Electronics and informatics solution in mobile robot orientation

Paul Ciprian Patic, Lucia Pascale, Luminita Duta, Mihaita Ardeleanu

***Abstract*—**In this paper one proposed to achieve an autonomous mobile robot to simulate movement in an unknown environment, for example, to move inside of a maze. One used some electronics and informatics solution to make possible the guidance of a mobile robot. With specialized documentation and follow some practical examples, we made the prototype model robot, which is an application with a didactical and scientific goal for the some didactical and research laboratories. Using hardware and software capabilities of the PIC16F877 microcontroller produced by Microchip, one realized the moving of the prototype robot and one can say that one can try to induce the desired movements. Also, one use the MikroPascal like a software program environment.

***Keywords*—**3D Projection, Catia, Detection Sensors, Mobil Robot.

I. INTRODUCTION

MOBILE robots is the most spectacular and representative class of mechatronic systems, particularly because of trying to copy and move closer to the models of the living world. A mobile robot has a complex mechanical structure, drive motors that provide movement in the environment, sensors that allow targeting, identifying and avoiding obstacles and a "brain" consists of one or more digital processors that provide overall system control [1], [2].

Robotics domain includes a wide range of technologies in which computational intelligence is brought into physical machines, making such systems with capabilities far exceeding those of simple machines [4[, [9].

Such robotic systems are then able to accomplish tasks that conventional systems can not carry out. The ability to move a car alone, independently, is an ability that opens a wide range of applications that are uniquely adapted to robotic systems.

Manuscript received July 22nd, 2010. This paper was created after a research together with a small group of students from our faculty. We had in view the large domain of Robotics and how to improve the work using the Computing Aided Design.

Paul Ciprian Patic is with Valahia University of Targoviste, Electrical Engineering Faculty, Automatics, Informatics and Electrical Engineering Department, 18-24 Unirii Boulevard, 130082, Targoviste, Romania (e-mail: patic@valahia.ro).

Lucia Pascale is with Valahia University of Targoviste, Electrical Engineering Faculty, Automatics, Informatics and Electrical Engineering Department, 18-24 Unirii Boulevard, 130082, Targoviste, Romania (e-mail: p_lucia@valahia.ro).

Luminita Duta is with Valahia University of Targoviste, Electrical Engineering Faculty, Automatics, Informatics and Electrical Engineering Department, 18-24 Unirii Boulevard, 130082, Targoviste, Romania (e-mail: p_lucia@valahia.ro).

Mihaita Ardeleanu is with Valahia University of Targoviste, Department of Material Sciences, Mechatronics and Robotics, 18-24 Unirii Boulevard, 130082, Targoviste, Romania (e-mail: miniarde@yahoo.com).

II. MODELING OF THE PROTOTYPE ROBOT

One starts with the conceptual modeling solution of the autonomous guidance system for carrying out parts of the system in the XOY plane, then one realized their 3D models, placing them in the parts that make up the prototype robot. One used for that Computer Aided Design software, which is able to confer a good visual prototype robot.

CAD - Computer Aided Design is the term used to use the software tools to design products. Constructive role of computer-assisted design is that based on functional requirements, aesthetic and construction to be determined, using computer, properties of form, material and quality of the object [8].

Design process is considered as an activity based on induction, deduction, intuition, experience and creativity. Using the software tools it is possible to gradually transfer the experience, deduction and induction from engineering design CAD system, making it an intelligent system. A CAD system requires constant dialogue, through the monitor design, the technical database and general database, on the one hand, and the algorithms, on the other hand

As human-machine system, CAD system based on intelligent human creative capacity and computing power of the computer, it possesses the operating speed and high capacity storage and retrieval of information [8], [9].

CAD systems are therefore integrating methods of computer science and engineering, including databases, banks fundamental methods and algorithms, communication systems, graphics systems, application programs. A CAD system should have capacity for a decision to include assignment of design requirements and design specifications. These features include natural language processing, processing and refining by asking the user (interactive) concerning the degree of detail design.

