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THE DESIGN AND CONSTRUCTION OF AN AUTONOMOUS MOBILE MINI-SUMO ROBOT

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Abstract: *The paper presents the design and construction of an autonomous mobile mini-sumo robot. The mobile robot is a combination of devices endowed with power drives and sensors, under the control of a hierarchical computing system operating in the real space, which has to plan the movements so as to perform a task depending on the initial state of the system as well as on the information received from the work environment. The robot was designed using Fritzing software and its programming has been done by means of Arduino programming language. In building the robot, the regulations of the sumo-type robot competitions were taken into account in order to allow it to take part in such competitions.*
Keywords: *robot, sensors, mini-sumo, programming language*

INTRODUCTION

One of the most important aspects in human evolution is the use of tools, meant to ease physical work. Robots range within this category, their complexity offering them a privileged position, though [7]. The mobile robot is a complex system that can perform several activities in a variety of specific situations of the real world. It is a combination of devices endowed with power drives and sensors under the control of a hierarchical computing system operating in the real space, marked by a series of physical properties (for instance gravity, which influences the movement of all robots functioning on the Earth) and which has to plan the movements so as to achieve a task according to the initial state of the system and depending on the existing information, related to the work environment. The success in performing these tasks depends both on the knowledge the robot has about the initial configuration of the work space as well on the information acquired during its evolution [2] [8].

The specific problems arising with mobile robots are the following: avoiding the impact with stationary or moving objects, determining the position and orientation of the robot in the area and planning an optimal trajectory of movement.

In the case of an automatically distributed robotic system, the spatial positions are of utmost importance as they influence the achieving of the desired targets, as well as the functioning of the whole system. In other words, the robot must be able to plan its movements, to automatically decide upon the movements to be made in order to carry out a task, according to the momentary distribution of objects in the work space. Movement planning does not consist in a single, well-defined issue, but in a set of problems of which some are more or less variants of the others.

Avoiding collision with fixed or mobile obstacles (for instance other mobile robots) existing in the work space of the robot can be done by several methods: building a mechanical guard which, by deformation, stops the robot, using sensors to measure distance up to the obstacles in the direction of movement, the use of proximity sensors, the use of the information correlated from several types of sensors [3] [4].

Object spotting can also be done by physical contact, but this involves restrictions on the movement speed and the handled structure. The physical contact between the robot and the environmental objects triggers reaction forces that modify the state of the robot. The high work rates make the dynamic effects of a physical contact with obstacles or with the handled objects risky (they may damage the objects or the robot).

The sensor system is also called gauging system. It helps measure some physical magnitudes and possibly perceiving some significant alterations of these magnitudes.

Robot navigation is possible even in the absence of position determination and orientation with respect to a fixed coordinate system, but this information is useful for the movement control systems. Among the most commonly used navigation systems the following can be mentioned: measuring the number of rotations made by the driving wheels, the use of accelerators and gyroscopes, electromagnetic buoys located on the terrain, passive or semi-passive optical or magnetic signaling systems [5] [6].

THE ROBOT DESIGN AND BUILDING

In order for the robot to win a mini-sumo fight, its constructor and programmer has to take into account several factors. If the strategy is focused on a powerful and slow robot, then the motors should be chosen to have a high transfer rate. If, on the contrary, the choice is a fast and agile robot, then the motors should have a low transfer rate. The transfer rate refers to the gear that transfers the movement to the wheels (included in the motor case). A transfer rate of 50:1 means that for 50 rotations of the motor, the wheel turns once. The robot is agile, *but less powerful. A transfer rate of 298:1 means that for 298 rotations of the motor, the wheel turns once. The robot will be slow, but very powerful. Other factors that influence the complexity and efficiency of the robot are:*

- *the type of distance and line sensors used (infrared, ultrasound);*
- *the response time of the sensors;*
- *adherence and the type of locomotion;*
- *the type of chassis;*
- *the duration of motor feeding (the robot should stay "alive" all along the fight, up to its end);*
- *the strategy of choice in programming the robot;*

Further on, a robot is presented, built to simulate a sumo fight, taking into consideration the above-mentioned elements.

Such robots can be used in various domains, as they are adaptable to the exploration of narrow or dangerous spaces, or even as a military application. Here is, next, the description of the robot and its main hardware elements. This is an autonomous mobile robot, which does not require its remote control by means of mobile phone applications.

The robot is fed by a set of 6 batteries located in a special case and connected to the GND (Ground) pin and to the 5V (Volt) pin [11].

