Team Faabs - Technical Paper

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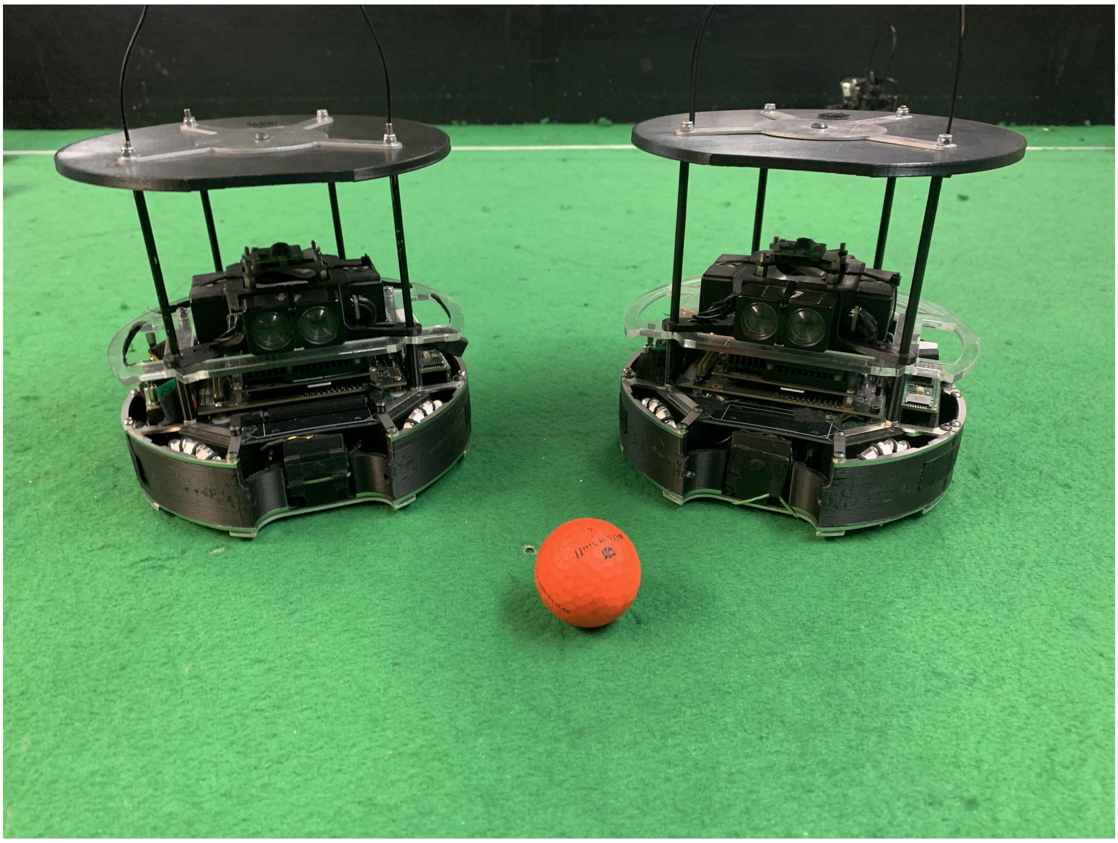

Figure 1: Team Faabs - Fabian Brune, Mark Krause, Jurij Lenz

Contents

1 introduction

1.1 Team

In our Team, everyone has a specific task to do.

1. Mark Krause: Software and circuit design
2. Fabian Brune: Hardware design
3. Jurij Lenz: Raw Hardware

Figure 2: Team Faaaabs - Fabian Brune, Mark Krause, Jurij Lenz

1.2 School

The Robotics program of our school was created 2011. Since then, we managed to win the World Open multiple times in either Soccer LightWeight, Soccer Open or OnStage. We try to put our new teams as fast as possible in the top leagues. With the gathered experience, we always have teams to follow our footsteps.

Figure 3: LGNU - our school

1.3 Abstract

We are a Team of three students from the Lessing Gymnasium Neu-Ulm in Germany. Furthermore, we founded our Team in 2019 and first participated in the RoboCup Junior in 2019. Robotic is a big part of our daily life. We meet on school days and even on weekends and holidays.

