Die Enten

Willibald-Gluck Gymnasium (Germany)

Team description

Robocup Eindhoven 2024

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1. About us

1.1 Logistical information

Team name: Die Enten

Name of robot: N10

School: Willibald-Gluck Gymnasium

Country: Germany

Contact Person: Tobias Wagner

Email: t.wagner@wgg-neumarkt.de

1.2 Team

- **Mr. Tobias Wagner**
  He is the team mentor, and he helps with delivering or ordering the needed parts for our robot. He also gives good advice and tips on how to assemble the robot. Additionally, our mentor also gives us directions when needed.
- **Jonas Nicklas**
  He is our main programmer and does most of the software work. He also helps the other team members with explaining and teaching them how to program.
- **Florian Schäff**
  He focuses on making the 3D design of the chassis of our robot. He also helps Florian Hierl and Luca with building the robot.
- **Florian Hierl**
  He mostly works on the mechanical aspect of our robot. Currently he is focusing on making the robot arm.
- **Luca Zylla**
- Luca is mostly working on the hardware, but he always lends a helping hand where it is needed. Recently, he has also been learning how to program.
- **Dalea Badri**
  Dalea takes care of most of the logistics and also organizes papers and translating them. She also helped designing our T-shirts with Fiona and another friend. She also helps with the hardware when needed.
- **Fiona Schäff**
  She also helps out with the logistics and helps Dalea with translating. Additionally, she also assisted with designing the T-shirts. If needed with the hardware, she lends a helping hand.
- **Simon Sturm**
  He is also mostly working on the hardware with Florian Hierl.
- **Christopher Zech**
  He is new member and recently he has been learning how to program so he can help.
- **Friedrich Worch**
  Friedrich is also one of our programmers, so he helps the others with the software.
- **Matteo Nowinski**
  He is a new member and lends a helping hand where it is needed.

Our official Team for the RoboCup in Eindhoven will be the first eight, but the others will be there as daily visitors and support.

1.3 Introductions

Our team, “die Enten”, is made up of the students who are in the “Mintex”-course, of the Willibald Gluck gymnasium in Neumarkt, Germany. We haven’t been able to compete on an international level before, so we are very motivated to be able to take part in this competition. We meet up weekly to improve our robot. We did have some delivery problems, which caused some time problems and created extra pressure. Though we quickly solved this, by meeting on the weekend an in our holidays.
The aspects we want to focus on are maneuverability and stability. We realized both these things were important when we were at the RoboCup German Open RMRC 2023 in Nurnberg. Since one of the problems, we faced was that our robot wasn’t stable enough, because it was a little too tall. But also, our 3D-printed tires didn’t have any grip. So, we want to avoid having that problem again, but also, we realized how important it is to be able to change positions and go back and forth quickly. Which is exactly why we want to focus on those aspects.
We also want to focus on making the robot arm good, because we believe that it will help us a lot during the competition. It was also something that we thought would a nice experience to make and it would evolve our skills.

1.4 Experience

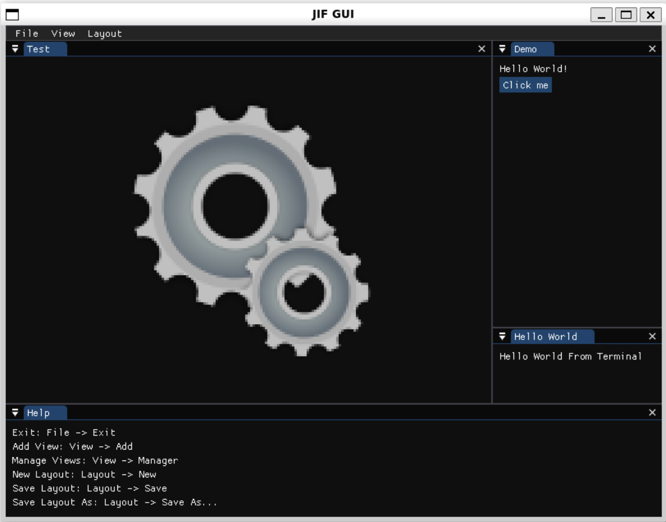
Numerous events at which we have taken part with our robot have enabled spectators to see them in action and to recognize the necessary aspects of building and control of such a robot. These events allowed us to exchange ideas with the other groups on site and receive helpful information and suggestions for improving our robot, but also to pass our ideas on to the other groups.
One of the events took place at the Christoph-Jakob-Treu school in Lauf. From the 17th to the 18th of March 2023, during our stay, several courses were offered to us so we can deepen our understanding in programming and building the parkour. During the project, the team had ample time to collaborate on the robot's development. Both software and hardware experts were able to freely exchange ideas and design new concepts with the guidance of teachers and experts.
Towards the end of the 2022/23 school year, the final of the "Robots unite!" project took place at our school. The project was supervised and organised by Professor Stefan May from the Georg Simon Ohm University of Applied Sciences and was designed to encourage the participating teams of students to get their robots to work together to complete a large course to which all teams had contributed. The course itself was strongly modelled on the well-known video game "Portal" and included challenging course passages as well as entertaining mini games. Despite minor technical problems, the day was a great success overall and the local press also reported on it. This test also drew our attention to some of our robot's faults, which we were subsequently able to rectify.
Our visit to the ‘Langen Nacht der Wissenschaft’ (November 2023) enabled us the access to different tools but also the professional knowledge of the organiser. Also, we get the chance to test our robot with different parcours elements. Even if they were very challenging for N10, we