The suite of software known as 3D management product life cycle, CATIA supports multiple instances of product development (CAx), from the conceptualization, design (CAD), manufacturing (CAM), and analysis (CAE). Version 5, for example, can run with other applications, including ENOVIA, SMARTEAM and some other applications of CAE analysis.

CATIA was introduced in robotics domain and this design environment is used primarily because of ease of design and multitude of tools that offer this software package, from basic schemes, of a robot, to a robot assembly and even to induce the movement, actions and its shareholders.

In figure 1 it is represented from different views the stepper motor of the mobile robot.

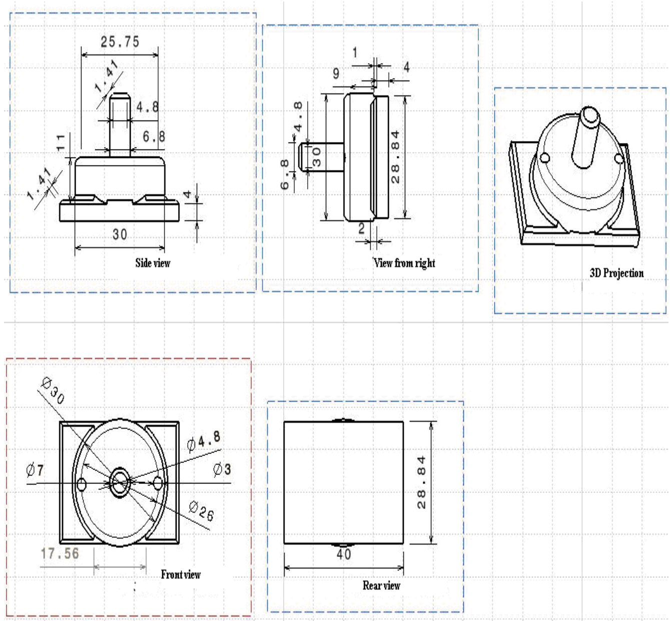

Fig. 1 Stepper motor (quotes and 3D Projection)

In figure 2 it is represented the proximity sensor of robot equipment. The sensor can be an element of artificial intelligence used in robot's construction.

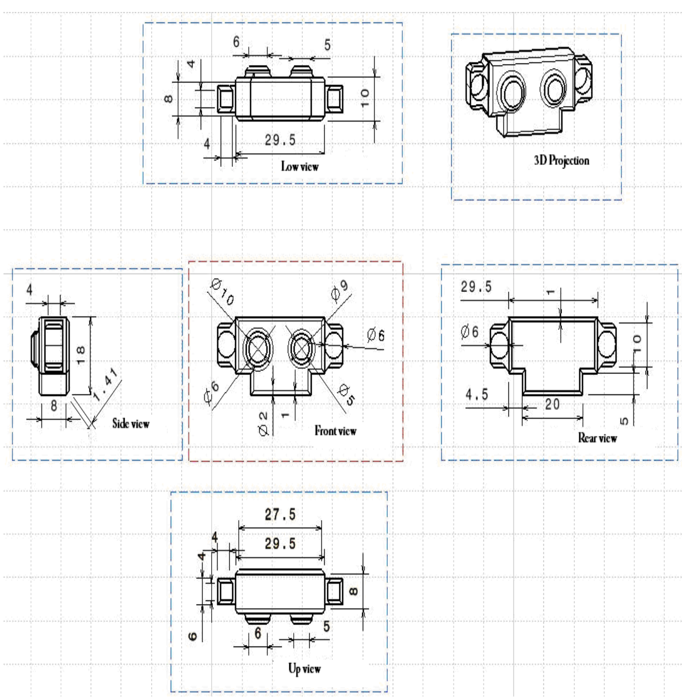

Fig. 2 The proximity sensor (quotes and 3D Projection)

In figure 3 one represented the robot assembly composed from one wheel, a motor and, also, the support of robot's engine. As well, in figure 4 is the main structure of the future robot.