Figure 1. Robot overall view and the robot in the ring

The main hardware components used in building this robot are: the Arduino Uno board; 2 (line) reflection sensors; a distance sensor; the L298N shield; 2 c.c. motors

ARDUINO UNO

The moni sumo robot needs a brain. The best option in this sense is an Arduino UNO board. Arduino UNO is an open-source processing platform, based on a flexible and user-friendly hardware and software. It consists of a small platform (6.8 cm / 5.3 cm – in the most common version) built around a signal processor and capable of taking in data from the environment through several sensors and of performing actions upon it by means of lights, motors, power drives and other types of mechanical devices. The processor is able to run code written in a programming language that is very similar to C++[9] [10].

(LINE) REFLECTION SENSORS

These sensors consist of two components: an IR LED and an IR photosensitive transistor. When a voltage of 5V is applied to the VCC and GND pin, the IR LED will emit infrared light. A 100 Ohm resistor is connected in series to the IR LED, in order to limit the current. A 10 kOhm resistor sets the output pin to HIGH, but when the light emitted by the IR LED is reflected back towards the phototransistor, the output pin switches to LOW. The more light the phototransistor receives, the lower the voltage on the output pin [1].

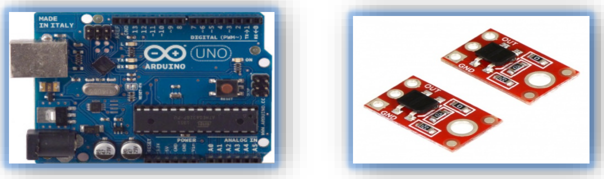


Figure 2. ARDUINO Microcontroller and Line sensors

DISTANCE SENSOR

In order for the robot to "see" its opponent, it needs at least one distance sensor. The Sharp distance sensor is a component that can be used with Arduino for measuring the distance to various objects in the surrounding area. They are the most suitable for this kind of robot, as they have a very fast response. The ultrasound sensors are not so efficient for sumo, as their response is relatively slow.

The principle underlying the functioning of the robot is the following: the sensor emits a pulse of infrared light of a certain wavelength and if the object is in the action area and on the trajectory of the IR beam, it will reflect the ray to the sensor. The sensor performs the readings with a certain frequency and reports the data as voltages. The Sharp distance sensors are available in three variants, according to their efficiency area. There are sensors that prove efficient within 3 cm to 40 cm, others between 10 cm and 80 cm, and also others between 15 cm and 150 cm. The sensor values cannot be used outside their efficiency area. The sensor of choice was in this case the one that is efficient between 10 cm and 80 cm[1][9].

C.C. MOTORS

The robot has two high power C.C. Pololu-type motors, with a transfer rate of 100:1. The transfer rate refers to the gear that transfers the movement from the motor to the wheels. A 100:1 transfer rate means that for 100 rotations of the motor, the wheel will turn once. If the strategy focuses on a powerful and slow robot, then motors with a high transfer rate are recommended. If, on the contrary, a swift and agile robot is needed, then the motors of choice will have a low transfer rate. In this case, the transfer rate chosen offers the robot a balance between speed and power.

Figure 3. C.C. motor and SHARP Distance Sensor

L298N MOTOR DRIVERS

Arduino is a very capable brain for this type of robots, but, as any brain, it can only perform precision operations. Arduino was not designed to offer high power for motors, but precise control signals. The motor driver is connected directly to the energy source (the battery) and it controls the motors according to the control signals received from Arduino.

Based on the L298N circuit, this motor driver can control 2 C.C. motors at a maximum current of 2 amperes. The driver is entirely assembled as an Arduino shield, which enables its simple usage. The connection to Arduino is done by plugging the shield board to Arduino and connecting the VIN and GND pins to the motor power source. The PWM pins controlling the L298 driver are 3, 5, 6 and 9 (also see the test program given further on). The two motors are connected to the screw pins marked "MOTOR1" and "MOTOR2". For this mini sumo robot the power needs to be high and continuously dissipated, so a radiator was used [11] [12]. The connection of the components that make up the mini-sumo mobile system is given herein after.