We started developing our robots in mid 2022 and had a first prototype in late 2022. After final design choices, we had our robots for the German South-Open in early 2023. From this point on, some progress was made in the Hardware sector. After optimizing our program, we managed to reach the second place.

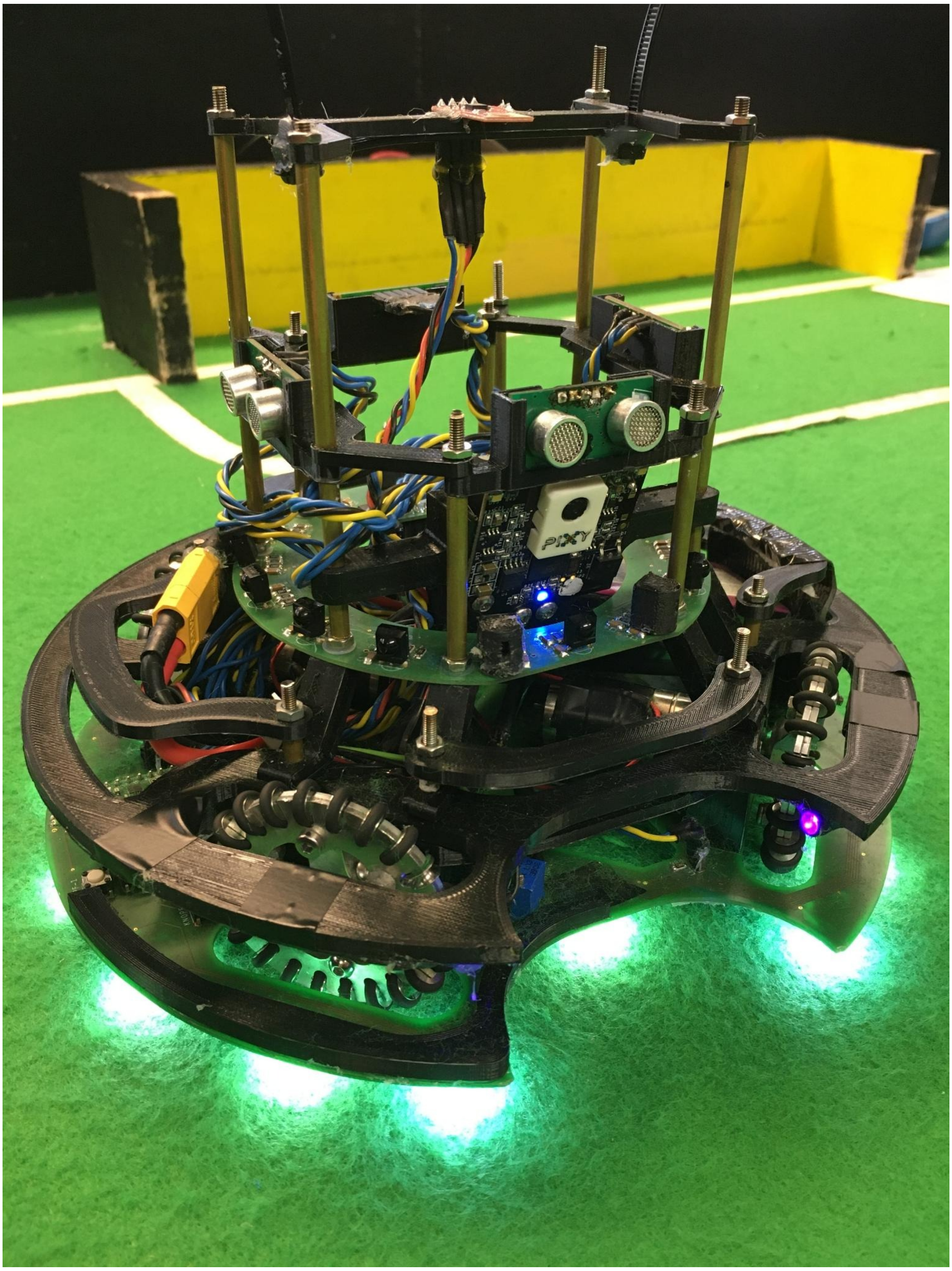

Figure 4: Robot from 2022 before the eruope open

After the South-Open we redesigned our kicker and continued fixing small hard-& software problems. Due to technical issues movement with the ball whilst dribbling was not possible and in the German Open we had to participate without a dribbler. With these improvements we managed to gather the second place at the German Open and qualified for the World Championship.

