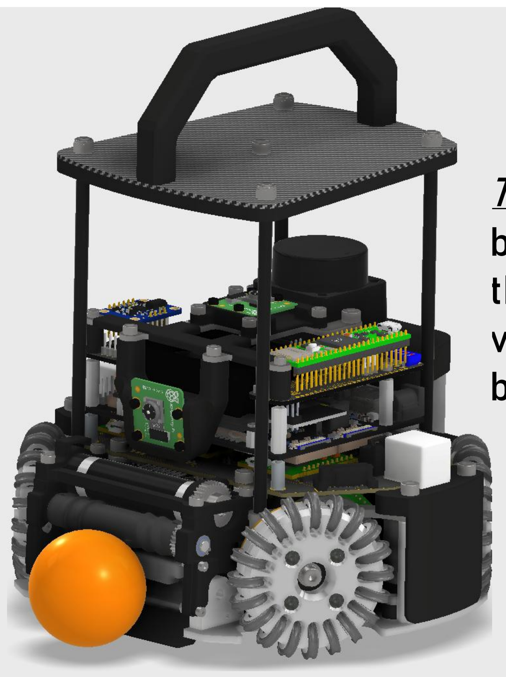
TEAMMEMBERS

1. Mark Krause → *Electronics/Software*
2. Jurij Lenz → *Hardware/Other*
3. Fabian Brune → *Hardware/CAD-Design*

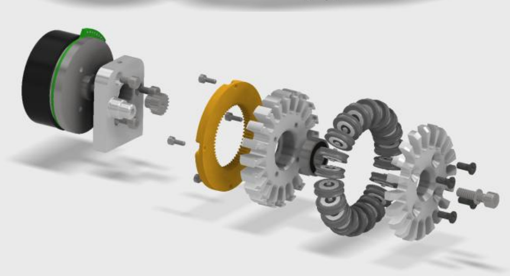
TEAM FAABS

Germany
2vs2 Open

HARDWARE

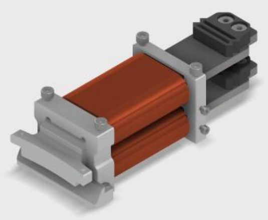


The Robot design has been significantly upgraded. Four 50W brushless motors with integrated gear reduction now drive the wheels. Dribbler uses brushless motor, with a new vertical kicker and optimized dribbler. The 4-LiDAR array has been replaced by a high-performance 360° LiDAR.



The Drivetrain consists of a wheel that is driven by a 50 W brushless motor from the Maxon EC series, combined with a 3:1 gear reduction to provide high torque and fast response. Hall sensors help keep the motor speed stable and allow precise movement control. The motor and wheel are mounted on a strong aluminium bearing block that improves stability and alignment.

The Dribbler uses a high-torque brushless motor to spin a rubber roller that gives the ball backspin. A spring system keeps constant pressure on the ball, reducing vibrations during motion. The roller speed is controlled by software, which adjusts in real time to keep the ball stable during fast driving and turning.



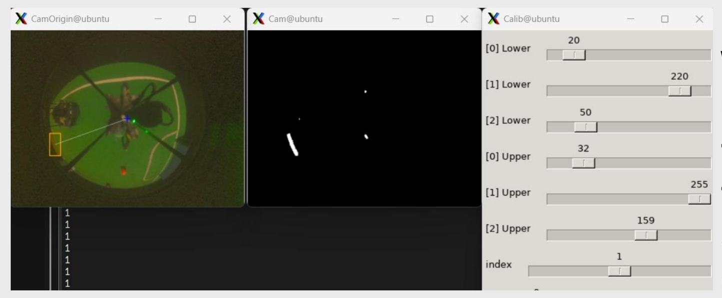
The Kicker works like a solenoid: electrical current creates a magnetic field that pushes a metal plunger to kick the ball. There are two plungers—one for flat shots and one for vertical chips. Both have spring return systems and can be adjusted by software and hardware to change the shot angle and strength.

ABSTRACT

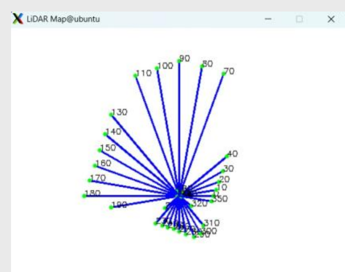
We developed a fully new robot system for RoboCup 2025, focusing on precision, integration, and control. With custom mechanics, electronics, and vision software, the robot is designed for stable ball handling, fast decision-making, and reliable in-game performance.

SOFTWARE

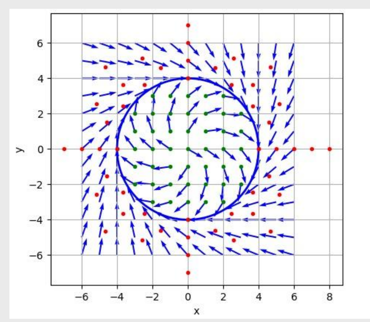
The robot runs on a two-processor system: the Jetson Orin Nano handles vision and LiDAR in C++/CUDA, while the Teensy 4.1 manages real-time control in C++ (Arduino). Data is exchanged via USB. This separation enables parallel processing, fast reactions, and clean task distribution between high- and low-level logic.