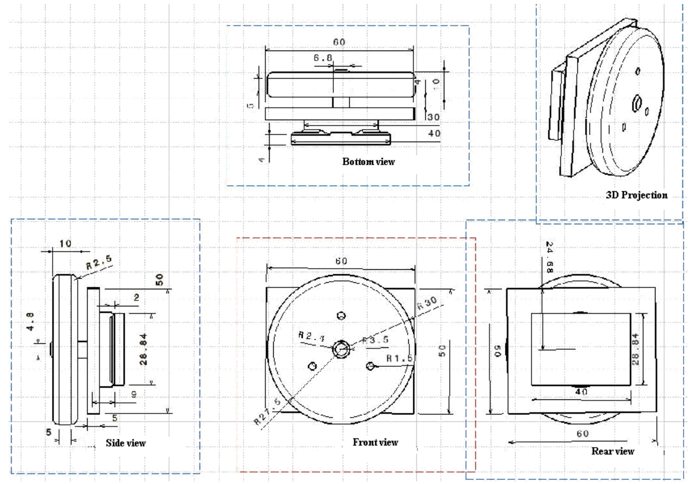

Fig. 3 The assembly composed of wheel, engine and engine support (quotes and 3D Projection)

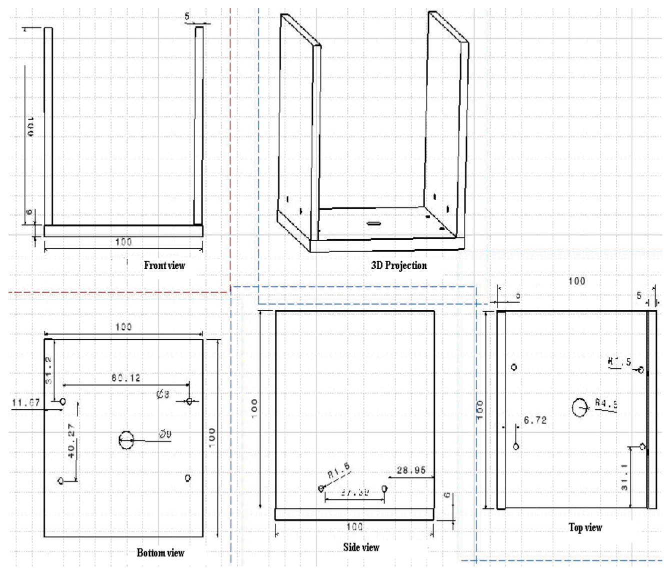

Fig. 4 Main structure of the prototype robot (quotes and 3D Projection)

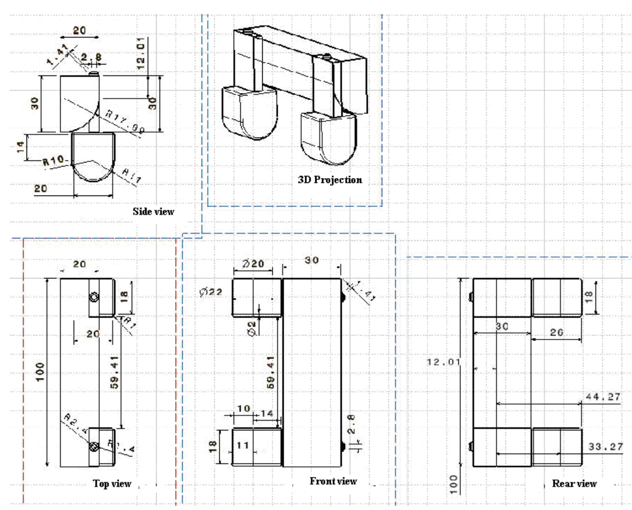

Fig. 5 The support of the robot with wheels in the rear (quotes and 3D Projection)

In figure 5, from above, it is represented the support of the robot in terms of wheels from the rear of the assembly.

