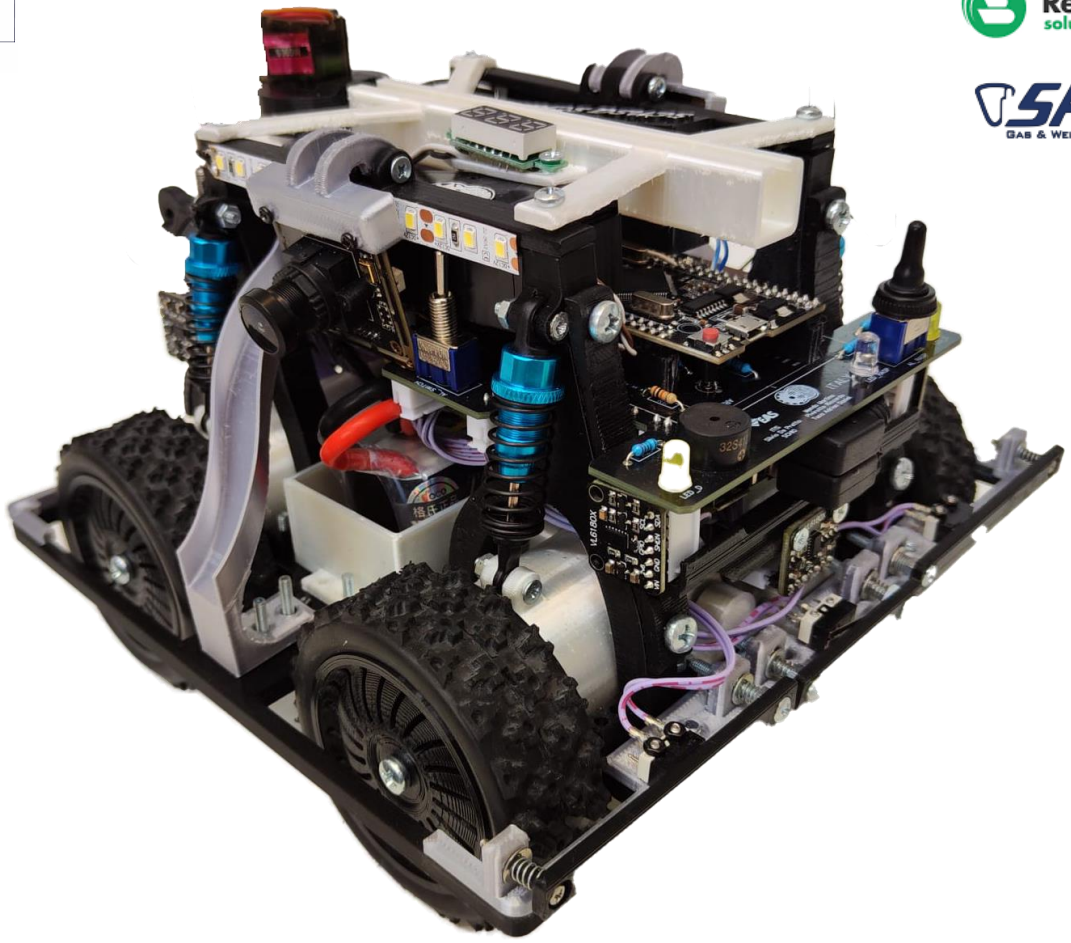
SENSA SCHEI

ENGINEERING JOURNAL



Rescue Maze subLeague robot
BLACK EMINENCE

Tuca Adrian Daniel – Mendo Martino – Pivirotto Riccardo
ITIS De Pretto Schio, ITALY

1. Introduction

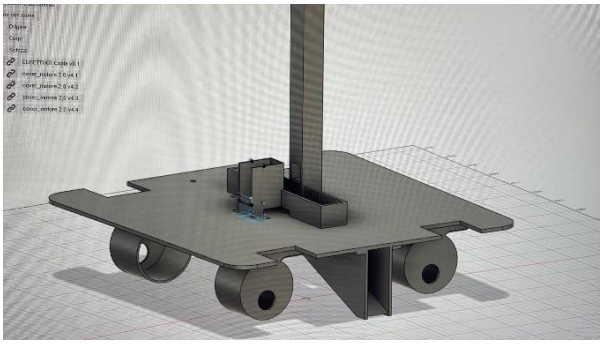
- Hello, we are the SENSA SCHEI from ITIS De Pretto in Schio, ITALY. The team was born in September 2022 with the intention of participating in the RoboCup Rescue Maze competitions in 2023. We are a group of three people: Tuca Adrian Daniel, Mendo Martino and Pivirotto Riccardo. We joined this project aiming to compete with other teams in the institute that were born at the same time.
  Right from the start we were able to divide our tasks according to our knowledge and passions:
  - Tuca A. Daniel (center) is the hardware, assembly, and sensor operator
  - Mendo Martino (left) has been put in charge of the Design and Programming
  - Pivirotto Riccardo (right) worked on Programming and Algorithms.

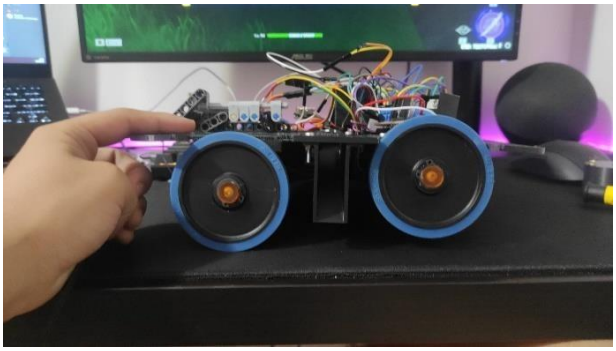
We started working at school, in our workshop, initially once a week until we started meeting daily both at school and at each other's homes so that we could finish the robot as soon as possible.
We started working in September, jotting down everyone's ideas and looking at the teams that participated in previous years, we were able to get a general idea of what we were supposed to do. Having only basic experience in both hardware and software design, we chose an approach that was based on testing: the ideas that came to us were immediately implementedand tested and if they were a success then they would be kept, otherwise, we would immediately move on to the next idea or try to correct the mistakes we made. By going in such small steps, we were able to advance much more than other teams who were choosing completely different approaches.

2. DAILY LOGS: FIRST VERSION "THE FACTORY"

(All the photos you will see were taken to be shared privately among the group, without knowing that they would then be shared so we apologize for the poor quality of the images)

- **SEPTEMBER**
  We started designing via software the first version of our robot at the end of September, after a few trials that failed...

