Bohlebots Linux
Team Description Paper
Virtual World Championship 2021

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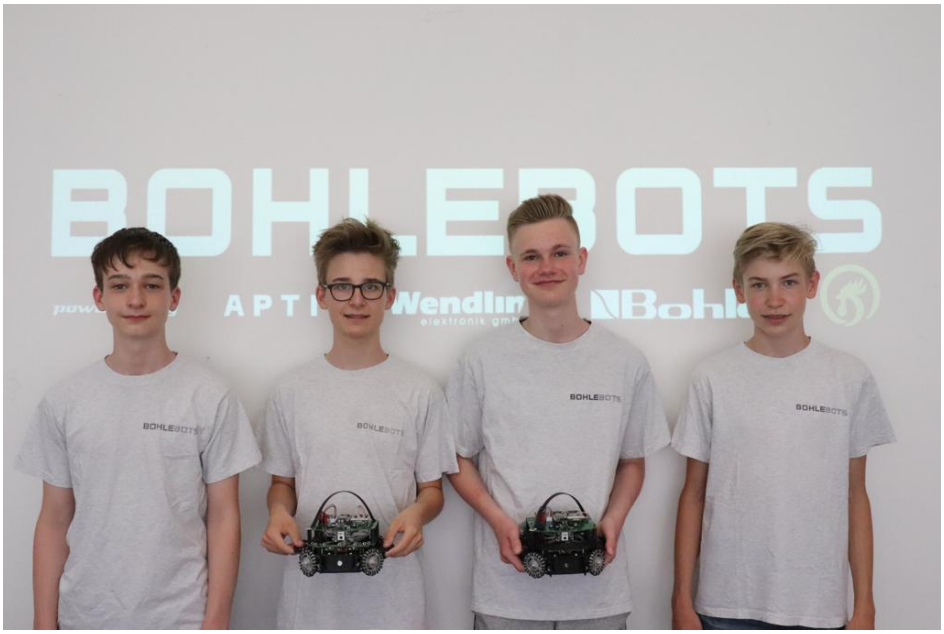
Abstract

In this Team Description Paper we, the Team Linux from Germany, will introduce our two robots which play in the 2vs2 Soccer Lightweight league. In the following pages we will report a lot about the structure and the hardware from our robots, as well we will talk a lot of about our programs and the logic behind it. We will also introduce us as a team and explain how we managed to continue working on the robots despite the Covid-19 pandemic. The hardware we use for the robots and the tactics we often thought about for weeks and then worked out are illustrated with pictures and graphics that we created ourselves. In addition to this paper we created a video for the word championship too. At the end we'll present our plans for the future and what we learned so far.

Introduction

Team photo



The team „Bohlebots Linux" with their two robots
From the left to the right side (all born in 2006):
Henrik Timmer, Linus Mertes, Alexander Graf & Maximilian Haarhoff
Software, Hardware, Hardware, & Software

Team background

We are sponsored by a company in Haan, which support us financially and by giving us a working space so that we work in a building provided by them.

2016/2017

We work in a workgroup from our school where two of us (Linus and Maximilian) started four years ago. We were asked by our coach whether we would like to work in the workgroup and to build robots, as we were already very good at computer science in school in 5th grade. As a team of

two, we first started building robots out of Lego. In the first year, however, we weren't as successful, so we started with rescue line entry.

2017/2018

In this league we were able to learn the programming language C++ with Arduino and we already had our first competition experience. After a season rescue line entry we finished it with the 5th place at the West-German Championship.

2018/2019

We started with our soccer career. Henrik now joined our team and we were now a team of three. We started to build or robot for 1vs1 soccer open. Overall we played two years in the Soccer 1vs1 league. In the first year of the soccer league we often had problems with our robot and unfortunately we didn't qualify for the German championship. The first season brought us a lot of experience and shortly before the West German Championship 2020 our team was filled by the 4th team member. Alexander joined our team and now took care of the hardware with Linus.

2019/2020

Our second year in the 1vs1, however, went significantly better as the first year. Our robot's hardware improved a lot and our software became more sophisticated.

