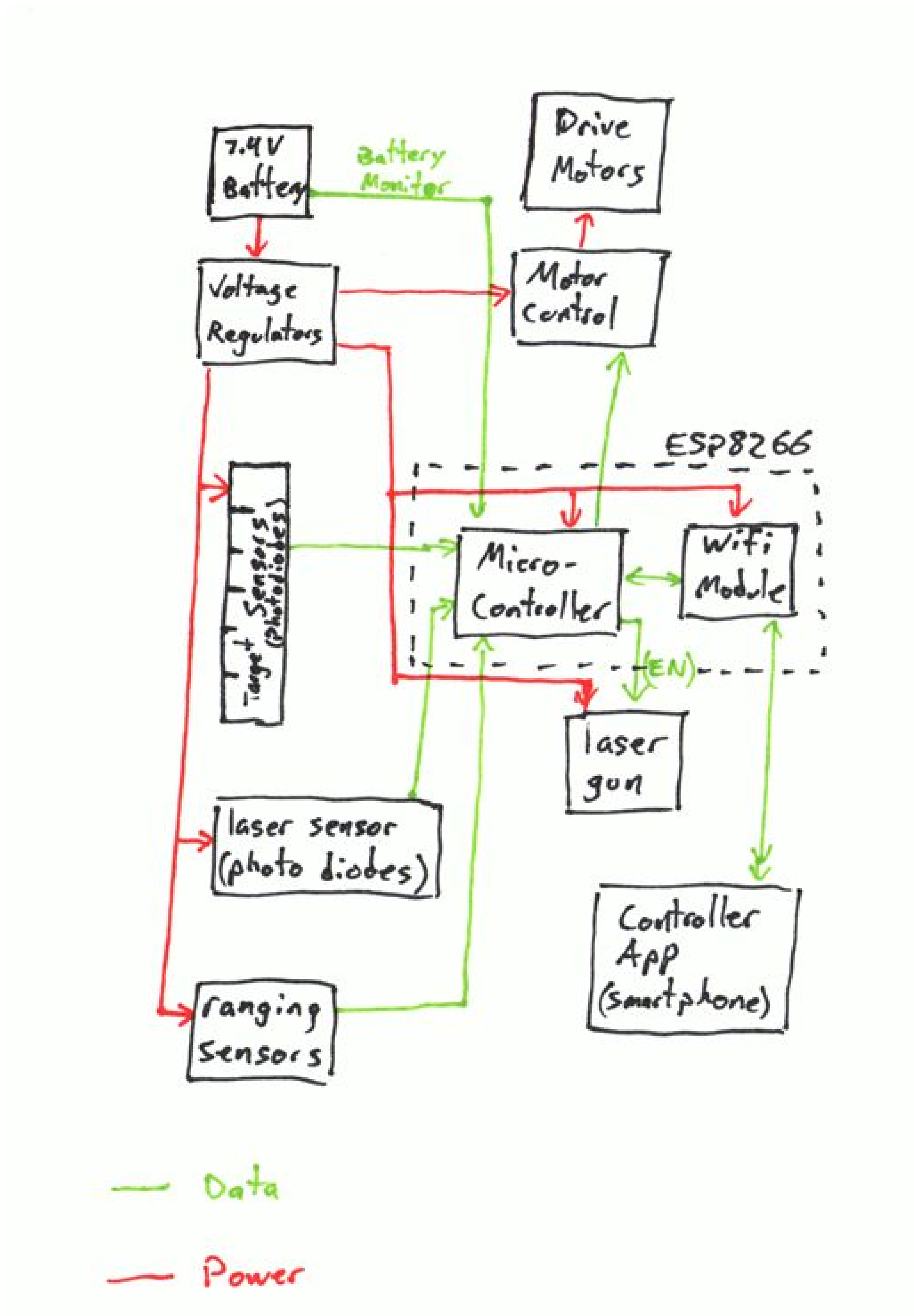

Figure 1: Block Diagram

Power block: Battery, Power Supply
Motor Drive Block: H-bridge motor control, DC brushed motors
Wireless module: ESP 8266 Wifi Module, Phone App
Control Unit: ESP 8266 Microcontroller Module
Sensor Unit: Ultrasonic Sensors, photodiodes

2.2 Physical Design

The vehicle chassis will be built from layers of sheet metal connected by standard hex stand-offs. Motor gearbox kit, wheels, and sensors will be mounted on lower level, while the microcontroller and PCB will be mounted on upper level. The overall 3-D physical appearance will be approximately 6x4x4 (WxLxH) inches. An array of photodiodes for detecting targets will be mounted around the circumference of the vehicle on the bottom layer. Several photodiodes for sensing incoming laser fire will be mounted on the top layer. Three sonar ranging sensors will be mounted on the front, left side, and right side on the bottom layer. The laser will be mounted on the top layer facing forward.

2.3 Functional Overview/ Block Requirements

2.3.1 Power Supply

The power supply is essential in keeping all systems working efficiently. The power supply will consist of 3 step down switching regulators [4]. One will be used for the microcontroller and the other two will be used for each DC brushed motor. Each motor requires its own regulator to avoid drawing too much current from the regulator. Also, we will implement protection circuitry to ensure safety.

Requirements: The power supply must be able to regulate the voltage for the microcontroller between 4.8-5.2 volts and it must be able to regulate the DC voltage to each motor between 5.7-6.3 volts.

2.3.2 Battery

The battery is an industry-standard 25C 7.4 Volt 2500 mAh battery [1]. This is a 2 cell battery which consists of 3.7 volts per cell. Its peak voltage is 8.4 volts and minimum is 6.4 volts. The max current is 62.5 amps which bodes well with our circuitry. This will power the microcontroller and the two DC brushed motors for a period of time.