2 Development & Testing

2.1 Development

Due to the pandemic we weren't able to get much experience. In 2022 we had our first real RoboCup in the LightWeight International League where we got second at the European Championship. With this experience we started to design the 2023 Open robot. The design of our robots aims to be as rigid as possible, while keeping the robot manouverable. To achieve this goal, we used metal and 3D printed Parts in combination with optimised circuit boards. With our Software, we are able to travel with high speeds to the ball use our dribbler and hit a goal without going out of bounce (most of the time).

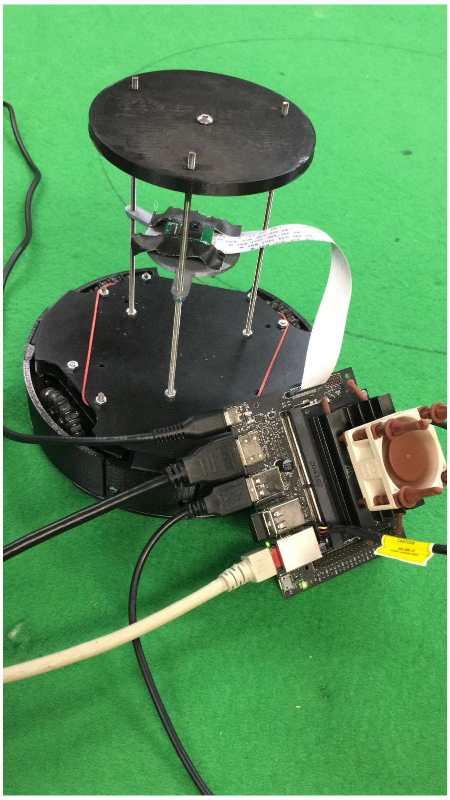

Figure 5: prototype from december last year :-

2.2 Mechanical Design

All our parts were designed using 'Autodesk Inventor 2023 Professional' and 'Autodesk Eagle 9.6.2'. Most of our parts are printed with our Prusa MK3S+ and the metal parts are produced by our sponsor "Blech und Techhnik".

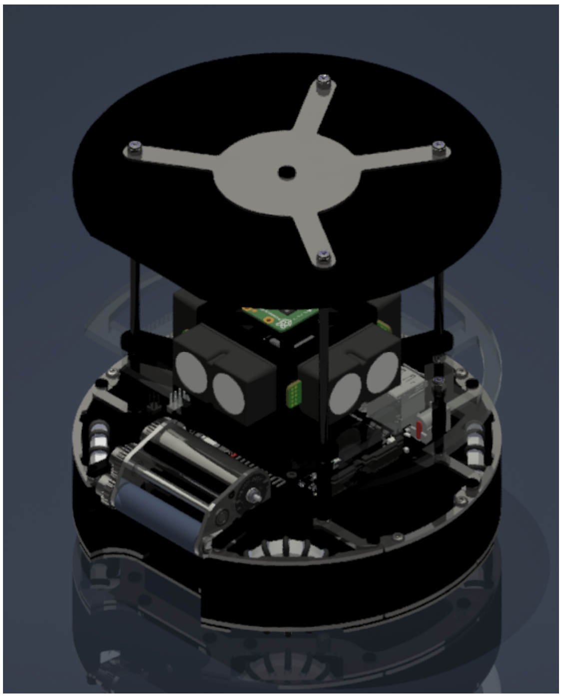

Figure 6: CAD design created by Fabian Brune (last updated 25.6.23)

Traveling with high speeds, while being strong is also a huge challenge. To achieve this, we use high quality Maxon DC Motors in combination with the VNH3SP30 driver chip. To put the force on the ground, we designed new OmniWheels. The OmniWheel consists of two independent aluminum pieces screwed together. For the small wheels we use a small aluminum piece covered with an O-Ring out of EPDM plastic.
To protect this whole construction from the opponent robot, everything is moved into the robot and a 3D print and metal protectors are covering the whole inner side of the robot. **??**..