We develop our first strategies, developed programs to get out of the corner with the ball and one strategy to reach the ball faster. This year gave us a different insight into the soccer leagues and we started to work harder because we have set ourselves goals for the first time. We wanted to qualify for the German championship, which we succeeded. We became Vice-West German champions.

Then the COVID-19 pandemic started in Germany in March, the German championship in April was canceled so that we needed new plans for the year.

2020/2021

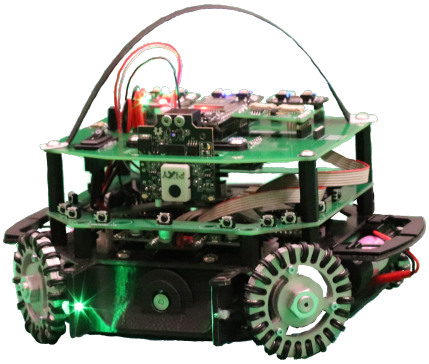
Due to Covid-19 the schools had to close and as already mentioned we work in a working group from the school, so that we were not allowed to visit the working group because of the school closure. Finally, we started with 2vs2 Lightweight. In august we started building our two robots, writing the software and developing strategies.

Team current year's highlights

We are very grateful that there is a competition we can participate on. However, we also wondered abut that because we think it is a very big expenditure to organize such a big, worldwide and also virtual event. As a team we qualified for this world championship in Germany after completing two challenges and presenting our robot in a short video. Now, we are hopeful to represent our country in our league very properly.

Robots and results

The section „Robots and results“ will help you to understand our two identical robots very well and to get to know them in more details. We will present our Robots in different subtopics like the „basic construction“. Later we will also come to the results and the resulting tactic our robots use to drive with.
If you are more interested in seeing how our robots are built after reading, you can also check this stop motion video.



One of our two identical robots

Basic construction

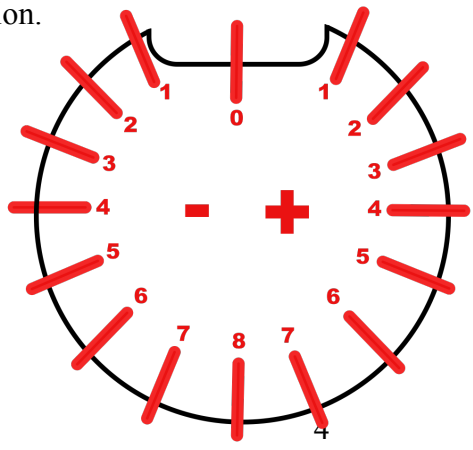
Our basic construction consists of a carbon plate with a diameter of 21cm, just as big as the robot itself. Our holders for our 3 batteries, which are made out of 3D print, are suspended in this carbon plate. These batteries are connected in series and together they provide our 12 volts, so each batterie itself has 4 volts.
Between the individual components, our self-designed circuit boards, we use black plastic housings that serve as threads on one side and screws on the other.
A plastic band diagonally above the upper board, surrounded by a shrink tubing so that you won't cut yourself, is fixed with two screws.

Motors and the kicker with their own board

Our self-designed circuit board for the four motors, for our kicker and for distributing the electricity is above these components and above the power supply. On this board we have four motor driver from the company „Maxon“ to each of which a brushless motor (GMP16-TEC 1636 brushless motor with a 16:1 transmission of the company „TT-Motors“) is connected and an Esp-32 Dev-Module for programming our logical for driving. Furthermore, as we said, we use also a kicker (self wound kicker with a diameter of 19mm and with six layers of the 0.5mm wire) which has also his own mini board on this whole circuit board what provides the hides of tension for kicking. The most important logic, with which we drive is a function that has three parameters. We call it „fahre(Direction, Rotation, Speed)“.