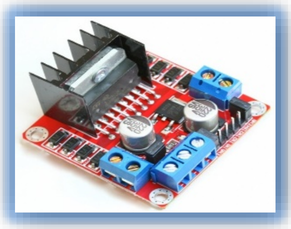


Figure 4. Motor driver

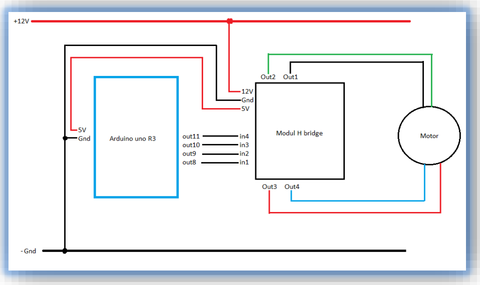


Figure 5. L298N Arduino connection diagram

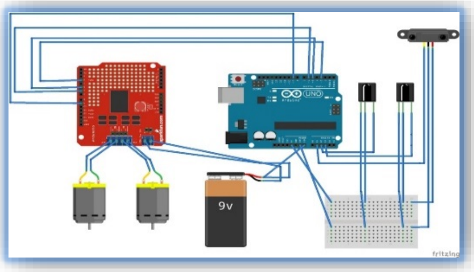


Figure 6. The connections of the robot components

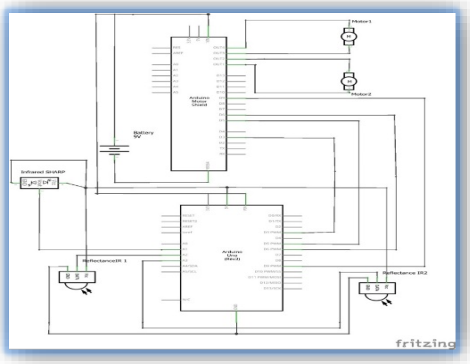


Figure 7. Connection diagram

SOFTWARE IMPLEMENTATION

The programming language used with the mini-sumo robot is similar to the C++ language and is called Arduino.

The window shown below is a programming editor used only for the Arduino development boards. To this purpose, it is needed to choose from the tools the board to be working with, as well as the port selected by the computer.

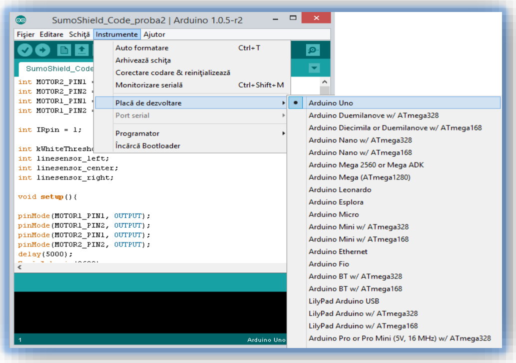


Figure 8. Choosing the Arduino board

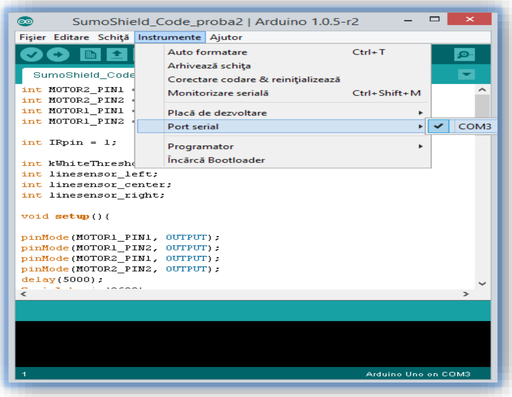
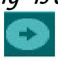


Figure 9. Port selection

Any code line has to be checked with the button  *that will check for errors in the program structure and, once the message "Done compiling" is displayed, the program can be run by pressing the upload button*  *that sends through port COM3 the instructions to the microcontroller, which processes it and sends it on to the output pins.*

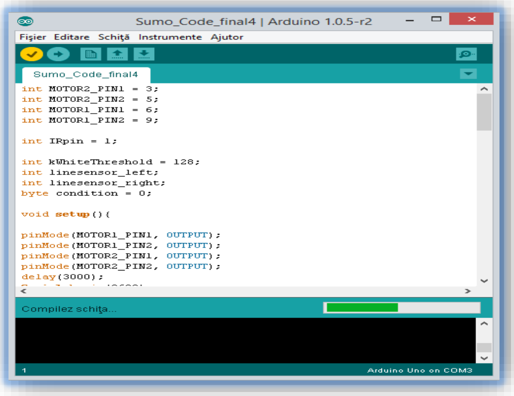


Figure 10. Program compiling

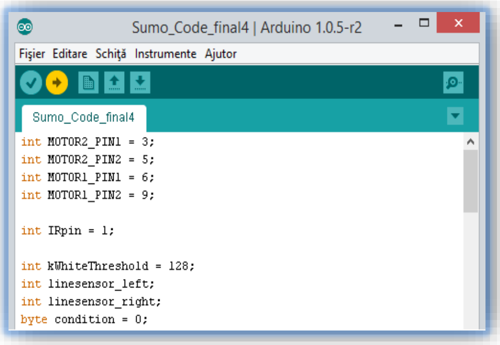


Figure 11 . Program uploading

Further on, some screen prints will show the code lines of the program.

