ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

Antweight Battlebot

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1. Introduction

1.1 Problem

Combat robots typically come with rules that limit what your robot can and cannot do. In this case, the robot must follow these restrictions:

1. Has to be less than 2lbs
2. Must be 3D printed using these materials: PET, PETG, ABS, or PLA, PLA+
3. Will have to be controlled from a PC via Bluetooth or Wifi
4. Must have a fighting tool and be able to move
5. Easy manual shutdown (Power switch)

1.2 Solution

Our solution is to create a robot (under 2 lbs) that consists of four wheels (2 on either side) for drive and motion as well as a vertical spinning disk as our fighting tool. A 3d printed chassis will be used to house the electronics and safeguard against our opponents. The robot will be driven wirelessly using Bluetooth from a PC and will also have a power switch for manual shutdown.

1.3 Visual-Aid

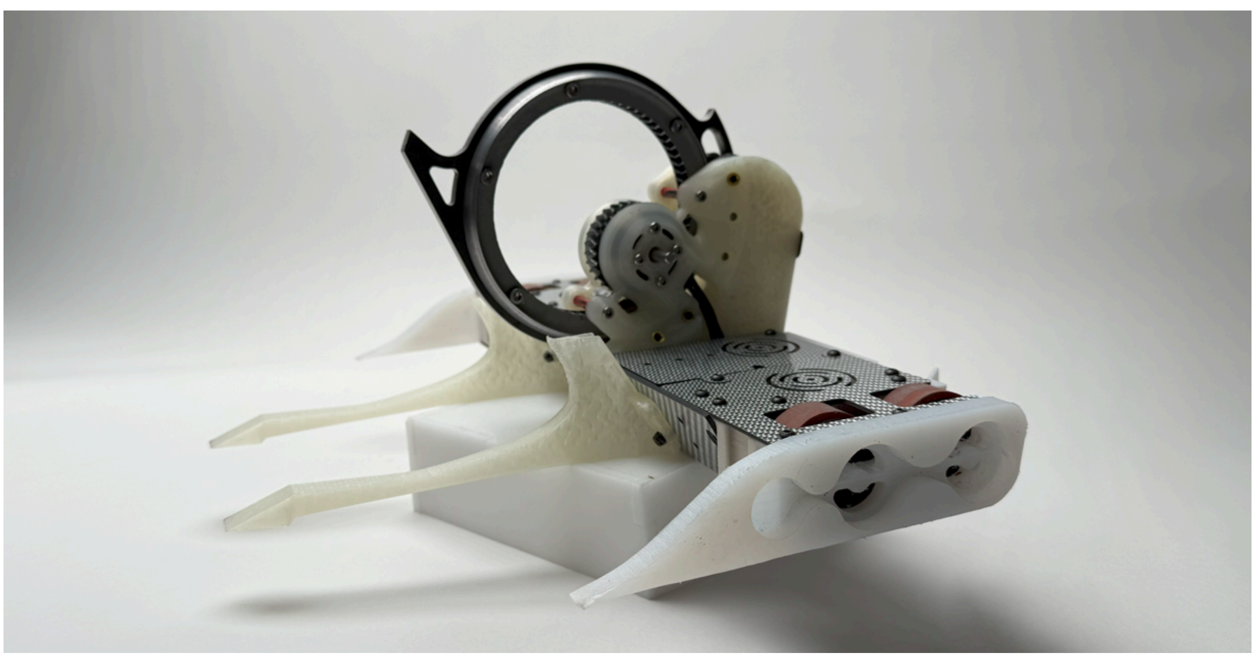

Figure 1: Example of a 4-wheel drive system with a vertical spinning fighting tool.

1.4 High-Level Requirements

1. **Top Speed:** Given a 10' by 10' arena and the fact that the bot will weigh no more than 2lbs, we will focus on maximum speed since acceleration is typically not an issue. We will aim for a speed of 20mph or around 9 meters per second.
2. **Weapon Tip Speed:** Typical combat robots of similar caliber (3 lbs) have tip speeds averaging 150-300mph (The speed at which the weapon's outermost radius spins at). We will aim to reach a maximum speed of at least 200 mph or around 90 meters per second.
3. **Latency**: The robot in an ideal world should have as little latency as possible within our control. Trying to reduce latency between the PC and giving commands to the robot via Bluetooth is crucial for an effective combat robot. We will aim for an input delay from the PC to the robot of no more than 1000 milliseconds (1 second).