Direction

First, we introduce the first parameter, the Direction. For this we have our TSSP-6038 IR-Sensor, that give us a direction of the ball with its infrared sensors that detect the ball just because of its infrared radiation and the TCS3103 RGB Sensor that also delivers directions, however, in this case of the white line and not of the ball. As you can see in the graphic on the right side, we use as well for the ball-direction as for the



white-line-direction directions from -7 to 8. So all in all we have 15 ball- and groundDirections. We also know whether we can see the ball or not, so if we can't see the ball, which actually never happens, our robot will stop driving.

Rotation

The second parameter forms the rotation which use the following hardware components: the Pixy2 and the cmps14 compass. While our camera, the Pixy2, is used always to detect the goal, the compass is just relevant if the Pixy can't detect the goal we have marked. Usually the camera delivers the goalDirection (the variable will be zero if the bot looks to the opposing goal perfectly) and the Distance to the opposing goal which is calculated from the height and width of the goal. You can understand that in a very practical example. So if you go away from a building you will see this building smaller and smaller. You will see that very well and understandable in our main program in the Pixy Header.

Other components on our main board

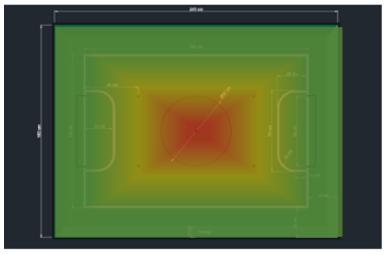
On our self-designed main board, also called as our sensor board, is the camera, the compass, an Esp-32 Dev-Module and 4 taster-/Led-boards connected. Each of these taster-/Led-boards has two Led and two taster that we use for example for setting the compass or for testing our kicker. We can also try out with them very easily different speeds in coordination with other things while testing different tactics. Normally, from this circuit board we control and program our robots. Furthermore, we use a photoelectric barrier to know whether we have the ball in our ball bowl out of 3D print.

Communication

For the communication in our robots, we use the Can-Bus system. On every circuit board we introduced, we have two Can-Bus ports, so one electric wire leads up and the other leads down to the next board. So totally we have a connection from each circuit board to all the others. In this system we send variables to the other boards, for example the directions to our main board or the command to drive from our main board to the circuit board where our motors are connected. Just because the Can-bus just can handle positive numbers in variables, we must calculate some variables, like the directions with +8, so that the variable is every time positive. On the receiver board then we must calculate it with -8. Moreover, we have begun to work with bluetooth hc-05 to communicate from one robot to the other. In the future we will be able to decide which robot is nearer to the ball and should drive to it.

The whole tactic

Using all this sensors, we have written our tactic. We decided to play with one goalkeeper and one striker, so that we can defend our goal very well and also strike goals. In addition, we thought it would be just a problem if there were two strikers