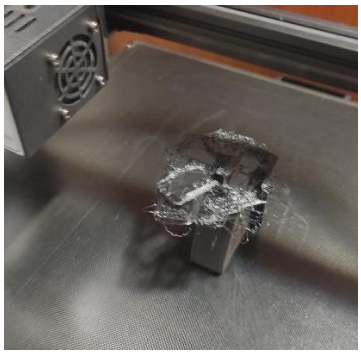




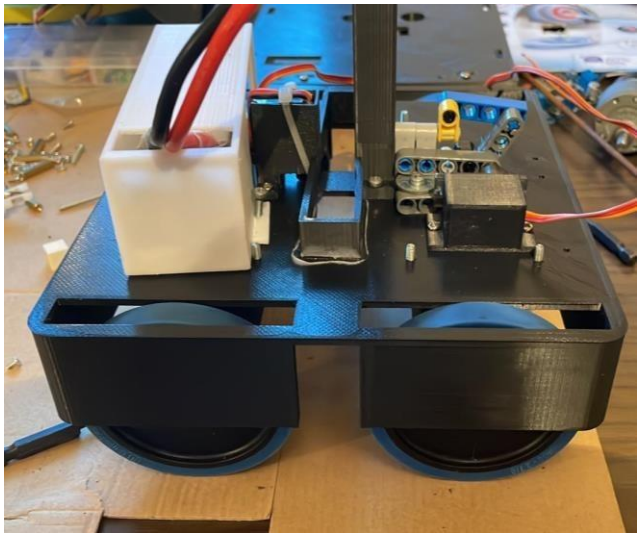
You can tell right away that there are some problems at the assembly level...After a few days of design improvements, the final model has arrived:

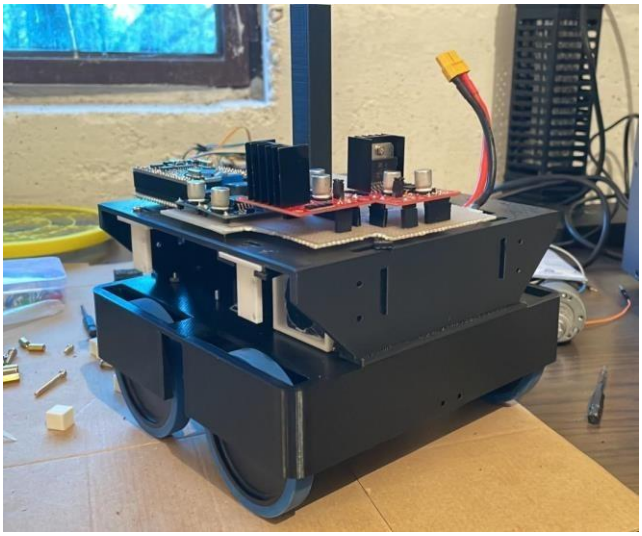
- **OCTOBER**

  In early October, it was already possible to physically have a few pieces of the 3D printed robot...

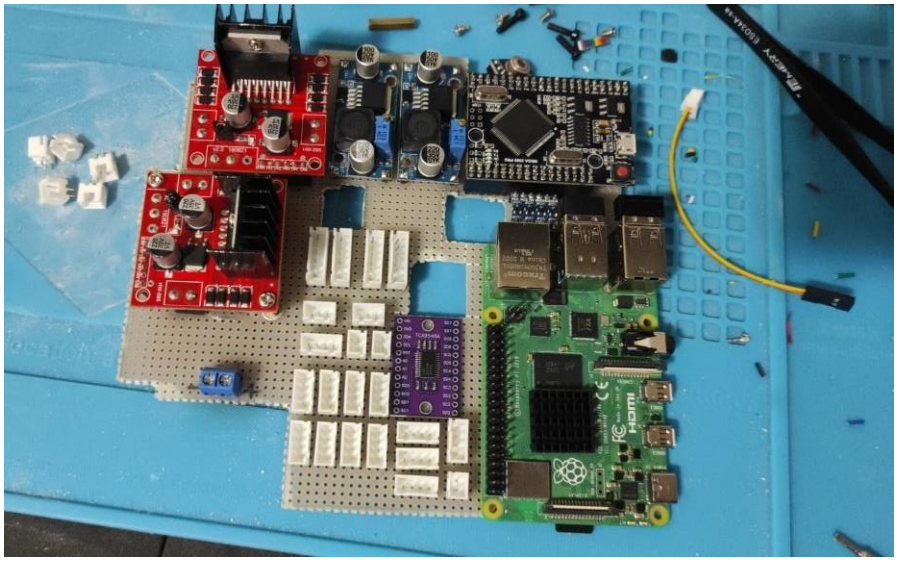


After a few unsuccessful attempts, we finally managed to have a half-robot assembled:

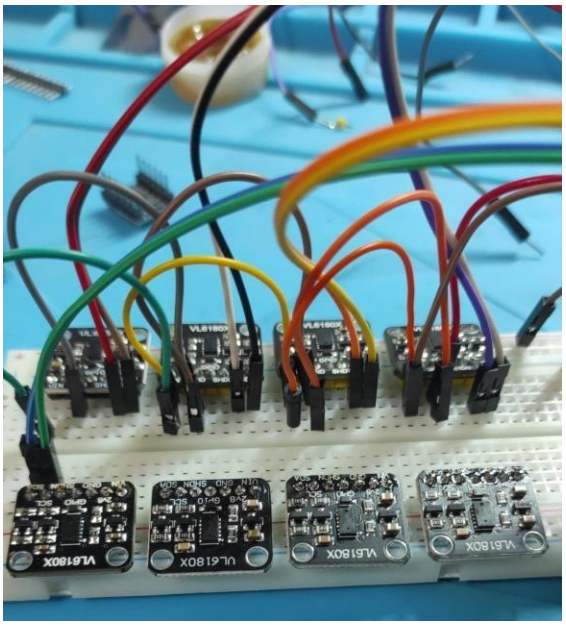




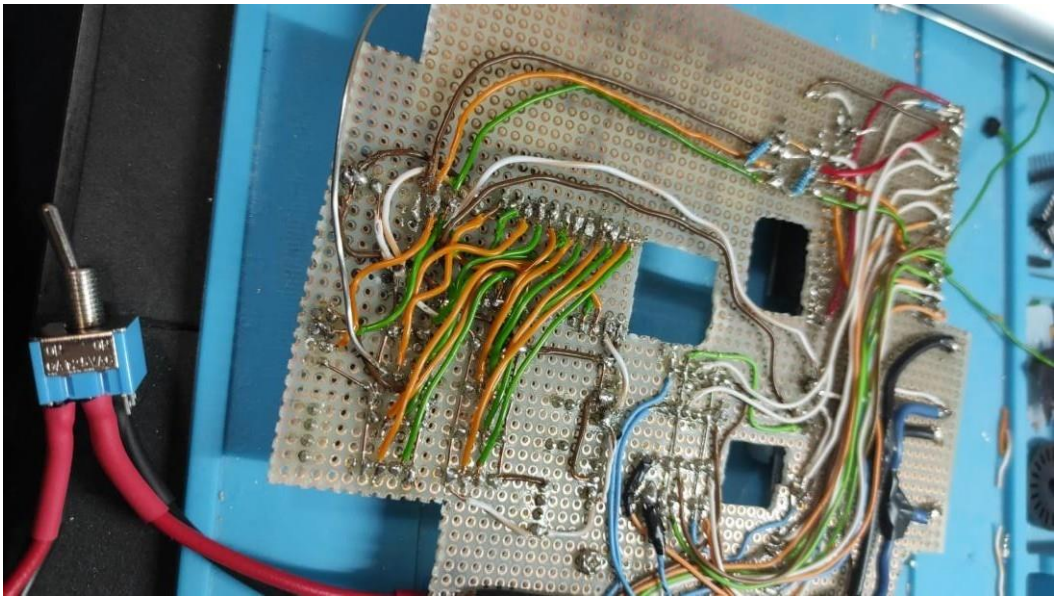
It can be seen that in the last photo a board containing a few components has already been placed on top: while Martino finished drawing and assembling the robot, Daniel had begun to create what would be the robot's motherboard. First, indicatively all the necessary components were placed on a breadboard:



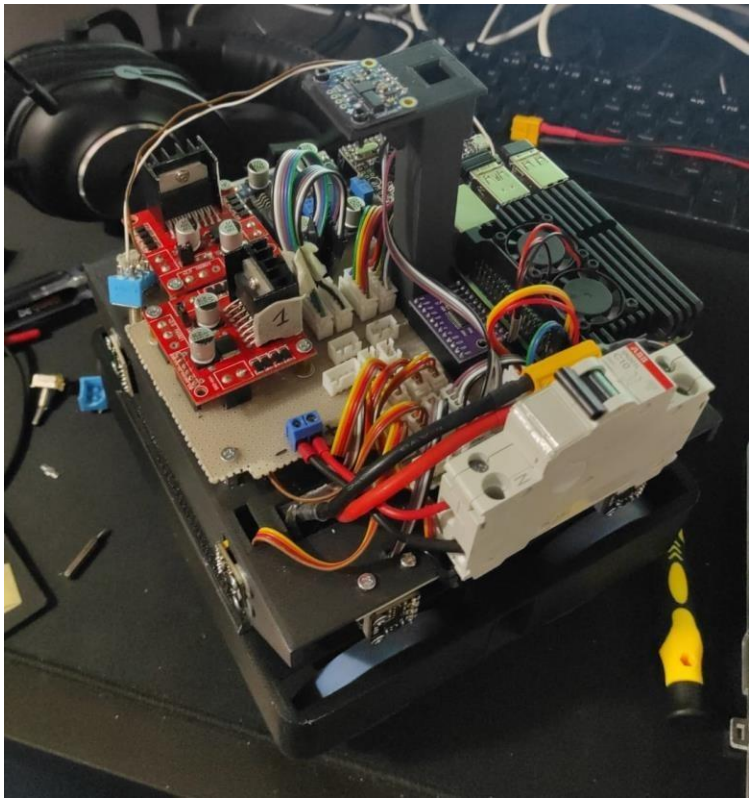
Before connecting them all, we made sure that all the sensors work with the help of a breadboard:



And after a thousand changes we started to connect the various components together....

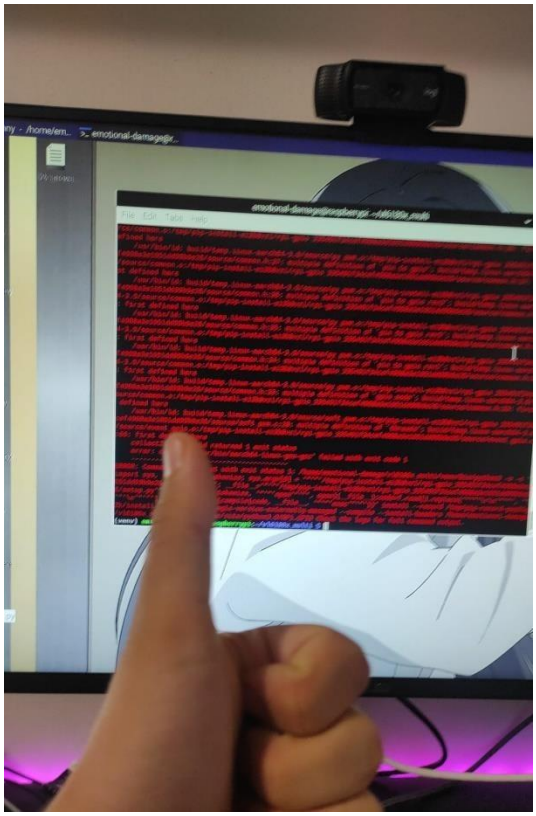


Thus we were able, by the end of October, to turn on the complete robot for the first time, except for a few missing components:

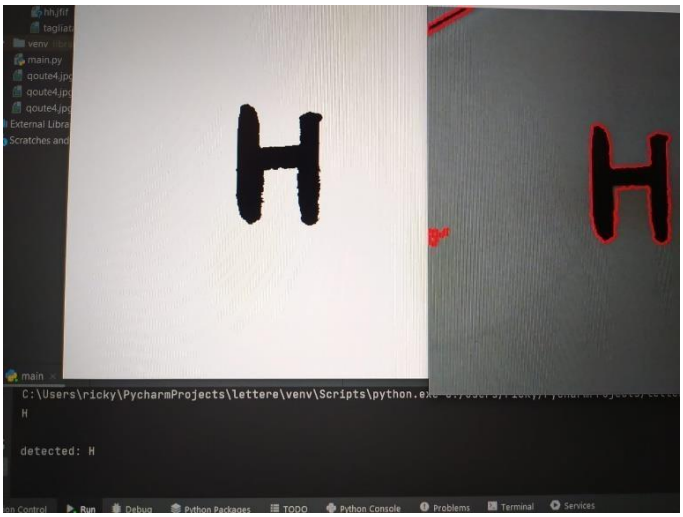


(Small detail: the circuit breaker acting as the main switch)

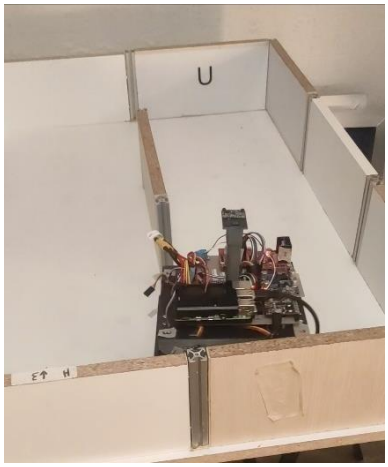
Once the assembly and wiring of all components is finished, we start programming the new Raspberry Pi 4.... Almost....

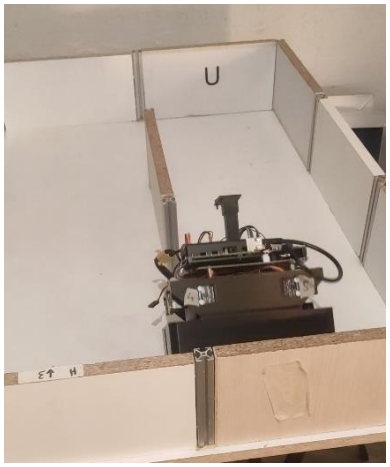


- **NOVEMBER**
  In November, our robot manages to make its first movements inside the maze, where we will encounter a variety of problems present at both Hardware and Software levels. Meanwhile, Riccardo autonomously begins to create code for letter and camera recognition, soon managing to make tangible progress:



Meanwhile, Daniel and Martino continue to program robot's movements:





Thanks to this first version of the robot, we learned about many aspects related mainly to physics and electronics that were previously unknown to us. The main problems (hardware and software) of the robot and how we managed to solve them will be explained below:

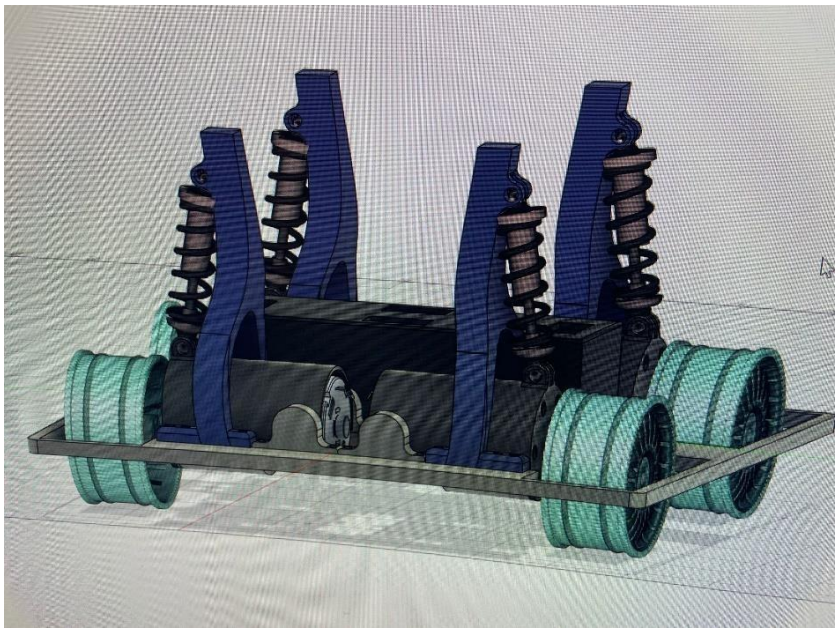
	PROBLEM	SOLUTION	RESOLVED?
Hardware	Center of gravity too high	Redesigning the robot	Yes (next paragraph)
	Difficulty in overcoming obstacles	Adding suspension	Yes (next paragraph)
	Interference in sensor reading (connection problems)	Creating a PCB	Yes (next paragraph)
Software	Same i2c address for distance sensors	Using a multiplexer	Yes

