ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

Autonomous Featherweight (30lb) Battlebot

Team #43

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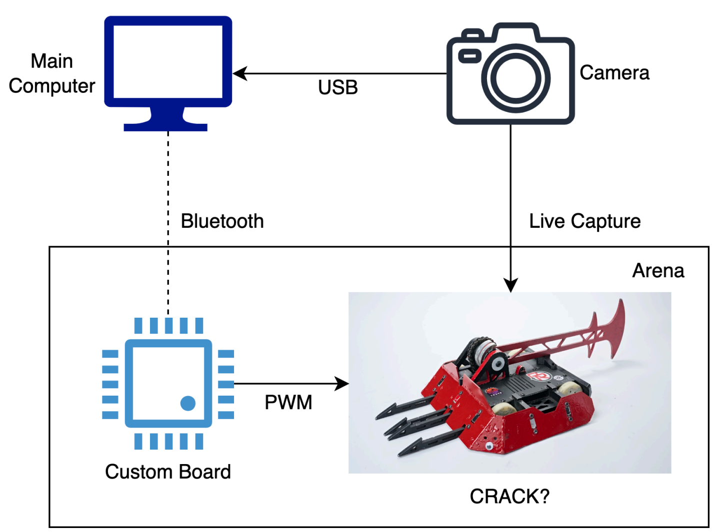
Introduction

iRobotics, a RSO on campus, has built multiple battlebots that are entered into competitions across the U.S. One of the robots that has been developed is called "CRACK?", a 30lb hammer-axe battlebot. The robot has already been designed and completed - however, the project would be to upgrade this robot from manual control to autonomous control. One of the main challenges to this project is the transition from the theoretical world to the real world. The designs that we are working on may be feasible in theory and in simulation, but the real world is a lot more complex, and especially so in the world of combat robotics. We need to design our product such that it can hold up to the rigors of a typical featherweight match.

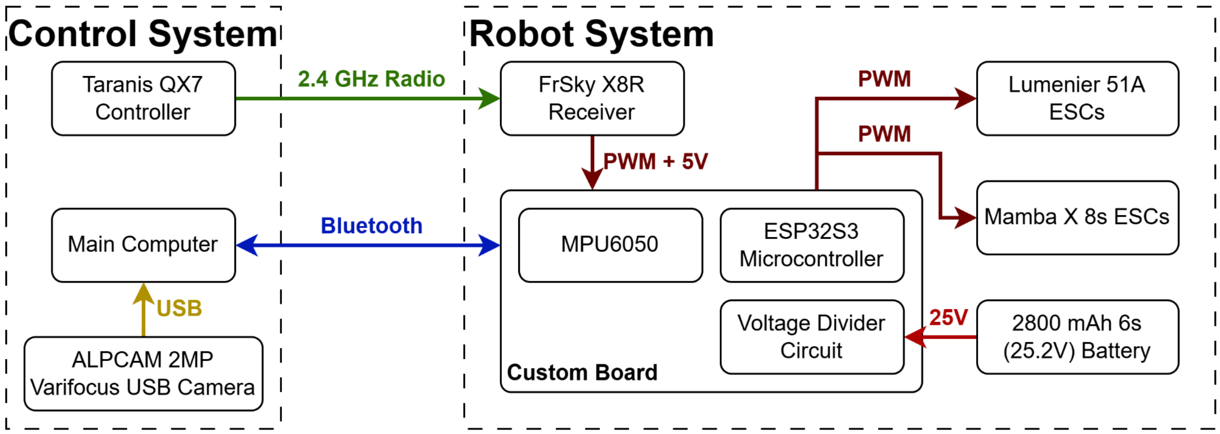
For this project, the plan is to use a camera mounted just outside the polycarbonate walls for a live state of the arena, sending information to a computer. The computer can then use image transforms to get an accurate top-down view of the field, which allows the computer to then calculate the next movements, either by using a pure-pursuit algorithm, or a machine learning algorithm potentially. The control is then passed over to a microcontroller board mounted within the robot, which sends signals to the motors, and drives the robot or fires the hammer.

