ECE 445 Fall 2025 Project Proposal

Antweight Battlebot - Blade Blade

Team 16: Jack Tipping, Sam Paone, Patrick Mugg

TA: Gayatri Pushpita Chandran

Introduction:

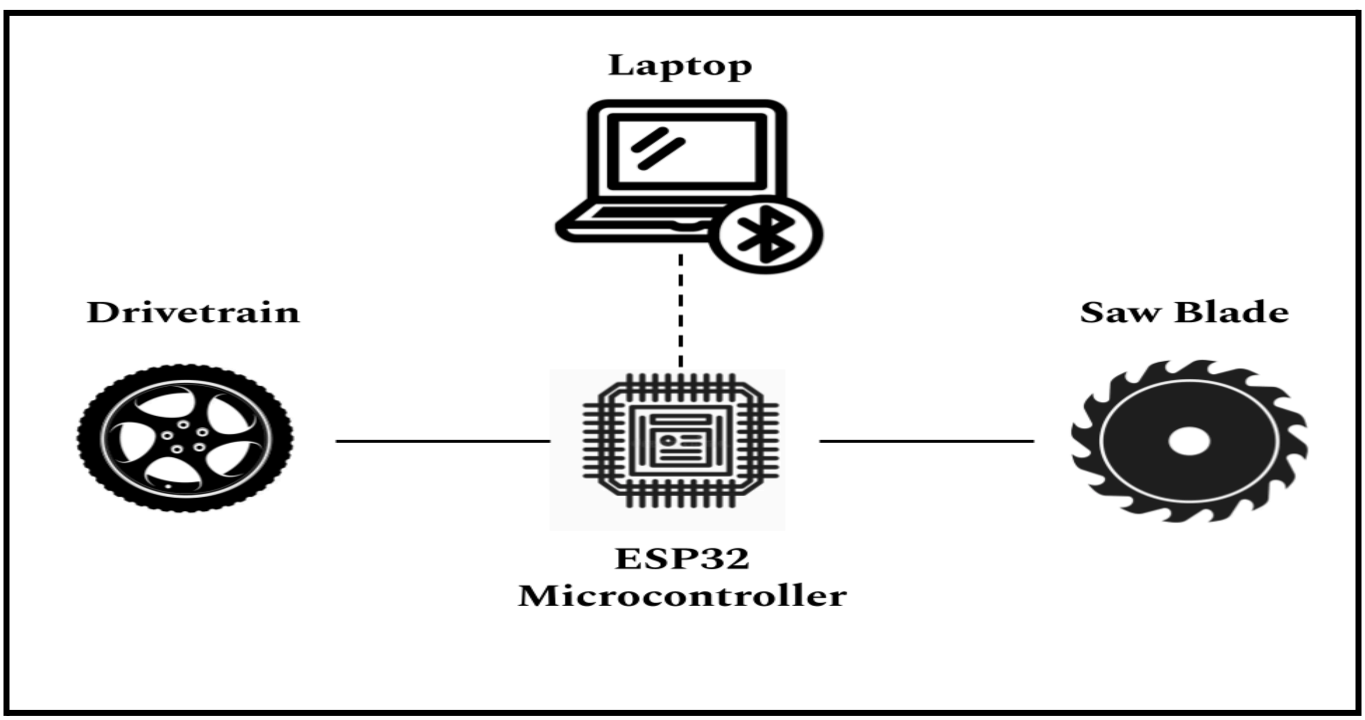
Problem

We don't have a problem, but other teams will when they see our lightweight battlebot. However, we must keep in mind certain design limitations to be eligible for competition, such as the battlebot weighing under 2 pounds. The battlebot must have a balance of being indestructible, lightweight, offensive, and long-lasting to survive the entire 2 minute battle.