Requirement: The battery must be able to deliver at least 6-7 volts with 1.8-2.2 amps of current for at least 15 minutes.

2.3.3 Motors

The two motors are going to be DC brushed motors. Each motor will have a max stall current of 1.2 amp to protect the step-down switching regulator from reaching its threshold current rating of 1.5 amps. They will be powered by 6 volts. We will also be implementing PWM and will be creating an H-bridge circuit in configuration with these motors. We will be using a tamiya motor gearbox kit to fit these specifications.

Requirements: The motors must be able to deliver consistent speed and consume consistent power for at least 15 minutes.

2.3.4 H-Bridge motor control/PWM

We will be implementing the H-bridge circuit as well as the PWM signal from the microcontroller. The H-bridge circuit allows us to turn in a smooth manner while the PWM control will allow us to control the speed of the droid. We will be creating two H-bridge circuits, one for each motor.

Requirement: The H-bridge module must be able to provide the droid with at least a 360 degree rotation turn to be able to maneuver smoothly. The PWM must be able to change the speed.

2.3.5 Ultrasonic Range Sensor Module

We will be using an ultrasonic range sensor on the outside of our droid to help with the autonomy of the droid [3]. The ultrasonic range sensor sends out a signal and then waits for the signal to determine how long it took. The sensor will then convert this time into a distance which helps us determine how far the object is.

Requirement: The Ultrasonic Range Sensor needs to detect accurately that it is at least one foot away from a wall or object consistently. It should also be able to detect the distance from the wall within 5-10% to create accurate readings.

2.3.6 ESP8266 microcontroller/wifi module

This device is a combined microcontroller and wifi communications module. We will use the microcontroller portion to poll all sensors and control all parts of the vehicle such as the motor control circuitry and the laser gun.

Requirement: This module requires it to be powered by 3.2-3.4V supply and a connection.

2.3.7 Mobile Application

The mobile phone application will enable a human user to control the droid. Through the app, the user must be able to accelerate the droid forwards and backwards, as well as turn to the left and to the right. The user must also be able to fire the laser from the app. Furthermore, the app will allow the user to toggle between autonomous driving mode and manual (driven by user through app) mode.

2.4 Risk Analysis

The wifi module presents the greatest potential challenge to the completion of this project. If we fail to fully and correctly implement it, we will have absolutely no communication between the mobile app and the droid. None of us has any networking experience, so this may prove difficult. We will have to learn how to send data to the droid from the mobile phone, as well as how to connect the ESP8266 to a wifi network and program it to send/ receive communications to/ from the app. If it happens that the wifi network needs to be hardcoded into the device, getting this to work on multiple networks could be a challenge.

3. Ethics and Safety

There are many safety hazards involved with our project but one of the main ones is the use of the 7.4 Volt 2500 mAh 25C LiPO battery. When using this battery, we have to ensure that each cell in this battery is kept above 3.2 volts (6.4 collectively) when discharging it or else the battery could get permanently damaged. Also, we have to ensure that the max voltage is not be above 4.2 volts (8.4 collectively) when fully charged. Furthermore, when charging the battery, we have to ensure that we don't overcharge or else it could cause a fire. We have to work within these minimum and maximum voltage restrictions to ensure that we use this battery safely. Also, the max rating for the temperature of the battery is 60 degrees Celsius but we will set the threshold at 48 degrees celsius to ensure the battery doesn't over heat. To ensure that these batteries are working properly, we will monitor the temperature and voltage of the battery while the droid is powered on. We will use a thermistor to measure the temperature and a voltage divider circuit to measure the voltage of the battery.
Also, while using this battery safely, we need to ensure that all our other modules have the correct power, voltage, and current rating to prevent the other components from overheating. As the design process continues, we may need to implement voltage/current readings for certain devices to establish optimal safety and efficiency.

As a group of aspiring engineers, we have to abide by the IEEE ethics and ACM guidelines. First and foremost, every project involved has to follow #1 on IEEE code of ethics to ensure the safety of those who will be utilizing this droid which involves power sources and electronic components that could catch on fire or explode [2]. We will also be working with #7 on the IEEE code of ethics to ensure we build the most viable, efficient, and safe project. We will be taking constructive criticism from professors, teaching assistants, and ourselves as group members [2]. We have to keep ourselves honest and ensure that we acknowledge and correct our mistakes. For example, if there is a better way to electronically design our PCB to avoid overheating of components then we have to keep ourselves honest and make this revision. This project entails the aspects of #8 and #10 in IEEE code as well [2]. Whether it is the treatment of group members or other groups, we have to ensure that we don't engage in discrimination of any kind. This will also bode well with #10 in the IEEE code of ethics because it will create a great aura for group members to work in which in turn will enhance the development of our project [2]. We, aspiring engineers, endure #5 on the IEEE code of ethics on a daily basis regardless of whether we are working on a project or not. We have to understand the technology we are using and know the applications/consequences that the project entails. Number 3 on the IEEE code touches in with #5 in the aspect of finding the best application with the available data

[2]. For example, if our ultrasonic range sensors aren't accurately reporting how far an obstacle is based on the data collected from the microcontroller, then we will have to either adjust the distance from the obstacle or try a new electronic component that fits this specification better.

References

[1] Onyx battery manual, Hobbico Inc. Available at: http://manuals.hobbico.com/dtx/dtx-onyx-lipo-manual.pdf

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[3] Parallax Ping Ultrasonic Sensor, web page. Available at: http://www.robotshop.com/en/parallax-ping-ultrasonic-sensor.html Accessed February 2017.

[4] LT1375/ LT1376 Datasheet, Linear Technology. Available at: http://cds.linear.com/docs/en/datasheet/13756fd.pdf Accessed February 2017.

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