We detect the orange ball, yellow goal, and blue goal using OpenCV on the Jetson. Frames are converted to HSV, thresholded, and processed in separate threads. The thresholded image is being cleaned with erosion/dilation and selected by relevance. This allows fast and robust object tracking during the match.



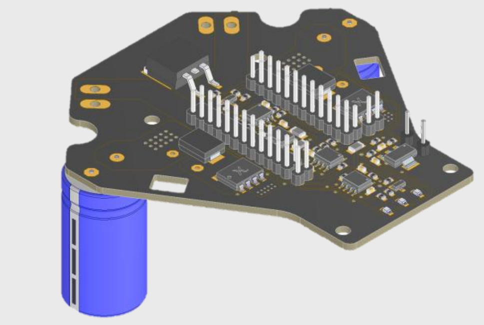
A 360° LiDAR scan is simplified to 36 values by averaging every 10°. This compact format enables fast position estimation and obstacle detection. Combined with the camera system, it provides reliable localization and collision avoidance in real time.



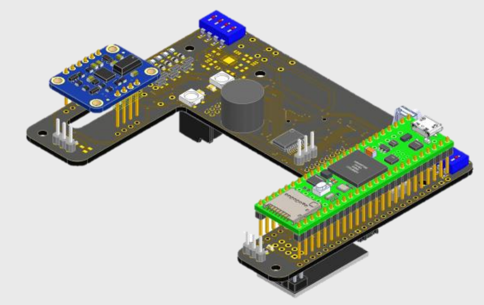
The Teensy reads sensors, controls all motors and solenoids, and executes the game logic. A new tangent-based path planner, inspired by RRT, calculates smooth trajectories to approach the ball from behind. This improves both stability and scoring efficiency.

ELECTRONICS

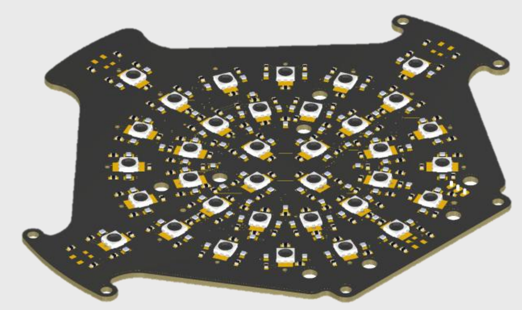
The Kickerboard drives two solenoids via N-channel MOSFETs. Two 3S LiPo batteries in series boost voltage to ~42 V, buffered by capacitors to prevent drops. Kick strength is controlled through signal duration. The board plugs directly into the Powerboard



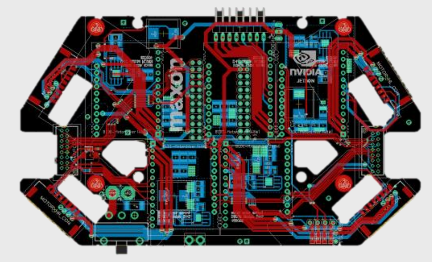
The Controlboard serves as the central control hub and hosts a Teensy 4.1. It handles all signal routing, firmware upload, and USB communication with the Jetson. Debug LEDs and buttons support development and testing / verifying during matches.

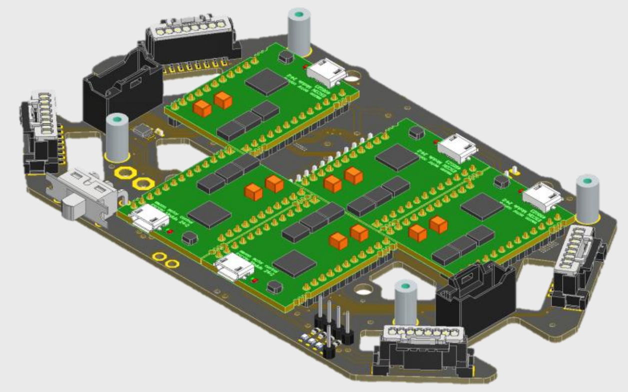


The Lineboard uses phototransistors to detect white field lines via reflected light. A multiplexer combines the signals to reduce required input pins and enables precise line detection, helping the robot stay within field boundaries.



The Powerboard distributes 3.3 V, 5 V, and 12 V using efficient buck converters from a 14.4–16.8 V Li-ion battery. It also hosts five ESCs for motor control and provides all power and signal interfaces for the other boards. Two iterations improved stability and reliability.





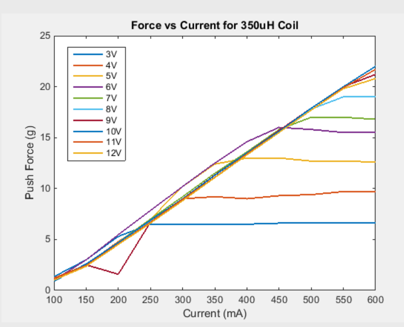
DEVELOPMENT

Since the beginning of development in early 2024, extensive prototyping was essential, as the technical and organizational complexity of this new robot generation initially posed a significant challenge. We nearly changed everything in this generation, but here you can find the most important changes

Hardware:

The drivetrain demanded high manufacturing precision and tight tolerances. We required support from sponsors and local workshops to produce the components exactly as designed.