Bellow, in figure 6 it is signify the sensor which is responsible with the surfaces on moving robot. One must say that this kind of mobile robot can make the displacement on different plane surfaces qualities.

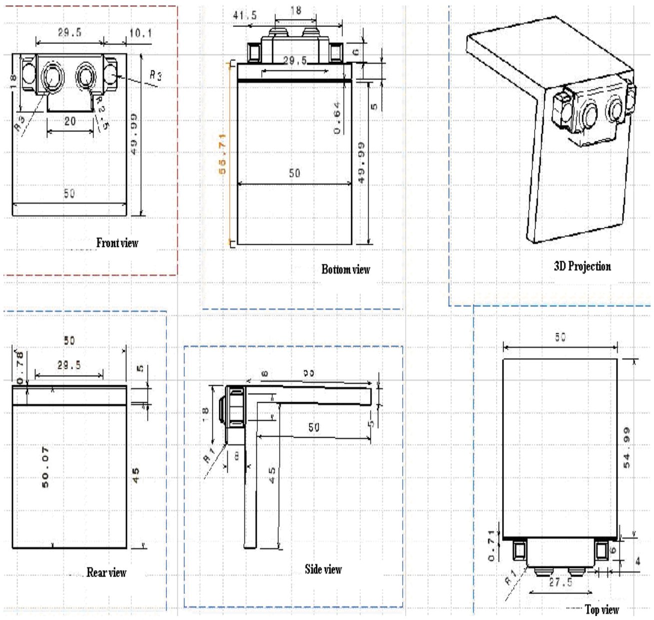

Fig. 6 The support of detection's sensor of the surface displacement (quotes and 3D Projection)

Also, one can observe that the robot contains a sensor which is responsible with obstacles detection for avoid them, as seen in figure 7.

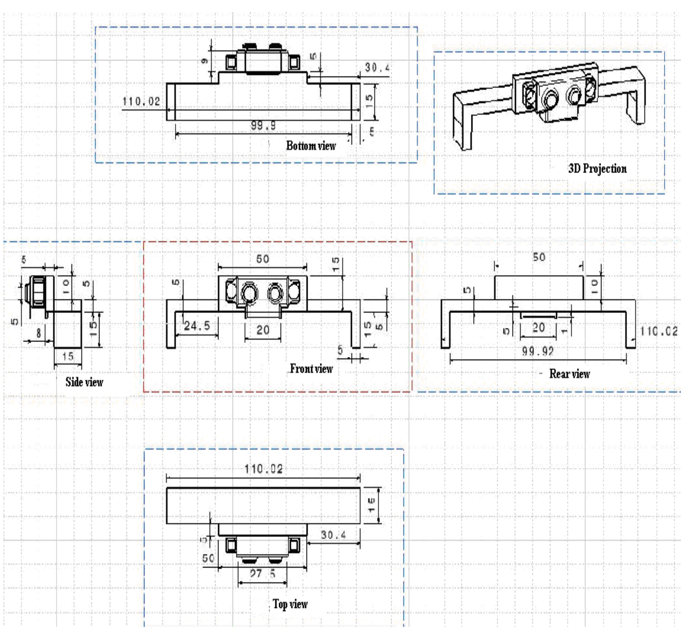

Fig. 7 The support of the sensor of obstacles detection (quotes and 3D Projection)

Finally, one made the prototype robot assembly modeling, using all parts previously designed components, as one observe in figure 8a and 8b.