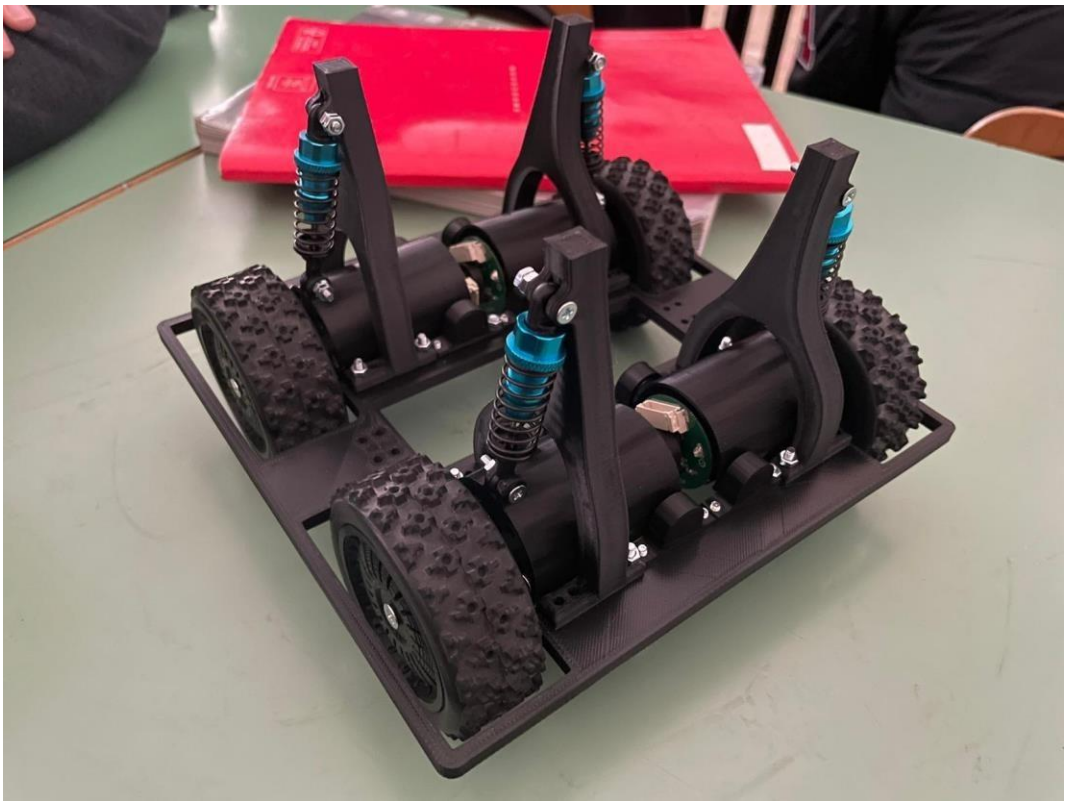
3. DAILY LOGS: SECOND VERSION "BLACK EMINANCE"

- **DECEMBER**

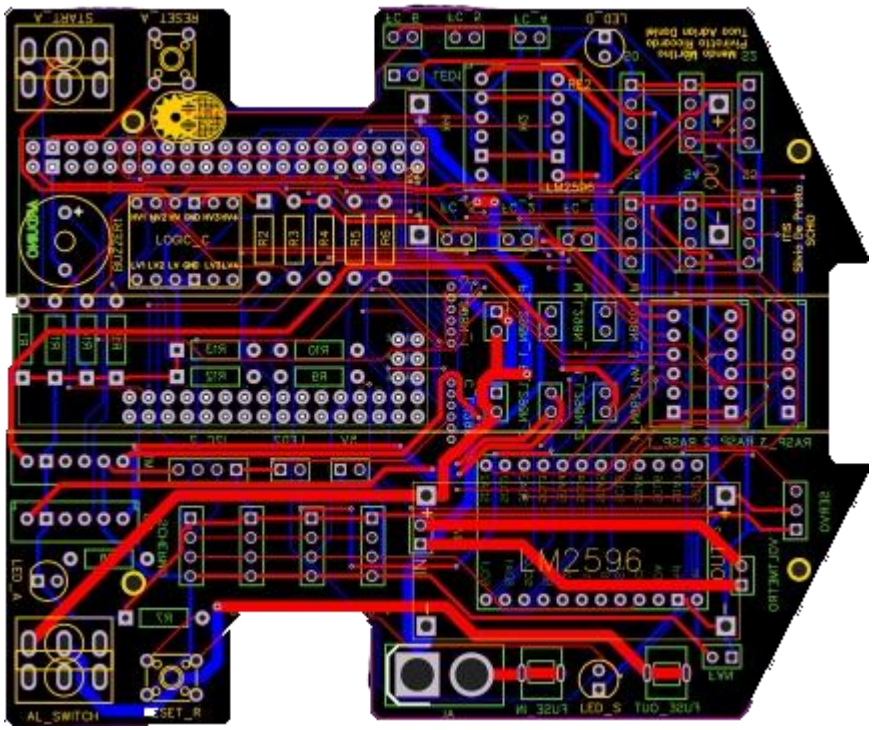
  Thus, discovering these problems, we decided to create a completely different robot from scratch in structure and electrical connection. In fact, the most important changes are in the structure, where the center of gravity was lowered to a minimum and suspension was added, and in the creation of a custom PCB to reduce the problems of hand-made connections with tin.

  With this new design, we have tried to minimize the waste of material and space, so as to reduce excessive weight, thus distributing the weight of the motors and battery throughout the structure. The suspension is the most important innovation at the mechanical level, helping the distribution of forces previously mentioned and providing superior stability in overcoming obstacles and ramps.

