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Polytech Nice-Sophia

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1st year of Master in ‘*Robotics and Autonomous Systems*’

French Robotics Cup 2024

Project retrospective

Summary:

1. Introduction

The "Farming Mars with the PolyMartian" project is an initiative developed as part of the Coupe de France de Robotique. This competition, the largest gathering of engineering schools in Europe, focuses on the design and production of autonomous robots capable of completing a series of thematic tasks within a given timeframe. This year's theme is about managing an autonomous greenhouse on Mars, making life possible for astronauts by allowing them to grow fruits and vegetables. To achieve this, our robots must accomplish various tasks: distinguish fragile from resistant plants (5), place them in pots, and release them in their respective planting areas (1, 2, or 7). Additionally, we can earn extra points by swiveling solar panels (8 and 9) to position a part of the vertical projection of the edge with the team color inside the table. Finally, we have the opportunity to develop a swarm of robots that will pollinate plants by touching them in the planting areas, but only during the last 10 seconds of the game. These robots are called the “Ladybugs”.

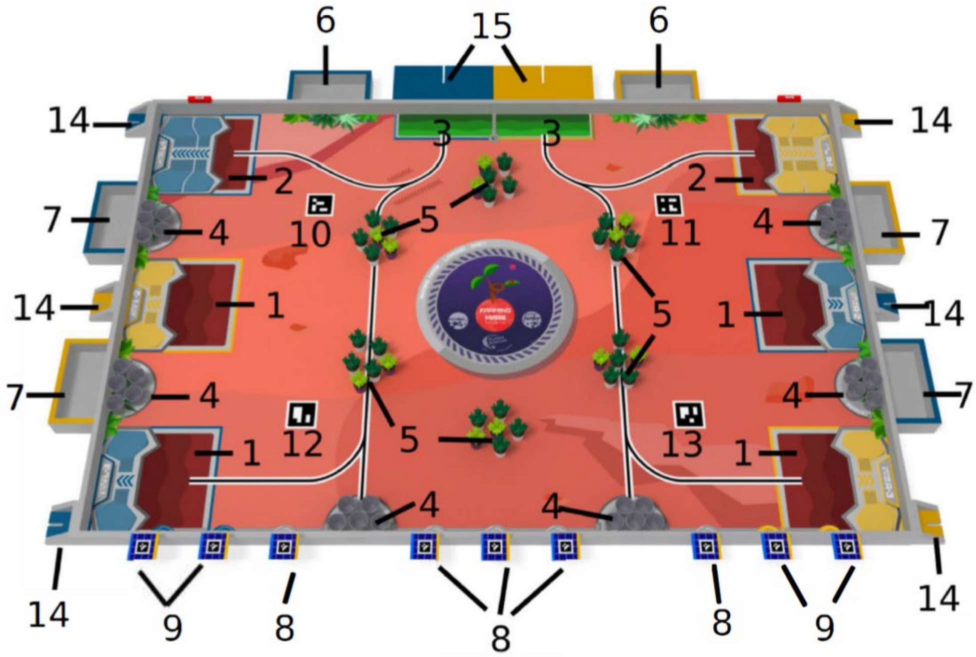
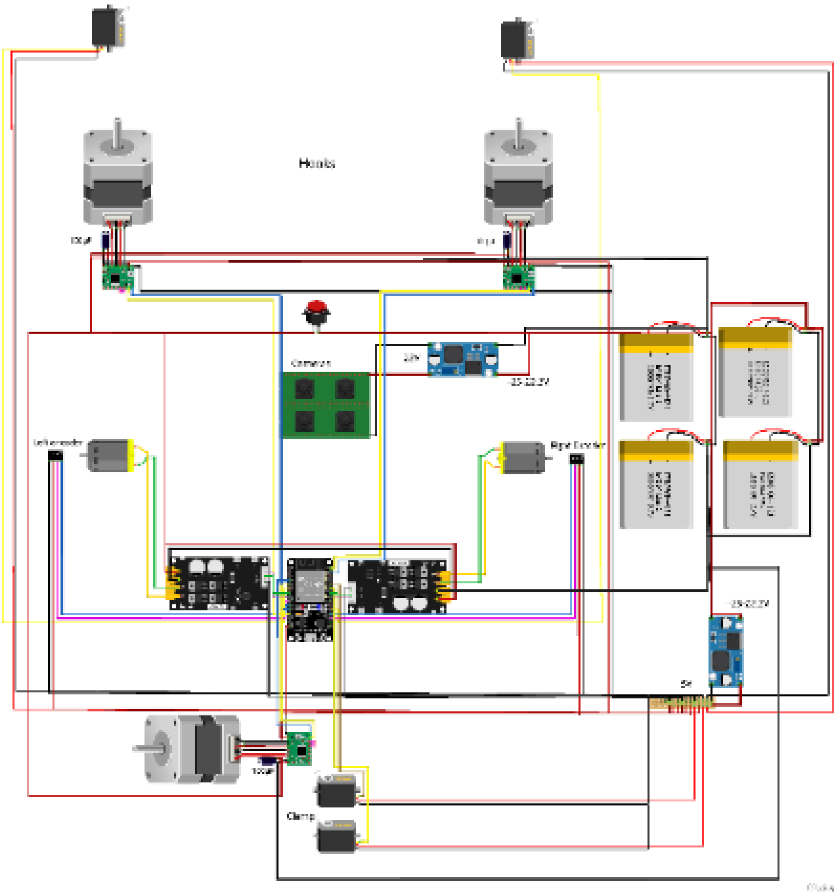