Solution

Our design will consist of a sturdy body for our bot, which has a horizontal, circular saw blade in the front that has the ability to not only spin, but also lift vertically. This will allow us to damage our opponent by exploiting their weakness, in that we can choose to damage them with a blunt force or by trying to throw them off balance. An initial component list is a 3D printed chassis, an ESP32 microcontroller, two wheels with two associated motors, a motor to spin the saw blade, and a servo to lift the blade. This will all be controlled over Bluetooth using the microcontroller and a custom made computer program. Our high-level goals are to design an antweight battle bot that maneuvers well with two wheels, has a robust chassis, a saw-like weapon that rotates using a motor, in addition to being able to flip opponents, the robot will be controllable over Bluetooth/wifi, and ideally, we do well in the competition.

Visual Aid

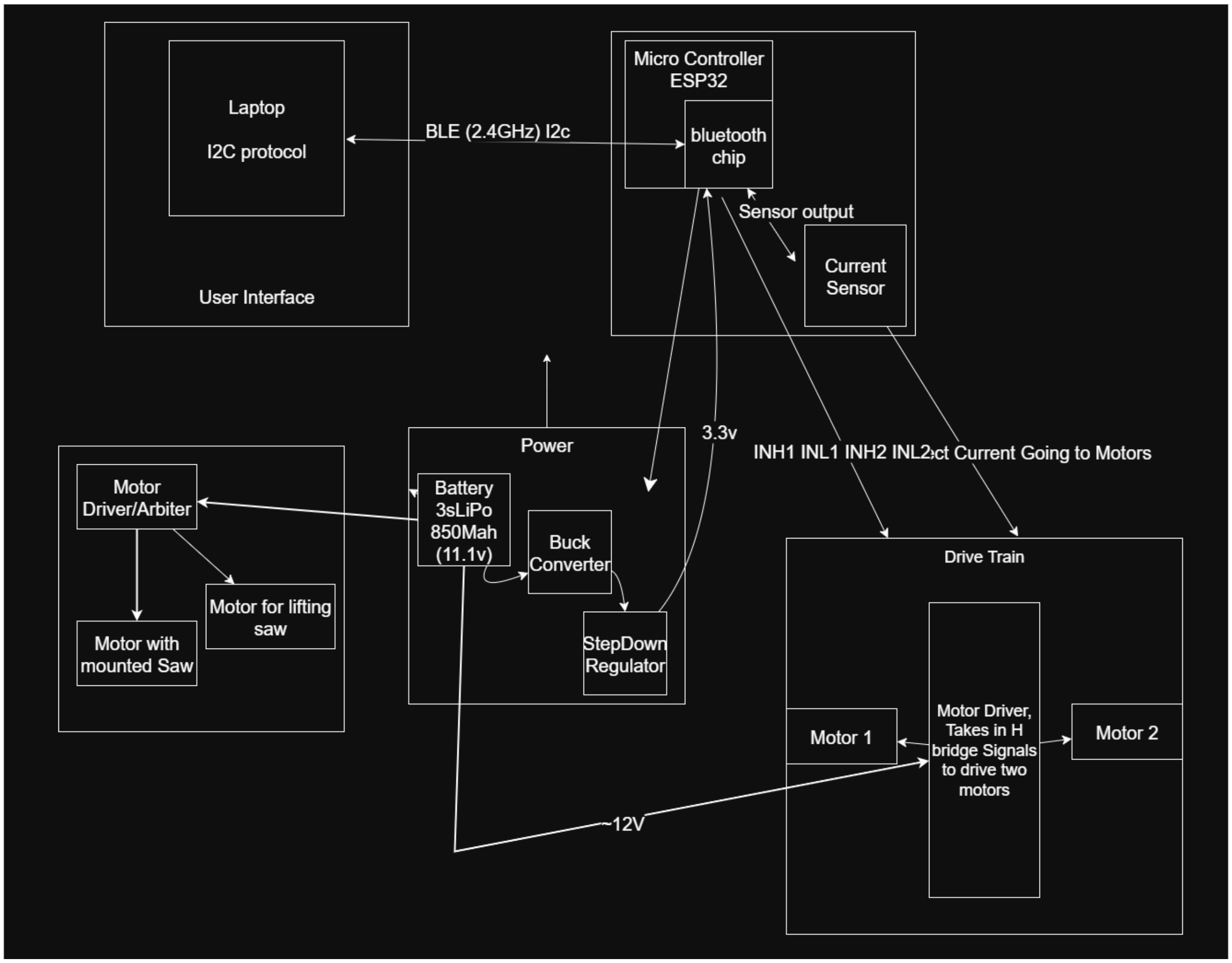


High-level requirements list

1. The total weight of the battlebot will be less than 2lbs. Combatting this through simplistic battlebot chassis design using lighter materials that are still strong (ABS/PETG). Also combatting this through minimizing battery size according to being able to run for 2 minutes and using lighter weight motors.
2. The battlebot will be controlled through Bluetooth over a laptop. The laptop app will have UI to be able to adjust direction, speed, attack mechanism mode, attack mechanism on/off. Additionally, within this will be able to monitor battery health.
3. The attacking mechanism will have two modes, one for turning a rotating saw on/off and the other for lifting the saw itself. Once that base functionality is reached, allow for the saw to have 3 different modes of speed to allow for longevity in case the battery starts to run low.

<u>Solution:</u>

Block Diagram (may need to zoom in):



Subsystem Overview:

Microcontroller Unit

- We will use an ESP32 microcontroller. The primary benefit is that it has integrated WIFI and Bluetooth. This will allow us to add custom telemetry to our laptop to control our bot. Such as controlling the motor speed, raising our wheel to flip the opponent's bot, or cutting our power as a fail-safe. The ESP32 has plenty of peripheral support. There are many PWM outputs, so we can directly drive multiple items. There are ADC inputs that will make it easy to read battery voltage, or any potential sensors we may have. It provides everything I mentioned, and is also very compact and doesn't use much power.

Chassis