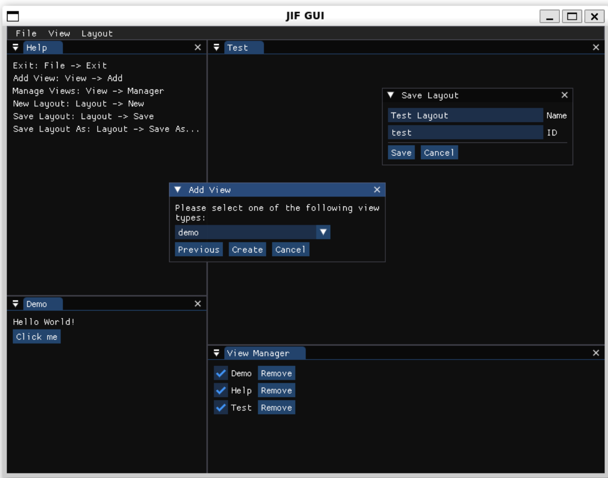
gained valuable information which aspects we had to improve. On this event we profit by the helpful and inspiring exchange with other schools and our teamwork skills were strengthened.
In Autumn 2023, we participated in the German Opens on the Consumenta, in Nuremburg. As an achievement we reached the 3rd place and won the Team-competition. There we experienced the weak points of N10 and get an impression how the competition in Eindhoven will work.

2. System

2.1 software

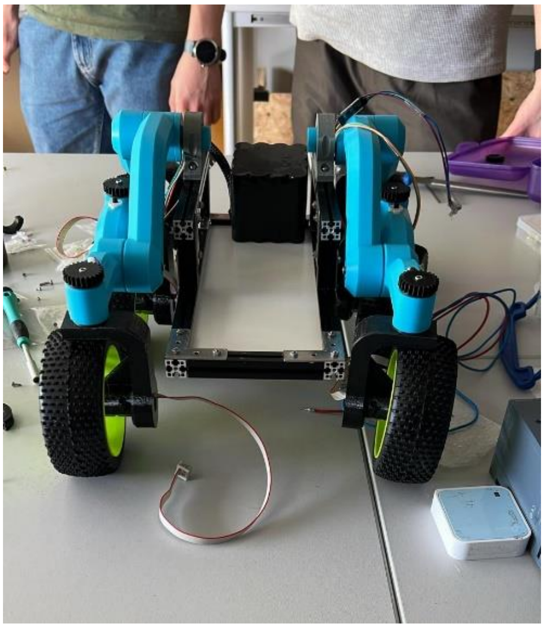
The software of our robot N10 is written in C++ and C and is based on the ROS 2 framework. Therefore, the software is divided into several nodes that communicate with each other via ROS 2 topics. To control it, we use an updated version of the "JIF" console, which originates from a youth research project by Jonas and two of his friends, Ilijan Odenbach and Felix Schreiber. This console receives the normal camera image from N10-CAM-PUB and a motion capture version of it from N10-CAM-DIF to recognize movements. For driving the robot, three nodes are responsible: N10-edu_drive_ros2, N10-TRANSLATOR, and N10-SERVO-CONTROLLER.
N10-TRANSLATOR receives a message from the "JIF" console for navigation and whether to use the steering control of our robot or not. Depending on the message, it then forwards it either to N10-edu_drive_ros2 or also to N10-SERVO-CONTROLLER.
N10-SERVO-CONTROLLER is responsible for controlling the servos for steering, and N10_edu_drive_ros2 is responsible for controlling the six motors. The nodes N10-CAM-DIF, JIF, and N10-TRANSLATOR run on our laptop. The nodes N10-CAM-PUB and N10-edu_drive_ros2 run on the robot's own Raspberry Pi. N10-SERVO-CONTROLLER is a microROS app running on an ESP32 development board. All our nodes are available on GitHub (https://github.com/orgs/wggRobotic/repositories).

