Jabuti Project: Maze Solver Micromouse Robot

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The present article discusses the development of the Jabuti Project, which consists of a micromouse, a maze solver robot. The project mainly aims to build a low-cost robot and to assist university students in the practical study of robotics. To solve the maze, a wall-follower algorithm was implemented for anarduino, and stepper motors constituted a PCB of the project to provide more stability to the robot, infrared sensors for area recognition, and a caster wheel to direct it. In conclusion, the circuit parts will be estimated to be assembled and integrated to implement the developed logic with tests in the physical prototype.

Keywords: Robot. Wall-Follower. Infrared Sensor. Labyrinth.

Introduction

In the last decades, robots have taken an active part in human lives, such as in industrial environments or in a regular daily routine; that became possible over time due to the Industrial Revolutions, mainly the Second, and intensified with the advent of IoT(Internet of things), Machine learning and AI (Artificial intelligence)technologies. There upon to innovations, it is possible to understand how to create and control robots in their most diverse applications in the technology field. Then, seeing the world's current pace, university students must have more than just theoretical studies about robotics. However, practical simulations with simple robots such as a micromouse, give them motivation and interest in this kind of development. Therefore, this educational topic was discussed at the 2016 International Conference on Advanced Robotics and Intelligent Systems and stated, "It is found that the micromouse is an excellent topic for students to learn the implementation of mobile robots because it contains multidisciplinary knowledge and skills."[1].

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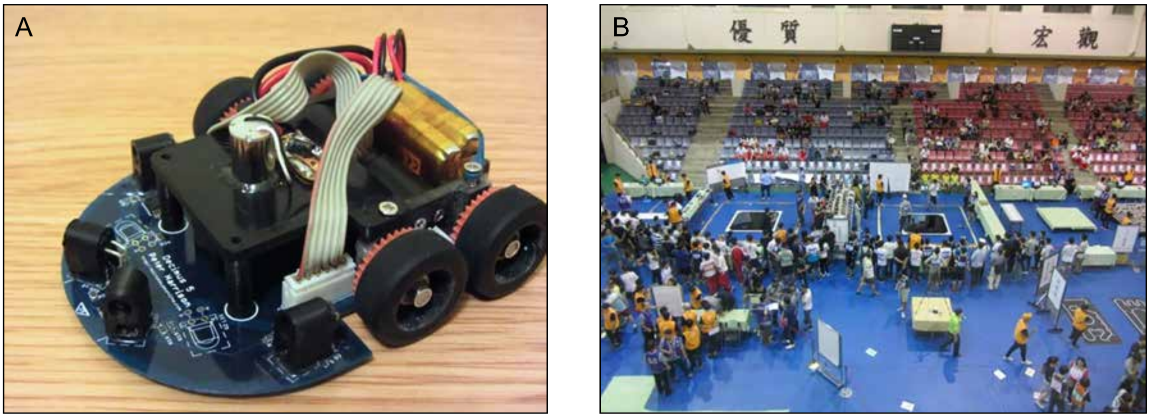
Micromouse History

The inspiration for Micromouses began in 1977 when Donald Christiansen [2] challenged his readers to design and build a robot called "micromouse": an autonomous robot that finds a path from a start cell to the end of every simple and unknown maze based on a variety of algorithms guided by sensors. The Institute of Electrical and Electronics Engineers (IEEE) Spectrum magazine announced as 'Amazing Micromouse Competition', which was first held in New York in 1979 [2,3]. The events are held worldwide and are most popular in the United Kingdom, United States, Japan, Singapore, India, and South Korea and becoming popular in subcontinent countries such as Sri Lanka (Figure 1A/B).

Building the Robot

According to the article "The development of a half-size micromouse and its application in mobile robot education" [1], the challenge is not only to build a robot that resolves mazes but one that move more efficiently and is smaller and lighter as possible. Therefore following the Harvardrobotics team in the 2016 Brown IEEE Micromouse Competition [4], this kind of robot is usually integrated by: 3 IR distance sensors and 2 Hall Effect motor encoders to determine the robot's position and orientation as well as for detecting walls; powered by 2 DC motors, controlled through

Figure 1A/B. Competitor Micromouse robot and competition of Taiwan Micromouse Contest 2017 [3].