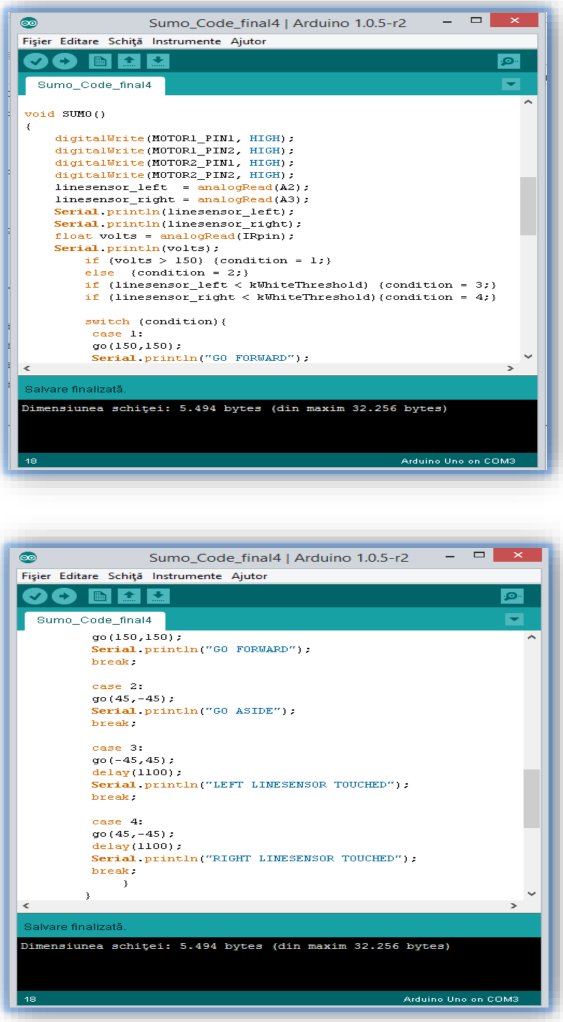


Figure 12. Program structure

CONCLUSIONS

The mobile robot is a complex system that can perform a series of activities in a diversity of real situations. It is a combination of devices equipped with power motors and sensors, under the control of a hierarchical system, operating in the real space and that has to plan the movements of the robot so that it can perform a task according to the initial state of the system and also in accordance with the existing information related to the work environment.

The paper presents the design and construction of an autonomous mobile robot used in mini-sumo competitions. The design has been done using the Fritzing software and the programming in the Arduino language.

This robot has several important advantages and it can be used as didactical equipment, a fighter in mini-sumo contests and, moreover, it can be adapted for the use in various domains, such as: the exploration of narrow or dangerous spaces, military applications, etc.

REFERENCES

[1.] Dumitriu A., Buçşan C., Demian T., – "Sisteme senzoriale pentru roboţi", Editura MEDRO, Bucureşti, 1996.
[2.] Ivanescu Mihai, - Robotica - Editura Universitaria, 1995
[3.] Ispas Victor, - Roboţi pentru aplicaţii speciale - Editura Dacia, 2001
[4.] Iovine J., - „Robots, androids and animatrons", McGraw-Hill, USA, 2002.
[5.] Laumond J.P.,- "Robot motion planning and control", Springer-Verlag, London, U.K., 1998.
[6.] PedreS., P de Cristforis, Caccavelli J., "A mobile mini robot architecture for research, education and popularization of science", 2010 - robotica.dc.uba.ar
[7.] Tirian G. O., " Robotică", Editura Politehnica Timisoara, 2013.
[8.] Tirian G. O., "Automation of a warehouse by means of a robotic arm" - Annals of Faculty Engineering Hundeoara – International Journal of Engineering Tome XI, Fascicule 4, 2013.
[9.] Sharp GP2Y0A21YK0F Distance Measuring Sensor datasheet,http://www.pololu.com/le/download/gp2y0a21yk0f.pdf?
[10.] http://www.roboter-info.de/index_en.htm
[11.] http://www.robofun.ro
[12.] http://www.sparkfun.com

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