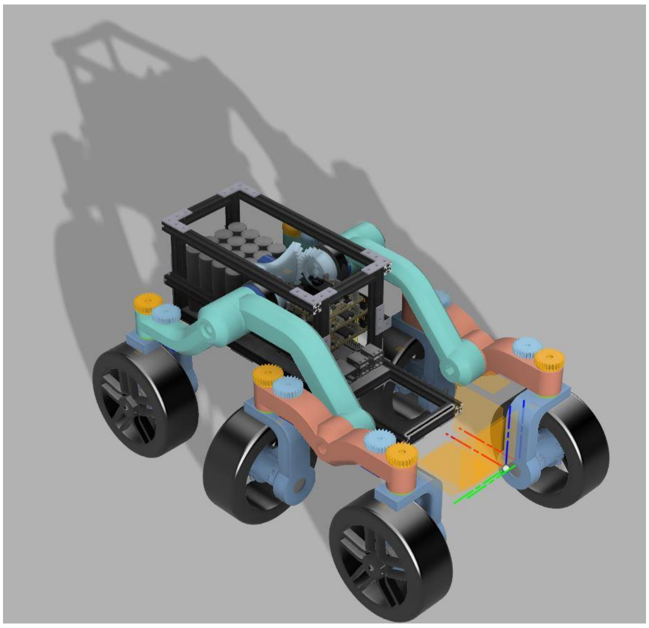




2.1 Hardware

We designed our robot with Fusion 360. The entire robot was designed in individual files and then in the end we added the files in one, so that we could visualize the robot better. Our CAD model is detailed so that it will be easier to build.
We assembled the individual 3D-printed components, securing the motors and installing the tires. Following this process, we made a main body using aluminum profiles, onto which we mounted the tire suspensions. It's important to note that the screws were not integrated into Fusion. It's noteworthy that our design facilitates steering through the implementation of six servo motors.





We will use a “Rocker-Bogie”-Suspension because we think that for the different terrain types, which we will encounter in the parcourse-elements, it’s the optimal solution. For Inspiration we used the models of the Martian rovers and also the 3D-Model by WildWilly “Stair Climbing Rover” (https://www.printables.com/model/194299-stair-climbing-rover). The 3D-printed parts of the later model will be redesigned for our purposes after testing and trial and error.

2.3 Communication

We use an Ethernet cable to communicate with our robot through a laptop.
We are able to send the data back and forth between the robot and laptop by using ROS2 nodes programmed in C++. The camera date is captured and processed using OpenCV.

2.4 Human-Robot interface

We use a Logitech X3D controller to drive the motor. The joystick moves the robot in the desired direction.

3. Application

3.1 Set up, pack up and operator station.

As for our operator station, our programmers use their own laptops for controlling the robot. The robot uses a Raspberry Pi 5 on board to interpret the messages send by the operator's computer. The Pi then sends the signals to either the ESP32 for the rotational servos and the motor shields.

3.2 Strategy

Our strategy is utilizing a combination of agility and the adaptable robot arm, which still isn't finished. The maneuverability of our robot enables it to effortlessly navigate obstacles, accurately position itself, and swiftly adjust to dynamic conditions on the competition field. Another advantage is that our robot will be able to drive sideways, this remarkable agility guarantees efficient movement, granting us a significant competitive advantage. Simultaneously, the precision, versatility, and independent functioning of our robot arms empower us to successfully overcome a wide range of challenges. With its precise and autonomous movements, the robot arm will serve as crucial asset, significantly enhancing our team's overall performance and our chances at winning.

3.3 Testing and experiments

We aimed to evaluate the robot's adaptability, so we tested the robot on a couple different terrains on "Lange Nacht der Wissenschaft" to see how the robot would do. We didn't have enough time to experiment as much as we'd like, so in the meantime we will make sure to let the robot drive on a couple more terrains and do some more tests to make sure we are ready. Therefore we are building some of the parcours-elements at our school.

3.4 Strengths

We all have our own roles, but our strength is that we all help each other out when it is needed and we understand each other really well, so we don't have any problems. Additionally, we also agree on meeting in our free time to finish our work. Another positive thing is that we have lots of members in this team, which means each role, which is explained in the introductions, has more than one person doing it, which means we always have a person around who understands a specific role. This is really helpful, since if one member who, let's say is our programmer, isn't there, we always have others who can still do his job.