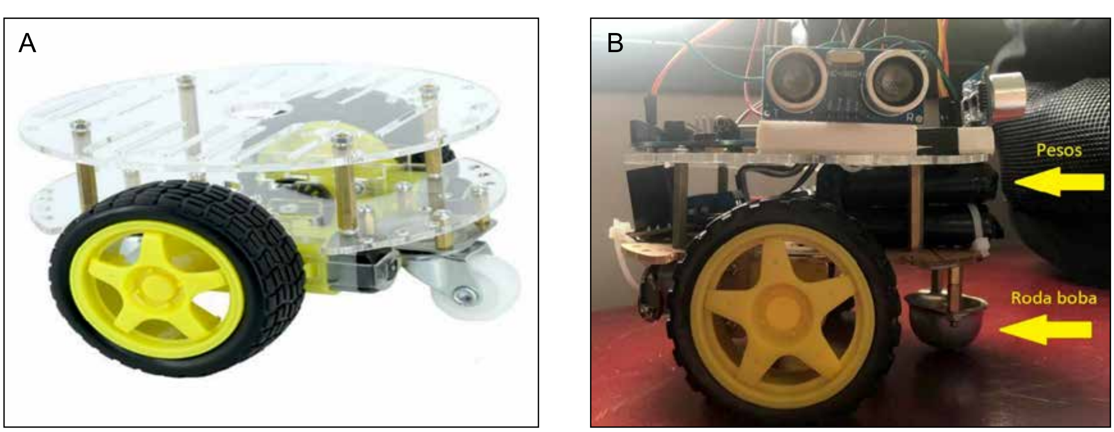
an H-bridge motor controller via a pulse-width modulated signal; using an Arduino micro that Integrates the information from onboard sensors into a flood-fill maze navigation algorithm; using a simple design of a rectangular and small chassis with two regular wheels and a caster wheel.

Jabuti Robot

The Jabuti project is a practical implementation of the micromouse robot with the primary goal of encouraging students of SENAI CIMATEC in the technology field to learn and adapt to the robotics scenario, stimulating them to participate and feel included in the modern world of innovation. Considering the context and needs of the project, we decided to create a robot using four infrared sensors to send information to the arduino by jumpers. So, through that, determine the robot's movement according to each situation by a wall follower algorithm with 2 regular wheels and a caster wheel (Figure 2A/B)) obemen. Then, developing a program that allows the robot to choose an exit autonomously was necessary. Then, the main idea was to map the maze while researchers for the exit.

It makes students develop skills like 3D modeling structures, programming problem-solving, sensor reading algorithms, and understanding microcontrollers, circuit boards, and mechanical parts. It also stimulates the will to innovate and be creative in future works. This article describes the production and development process of a Micromouse robot.

Figures 2A/B. Robot model [5].



Materials and Methods

Algorithm

The programming aimed to solve the maze through the C language based on a wall-follower system that consists in prioritizing turning to the right, with the second option to follow the front and the third option turning left [6,7]. This criterion will be used to map the maze to find the way out of it. So, we formulated a flowchart (Figure 3).

