ROBOTICUS

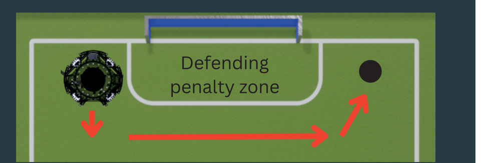
Excelling at robotics!

Region: Rotterdam, The Netherlands
Institution: Lyceum Kralingen
Team name: Roboticus
Team members: Aelyn, Ayisha, Bram, Lucy, Maksym, Micha, Sophia & Twan
Subleague: 2v2 Soccer Lightweight

Improved software features

Line Avoidance

If the robot sees a line, instead of it only moving away from it, it also factors in the position and range of the ball to determine a correct route. This new approach enables us to fix the problem of the robot getting stuck in a corner on the playing field. Since the ball will always have a certain range in that scenario, we were able to program to use the ball range and specific direction to make it go towards the ball in the opposite corner, without being interrupted by line avoidance.



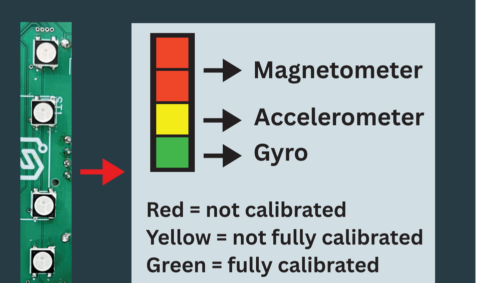
Improved line avoidance

SCAN ME!

Old vs. new line avoidance strategy

Calibration

To quickly calibrate our robots before a match, we use a 3-position-sliding switch to choose between the different calibration modes: Line calibration, IMU calibration and default playing mode. We also added additional neopixel LEDs to indicate the current status of calibration. After calibration is done, the values are saved on the built-in EEPROM storage on the teensy 4.1 microcontroller.



Neopixels *Calibration status*

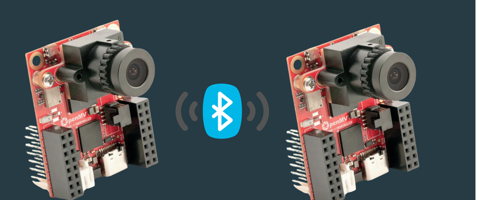
Goal detection

Our new camera setup doesn't use a conical mirror, instead it is facing straight to the goal. This change allows us to easily detect the blue or yellow goal in higher resolution. This new setup makes it also possible to detect black walls. By combining our goal and black wall tracking algorithm we are able to calculate if the robot is left, in front or right from the goal even when the robot is turned towards the goal. Due to this new method, the robot rotates to face the goal with significantly more confidence.

Determining goal position based on visibility

Role switching

By using the built-in Bluetooth chip between our OpenMV cameras, we can allow the defender to attack if the attacker is removed from the field. Thanks to this feature, the dedicated defending robot can still score by switching to an attacking role. We decide when to switch when one robot is closer than the other (i.e. has lower TSSP values).



SCAN ME!

Role switching strategy

Hardware

Camera Module
We are using 2 OpenMV RT1062 Camera modules to observe the goals and the black walls of both sides.

Top PCB
Our top PCB contains 18 IR Receivers, the secondary Teensy and neopixels for trouble shooting.

Bottom PCB
Our bottom PCB contains the phototransistors, LED's, motor controllers and a 32V boost regulator for our kickercircuit.

Phototransistor + LED Array
We are using phototransistors in combination with LED's to observe the color of the field and the white lines.

Omnidirectional Wheel
We are using omni-wheels, which allows the robot to move instantaneously in every direction.

Dual Camera Bracket
The bracket holds two camera lenses facing away each other to create a front and back image

IR Receiver
We are using an array of 18 TSSP4038 IR Receivers for detecting the IR ball.

Microcontroller
We are using two Teensy 4.1 microcontrollers which ensure fast processing.

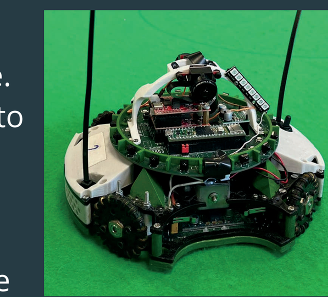
Carbonfiber Frame
Our two carbon fiber frames are optimized for weight and strength. Together, the top- and bottom frame weigh only 20 grams.