4 Conclusion

4.1 What we learned

Through various events (see 1.4 for more information) we not only gained a lot of new experience, but also improved our ability to work under time pressure, to communicate effectively and identify problems in order to enhance and adapt our robot. For example, our wheels had very little grip, so we had to temporarily drill nails into them to create something like spikes. Furthermore, we struggled with the wireless connection between the robot and computer because the router was too weak. To solve this problem, we switched to a connection with cable. Another difficulty that occurred, were problematic software issues. In this case, we weren't able to find a solution ourselves, so we asked for professional support in a forum.

4.2 What we plan to do

We have a lot of work to do, but we are motivated and confident. By the time of the competition, we want to build and install our robot arm prototype. Moreover, we'll improve and think about the position of our cameras and also the image recognition. The most important is the testing, we plan to test our robot as much as possible and plan to redesign the parts if necessary.

5 Appendix

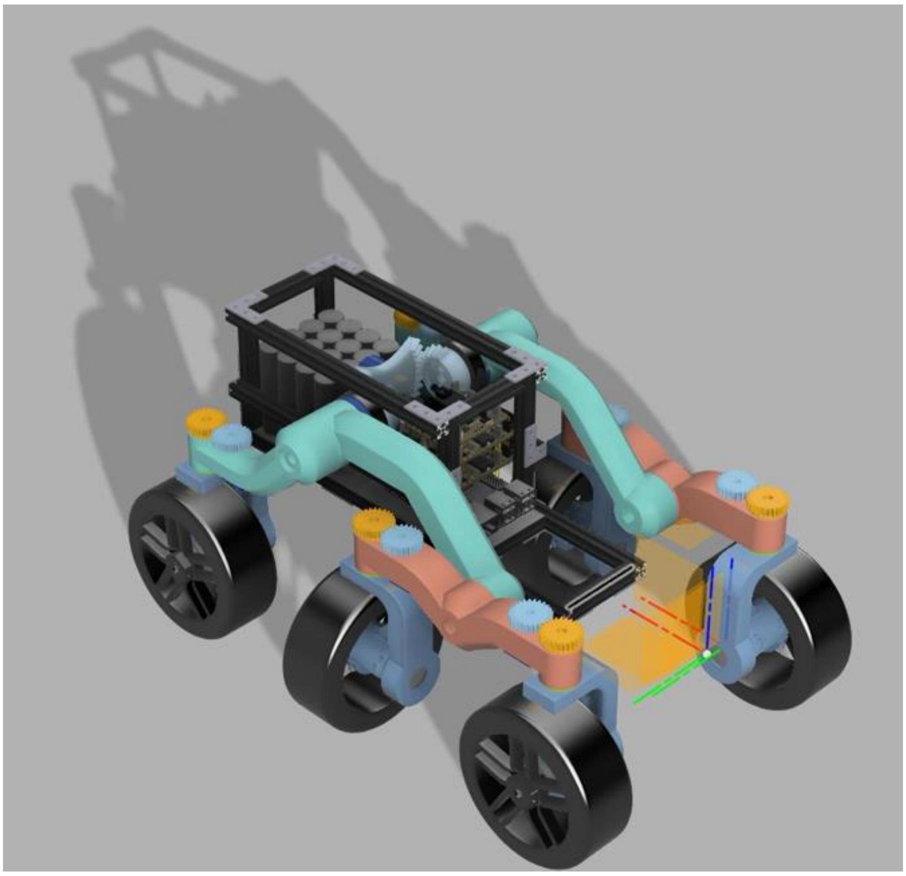
5.1 Components

Any 3D printed parts were via our school's Printers in PLA or PETG. Costs for the robot arm aren't counted (not build yet). It's estimated to be around 100€.

Item	Quantity	Price in € (individual price)	Link
SWHstore 4 Stück Grüne RC 1:8 Offroad Rennauto Gummireifen 5 Speichen Reifen & Kunststofffelge für HSP Buggy Auto	2	16,40	Amazon.de
Raspberry Pi 5, 8GB RAM	1	86,50	https://www.berrybase.de/raspberry-pi-5-8gb-ram
Intel RealSense Depth Camera D435, Weiß, 1" x 3.9" x 1"	1	80	Ebay
Faulhaber dc motor series 2224 with gearbox 22GPT 44:1	6	Sponsored by Faulhaber	Faulhaber
Alternative motor: 131:1 Metal Gearmotor 37Dx73L mm 12V with 64CPR Encoder	6	45	https://www.pololu.com/product/4756
Black Starter Kit Regular MakerBeam	1	117	MakerBeam
Battery pack Ni-MH 19,2V	1	n/a	N/a
AZDelivery 3er Set ESP32 Dev Kit C V4 NodeMCU WLAN/WiFi	1	23.99	Amazon.de
10 Psc SG90 Micro Servo Motor 9G	1	17,89	Amazon.de
Estimated total price:		718,18 €	