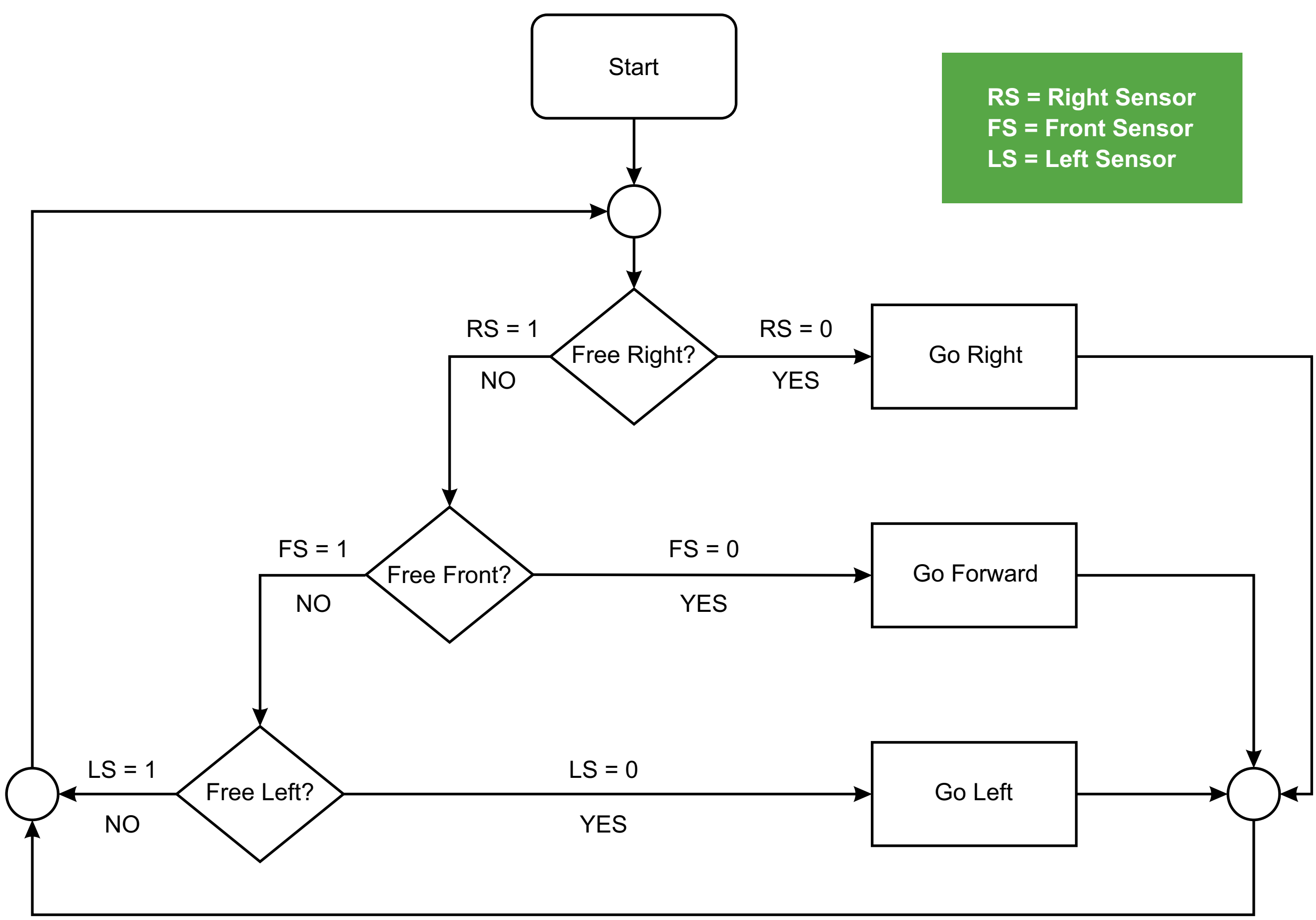
Infrared Sensor

Micromouse is formed by 4 distance sensors: two for the front, one for the left, and one for the right. They give the robot direction robot in the maze, so if the robot detects a presence by any sensor, the robot goes in another direction. The infrared sensor, widely used in robotics to detect the presence, was selected to perform this task. The handicap of this sensor compared to the ultrasonic is its lack of liability, as it is more sensitive to interference such as sunlight. The choice of the IR sensor was due to its low cost and the micromouse´s environmental factor, which would be indoors, such as in colleges and laboratories. (Figure 4A/B).

Printed Circuit Board (PCB)

After researching the algorithm and infrared sensor functions, we developed the PCB project. Therefore, the PCB is constituted of 2 Stepper motors, controlled by an H-Bridge, 4 connectors to the 4 Infrared sensors, and a caster wheel attached to the structure (Figure 5).

Figure 3. Flowchart of the algorithm.