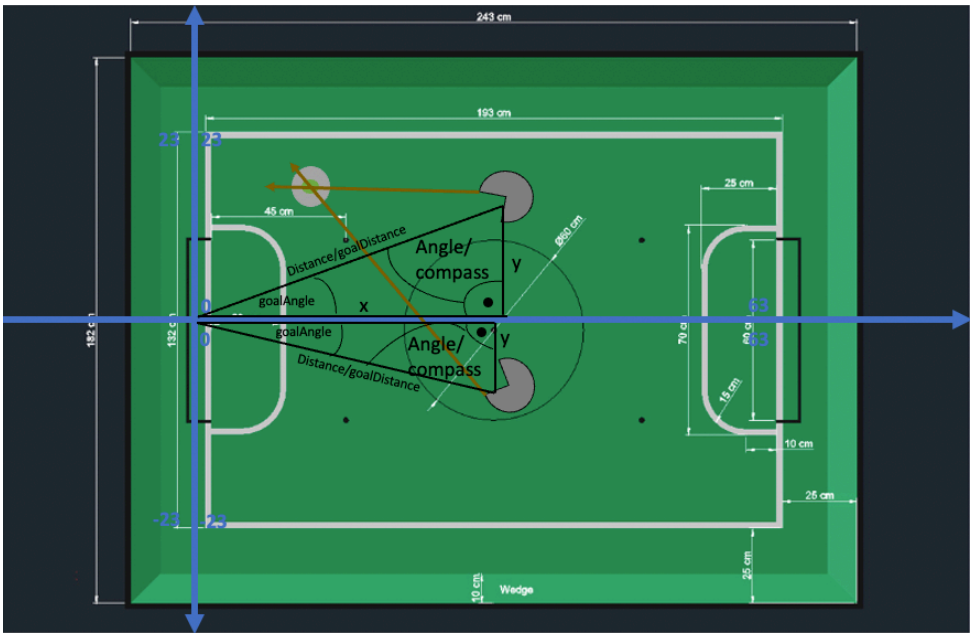


Speed calculation on the playground

because they would drive both at the same time to the ball so that they would block each other. In general the goalkeeper is just driving in front of our goal laterally to protect it very well. At a white line we drive something like „zig zag“ to work around the situation. However, the striker will stop at a white line if there is no chance to reach the ball in the playground without trespassing the white line. Otherwise, this robot is just driving after the ball to score a goal and if the goal Distance is smaller a certain value we will kick. The speed is calculated with the compass. It means that if we are near to a line we know that very safely because we always rotate after the pixy value, so we know that the compass value is quite high or quite small.

Determination of coordinates

We thought about how getting our coordinates on the playground with our sensors we have. After lots of considerations we decided to build a triangle using the goalDistance of the pixy and the compass value. Later we can also determinate the coordinates of the ball with both ballDirections of the two robots (the intersection of the two directions). In the graphic under



this description we show this tactic very vivid.
The Mathematical concept is the following:
The variables are assigned as described in the picture. We calculate the position using the sine law.
Sine law: $a/\sin(\alpha) = b/\sin(ß) = c/\sin(y)$
Case 1 : $Distance/\sin(90°) = y/\sin(goalAngle)$
⇔$Distance = y/\sin(goalAngle)$
⇔$Distance * \sin(goalAngle) = y$
Case 2 : $Distance/\sin(90°) = x/\sin(Angle)$
⇔$Distance = x/\sin(Angle)$
⇔$Distance * \sin(Angle) = x$
In our code it looks like this:

```
void getPosition(Point from,int Angle,int Distance){
 bool isUp = Angle > 0 ? true : false;
 Angle = Angle > 0 ? Angle : Angle * -1;
 int goalAngle = 90 - Angle;
 from.y = Distance * sin(goalAngle);
 from.x = Distance * sin(Angle);
 if (!isUp){from.y = from.y * -1;}
}
```

At the moment we don't use this determination because of some problems in the game. However, we are in process of fixing these problems to use the coordination system later for other problems we have like to optimize the acceleration or the coordination of the two bots.

The results

As a result, we can say that the software is coordinated on the hardware components very well. With four motors, the kicker and the three batteries our center of gravity is very far below so that we shouldn't be pushed away. In addition, we also know that we can work on our program harder for the next season so that we can improv for example the determination of the coordinates.

Conclusion and future work

Over the past year we've really learned how to use kicad to design our own circuit boards and how they work. We also trained in programming and learned how our robots are communicating.
In addition, we trained ourselves to the limit in OpenScad, which we use for 3D modeling and we learned how to organize the team management.
We learned more about how each of our robot parts work and what it does.
As the matter of fact, we also learned how to properly use every tool and also a lot of exquisite ones we usually don't use.
During the year we had a lot of issues to solve but we really learned how to solve those problems and how to avoid them in the future.
Over all, you can say we educated us in every way possible during the last year, which we appreciate.
In the future we try to have as much fun as possible, to learn more from every mistake and to gain more experience and hopefully qualify for the next champion chip.

References

Programms

- IR-Sensors
- RGB-Sensors (bottom ring)
- Circuit board for the motors
- Main board
- Algorithm for the compass (for the future)

Circuit boards

- Main board
- Board of the motors
- IR-Sensor board
- Bottom ring board

Applications

- 3D Modeling: Cura and OpenScad
- Circuit board design: kicad
- Coding: Arduino IDE
- Pixy: pixymon