Solenoid
We are using a solenoid on our robot so that it's able to shoot the ball and score from a distance.

Maxon Motor
We are using 4 Maxon DCX16 motors with a 21:1 gearbox, which allow the robot to move quickly but also provides enough torque.

Abstract

This poster shares our team's experience as some of us are first-time participants in the RoboCupJunior Soccer Lightweight League. Our main focus this season was improving key parts of our robot to boost both performance and reliability. On the hardware side, we strengthened the mechanical design to better handle impacts during matches. In terms of software, we improved our line detection algorithm, made the calibration process faster and more efficient, and fully redesigned the camera system to get more out of machine vision. Alongside building the robot, we also created an engineering journal aimed at helping new teams. It includes real examples of the problems we faced, how we solved them, and what we learned. Our goal is to make it easier for others to get started in the league by sharing practical, beginner-friendly knowledge. Through testing, tweaking, and learning, we've grown as a team and we hope our work can help others do the same.



Engineering Journal

Parts, Finances & Sponsoring

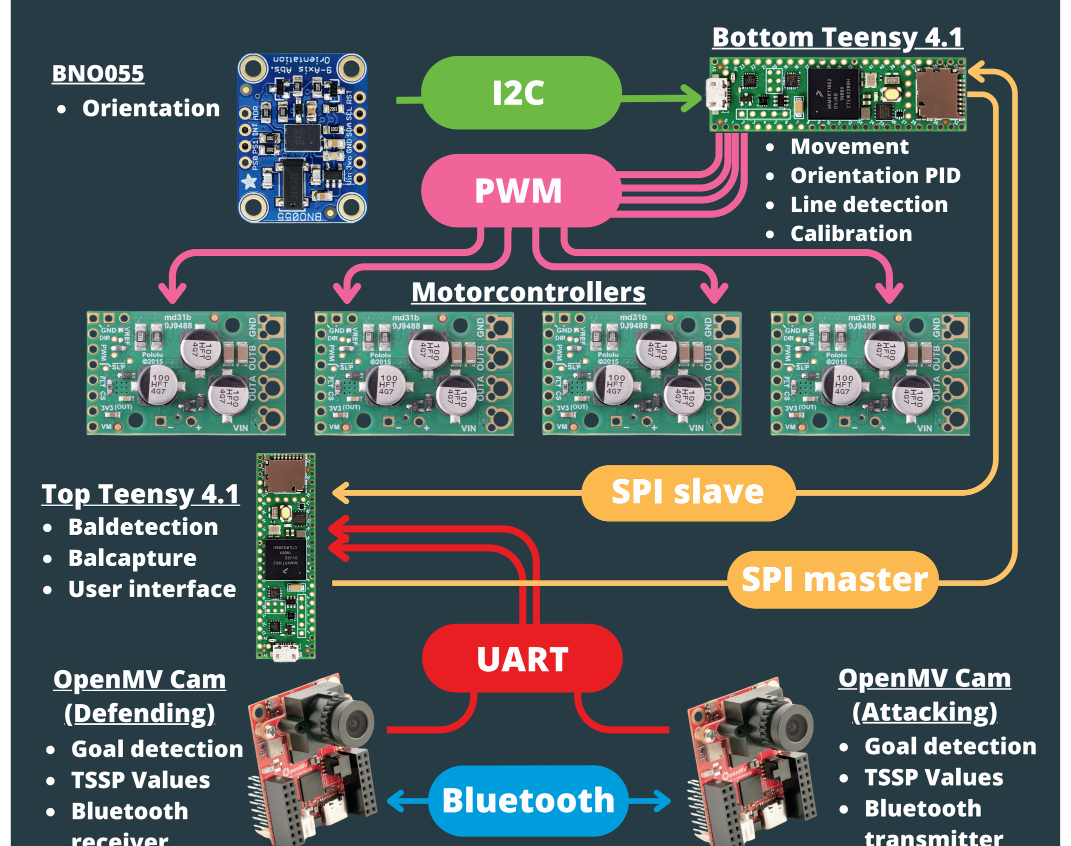
Robotics is an expensive field, that is why our robots are partly funded with the help of our sponsors. They allow us to focus on an optimal robot design without having to make too many compromises. In order to maintain a good relationship with our sponsors, our return offer must be attractive. Our sponsors often want to be promoted to a relevant community, we offer them promotion through self designed stickers, logo placement on our seasonal team shirts, logo placement on our website, social media posts, video's, blogs and we even offer educational robotics workshops to our main sponsor Robeco to help with its goal to create equal opportunities for kids!