Figure 1 : Playing area

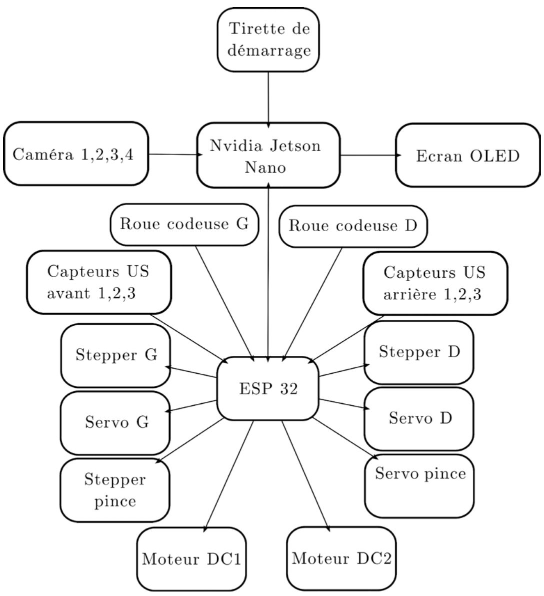
1. Departure/arrival and drop-off areas
2. Departure/arrival and reserved drop-off areas
3. Departure areas SIMA (ladybug hive)
4. Pot supply
5. Plant supply
6. Planters
7. Reserved planters
8. Solar panels
9. Reserved solar panels
10. ArUco marker number 20
11. ArUco marker number 21
12. ArUco marker number 22
13. ArUco marker number 23
14. Fixed beacon supports
15. Remote computing area

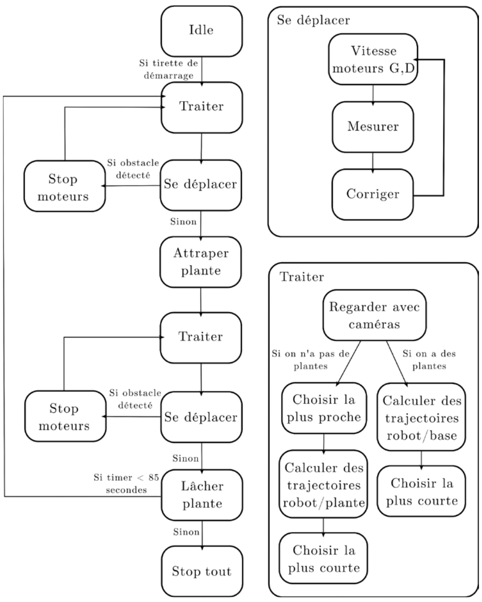
2. Electrical diagram

To power our system, we use two different circuits grounded together. The first one utilizes 2 LiPo batteries in series (2*3s = 24V) for the main circuit below, and the other one involves only one LiPo battery (12V) for the cameras.



3. Operating algorithm





To use our robot, we advise proceeding as follows:

1. Position the robot in its starting area.
2. Insert the starter pull cord into its housing.
3. Hold the starter button vertically, keeping as far away from the robot as possible.
4. Turn the emergency stop button to switch on the robot.
5. Wait 15 seconds.
6. Pull the starter grip upwards until it is completely withdrawn from the robot.
7. The robot will start up, following its program.
8. The robot will automatically move to its designated area and stop all movements after 100 seconds. In case of an anomaly, the emergency stop button can be activated at any moment to completely stop the robot.

Be careful! Before switching on the robot, ensure that the batteries are fully charged and placed in fireproof bags. Additionally, never use a battery that is swollen or hot, as this could cause a fire or even an explosion.

4. Project costs

To maximize our chances, it was important to work with accurate and reliable components. This often requires the use of professional materials and spare parts to fix unexpected damages or faulty components. To meet our needs, we established sponsorships with various entities that we would like to thank again. We gratefully received funding of up to €8500 from Université Côte d'Azur, our school Polytech Nice-Sophia, Elsys Design, and Sofab Telecom Valley. Additionally, we were extremely fortunate to benefit from a workspace provided by our school, which included a wide variety of tools purchased specifically for our needs.