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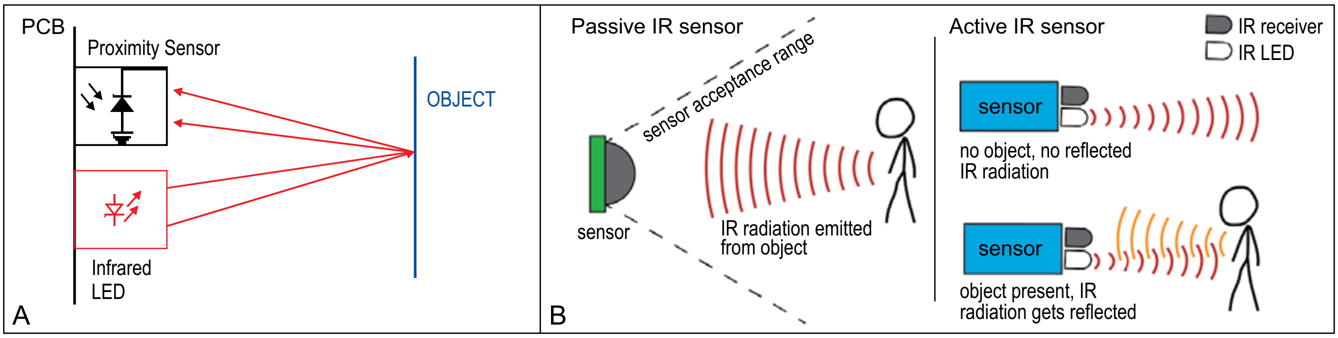
Figures 4A/B. IR sensor operation [10,11].



3D Chassis's Model

According to the PCB model and components needed for the robot, we made a 3D model of the chassis (Figures 6 and 7). It includes battery support, 2 stepper motors support, a designated space to fit the PCB and some screw holes to the IR sensors, and the support for the caster wheel.

Results and Discussions

As a result of this paper and studies, a diagram of the sensor arrangement, a wall follower algorithm, a PCB (Printed Circuit Board) model, and a project simulation in the Webots software, and a Workshop about this study has been developed and presented.

Figure 5. Different point of views for the PCB layout.

