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Building A Robot Platform Based on Pololu Zumo

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ABSTRACT

In this article is presented the design and implementation of a robot platform based on Pololu Zumo. The platform is controlled by an Arduino Leonardo board, which ensures the required programmability and flexibility. The hardware and software structures are described, as well as the main steps in building and testing the autonomous system. Experimental results from the developed platform are shown, demonstrating its capabilities in navigation and task execution. The presented work can find application in educational environments, robotics competitions, and as a basis for further development of intelligent robotic systems.
Keywords: robotic platform, robot, sensor, robot navigation, prototype development.

INTRODUCTION

With the rapid development of new technologies and the growing interest in robotics, small autonomous robots are becoming increasingly important both in education and in scientific research. Such robots offer a practical and accessible way to understand fundamental concepts in robotics, programming, and control systems. They serve as platforms for experimentation, allowing students and researchers to test algorithms, integrate sensors, and develop autonomous behaviours in a controlled environment.

A robot platform is essentially the physical base or structure that supports the robot's movement, perception, and task execution. It provides the necessary framework for attaching sensors, motors, and other components while enabling modularity for future expansions. By using a well-designed platform, developers can focus on programming and algorithm development without being limited by mechanical constraints.

Pololu Zumo is a compact and versatile robot base designed for educational and research purposes. Its small size, ease of assembly, and compatibility with Arduino microcontrollers make it an ideal choice for experimenting with autonomous systems. The Zumo platform allows users to explore concepts such as line-

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following, obstacle avoidance, sensor integration, motor control, and more complex autonomous navigation algorithms. Additionally, it provides an opportunity to learn about embedded systems, real-time control, and energy management in mobile robots.

EXPERIMENTAL

The robot platform based on Pololu Zumo was built using both hardware and software components. The hardware design includes the Pololu Zumo 32U4, which integrates an ATmega32U4 microcontroller, motors, and various sensors. Infrared (IR) sensors were employed for line-following and obstacle detection, while a gyroscope and accelerometer were added to enhance stability and support navigation tasks. Motor encoders provide precise measurements of speed and position, enabling accurate manoeuvring. Additional modules such as Bluetooth or Wi-Fi can be optionally integrated for wireless control, and ultrasonic sensors can be added to improve obstacle avoidance [1].

The software was developed in the Arduino IDE using C/C++. Official Pololu libraries were utilized to facilitate motor control, sensor reading, and module communication. A PID controller was implemented to ensure smooth movement by dynamically adjusting speed and direction according to real-time sensor data. Autonomous navigation algorithms, including shortest path finding using A* or Dijkstra methods, were also developed. Communication protocols such as I2C, UART, and SPI were used for interfacing with external modules and sensors [2, 3].

At the core of the system is the Arduino Leonardo board, which features an ATmega32U4 microcontroller operating at 16 MHz. The board has 32 KB of flash memory, 2.5 KB of RAM, and 1 KB of EEPROM. It provides 20 input/output pins, of which 7 support PWM and 12 can serve as analog inputs. The board operates at 5V and can be powered either through micro-USB or an external 7 - 12V supply. Its support for UART, SPI, and I²C protocols makes it highly suitable for embedded and IoT projects. Fig. 1 shows the main parts of the Arduino Leonardo board [4].

To complete the robot construction, the Zumo Shield for Arduino was used as an add-on board to control motors, sensors, and power distribution. Compatible with both Arduino Uno and Leonardo, the shield includes two motors, reflection sensors, an accelerometer, gyroscope, magnetometer, and a buzzer. Using the integrated