The chip kicker, integrated with the dribbler, posed even greater challenges. Its compact design required precise geometry and angle calculations. After solving machining issues, we fine-tuned the chipper angle to ensure consistent and efficient ball lift.



Software:

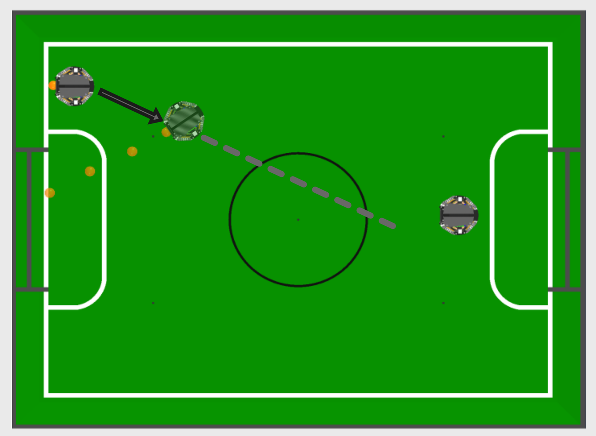
The core improvement in software was the integration of the Jetson Orin Nano, enabling significantly faster and more reliable vision processing — essential for accurate ball localization. We also implemented a second camera into the same vision pipeline, which expanded the field of view and improved object detection. Alongside this, we optimized key algorithms, leading to major gains in overall system efficiency and robot performance.

Electronics:

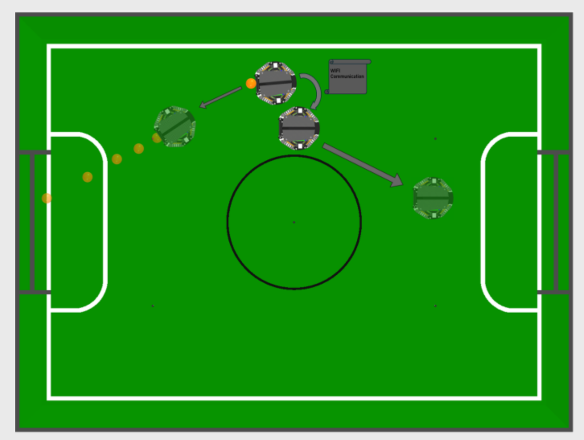
The most significant improvement was the transition to an almost fully SMD-based design, allowing for more compact and reliable PCBs. We successfully developed our first 4-layer board, implemented a custom buck converter, and designed a dedicated high-voltage circuit for the kicker — all tailored for optimal integration and performance.

STRATEGY

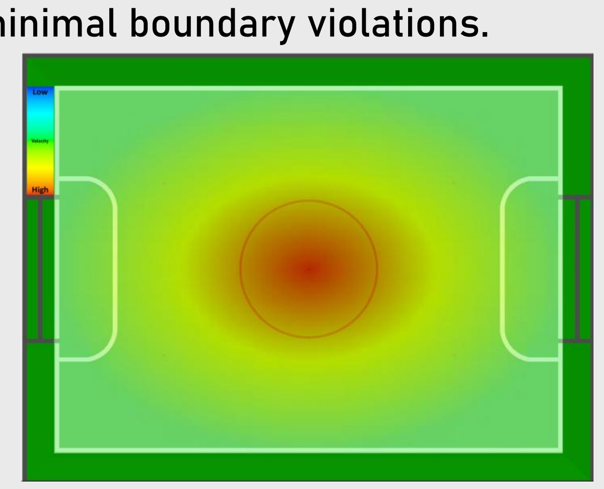
Kicker Logic & Ball Extraction:
Our robot is designed to reach the ball first and disrupt opposing play. If the ball is stuck in a corner, it is extracted via the dribbler and guided along a tangent path to a predefined point X. As soon as the goal is detected and the algorithm confirms a valid opportunity, the robot immediately executes the kick.



Radio Communication:
Once a robot secures ball possession, the second robot retreats in front of the own penalty area to avoid interfering with its teammate's movement. If possession is lost, the supporting robot transitions into a defensive role, positioning itself to protect the goal from opposing attacks.



Speed regulation with LiDAR:
To avoid going out of bounds, we define concentric speed zones using LiDAR-based localization. These zones are computed with a continuous formula, ensuring smooth transitions without abrupt speed changes or jittering. In the center, the robot accelerates aggressively; near the field edges, speed is reduced — enabling fast, stable navigation with minimal boundary violations.



Excenter rotation:
When turning with the ball, the robot rotates around the ball as the center of rotation. This means the ball is only subjected to a single, consistent force vector, keeping it stable inside the dribbler. As a result, the robot can perform fast directional changes and turns without losing ball control.