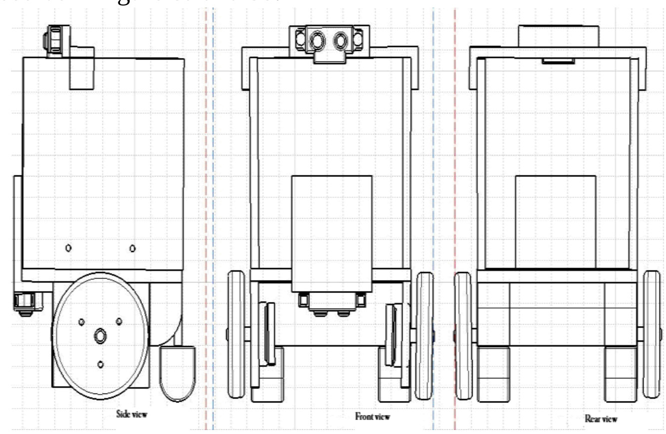

Fig. 8a Robot prototype (3D Projection)

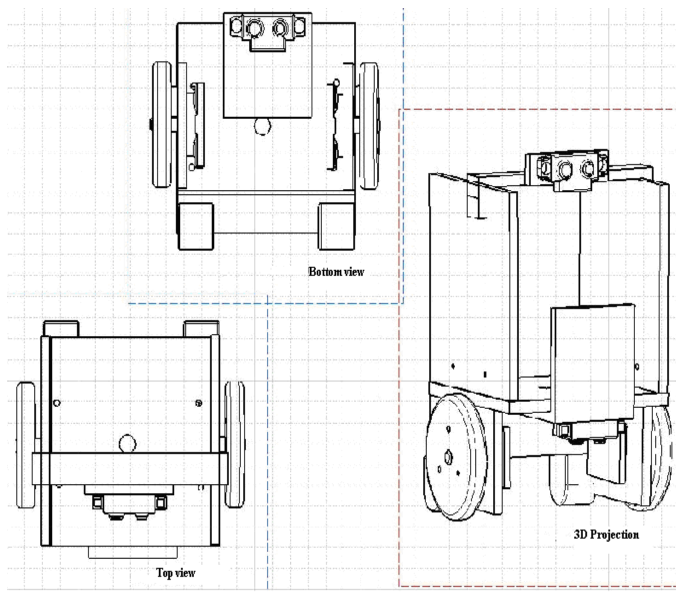

Fig. 8b Robot prototype (3D Projection)

The proposed application is to simulate the movement of autonomous mobile robot in a maze. This application is composed of two main parts, one part hardware and software. Hardware part of this project is the prototype model robot with maze model and the second, the software part is a microcontroller program that controls the prototype robot.

To control all the processes, inside the robot model are implemented the next functions:

- the detection of displacement surface;
- the detection of the appears obstacles during displacement;
- the control of the stepper motors and their synchronization;
- the changing of the displacement direction when an obstacle was detected;
- stopping of the robot system in case of the displacement does not realized.

In figure 9 is the 3D model of the prototype robot in CATIA design environment, seen from several angles (9a, 9b, 9c).