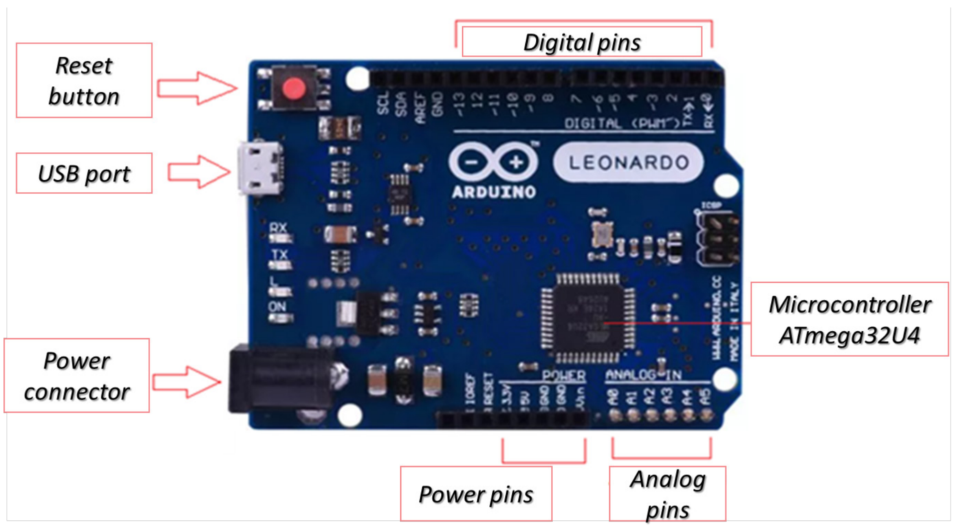

Fig. 1. Main parts of the Arduino Leonardo board.

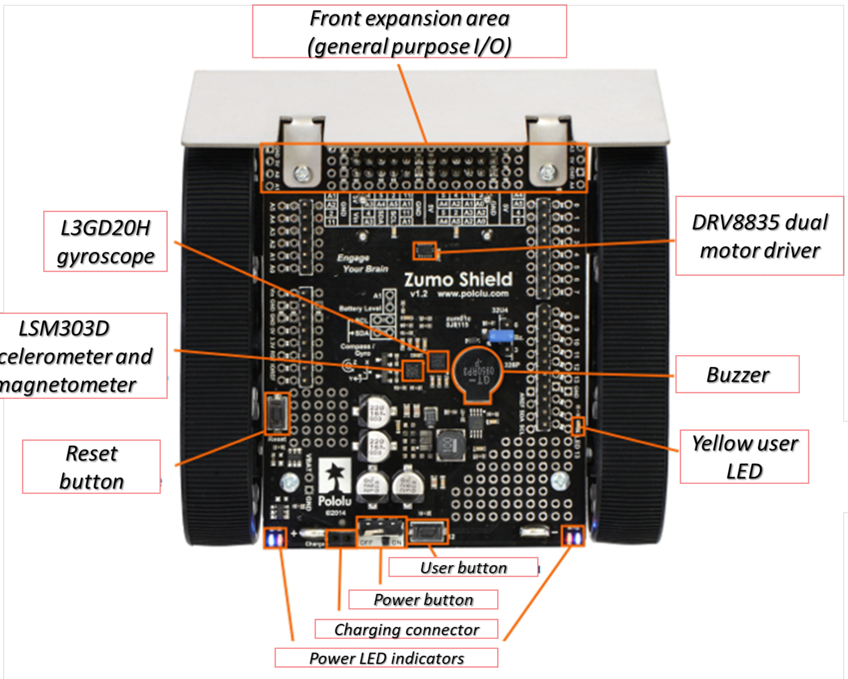

Fig. 2. Main parts of the Zumo Shield.

sensors and motor encoders, the Zumo Shield enables line following, obstacle avoidance, and precise maneuvering. Programming is simplified with the support of official Pololu libraries in Arduino IDE. Fig. 2 illustrates the main components of the Zumo Shield [5].

The combination of these hardware and software elements allowed the creation of a flexible, autonomous robot platform capable of performing complex tasks while being easily extendable for further research or educational purposes. The integration of multiple sensors, controllers, and communication interfaces provides a robust foundation for testing advanced algorithms and exploring intelligent navigation strategies.

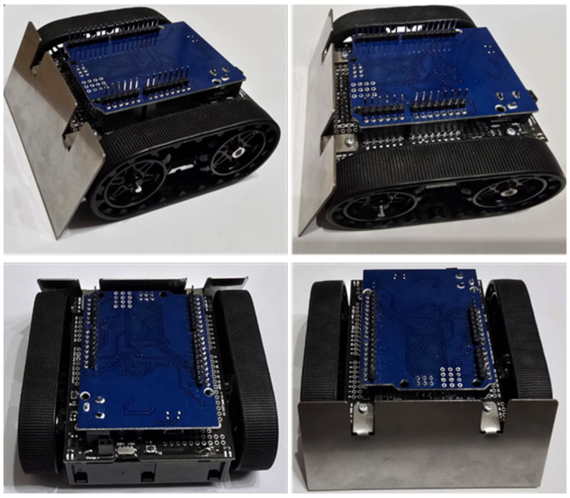

Fig. 3. Built model of the Zumo Shield robot [6].

RESULTS AND DISCISSION

Fig. 3 shows the built model of the Zumo Shield robot. The platform moves using a tracked system and employs infrared sensors to follow lines or detect obstacles. It is designed for autonomous navigation, analysing the environment with an accelerometer, gyroscope, and magnetometer to maintain balance and perform more complex maneuvers. The combination of sensors and the tracked system allow the robot to execute smooth and precise movements even on curved path [2].