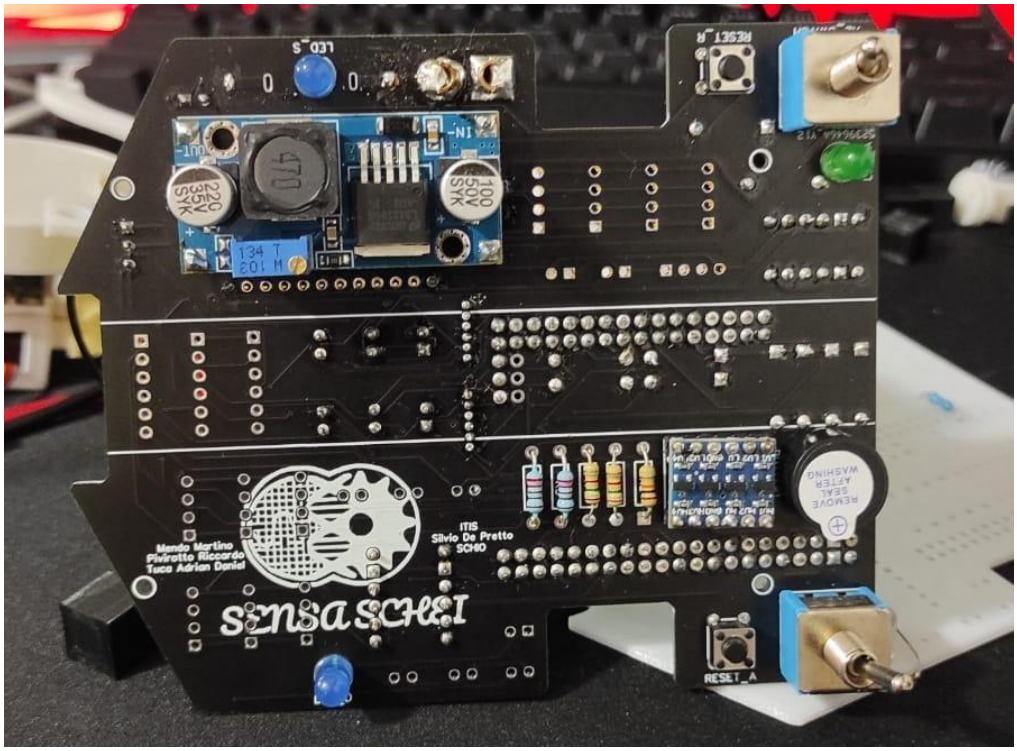




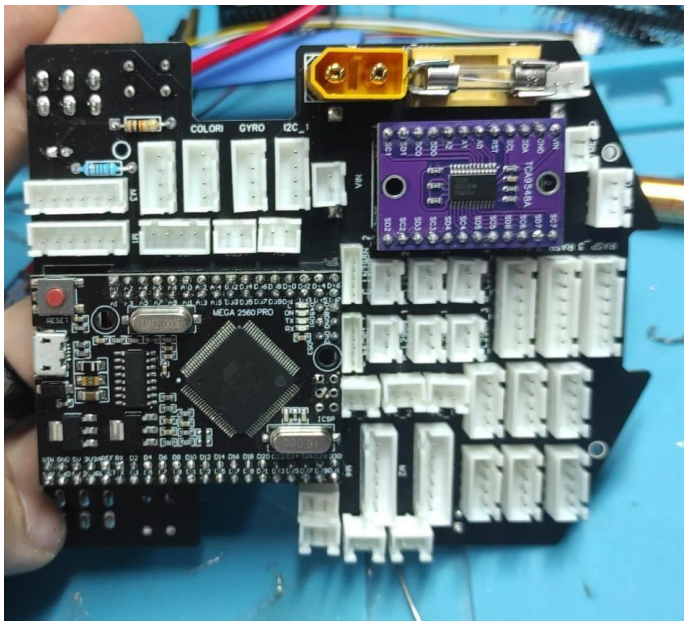
- **JANUARY**
  Once the structure is made and the available PCB spaces are determined, we immediately start designing it via software, trying to understand most of the connections necessary, while still ensuring that any component can be replaced quickly and safely.

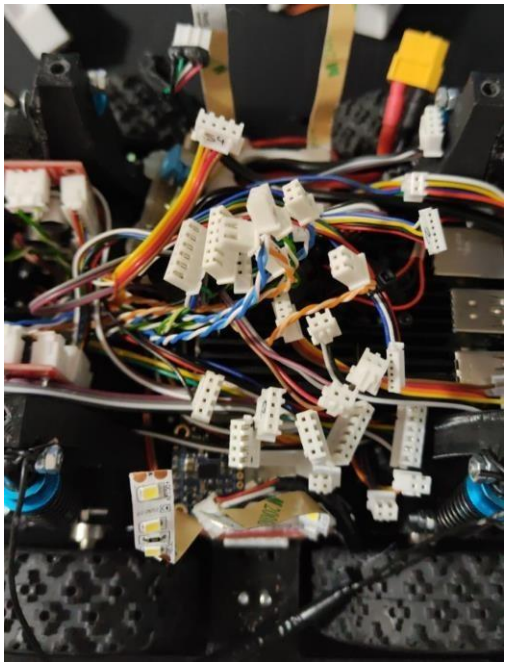


Once the PCB arrived, we immediately started assembling it:



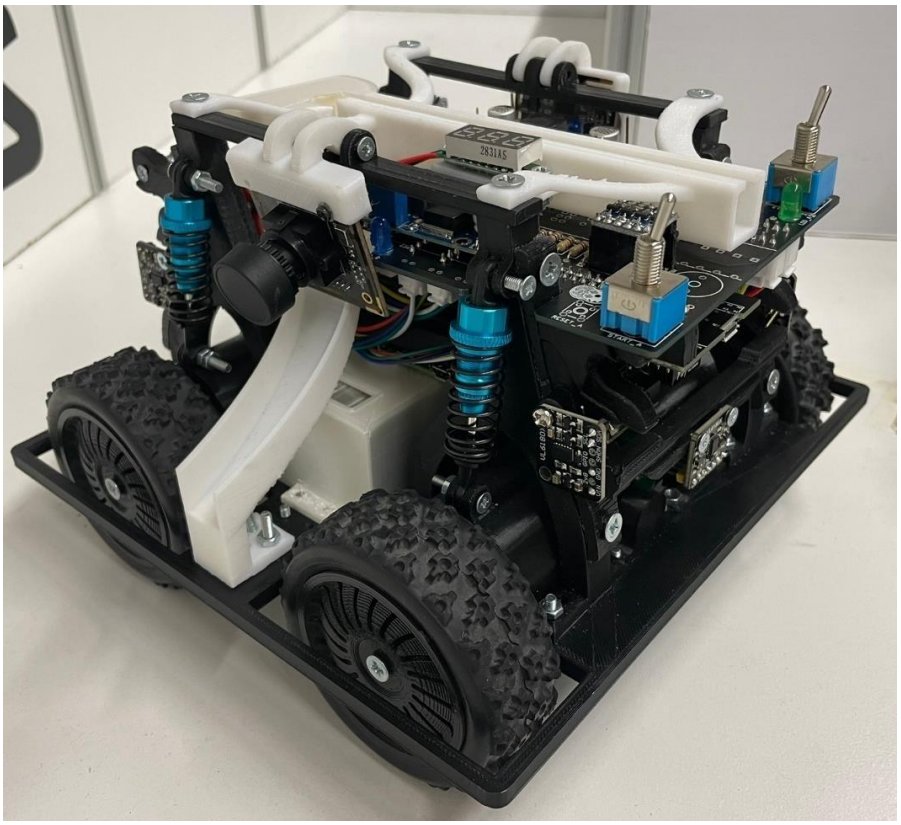
In the meantime, all the sensors were attached to the robot structure, and all the cables were ready to be connected (there were quite a lot):





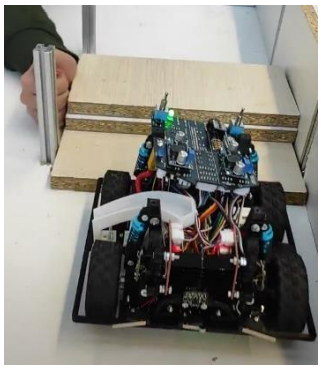
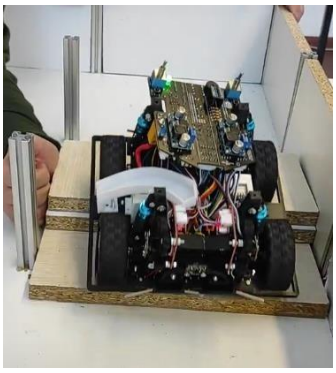
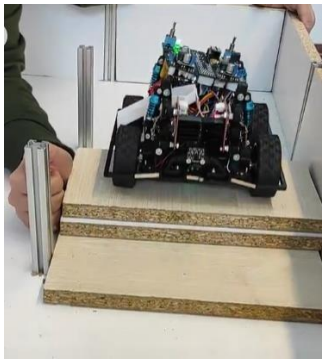
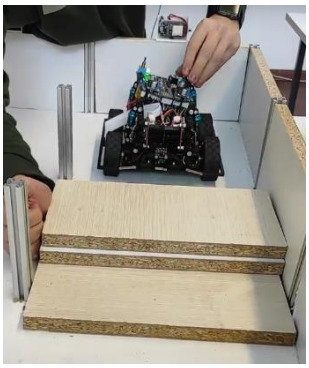
Once connected, everything seemed to work except the i2c communication between the Arduino and Raspberry. After several attempts in looking for the error within the code or in the connection of the PCB, we decide to wire the second version of the PCB, ordered
together with the version that was first shown in the photo, with the only difference being that the second version had two voltage regulators instead of one, thus managing the power supply Of the Arduino separately. It is not known how, however, with the new PCB everything works.