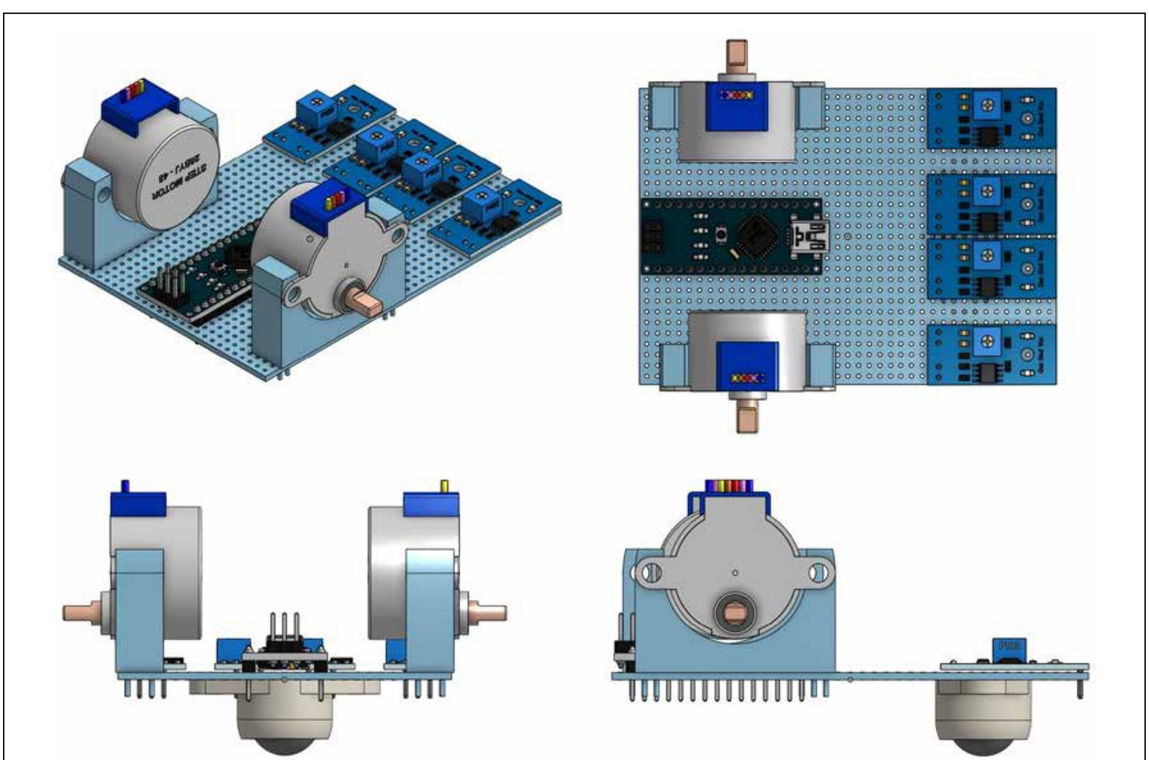


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Figure 6. A different point-of-views of the 3D chassis.

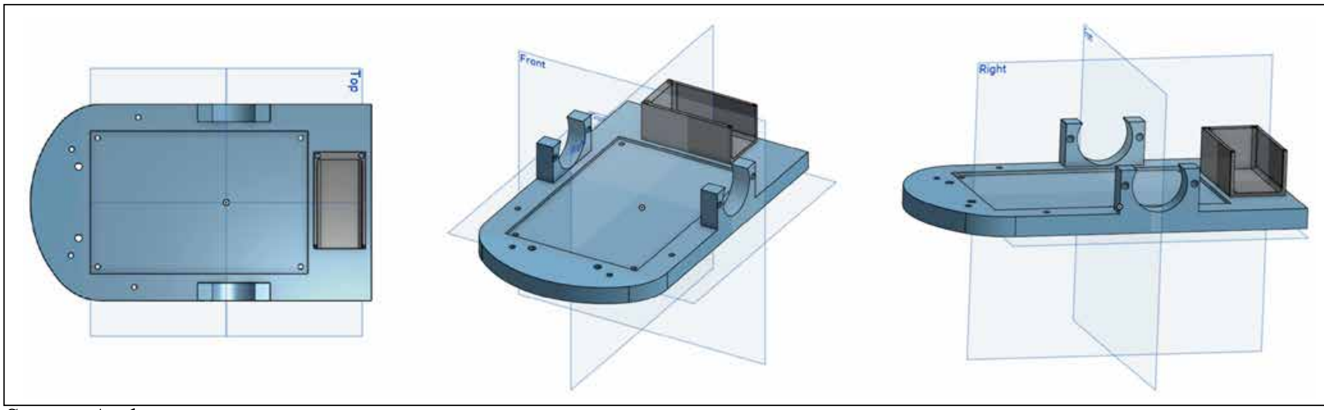

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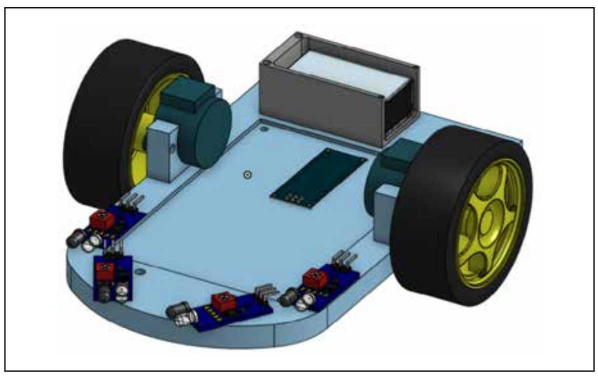
Figure 7. Preview of the assembled robot.



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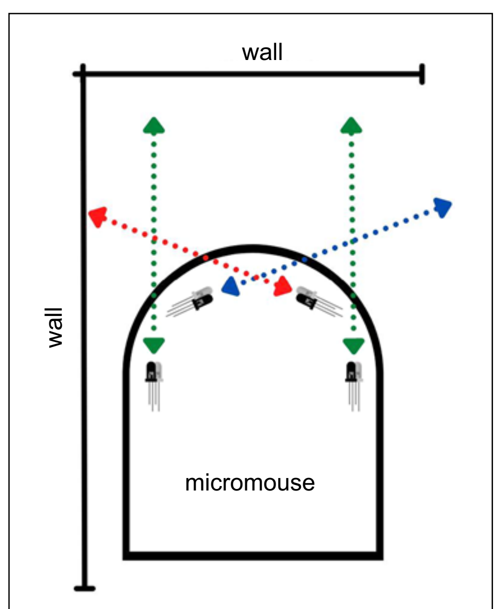
Sensor Arrangement