The program code for the Pololu Zumo robot, which uses the Zumo Shield board with built-in sensors and motors, begins by including the necessary libraries. Objects are defined to control the buzzer, reflection sensors, motors, and buttons [1]. Two main libraries are used for the software implementation: Wire.h and ZumoShield.h.

Wire.h is the standard Arduino library for I²C communication. It enables the microcontroller to communicate with other I²C-compatible devices such as sensors, expansion modules, or additional microcontrollers. In the Zumo Shield, it is used to interface with built-in sensors, including the accelerometer and magnetometer. ZumoShield.h is a dedicated library providing simplified functions to control the Zumo Shield. It contains functions for motors, sensors, buttons, the buzzer, and other parts of the platform, which simplifies programming and accelerates the implementation of autonomous navigation and control routines. Fig. 4 shows a fragment of the Arduino IDE program code, illustrating how the Zumo Shield functions, including motor control, sensor reading, and initialization of objects for autonomous navigation.

In the setup() function, the robot produces a sound when starting and waits for the button to be pressed. After this, sensor calibration is performed: the motors move left and right to learn the difference between the line and the background. Once calibration is complete, the robot waits again for the button press and plays a melody before starting autonomous operation. During the loop() function, the robot continuously scans the line using the infrared sensors and adjusts its movement through a PD (Proportional-Derivative) controller. The error is calculated as the difference between the current line position and the central reference value (2500). Proportional and differential coefficients are then applied to adjust the motor speeds. After setting the new speeds, the controller ensures that the motors do not exceed the maximum allowed speed and fine-tunes the direction to keep the robot on the line. Through this combination of sensors and control algorithms, the Zumo robot can autonomously follow a drawn line while making smooth and precise corrections. Fig. 5 demonstrates the robot in action following a line path, illustrating the effectiveness of the sensor integration and PD control algorithm [2].

The experimental results confirm that the Zumo Shield robot is capable of stable and accurate autonomous navigation. The integration

Fig. 4. Fragment of the program code in Arduino IDE.

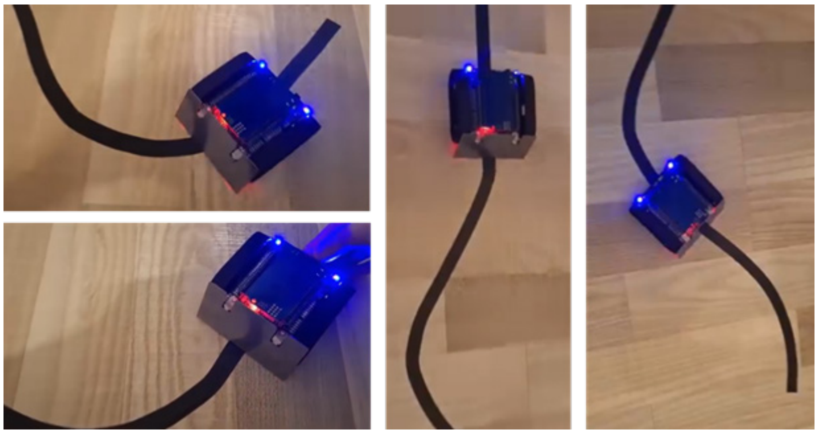

Fig. 5. Demonstration of the Pololu Zumo robot following a line.

of multiple sensors and control algorithms enables reliable performance in line-following tasks, obstacle detection, and general maneuvering. This demonstrates the suitability of the platform for both educational purposes and preliminary research in autonomous robotic systems.

CONCLUSIONS

In this work, we successfully designed and implemented a robotic platform based on the Pololu Zumo system, resulting in an autonomous robot capable of line following and dynamic movement correction using integrated sensors and control algorithms. The project combined both hardware components, including the Zumo Shield, motors, and various sensors, and software solutions developed in the Arduino IDE for motor control, sensor integration, and autonomous navigation. The completed robot demonstrates reliable performance in line following and obstacle avoidance, executing precise autonomous maneuvers with high accuracy and stability.

Future developments may include the integration of wireless communication modules, such as Bluetooth or Wi-Fi, to enable remote control and monitoring. Further enhancements could focus on improving the robot's autonomy, expanding its environmental perception, and implementing more advanced navigation algorithms. Overall, this project highlights the potential of small, programmable robotic platforms for educational, research, and experimental purposes, providing a flexible foundation for exploring intelligent robotics and autonomous systems.

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