As we plan to continue developing the association in the coming years and participate in future editions, we did not spend our entire budget this year. Here is our financial account:

Robotics Cup registration fee: 200 €

Tools: Total of €600 including a drilling machine, screwdrivers, measurement tools, and more.

Sensors and actuators:

- Polymartian (our main robot)

4 JeVois Cameras with processing units included	2600 €
4 Ultrawide camera lenses	40 €
1 Nvidia Jetson	225 €
1 ESP32	8 €
2 MD36 DC motors with encoders	240 €
2 Cytron drivers for DC motors	36 €
3 Nema17 pancake steppers	45 €
4 Servomotors 9g with metallic gears	20 €
6 Ultrasonic sensors	12 €
8 Lipo 3S 2200mAh	140 €
1 Charger for LiPo batteries	45 €
3 Linear guides	90 €
4 Rubber wheels	40 €

- Ladybugs (our swarm of 7 robots) :

7 Raspberry Pi Pico W	105 €
7 DC motors	78 €
7 Servomotors	85 €
21 Ultrasonic sensors	84 €
10 Gyroscope chips	36 €
10 DWM1001-DEV chips	190 €

<u>Spare parts:</u>

1 MD36 DC motors with encoders	120 €
2 Cytron drivers for DC motors	36 €
2 ESP32	16 €
5 Ultrasonic sensors	10 €
4 Rubber wheels	40 €

<u>Consumables:</u>

2kg PETG Prusament (for 3D printing)	60 €
3 Acrylic slabs (used with laser cutting machine)	90 €

<u>Transportation and accommodation:</u>

Accommodation: Airbnb, 5 nights, 4 students	400 €
Transport round trip: Highway tolls and gasoline	500 €

This results in a total of 6191 €. The expenses may seem quite significant for a school project, but most of the materials used will be reused in the following years. This allows our association to reduce expenses progressively while being equipped with a wide variety of tools, motors, and sensors.

<u>Engineer's salary:</u>

With a total working hour of around 1000, including schoolwork sessions, home development, and day and night work during the competition, if we were to estimate a work price based on a gross salary of €38k for 1600 hours per year, it would require a salary of €23.75k. This significant estimation also accounts for research and development time and commitment to making prototypes.

<u>5. Problems encountered</u>

During this project, we encountered several hardware difficulties. We accidentally damaged the USB port on the ESP32 twice, necessitating many hours of repairs to reconnect it to a new board. To enhance circuit reliability and prevent unintentional disconnection, we soldered wires directly to the board.

While working on the coding wheels, we broke a magnet from an encoder. Since this component is not readily available on the market, we had to liaise with the manufacturer to obtain a replacement.

On the software side, we initially struggled to adapt to the ESP32, which operates quite differently from the Arduino due to its 32-bit architecture (compared to Arduino's 16-bit) and dual-core design (compared to Arduino's single core). When training the camera AI, we invested significant time in generating random obstacles to simulate real-world scenarios for the robot.

Determining the PID was also challenging since theoretical coefficients were not readily definable. We adopted a hands-on approach, calibrating the encoder wheels and testing various coefficient combinations before achieving satisfactory results.

During the competition, one of our four cameras exploded due to incorrect specifications provided by the manufacturer. We intend to replace the faulty component to salvage and reuse the camera in the future.

6. Conclusion

a. Accomplishments, Functionalities, and Issues

During this project, we designed and built a complete autonomous robot. The following functionalities are mechanically fully operational: the rolling base that enables the robot to move, the gripper system mounted on a linear rail that enables the robot to manipulate a particular plant, and the hook system on linear rails that enables the robot to grab a batch of 6 plants in one go and keep them from falling as it moves. On the code side, the AI is functional, although not yet fully implemented on the robot. The robot is able to carry out an autonomous movement sequence thanks to the PID coded on the ESP32. It can also locate and move in space. Finally, the code that manages the use of the linear rails and the actuators mounted on them is not integrated with the rest of the functionalities but works individually.

b. Next steps

This first participation was an incredible experience that allowed us to develop advanced skills in robotics through the realization of a fully autonomous robot. It laid the foundations for future years, as we now have experience to pass on to future participants. As our team plans to return next year, we already have a fully functional rolling base that will only require a few adjustments to align with the next strategy. This will allow us to improve our algorithms even before constructing our rolling base for 2025. Our main focus will be on developing new actuators to meet the tasks outlined in next year's rules and dedicating more time to implementing the robot's decisions.

While our experience with AI and vision technology seems promising, our experience has taught us that it's prudent to simultaneously consider simpler alternatives for next year's challenges. It's often safer to have fewer functionalities that are fully implemented.

5. Bibliography

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    - **https://www.eurobot.org/**