The sensor arrangement (2 facing the front and two on diagonal to each side-Figure 8) was thought to make the most precise and economical collection of information for the robot to move and map the maze. That makes better modeling of surroundings than the traditional way to use 3 sensors (1 in the front and one on each side) like the Harvard robotics team in the 2016 Brown IEEE MicromouseCompetition [4], or save to use 8 IR sensors like the model of Lunghwa University of Science and Technology in Taiwan [1].

Figure 8. Diagram of the sensor arrangement.



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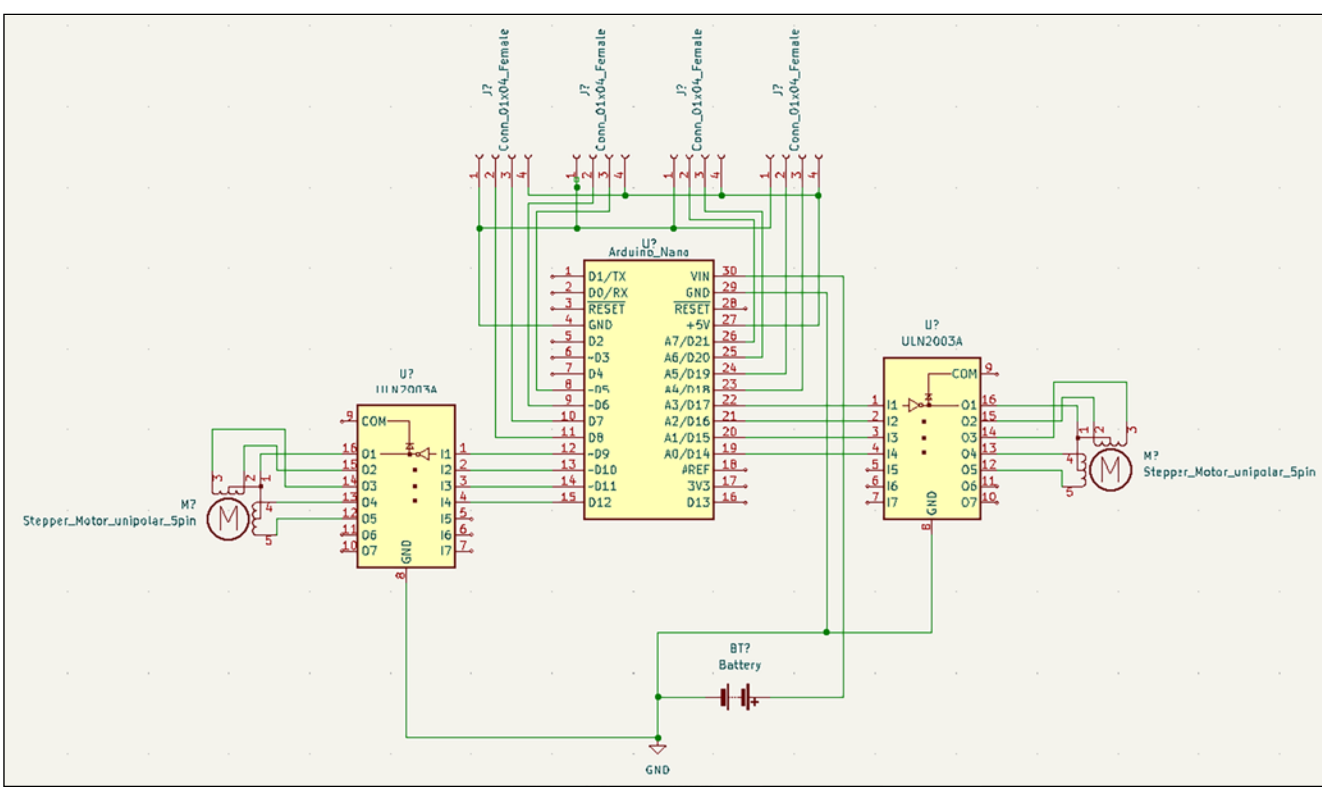
Algorithm