Bill Of Materials

Product	Price(€)	Amt.	total (€)	sponsor	disc.(%)	final price (€)
4-layer Top PCB	71,98	1	71,98	Eurocircuits	100	0,00
4-layer Bottom PCB	100,22	1	100,22	Eurocircuits	100	0,00
OpenMV RT1062 Camera	120,00	2	240,00	OpenMV	100	0,00
Pololu G2 Motorcontroller	49,95	4	199,80	Pololu	50	99,90
Pololu S13V30F5 5V VR	12,95	1	12,95	Pololu	50	6,48
Pololu U3V70F12 12V VR	22,95	1	22,95	Pololu	50	11,48
Pololu U3V50AHV 30V VR	29,95	1	29,95	Pololu	50	14,98
Pololu S13V25F3 3.3V VR	13,95	1	13,95	Pololu	50	6,98
JST-XH 2P with cable	0,40	6	2,40	Tinytronics	40	1,44
JST-XH 4P with cable	0,80	1	0,80	Tinytronics	40	0,48
JST-XH 8P with cable	1,20	2	2,40	Tinytronics	40	1,44
Teensy 4.1	36,00	2	72,00	Tinytronics	40	43,20
S13V10F5 5V, 1A	8,45	1	8,45	Pololu	50	4,23
S8V9F3 3.3V, 1.5A	8,45	2	16,90	Pololu	50	8,45
TIP 120 Transistor 50V	0,50	1	0,50	Tinytronics	40	0,30
XT30U connector set	0,85	4	3,40	Tinytronics	40	2,04
Black PLA filament 1kg	18,00	1	18,00	Tinytronics	40	10,80
Thick wires 1m	1,00	1	1,00	Tinytronics	40	0,60
bolts and nuts set	11,00	1	11,00	Tinytronics	40	6,60
m2 standoffs set	8,00	1	8,00	Tinytronics	40	4,80
Tactile Pushbutton	0,10	4	0,40	Tinytronics	40	0,24
BNO055	41,30	1	41,30	Opencircuit	65	14,46
Maxon DX16 + GPX16	327,99	4	1311,96	Maxon Motors	40	787,18
Tattu 850 mAh 75C	14,99	1	14,99	-	0	14,99
Multiplexer	6,90	4	27,60	-	0	27,60
Phototransistors	0,37	32	11,75	-	0	11,75
100 kOhm Resistor	0,05	32	1,60	-	0	1,60
22 kOhm Resistor	0,04	18	0,65	-	0	0,65
10 kOhm Resistor	0,02	10	0,23	-	0	0,23
1uf smd capacitor	0,09	18	1,62	-	0	1,62
Neopixels	0,10	18	1,80	-	0	1,80
0,22uf 50V capacitor	0,14	18	2,53	-	0	2,53
tssp 4038	1,14	18	20,52	-	0	20,52
Capacitor 50V 4700uF	1,92	2	3,84	-	0	3,84
Solenoid	19,00	1	19,00	-	0	19,00
PVC Vinyl 30x135cm	11,48	1	11,48	-	0	11,48
2mm Carbon fiber frame	54,00	2	108,00	Carbonwebshop	20	86,40
Waterjet cutting service	30,00	2	60,00	Carbonwebshop	20	48,00
			2475,92			1278,05

Sponsoring saved us almost 50% of the total costs!

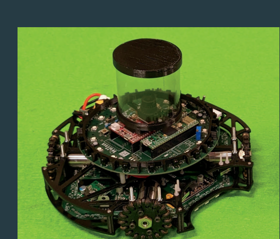
Operations Framework



Programming IDE's

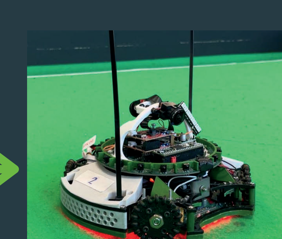
We use Visual Studio Code (C++) to program our microcontrollers, together with the extensions PlatformIO and GIT. Our camera module is programmed using the OpenMV IDE (Python based).

Testing & Evaluation



Previous design

Intermediate Design

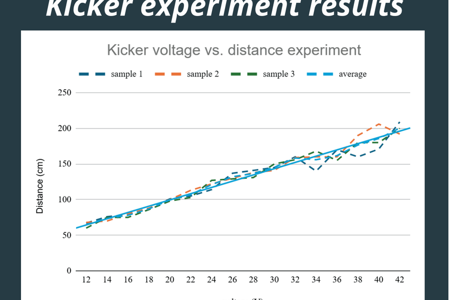


Final Design

Old vs. new camera setup

SCAN ME!

