Drivetrain for an Autonomous Vacuum Robot

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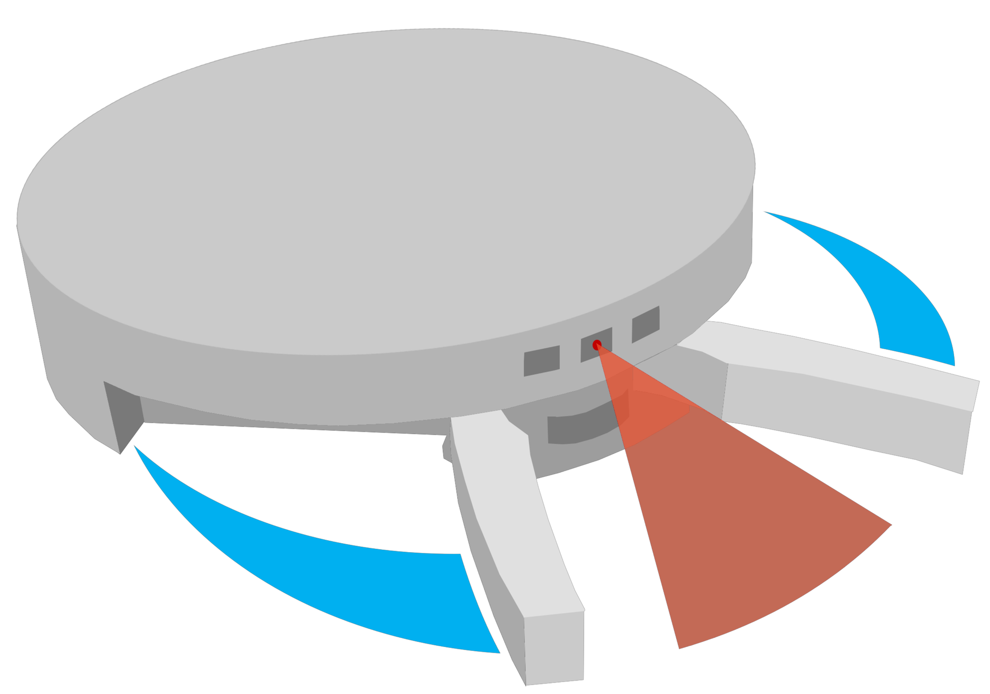
Abstract

This work presents the development of an autonomous mobile robot designed to vacuum large surfaces, with the added capability of detecting and manipulating small objects in its path to clear more space for cleaning.

Using an Arduino-based mechatronic system, the robot employs several interacting hardware components: time-of-flight sensors, DC motors, magnetic rotary encoders, and motor drivers with pulse width modulation (PWM) control. These were incorporated to meet the constraints of an existing chassis and mechanical design. Programming for autonomy in C++ and power requirements for the electronics, excluding the vacuuming operation itself, are also addressed.

Limitations of this system fall largely into the category of accurately interpreting the robot's surroundings, which calls for a much more advanced approach involving computer vision, and may be an avenue for future work.