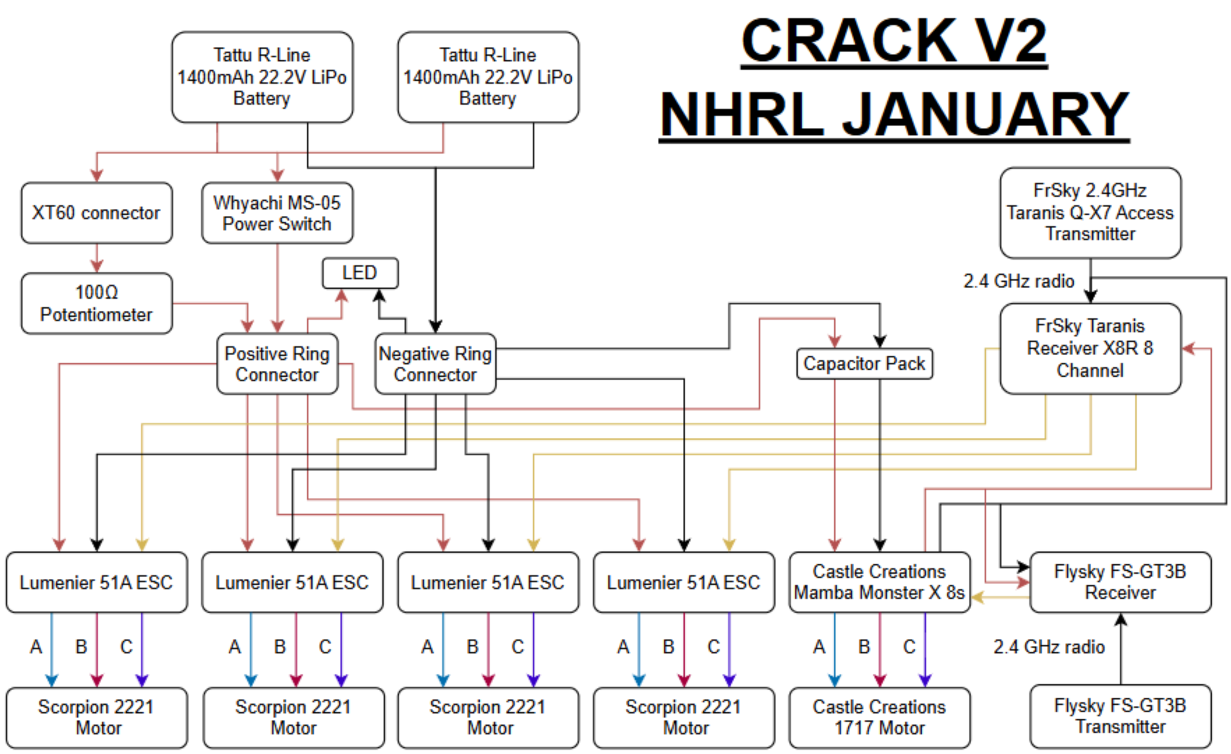


We would define a successful project with a specific set of goals:

- The system can identify the pose of the robot within the arena to a +/- 5 degree precision, and +/- 3 in precision assuming ideal lighting and mounting conditions.
- The system must read the voltage off of the battery accurately, to the precision of +/- 0.25V.
- The system must be able to shut off safely and immediately if there are ever any safety violations. For example, the robot should be able to E-STOP over bluetooth, and will failsafe properly if either Bluetooth or radio signal is lost.
- The robot will compete at Robobrawl X, an event that is held this year on campus (April 4th and 5th, 2025).

Design


Control System
Robot System
Taranis QX7 Controller
2.4 GHz Radio
FrSky X8R Receiver
PWM
Lumenier 51A ESCs
PWM
PWM + 5V
Mamba X 8s ESCs
Main Computer
Bluetooth
MPU6050
ESP32S3 Microcontroller
USB
Voltage Divider Circuit
25V
2800 mAh 6s (25.2V) Battery
ALPCAM 2MP Varifocus USB Camera
Custom Board