Kicker experiment results



Our team used to have a singular camera facing upward towards a conical shaped mirror, creating a 360 degrees view. But this setup led to a very low image resolution and we had to keep cleaning the mirror. We also realized that we didn't really use the 360 view feature of the conical mirror. This eventually led to the decision to design a new camera setup that uses two cameras: one facing forwards to observe the opponent's goal and one facing backward observing our own goal.

Kicker experiment:

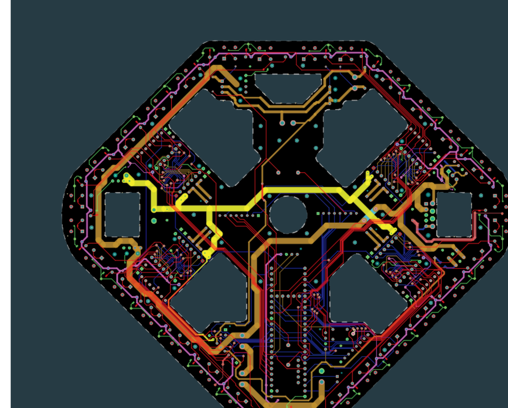
We were questioning whether it is worth redesigning our initial 32V kicker circuit to be able to use the full 40V that is allowed in the competition. So, we decided to conduct an experiment. The objective of this experiment is to determine the correlation between the kicking distance and the increase in voltage. We concluded that while the kicking distance increased linearly with voltage, the variance in distance also grew, likely due to increased field resistance or solenoid inefficiency. Notably, the jump from 32V to 40V yielded nearly a 50 cm increase in distance. This experiment confirmed the hypothesis that redesigning our kicker circuit would benefit us greatly. Details on this experiment can be read in our engineering journal.

Production & Design

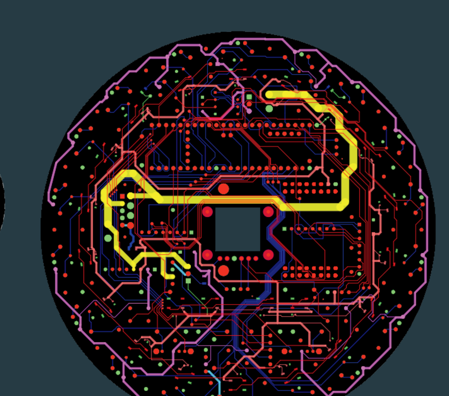
We used various production methods to build our robots. The frames are cut using a waterjet cutting service and the other self designed components are 3D-printed. The models were designed in OnShape, a web-based open-source CAD software.

We have designed new protection bumpers to increase the robots resilience. They are 3D printed because they had to be strong yet also lightweight. That's why we chose a honeycomb inner wall design to find the perfect balance between durability and weight optimization. Additionally our new camera setup uses a new dual camera holder.

The PCBs are designed in Altium Designer, a supporter of our team. To further protect our bottom PCB we applied a protective film material since in the past loose metal objects from robots on the playingfield would risk shorting out our bottom PCB which is placed close to the ground.



Bottom PCB

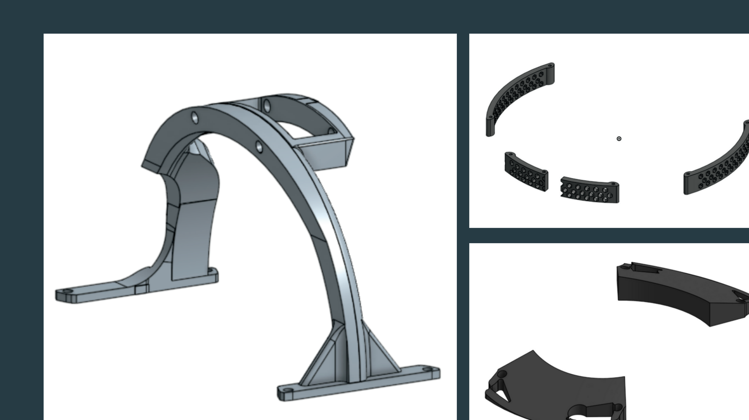


Top PCB

PCB Schematics

SCAN ME

CAD Models



New CAD Designs

3D Printing