- For the project, we have access to 3d printing with 5 different types of plastics. The options are PET, PETG, ABS, PLA, and PLA+. After some research and evaluating tradeoffs, we are going to opt for PETG and ABS. PETG tends to be lighter and stronger than PET and is also easier to build with and more flexible than ABS. Because of this, it is optimal for the chassis. For the saw itself, the build will be done with ABS since manufacturing defects are not as important as being lightweight and strong.

Power Unit + Motors

- We plan to use a 12V Brushed DC Gear Motor with a 37mm gearbox and an RPM of 60. These motors were chosen to give us high torque for good control of the bot's movement. This limits our batteries to 12v unless other batteries and circuitry are used for other peripherals. Evaluating batteries, we chose a 11.1V 3S LiPo battery with a capacity of 850mAh and is 80g (0.18lbs). This gives us a good enough battery life to survive for a round, but won't sacrifice too much weight that could be used elsewhere.

Drive Unit

- We will implement a dual h-bridge with motors listed above. We will only have two wheels so we can have reverse/forward acceleration as well as steering while saving weight (vs having more wheels with the same number of motors with less maneuverability).

Saw Spin Unit

- When it comes to our weapon, it is going to be a tombstone design with a circular saw blade instead of a bar spinner. It's going to be hooked to a high rpm motor to inflict the most damage.

Saw Lift Unit

- The saw lift mechanism will be controlled by a micro servo that includes a high enough torque and speed to lift the weight of the blade as well as doing it quick enough to flip over an opponent. We found an Adafruit Micro Servo that has 2.5kg-cm of torque and rotates quickly.

Current Sensor/Battery life detector

- To allow for kill switch functionality, we will have a current sensor which detects current being sent to the motors. If current ever goes above a certain threshold, a signal is sent saying to turn off the system. Important for motor longevity in battle bot competition, where current might spike if the motors are stalled. Additionally, this can be used to monitor current draw of the system and with given voltage drops we can approximate battery life. With this information, we can choose to turn on or off different subsystems such as the blade spinning to conserve battery power.

Subsystem Requirements:

Microcontroller Unit

- Not too much to mention, microcontrollers are expected to have GPIO pins for system control and GPIO pins for ADC. Additionally, it must sport bluetooth capabilities. ESP32 covers these requirements. This requires a stepped down voltage to run, that is 3.3V coming from our power unit using a buck converter.