Here is the second version of the full robot:



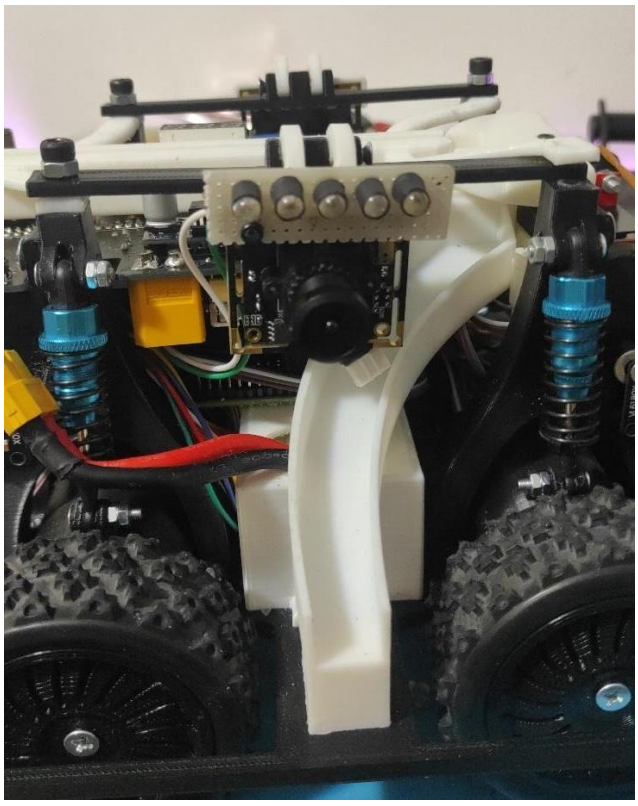
- **FEBRUARY**

With the beginning of February, we are finally able to begin programming for the new version of the robot, which will participate in regional competitions. The first thing you go for is obviously the obstacles, to test the new suspension:

With this exaggerated test, we confirmed that the structure of the new robot was being designed in the right way, being able to smoothly overcome any obstacle.

Because of the method we used to identify victims, that is, with Tesseract, we needed even lighting for the cameras so that there are no shadows, which would otherwise be detected as letters. Initially, in fact, it happened very often that victims were randomly detected on white walls during rehearsals, either because of shadows or simply because of poor lighting. So, we decided to create a lighting system with what we found the lab...

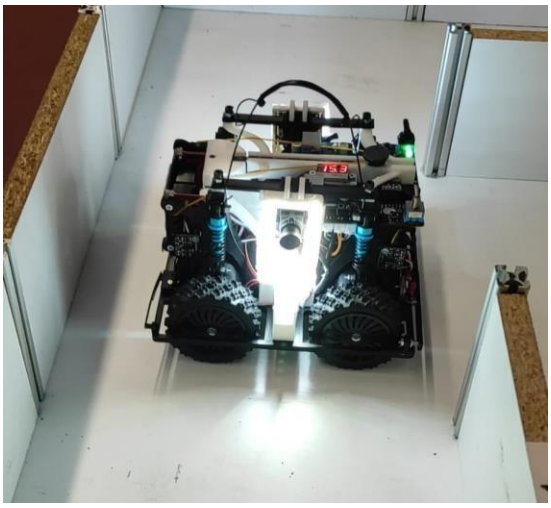


However, we found that manually mounted lights create even more shadows than before.

Then we bought white LED strips and attached several of them:

With these new strips we were able to illuminate the walls evenly though, the light was too bright covering also the colors and letters on them.

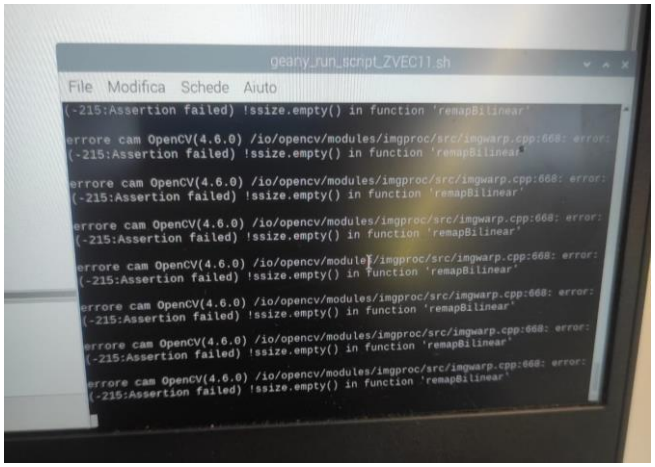
SOLUTION: Put toilet paper on the LEDs to block the light.



As for the programming of the robot, everything was going well, although we were behind schedule.

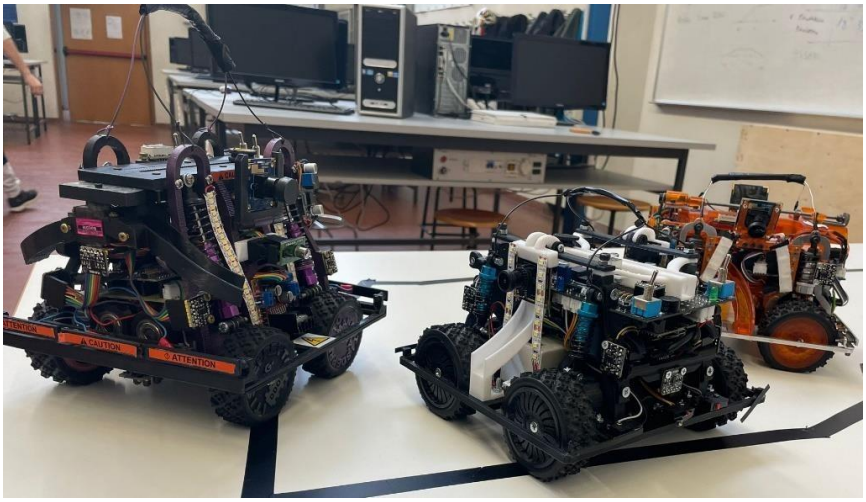
- **MARCH**

  The beginning of March was a time of complete turmoil, the regional competitions were to be held on March 3 and we were still not ready. In fact, as far as the robot's movements were concerned, we were almost ready, it could follow the right-hand rule in exploring mazes however there was an existential problem, it was missing the sensor to detect the black and blue tiles. Not to mention some unwanted errors popping up....