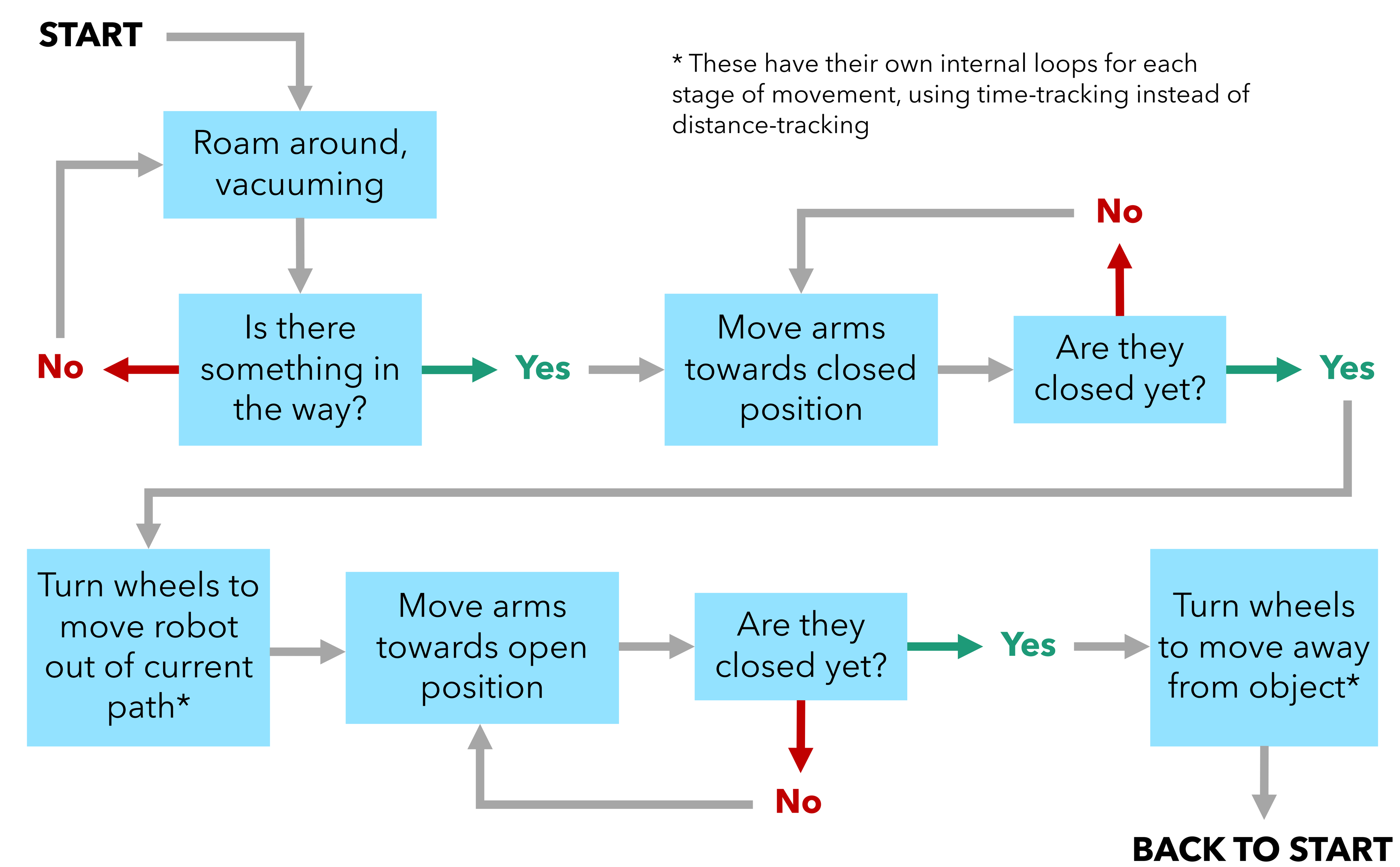
Objectives

The goal of this project is to build and program a vacuum cleaner robot that can:

- Detect objects in its path
- Pick up and manipulate an object
- Move the object elsewhere so that the area underneath it can be cleaned

This device was initially designed for appliance firm Arçelik A.Ş. for use in domestic environments.