2.3 Electrical Design

To detect various elements and control the whole robot we use a Teensy 4.1 microcontroller and a Jetson Nano for ball detection. All electronic parts are soldered to circuit boards.
We have a total of three Circuit Boards:

1. Line Detection& motordriver PCB
2. camera&lidar PCB
3. Controller PCB

Each Circuit Board has a predetermined task and all the above are controlled by the Teensy 4.1 and the Jetson Nano 2GB.

We order our Circuit Boards from a local company and solder the parts manually on the boards.

2.3.1 Line Detection& motordriver PCB

The Line Detection PCB consists of three circles of phototransistor pairs, our motordrivers and the kicker control. To connect all 48 sensors to our main controller, we use analog multiplexer. The multiplexers are switched parallel to save ports.
We use pairs of two phototransistors and one led. For us, this is the best way to detect the line.

Camera&Lidar PCB

On this very small and special PCB, we combine our most important sensors, the lidars and our Raspberry Pi cam. The camera is used for ball and goal detection. It is directly programmed on our Jetson in OpenCv. Our lidars are connected to the Teensy 4.1 on the Controller PCB via I2C.

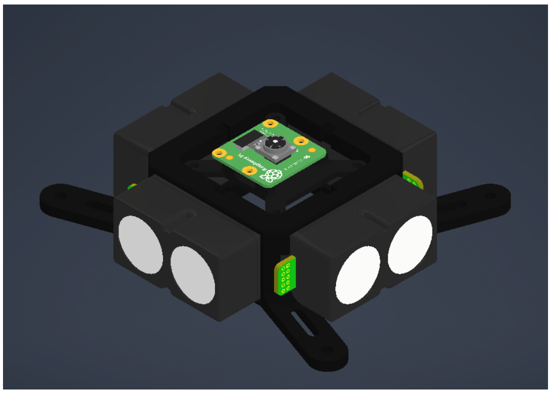

Figure 7: lidars

2.3.2 Controller PCB

On our Controller PCB we got the most imortant parts of our robot like the Nvidia Jetson Nano 2GB Developer Kit and the Teensy 4.1. Our dribbler is also located on our main PCB. We use our dribbling device to give the ball a backspin, so that it stays right infront of our kicker.

2.4 Software

As we all know, that's the objective:

1. Approach the ball quickly and precisely to get it into the ball pit.
2. Aim for the goal as quickly as possible, while the ball is save.
3. Score as fast as possible.
4. Stay inside the playing field very consistently

Accordingly, a modularization of the code can be set up.

2.4.1 Object detection

We detect the orange ball, the yellow and the blue goal. This is done with the open-source computer vision library "OpenCv" (v4.1.1) on our Jetson Nano. We also do multithreading to achieve this three detection processes parallel with the lowest latency possible. Our resolution is 816 on 616 pixels in one frame.

2.4.2 Onrobot communication

The Jetson programms and talks to the Teensy via an USB cable and a raw HID interface. This proved to be very stable and fast. The Teensy decides where to drive because it receives all sensor data.