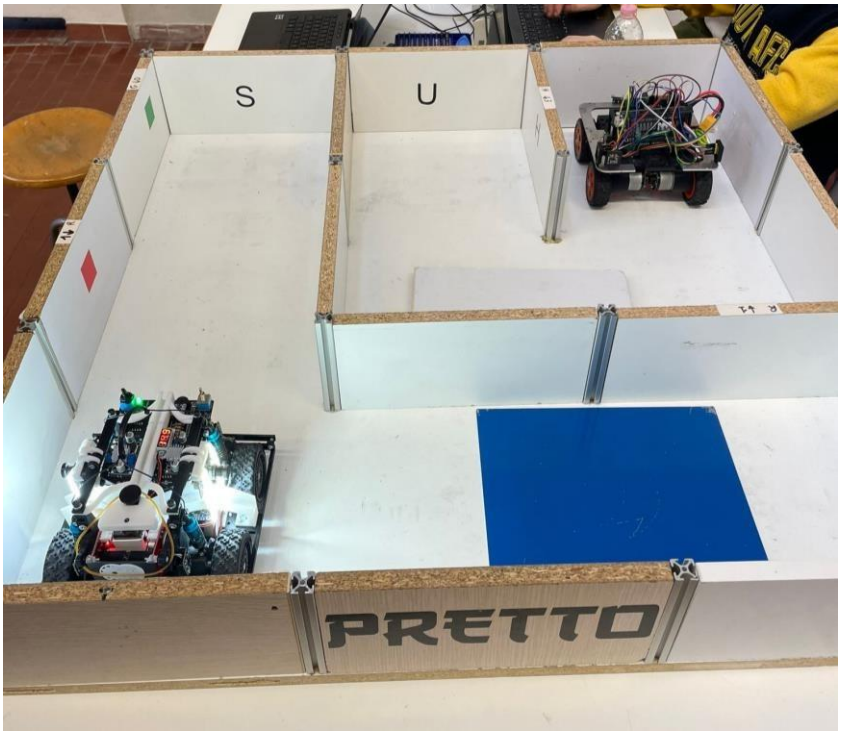


In the meantime, however, we had the new poster:

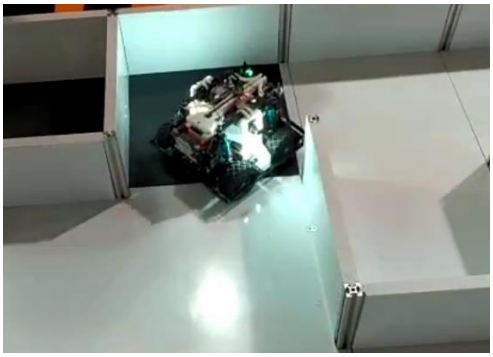
And here is also the robot compared to the school's champions from previous years:



So, we started the regional competitions on March 3, where, while waiting for our turn we kept rehearsing in the mini maze we had available:



Once the races began, despite the still unresolved problems, such as the detection of black and blueplates...



...we still managed to finish in SECOND PLACE, with a clear gap from the third-place finisher:

Here is a summary table of problems and solutions during regional competitions:

	PROBLEM	SOLUTION	RESOLVED?
HARDWARE	Does not detect colored tiles	Add color sensor	Yes (approximately)
HARDWARE	Too violent in movements	Better fix the walls of the labyrinth	No
SOFTWARE	Detected letter S without it being present physically	Remove from the code the detection of the letter S	Yes
SOFTWARE	Labyrinth that cannot be explored with the "right-hand rule."	Implement a random of movements in the code	Yes
SOFTWARE	At the start he was doing reverse gear	Never found	No

From February until the end of these competitions, we discovered the potential of our robot; however, being only at the beginning, it was impossible to make a fully functioning code, starting from the robot's movements, which were quite mediocre to the victim recognition method, which was very inaccurate and caused many wrong detections. These findings gave us a way to reorganize our project, starting with rewriting the codes from scratch by changing approach and methodology. However, the time we had was quite tight since the national competitions were just over a month away.

- **APRIL**

(Due to some events, we lost most of the codes we had before April, making a comparison of old and new codes impossible, we apologize for the inconvenience)

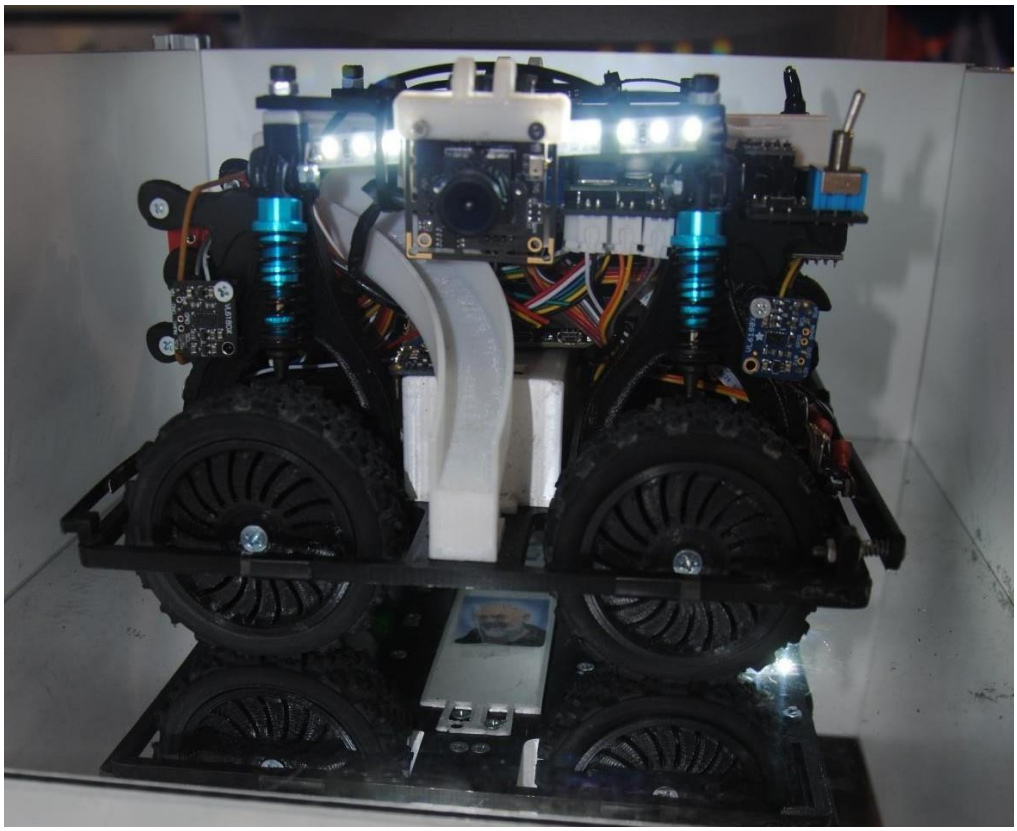
The robot is progressing swimmingly in its programming, encountering no particular problems other than time. At the beginning of the month, we finally managed to integrate the color sensor into the codes, being able to detect the black and blue tiles in any situation, regardless of the state the robot was in inside the maze. To help this sensor detect the two, almost similar colors, we attached three LEDs next to it, thus illuminating the ground, better highlighting the colors.

One of the most significant changes at the code level is definitely the victim detections, completely eliminating the old method, which was unsafe and required perfect ambient lighting, with a new system, explained in the TDP under 4.a "Finding Letters" where it ensured the correct detection of victims, even with different or low lighting.

We were also able to implement Multiprocessing to identify victims while the robot was moving. With the new method, there were no problems identifying victims, but it happened that the machine did not center itself well on the respective cell, putting the cameras in trouble, which, if they had done only one detection per cell, would probably not have identified anything. With multiprocessing instead, leaving the detection of victims independent and continuous with respect to movements, we were able to solve this problem.