2. Design

2.1 Block Diagram

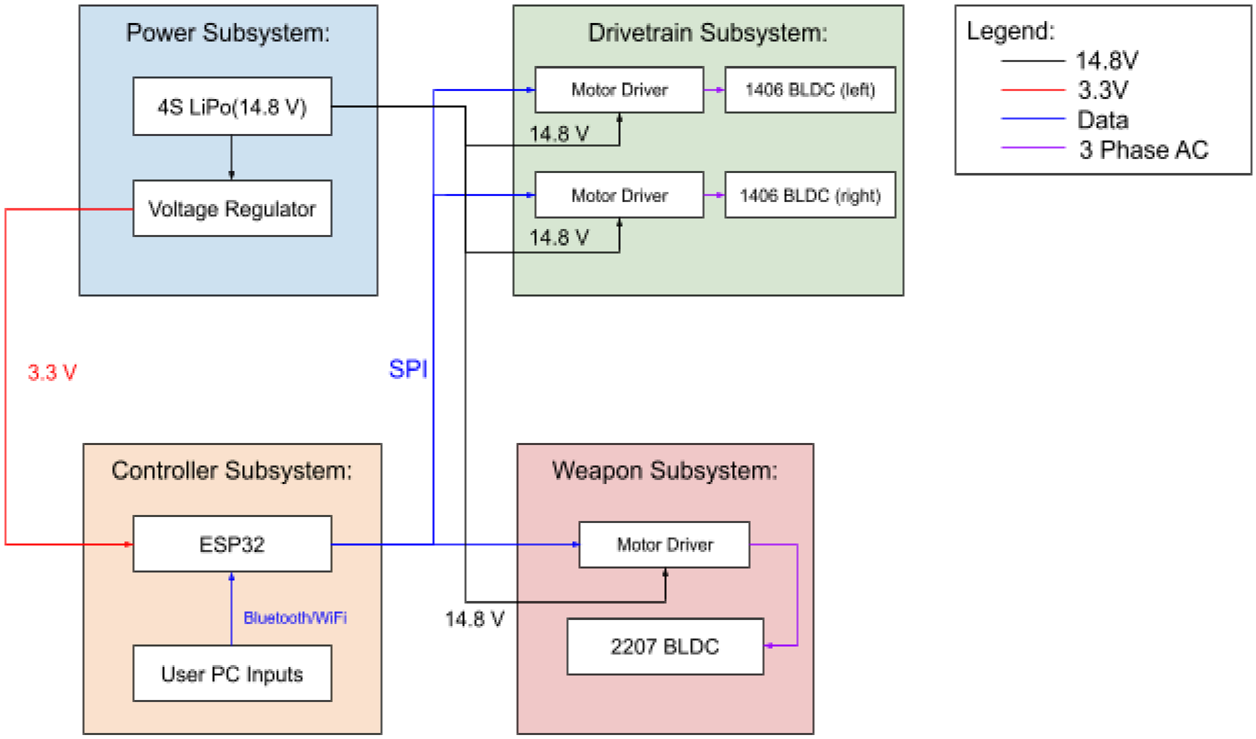

Figure 2: Block Diagram of Design

2.2 Subsystem Overview

2.2.1 Power Subsystem

The power subsystem is responsible for supplying the necessary voltages for each of the other subsystems. There are two key components from the power subsystem: the raw 14.8 V that comes from the LiPo and is used to directly power the weapon and drive motors through the motor drives and the 3.3 V that is converted from the LiPo to power control electronics like the ESP32 for Bluetooth communications.

2.2.2 Controller Subsystem

The controller subsystem consists of an ESP32 WROOM that has built-in Bluetooth and Wi-Fi modules. This allows it to wirelessly communicate with a PC via Bluetooth to receive commands. The ESP32 also has plenty of GPIO pins to communicate with the motor drivers with SPI or I2C depending on what motor controller we decide to use. It will be powered with 3.3 V from the power subsystem.

2.2.3 Weapon Subsystem

The weapon subsystem consists of a motor driver and a 2207 hubmotor from Repeat Robotics. The motor driver will convert command signals from the microcontroller to 3-phase AC signals to control the rotation speed of the motor connected to a fighting tool. The motor will use 14.8 V from the LiPo battery.

2.2.4 Drivetrain Subsystem

Similarly, the drivetrain subsystem takes the signals from the control subsystem to maintain a desired speed at any given moment. It will consist of 2 motor drivers and 2 tangent drive motors from Repeat Robotics. We plan on using tank drive to control each motor and each motor is attached to two wheels, therefore enabling 4-wheel drive. Control signals from the ESP32 will be converted to 3-phase AC signals to the two motors to control the speed and rotation of the robot. The motor choice for both the weapons and drivetrain is a result of motors' known reliability within combat robotics.

2.2.5 Mechanical Subsystem

The chassis of the robot will be made out of 3D printed PLA+ as the material is durable and more reliable when 3d printing. This will hold all of the electronic components including the PCB, motors, and battery. It is the main body of the robot and will be used to protect the electrical components. The weapon will also be 3D printed with the same material and will be attached to the weapon motor.