CRACK V2
NHRL JANUARY
Tattu R-Line 1400mAh 22.2V LiPo Battery
Tattu R-Line 1400mAh 22.2V LiPo Battery
XT60 connector
Whyachi MS-05 Power Switch
FrSky 2.4GHz Taranis Q-X7 Access Transmitter
100Ω Potentiometer
LED
2.4 GHz radio
Positive Ring Connector
Negative Ring Connector
Capacitor Pack
FrSky Taranis Receiver X8R 8 Channel
Lumenier 51A ESC
Lumenier 51A ESC
Lumenier 51A ESC
Lumenier 51A ESC
Castle Creations Mamba Monster X 8s
Flysky FS-GT3B Receiver
A B C
2.4 GHz radio
Scorpion 2221 Motor
Scorpion 2221 Motor
Scorpion 2221 Motor
Scorpion 2221 Motor
Castle Creations 1717 Motor
Flysky FS-GT3B Transmitter

Camera Subsystem

The main computer takes in the data from a camera (ALPCAM 2MP Varifocus USB Camera) mounted on the outside of the arena. The camera uploads a standard size (640x480 or 1280x720) to the computer. For every frame, the python program (utilizing OpenCV) creates a binary image with perspective transforms, color filters, and other information. It will also scan for april tags, which will be mounted on specific sides of the robot, allowing for the computer to identify the both of the robots' full pose (position and orientation) within the arena.
Requirement: The camera can identify the pose of the robot within the arena to a +/- 5 degree precision, and +/- 1 ft precision assuming ideal lighting and mounting conditions.

Autonomous Control Subsystem

After gaining both of the robot's poses, the computer will identify the next actions for the robot to perform. Initially, we will use a standard pure pursuit algorithm, where the robot will simply minimize the distance between itself and the opponent without regard for orientation. Potentially, we may switch to using a reinforcement learning algorithm, utilizing machine learning within a custom OpenAI environment. The computer will then use bluetooth to connect wirelessly to the robot, and then send over the instructions.
Requirement: The robot should be able to E-STOP over bluetooth, and will failsafe properly if either Bluetooth or radio signal is lost.

On-robot Subsystem

The motors on the robot itself are typically controlled by a receiver, which uses PWM signals (1.5 ms on a 50 ms period is a "neutral" signal). We will be inserting a microcontroller

(ESP32S3) board in between the receiver and the motor ESCs (electronic speed controllers), to analyze the information from both the receiver and the computer. Additionally, to maximize the information available to the user, we will be adding both a voltage divider to analyze battery voltage, as well as an accelerometer sensor (MPU6050) to display the robot's movement. Power to the board will be 5.5V coming from the BEC (battery eliminator circuit) of the Mamba ESC. Requirement: The system must read the voltage off of the battery accurately, to the precision of +/- 0.25V.

Tolerance Analysis:

One aspect of the design that may pose an issue to the completion of the project is the timeline - we need to complete this project by April 4, 2025, as that is the date of Robobrawl. Additionally, without the creation of the arena, we will not be able to fully test the project until likely the day before. We plan to resolve this by completing the work required in an earlier manner, and allowing the vision (the side most prone to the shift from a test area to the arena) system to be flexible to be able to be dialed in quickly.

Ethics and Safety

Our project must adhere to all IEEE and ACM ethical guidelines to maintain safety standards. Several potential ethical considerations warrant attention. Regarding ACM code 1.2 on harm prevention, the emergency stop system utilizing Bluetooth technology must respond immediately to ensure all autonomous robot functions cease safely. Additionally, in compliance with ACM codes 1.4, 1.6, and 1.7, our project must align with all of the Robobrawl competition requirements. Since our robot incorporates autonomous capabilities, we must ensure it provides no unfair advantages over competing robots.

Following ACM code 1.6 and IEEE code I, our vision system must maintain privacy standards by avoiding the storage of unnecessary data. To address safety and ethical concerns, we will implement a robust emergency shutdown mechanism that responds instantly through Bluetooth connectivity to prevent loss of control scenarios. As a backup measure, we will incorporate multiple redundant safety systems, both physical and wireless.

For our machine learning implementation, we will employ reinforcement learning techniques and conduct thorough testing in simulated environments prior to actual deployment. This testing will progress through controlled settings before advancing to real-world applications. Regarding hardware reliability, we will conduct systematic inspections of all sensors, cameras, and power components to prevent system failures.