To initialize the algorithm, the Stepper.h library was added, which includes specific functions for the stepper motor in the arduino IDE. After that, the motor's number of steps per revolution was defined as equal to 32, with 2048 revolutions per revolution. Next, the variables for the sensors and stepper motors were declared, along with their inputs. The functions of sensors and motors were also created; the first was to read and display the distances detected by the sensors, and the second was to determine the motor speed and its pin configuration on the board. In the loop function, if and else conditionals were used to relate the information received by the sensors (Presence or not of a wall) with the respective desired motor outputs. Lastly, a repository was created in GitHub to keep the code (Figure 9) [12].

PCB

The Jabuti robot uses stepper motors, unlike conventional micromouses that use DC motors with encoder, because the stepper motor united to the information of the active infrared sensors gives the robot more control, avoiding crashing into the walls. As a result, it improves the ability to map the maze without the high cost of an encoder.

Figure 9. PCB in Kicad.



Workshop

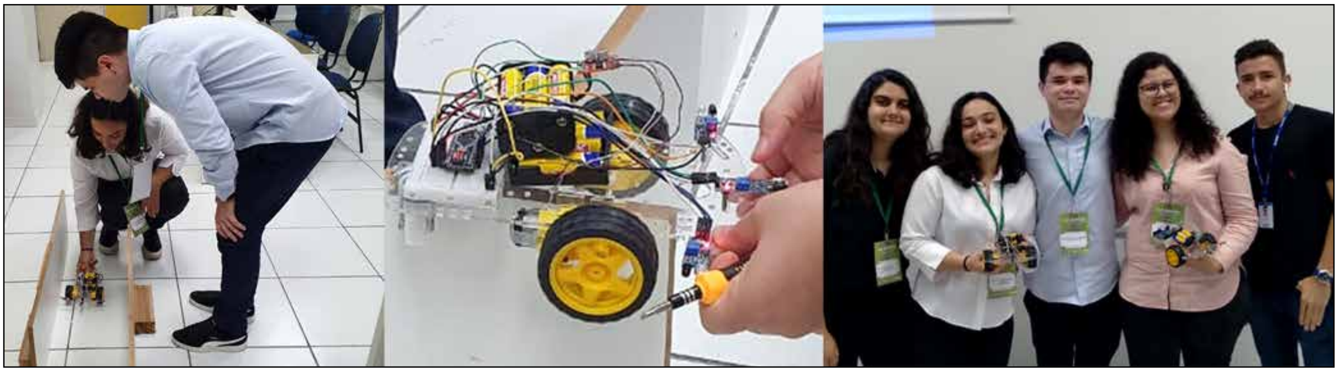
Considering the knowledge we acquired during research, the Jabuti team, united with colleagues of IEEE CIMATEC, promoted a workshop about the need for maze-solving robots and programming logic and developed two small robots with the same principles as the one presented in this article (Figure 10). Therefore, it was an excellent experience that showed us the importance of this project and how it activates creativity and presents it from an educational perspective.

Conclusion

In this paper, we presented the current situation of an autonomous robot's development and assembly processes and the understanding of its programming and its application. In addition, we showed how sensors would be used to assist in autonomous movement.

The current progress of the electronic design and simulation of the Jabutiproject was also shown,

Figure 10. Workshop.



taking into account how the robot would need to move in places that could have more than one exit in the maze and the need to install a caster wheel to assist in moving the robot. The PCB model was also made, showing the connections between the arduino nano, the chip, and the stepper motors.

For the next steps, the ideal robot proposed in the article will be assembled with the PCB and the chassis designed alongside the studies of the sensors. In consequence, the project will be continued and has the goal to be applied in schools and other universities events

Therefore, the goal of building a low-cost robot was achieved by being a compact structure with simplified and amplified use of the components, like the disposition of the sensors to cover more area. Through that, the secondary objective was also achieved, leading the students to study and put into practice the concepts needed for project construction.

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