SOONER COMPETITIVE ROBOTICS

The University of Oklahoma
"TBD"

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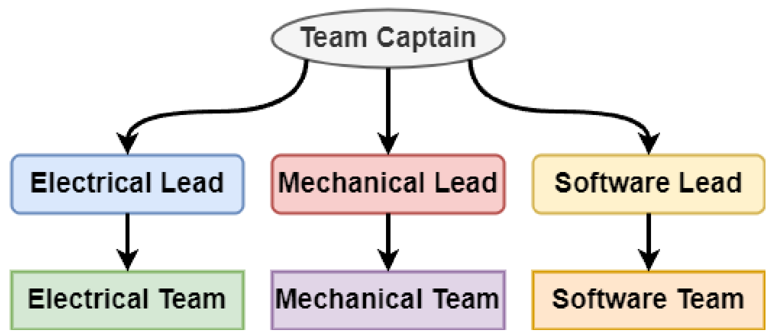
Design Process, Team Identification and Organization

Introduction

Sooner Competitive Robotics, representing the University of Oklahoma, is proud to present TBD, the team's entry for the 2025 STORM competition. The university faculty advisors are Noah Zemlin, a radar research engineer, and Dr. Golnaz Habibi, an assistant professor with a research focus on robotics.

Organization

The team is organized into electrical, software, and mechanical sub-teams, each led by an experienced member or upperclassman who guides the team members in completing their tasks. Sub-team leads regularly checked in with their members to ensure tasks were being completed sufficiently and to provide assistance when needed. Sub-team leads report to the team captain to ensure alignment and progress in the robot's design and development.



Design Process

The team's design process is structured around constant refinement, with continuous iteration and testing of solutions. As shown in the figure on the left, the team begins by defining the high-level problems and then breaking them up into smaller research tasks. After each sub-team conducts their research, the team comes together and designs solutions collaboratively. Once designs, models, and documentation are ready, the team moves to the build stage, where these ideas are created. Building often spans multiple months, and involves ongoing refinement as solutions are tested. Finally, the solutions are implemented and final testing is performed. If the implementation fails to meet the requirements, the team returns to the problem definition stage. This process enables the team to create robust, innovative robots that can be continuously adjusted based on environmental factors and team conditions.

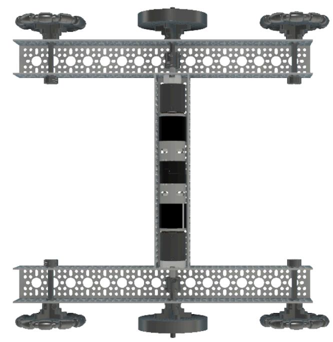
Description of Mechanical Design

Overview

Designed for both agility and precision, TBD integrates a robust drivetrain with specialized field interaction mechanisms. Its drivetrain balances maneuverability and stability, ensuring smooth operation across varied terrain. Meanwhile, its advanced collection and manipulation systems enable efficient game element handling, from strategic object retrieval to controlled deployment. These features work in tandem to optimize performance throughout the competition.

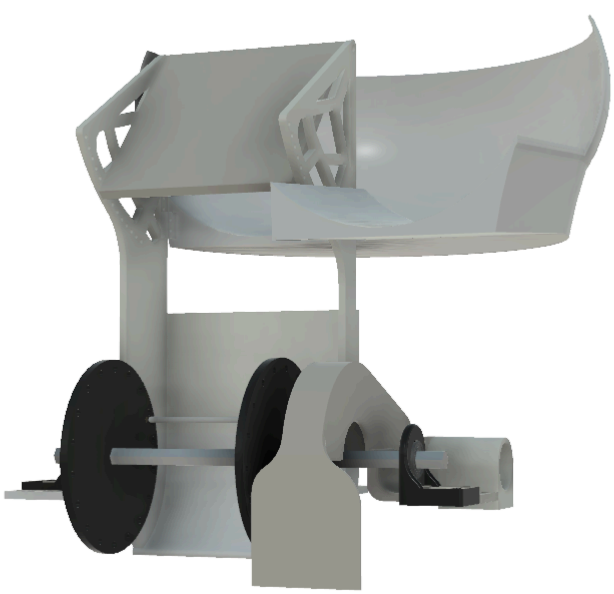
Drive Train Analysis

The drivetrain is powered by two GoBILDA motors, which drive the TBD's central wheels. To enhance maneuverability, the outer four wheels are omni-directional, allowing smooth steering. Additionally, one omni-directional wheel on each opposing corner is chain-driven to the central drive wheels, improving traction and stability on uneven terrain.



Field Manipulation

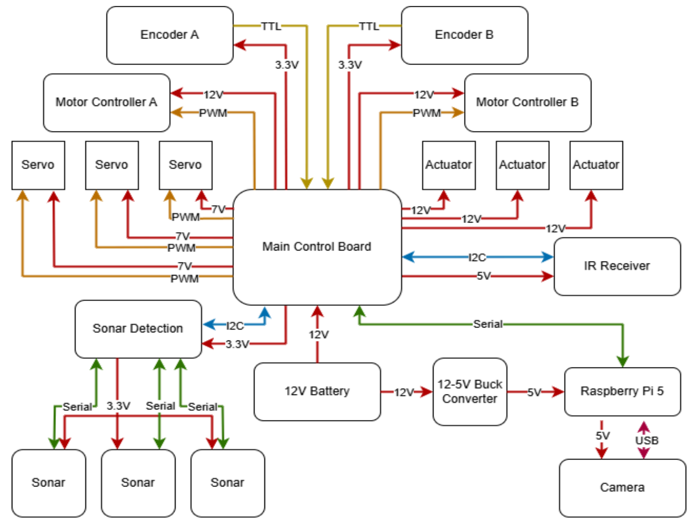
TBD features a dual-purpose, two-section arm and a specialized drum collector for hailstone retrieval. The arm serves two key functions: pressing the button to exit the van at the start of the competition and lifting the sign to its vertical position. The drum collector, equipped with surgical tubing, efficiently grips and launches hailstones into a diverter wall. From there, the hailstones navigate through a collection chute and await deposition. A linear actuator gate ensures precise control, keeping the hailstones contained until the robot is properly aligned with the deposit boxes.