Full System Overview

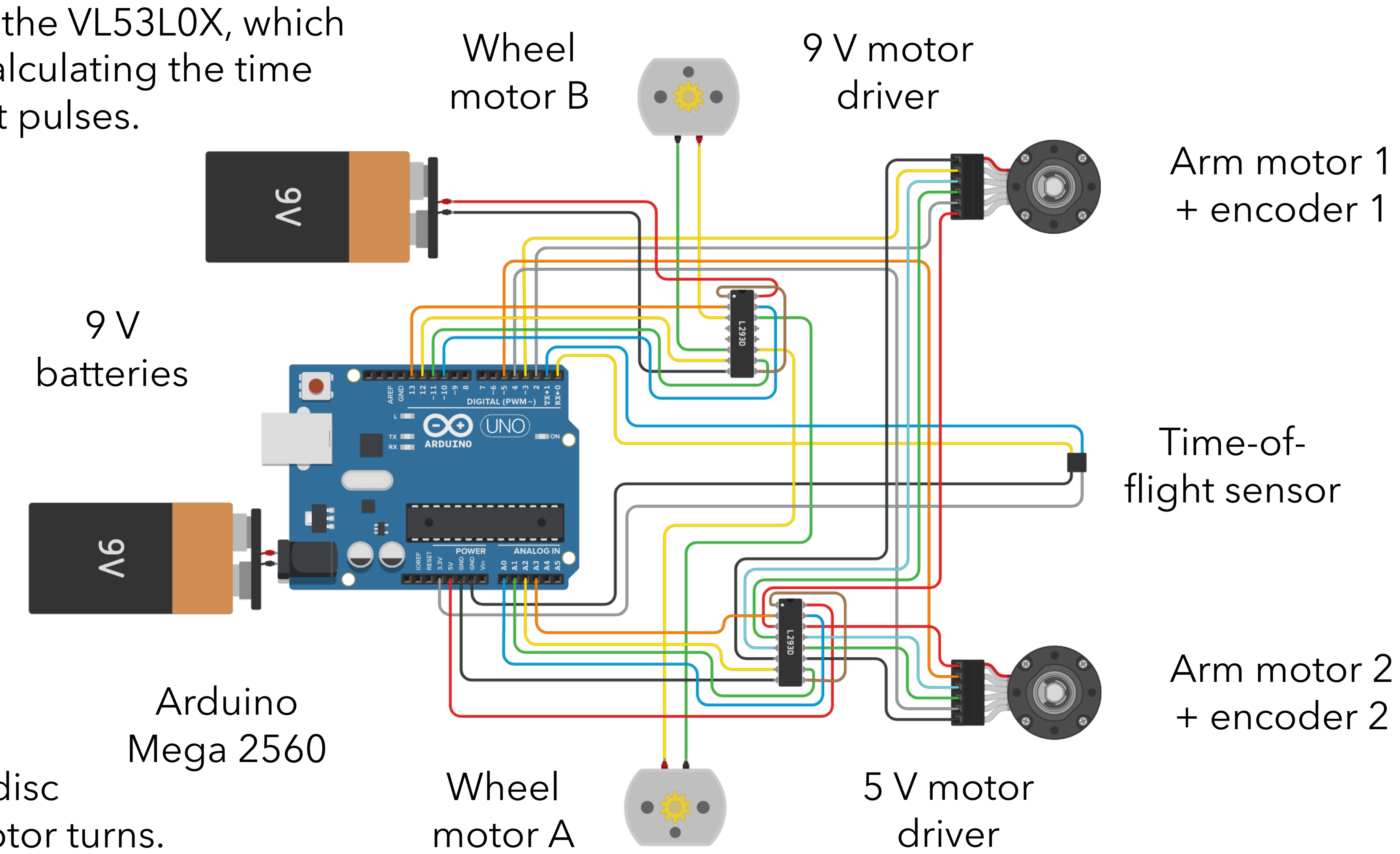


Hardware

To prototype the electronics, an Arduino Mega 2560 microcontroller was chosen for its broad compatibility with other hobbyist parts. This board also has the greatest number of pins out of the entire Arduino family, making it a good choice for controlling many motors and sensors.

The system looks for nearby objects using an optical sensor called the VL53L0X, which measures distance by calculating the time of flight for infrared light pulses. Motor drivers provide power to DC motors for both the wheels and the arms. In addition to direction, the drivers also offer speed control via pulse width modulation (PWM).

To track how far the arms have moved, each arm motor has a rotary encoder, which uses tiny magnets on a disc to count steps as the motor turns.



Programming

Writing code (C++) for this robot involved several different tools, including libraries for:

- Encoders
- Time-of-flight sensors
- USB serial communication for debugging

The numerous components required strategies for multitasking; for instance, running a function for a certain duration must not prevent the system from doing something else while it waits.

The program also features a custom object class to manage functions for the DC motors, which pass information about motor position between the encoders and their corresponding motors.

Conclusion

Despite several challenges relating to faulty components and sparse part documentation, the robot prototype has autonomous capabilities that meet the identified objectives. Continued work on the project would focus on improving accuracy of motor control by adding encoders to the wheels, while replacing the arm motors with high torque servos to conserve output pins.

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