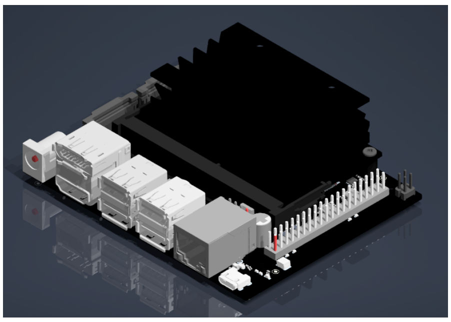

Figure 8: Jetson Nano

2.4.3 Ball approach

In our understanding, to achieve a good base for all soccer actions, it should be key factor to get the ball consistently and fast into the ball capturing zone. As we nearly always drive alined to the enemy-sided wall (to minimize the risk of scoring in our own goal) our calculations follow the same pattern over and over again. As an input they get the x and y coordinate of the ball, relative to the robots origin. As an output the algorithm generates a direction and a velocity where to drive. Concretly we try to get a fix position realtive to the ball and move this point in a cone in front of the ball-capuring-zone. As the ball is directly in front of the robot, it can just drive forward to get the ball in the dribbler. The biggest challenge is, to calculate the optimal curve with direction and velocity vectors.

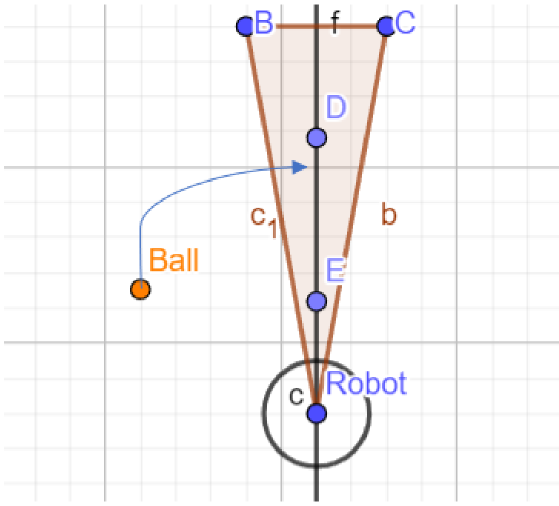

Figure 9: ballaproach

2.4.4 Aiming at the goal

To detect the goals we are also using our Jetson Nano. We only use the angles of the goals for the positioning on the field and shooting in the right direction and not blind. The bot only shoots when it is in range and good alined with the goal to minimize unnecessary ball losses.

2.4.5 Detecting the white lines and avoiding out of bounds

To know where the robot has to drive when it sees a white line, it collects all coordinates of all linesensors that have seen the line in a short period of time and calculate the opposite vector. In the future we plan to update it because it proofed to be very annyoing and not quiet a hundred percent secure. Also we use our LIDAR sensors to avoid to close wallcontacs on high velocities, which turns out really reliable and usefull.

2.4.6 Special tricks and gimmics (butch)

In case that we don't see the ball on the field, we drive to fix points on the field to save some time driving to the next neutral spot. Also we try to communicate if the ball is close to one robot via buetooth, so that the other one can drive to the back not disturbing the attacker. We didn't want to have a set goalie because of the fact that it may be more usefull to have two attackers.

2.4.7 Kicking device

For our kicking device, we use 3D printed parts with an optimal design and a self wrapped coil, wich forces an iron bolt to move towards the ball. With this technique we can transfer nearly all of the kinetic energy from the iron bolt to the ball. This allows us an direct shot at the goal on the other side of the field.

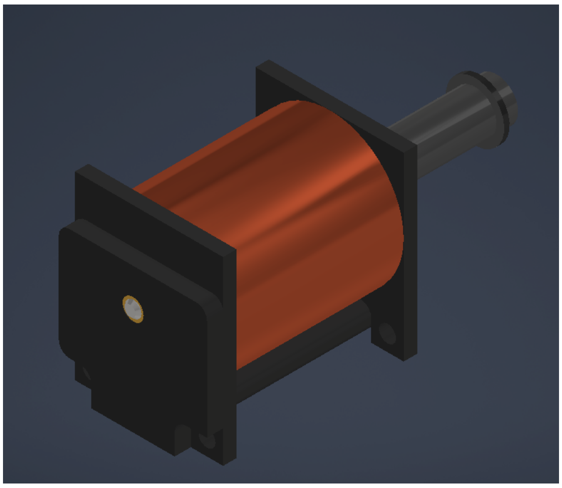

Figure 10: kicker

3 Experience 2023