2.3 Subsystem Requirements

2.3.1 Power Subsystem

- Must provide a stable 3.3 V voltage to the ESP32
- Must provide enough power to all motors for the duration of a match

2.3.2 Controller Subsystem

- The ESP32 must be able to connect to the PC via Bluetooth.
- Must be able to receive instructions from the PC and send out the corresponding controls to the motor drivers.

2.3.3 Weapon Subsystem

- It must be controllable by the ESP32
- Weapon speed must be able to reach 200 mph to damage opposing robots

2.3.4 Drivetrain Subsystem

- Must be controllable by the ESP32
- Must allow the robot to drive forward, backward, and rotate
- Must allow the robot to reach 20mph

2.3.5 Mechanical Subsystem

- Chassis be capable of storing all electronics
- Chassis be strong enough to protect electronics when colliding with opposing robots or the arena
- Weapon must be capable of surviving multiple impacts with opposing robots.

2.4 Tolerance Analysis

Motor speed and battery life are crucial factors in determining the success of a battlebot. We must ensure that our motors can operate at adequate speeds for mobility and offense. Our battery must also be able to supply enough power throughout a 2-minute match.

2.4.1 Motor Speed

Looking at motor speed first, the 1406 repeat tangent drive motors are rated for 2500kv and the weapon's 2207 hubmotor is rated for 1800kv. To determine motor speed in RPM we can use the following equation:

$$\omega_{rpm} = kv * Voltage$$

Since we are running at 14.8v nominally, our drivetrain motors, the 1406 repeat tangent drive motors rated at 2500kv, will have an RPM of 37,000 revolutions per minute. The weapon motor, the 2207 hubmotor rated at 1800kv, will have an RPM of 26,640 revolutions per minute. To determine our robot's velocity, we need to take the wheel's diameter into account. Solving for the circumference will allow us to convert from angular velocity to linear velocity of miles per hour. We can use the following equation:

$$Velocity\ [mph] = \omega_{rpm} * \pi D\ [in] * \frac{60[min]}{1[hr]} * \frac{1\ [mile]}{63360[in]}$$

With a wheel diameter of approximately 1 inch and an RPM of 37,000, our ideal linear velocity is around 110 miles per hour. Given our initial high-level requirement in section 1.4, this should be sufficient to account for external factors such as load, friction, and air resistance.

Similarly, with a weapon diameter of approximately 4 inches and an RPM of 26,640, our ideal weapon tip speed is around 317 miles per hour, which meets our requirement of at least 150 mph.

2.4.2 Battery Life

The main current drawing elements of the design are the motors. There aren't any datasheets for the Repeat Robotics motors that we found so the calculations are based on similar motors. The drive motors would have a current draw of about 0.5 A and the weapon motor would have an idle current of 1.2 A with a max burst current of 35 A. It would only reach the max burst current likely on startup so we will use its current draw under constant load which would be around 15 A. The total current from the motors would be:

$$I_{totalmotor} = 2 * I_{drive} + I_{weapon} = 2 * 0.5\,A + 15\,A = 16\,A$$

The ESP32 will also draw a small amount of current of about 0.25 A. Thus the total current draw is:

$$I_{total} = I_{totalmotor} + 0.25A = 16\,A + 0.5\,A = 16.5\,A$$

Thus, the total battery capacity for a 2 minute match would be:

$$I_{total} * time = 16.5\,A * 2\,minutes * (1\,hour\,/\,60\,minutes) = 0.55\,Ah = 550\,mAh$$

As such, using a 650 mAh 4S LiPo battery will be sufficient to power the robot for the duration of the match. It would also have the capacity to handle the occasional burst current from the weapon motor.

3. Ethics and Safety

3.1 Ethics

The IEEE Code of Ethics Section I [1] states that we disclose any factors that may endanger the public or the environment. One such factor is the use of an active weapon or fighting tool. If carelessly handled, the fighting tools of these bots could cause harm that could be lethal. Therefore, proper safety measures on our part will be taken with the utmost importance, guaranteeing the safety of the public and its members such as designated destiny zones and safety procedures when handling combat robots.

3.2 Safety

In combat robotics, safety is the most important aspect. There are some variations in rules for safety from competition to competition but here are some of the most important based on NHRL rules [2]:

1. The robot should not be tested (with an active weapon) unless placed inside an enclosed test arena. This is to keep you and everyone else safe from coming into contact with the fighting tool.

2. Since the requirements of this project call for wireless Bluetooth or wifi connections to the robot, it should be expected that the robot automatically shuts down to a safe state if the connection between the PC and the robot is lost.

3. Batteries should never be left charging unattended.

4. References

[1] IEEE. ”IEEE Code of Ethics.” (2025), [Online].
https://www.ieee.org/about/corporate/governance/p7-8.html (accessed Feb. 13, 2025).

[2] NHRL, https://wiki.nhrl.io/wiki/index.php?title=NHRL_Open_Rules_-_2025 (accessed Feb. 13, 2025).