Chassis

- The entire battlebot must be under 2lbs. The chassis must have a physically sound structure so that our opponent is not able to break into it, flip it over, or destroy its internal circuitry.

Power Unit + Motors

- The power unit must be able to sustain power for 2 minutes, supply the voltages needed (3.3v for the microcontroller and 12v (~11.1v) for everything else). To be able to supply power for 2 minutes we have estimated the intake to be around 22A so the battery will reflect this. We also have to consider weight with the battery so the battery will be 500mAh at least and if the chassis + other components allow for more space on the battery then we will upgrade accordingly.

Drive Unit

- Not too much here in terms of requirements, just have a H-Bridge circuit that can run stably at the highest voltage (11.1v)

Saw Spin Unit

- Will operate on a different motor, EMAX MT2204 for high rpm capabilities. The motor will run on the highest voltage (11.1v), and if reasonable will be available step down voltages which you can arbitrate between. Will require a saw 3d printed from ABS.

Saw Lift Unit

- The saw lift will be actuated by a high rpm Micro Servo. This will give us a quick and controllable position of the height of the saw. We will use the Adafruit TowerPro SG92R or a similar model that is lightweight, can apply enough torque to lift the blade, and spin with enough rpm. The servo can take voltages 3.3V to 6V, so it will take 3.3V like other components.

Current Sensor/Battery life detector

- Current Sensor will be SEN0211 which requires 3.3-5V. Because 3.3V is an available voltage we will just use that for the chip. It requires an ADC input which the microcontroller has covered.

Tolerance Analysis:

The largest concern in our project is the weight restriction. Having two functionalities to our weapon creates means more weight space has to be allocated to adding these objects. In addition it also means our system will have a larger current draw which means to sustain for 2 minutes of operation we need an increasingly larger battery. With some initial estimates:

Wheel Motors (Kohree's 12V 60 RPM 37 mm)x2 = 276g
Saw Motors (EMAX MT2204) = 25g
Air Pump (Adafruit Micro Servo) = 60g
Current Sensor = 5g
500mah battery (Ovonic 3S 500 mAh)= 44g
These components add up to 410g which constrains our chassis + pcb to weigh ~500g. Given this weight is definitely something to consider.

Ethics and Safety

3.1 IEEE Code of Ethics - Safety and Well-Being

In line with the IEE Code of Ethics, we will ensure that our team, *Blade Blade*, will take all steps necessary to protect the safety of our team, other participants, and any spectators. We however cannot ensure the safety of the opposing bot. The robot will only be tested in environments that are entirely controlled such as enclosed labs or designed competition arenas. Attention will be given to safely handling batteries, motors, and our blade blade weapon. We will use safe practices when charging our battery, fire-resistant containers for storage, and physical guards to minimize the risk of accidental injury

3.2 IEEE Code of Ethics - Security and Responsible Use

Since our project uses wireless communication between our laptop and the ESP32 microcontroller, we see the potential risk of unauthorized access. Following IEEE guidelines on responsible technology use, we will make sure that we can safely and securely pair and authenticate to prevent issues such as remote hijacking or intentional harm by unwanted individuals.

3.3 ACM Code of Ethics - Fairness and Compliance

The ACM code puts an emphasis on adherence to rules and fairness. We will build our bot to fully comply with the regulations of the competition. We will ensure there are no hidden features or modifications that give us an unfair advantage in the competition. The materials we choose to use will be properly documented and transparent to the organizers. We are big fans of supporting integrity and fair competition.

3.4 Anticipated Safety Concerns

- Battery risks: Overcharging or overheating could lead to a disastrous fire. We will ensure this is mitigated by balanced charging, fire-safe storage, and regular monitoring
- Mechanical risks: Since we do have a spinning blade, we will need to mitigate danger using mechanical guards, kill-switches, and potential disassembly when transporting
- Electrical risks: Short circuits and exposed wires. We will mitigate this through excellent insulation, fuses, and circuit breakers.