Description of Electronic and Power Design

Overview

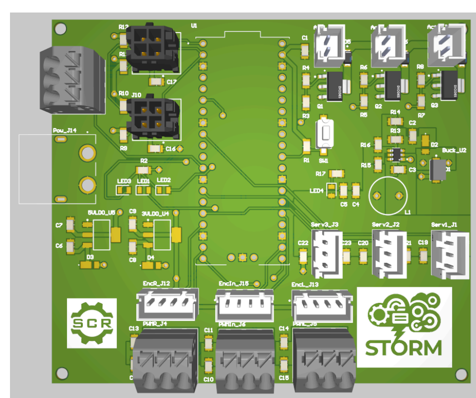
TBD's electrical system is built around custom PCBs, integrating multiple subsystems for efficient operation. At its core, a Raspberry Pi 5 serves as the primary processor, communicating with the main control board over serial using custom message definitions. The main control board, along with dedicated IR and sonar detection modules, are powered by Raspberry Pi Pico microcontrollers. It collects sensor data via I2C and relays it back to the Raspberry Pi 5 for processing. The entire system operates on a 12-volt power source.



Power Distribution

TBD is powered by a 12-volt LiPo battery, selected for its balance of capacity, safety, and availability. Power is distributed through two primary connections: the main control board and a 12V-to-5V buck converter. The main control board supplies power to the subsystems, Spark Max Mini motor controllers, servos, and actuators. All PCBs are equipped with linear dropout regulators, while the main control board includes an onboard buck converter to ensure proper voltage regulation for peripherals. The external buck converter provides stable 5V power to the Raspberry Pi 5, ensuring efficient and reliable operation.

Main Control Board



The main control board functions as the hub of the electrical system. It receives commands from the Raspberry Pi over serial and controls the motors, actuators, and servos accordingly. It also relays any pertinent information back to the Raspberry Pi from the IR receiver and sonar detection systems to be displayed on the operator computer.

IR Receiver

Using the NEC protocol, the IR receiver board continuously listens for IR messages and sends them over I2C to the main control board.

Sonar Detection

The sonar detection board continuously monitors three MaxBotix ultrasonic sensors to avoid hitting obstacles on the left, right, and back of the robot. It sends the current distances over I2C to the main control board.

Description of Software Systems

Overview

TBD's software consists of two components: Operator Software (Python) and Robot Software (C++). The Operator Software provides a PyQt6-based GUI for control, handling UDP communication, control input via pygame, and video streaming using OpenCV. The Robot Software manages serial and UDP communication via Boost ASIO and captures camera frames with OpenCV for transmission back to the operator

Operator Software

The Operator Software is developed using PyQt6, providing a graphical user interface (GUI) for remote robot control. The UI displays controller input values, a terminal window that outputs log data from each of its systems, sonar distances, IR messages, and the robot's camera feed. It utilizes QThreads to manage multiple concurrent processes efficiently. Key functionalities include:

- **Communication:** The software communicates with TBD over UDP, ensuring real-time data exchange.
- **Control Input:** The operator's input is captured using the pygame library, allowing responsive and intuitive control.
- **Video Streaming:** Camera frames from TBD are continuously received and displayed in the interface using OpenCV.

Robot Software

The Robot Software is implemented in C++ and employs Boost ASIO for efficient asynchronous communication. It is responsible for:

- **Serial Communication:** Communicating with TBD's electrical system via serial interfaces to send and receive operational commands.
- **UDP Communication:** Exchanging data with the Operator Software over a network connection to relay control inputs and telemetry data.
- **Camera Processing:** Capturing frames using OpenCV and transmitting them back to the operator for real-time monitoring.

Safety and Reliability

Many precautions were taken to ensure safety and reliability. TBD was continuously tested throughout its design lifecycle to guarantee that it can run without issue and has redundancy measures implemented to ensure safety.

Electrical	● Protective diodes on power inputs ● Watchdog timers to ensure that motors and servos are not driven without input from the Raspberry Pi ● Sonar distance sensors are used to ensure that TBD does not accidentally run into walls or other robots on the field
Software	● Control messages are "zeroed" out when no input is detected
Mechanical	● Most parts are 3D printed and easily replaceable in the event they are broken

Bill of Materials

Item	Unit Cost (USD)	Quantity	Team Cost
Raspberry Pi 5 (4 GB RAM)	$60.00	1	$60.00
Ultrawide Camera	$40.00	1	$0.00
SparkMax Mini Motor Controllers	$32.00	3	$86.00
goBilda Motors	$44.99	3	$134.97
Servos	$16.99	3	$50.97
Solenoid Actuators (4-Pack)	$15.99	1	$15.99

goBilda Drivetrain Materials	$407.15	1	$407.15
Printed Circuit Boards	$7.00	6	$42.00
MaxBotix Ultrasonic Sensors	$29.95	3	$89.85
Misc Electrical Parts	$109.87	1	$109.87
Total Cost	**$763.94**	**N/A**	**$996.80**