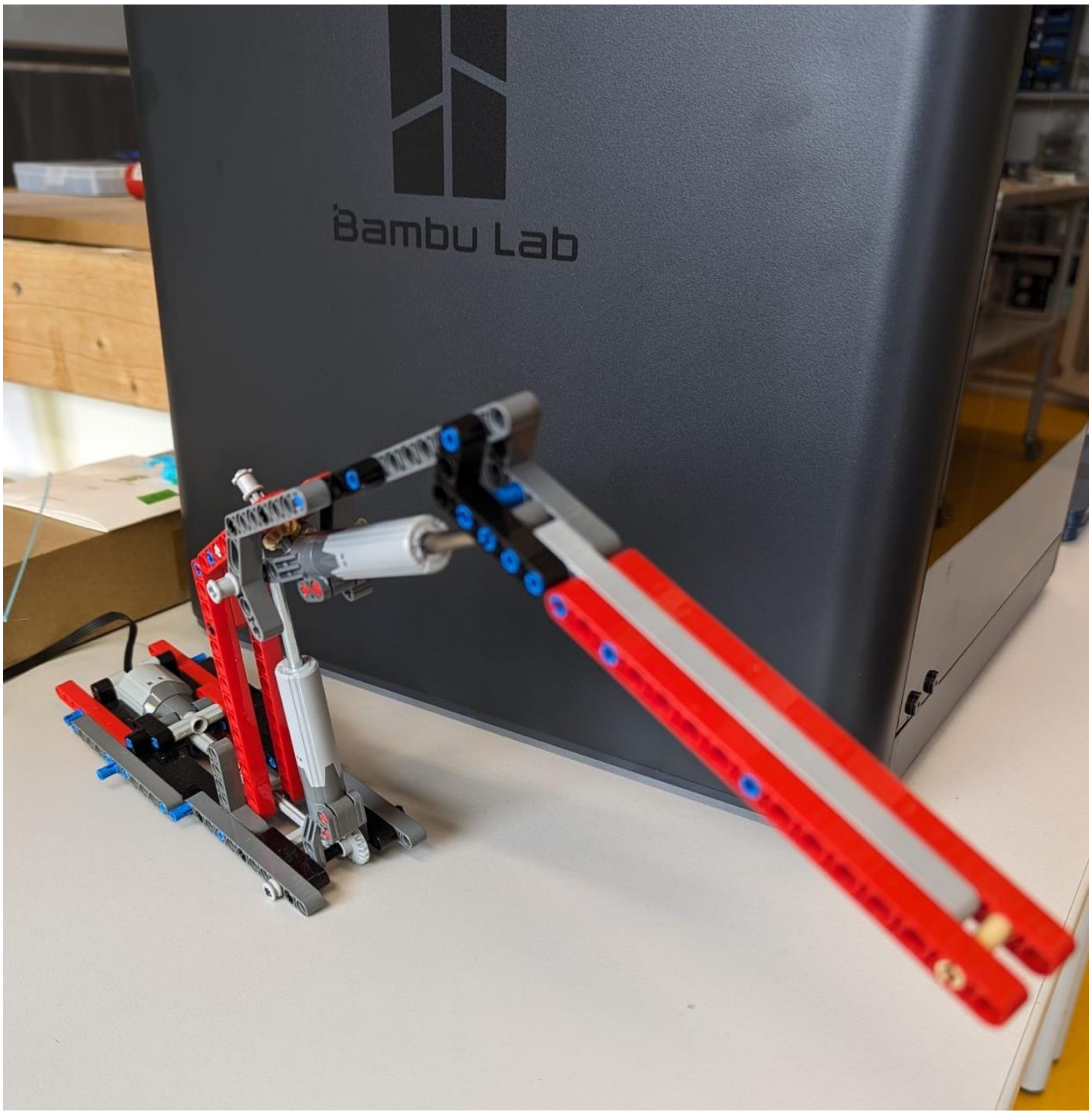
5.2 3D rendering

All 3D designed parts will be available in our github as .step-files after we finished redesigning and testing.



5.3 Robot arm prototype in LEGO

Our first prototype was built from Lego parts. We are in the middle of designing the model for 3D-printing. In the end the arm will be moved by 3 servo-motors and controlled by an ESP-32.



5.4 N10 pictures (building process)