- **NATIONAL COMPETITIONS (APRIL 19-21)**

We arrive on the first day at the races and immediately begin with the various tests to adapt the robot to the new maze by finalizing it for the following days.

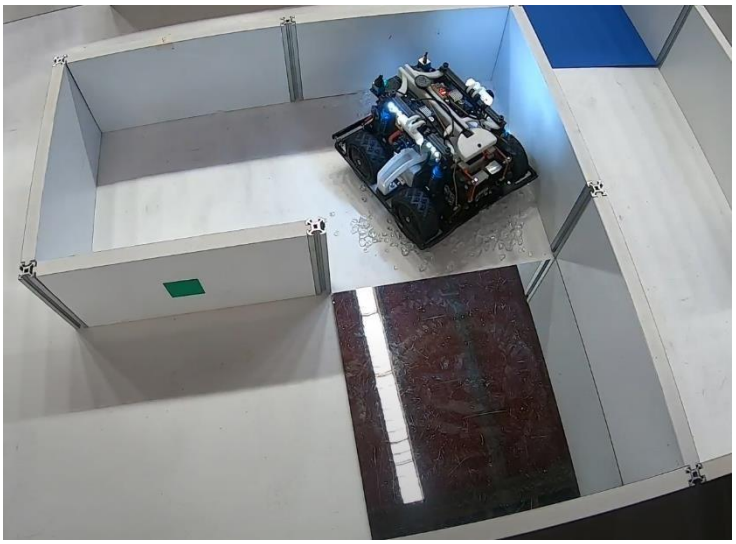


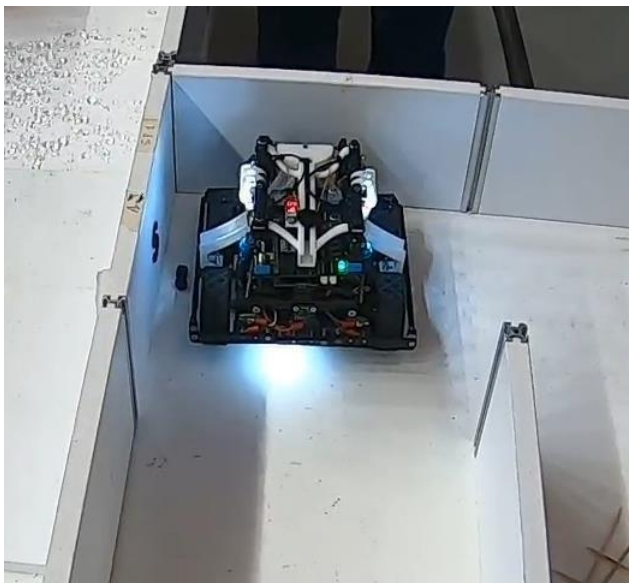
Thus we start the second day, with the first race, forgetting the camera LEDs off causing a Lack of Progress in the first 10 seconds of the race:

In the second race, however, due to wrong calibration, we fail to detect the black plates:

In the third and fourth races, on the other hand, we encounter several problems including, color sensor continuously disconnecting because of the cable, a distance sensor exploding, and a motor that stops working

The fifth and final race, was the best of all, which made us catch up with the ranking, confirming our SECOND place this time as well.

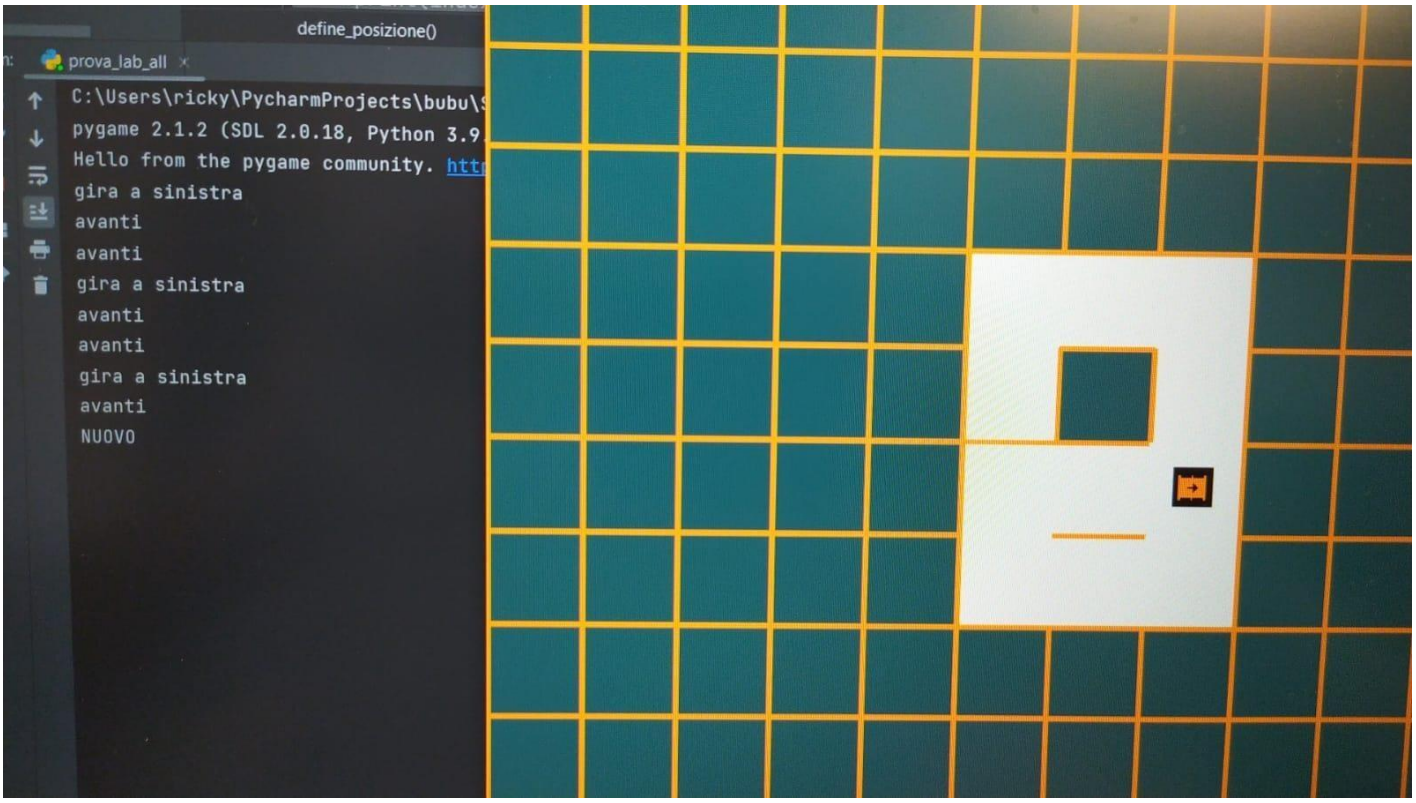




So, we arrived at the last day with the big surprise: while we were on the stage to take our award as Second Classified, we are announced that we have qualified for the world championships and not the European ones!!!

At the end of these races, we discovered many other problems with our robot, such as the I2C communication between Raspberry and Arduino that caused most of the errors during the races, or the LEDs that had to be turned on manually. This led us to a drastic but necessary decision, to build a third version of our robot, which is still under construction.

- **MAY-JUNE**
  While the new robot was being designed, the robot that participated in the nationals was continued to be programmed, implementing for the first time the mapping algorithm, which had been ready for some time at the code level, however never implemented before due to limited time and other problems.



Around early June the new robot began to take shape, and on June 19, '23 it was completed and the first tests began...