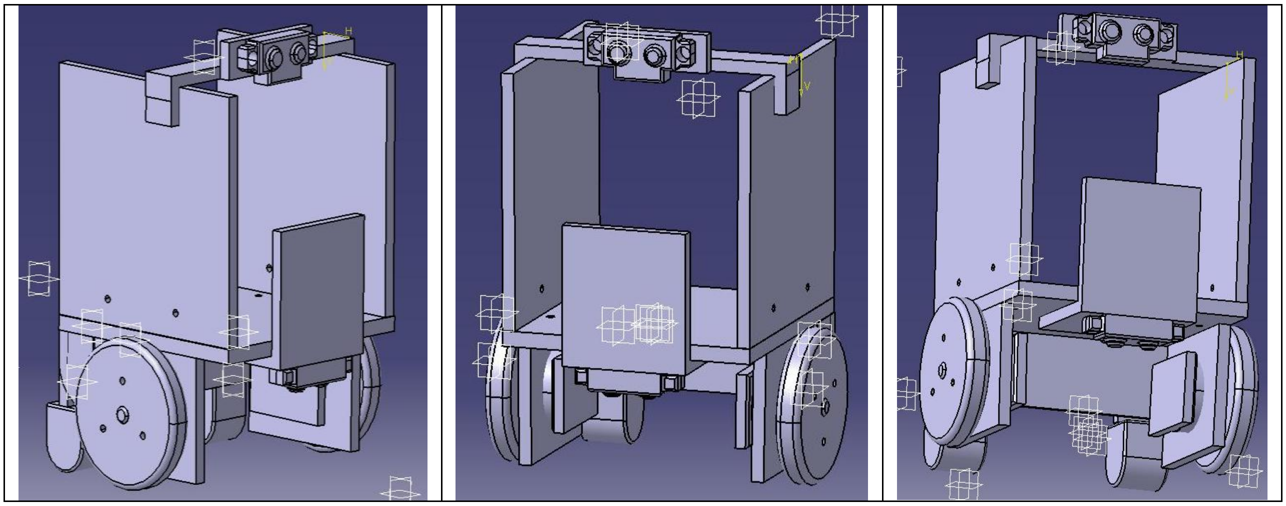

Fig. 9 The prototype robot in CATIA, seen from several angles

In the next two figures it is shown the robot prototype and the components from its structure.

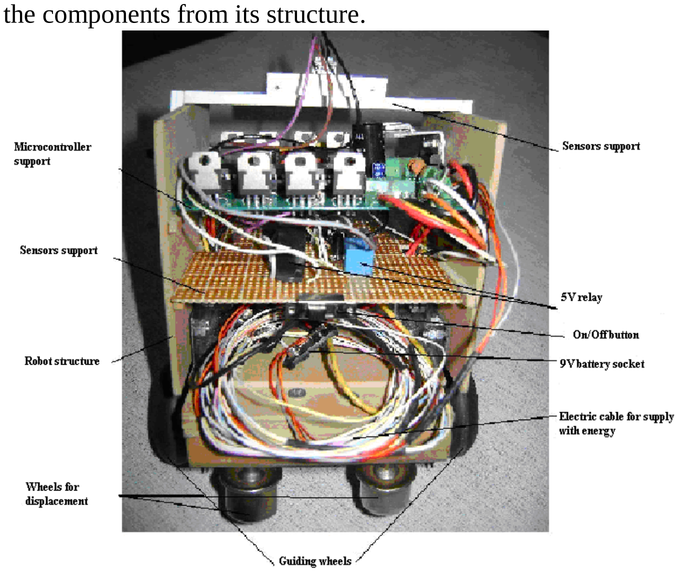

Fig. 10 The structure of the Robot (rear view)

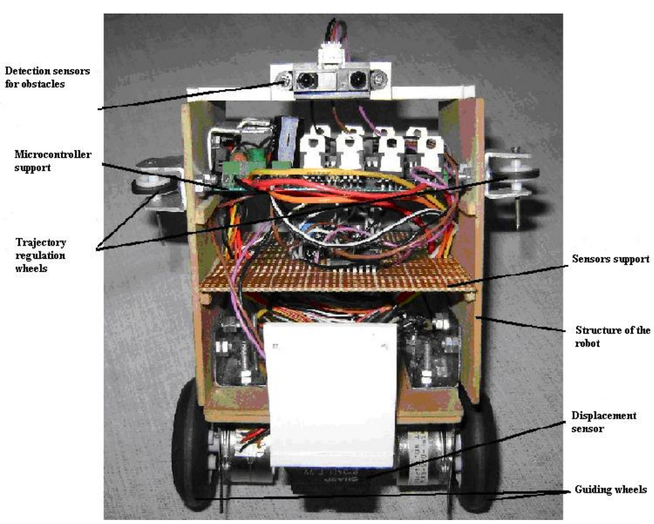

Fig. 11 The structure of the Robot (front view)

In the same time with designing of the robot prototype, we had realized the effective maze, in which the robot will move. The maze scheme is shown in the next figure:

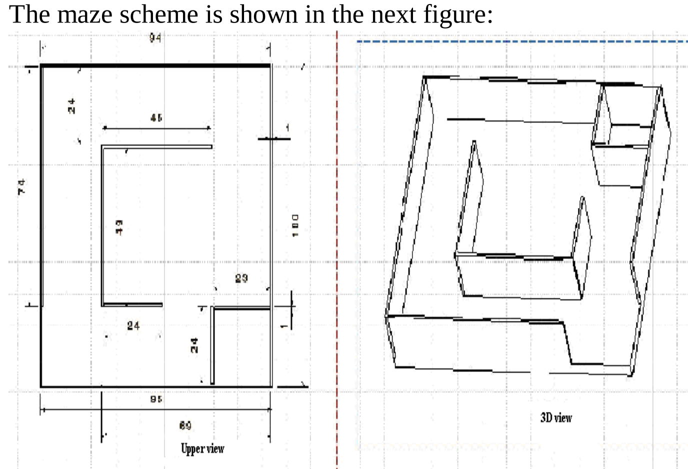

Fig. 12 The displacement of the robot prototype inside the maze (quotations and 3D Projection)

III. Robot Type Operation

Once placed inside the maze, the prototype robot is running. It has a waiting time can be seen easily by following the green LED flashes three times during boot, allowing the operator to be near him for support the supply cable. After this waiting period, if the sensor placed below the surface detects movement, the robot starts. This sensor analyzes real-time presence of surface travel. If the sensor detects an obstacle placed higher at a minimum of six centimeters of the robot, the microcontroller receives the information [6].

At the obstacle detection the robot stops moving and the light turns green again. At this point the robot changes its trajectory with a move to the left by six steps, and then analyzes the presence of obstacle. If the obstacle is still present, it repeats the cycle of changing trajectory, and LED lights whenever the sensor detects the obstacle. If, after changing the trajectory, the upper sensor no longer detects obstacle, the robot continues its forward motion [7].

Thus, after completing the maze, the exit from it, the sensor placed below detects the absence of surface movement and the robot stops and the green light flashes five times, after which all processes are suspended.

Due to construction, the prototype robot can not move in a purely autonomously way, because of supply.

Consumers will also be found in the structure of the robot requires a power that exceeds the capacity of two or three 9V batteries linked in series, and because of the small size of the robot can't be mounted other type of battery. Thus, we used a 24V transformer, 2A, connected to power the robot through a rectifier bridge in DC.

After one realized the 2D and 3D design of the prototype robot, we started by realizing its main skeleton. The skeleton is composed of slabs of pale pressed wood, cut at quotes, and supported each other by stainless steel brackets. The lower supports attached to the main skeleton of the robot were both supportive role of the entire skeleton and stepper motors [10].

The link between stepping motors which induce the displacement of the robot and its wheels is achieved through its gears that are on the axis motors.

The side walls have two pairs of "drawers" made of pale wood, with supportive role of the two electronic assemblies: assembly sensors and microcontroller assembly. At the top of the side walls, outdoor, are placed two mounting type: support shaft and wheel, which serve to guide the robot when it reaches the side wall of the maze.

At the back of the robot is fixed a support made of wood that are fitted with ball bearings that have two stands supporting role and navigation of the entire ensemble. Because the robot can move without slippage or turns uncontrolled, we placed an extra weight on the main board, in addition to the two batteries present.

In front of the robot is fixed a support in the form of "L" of polyethylene, which one attached one of the proximity sensors – Sharp type. This sensor has a controlling role of movement in the sense that the whole robot can move only if the sensor indicates the presence of surface displacement, otherwise the robot stops.

On top of the prototype robot is placed a cross made of polyethylene, which we fixed the second sensor Sharp, oriented to detect in front of the robot.

The microcontroller received from the sensor, information in real time, related to the presence of obstacles throughout the displacement [3], [10].

IV. Electronic Design

The software design interface used is called Eagle Professional (v.5.3.0.). This program is used to create and verify the wiring diagrams and electrical schemes, to create and verify the wiring, electronic components on the plate positioning, targeting signals and their self-running.

The next image (Figure 13) is presented the electronic design using Eagle Professional program interface [8].

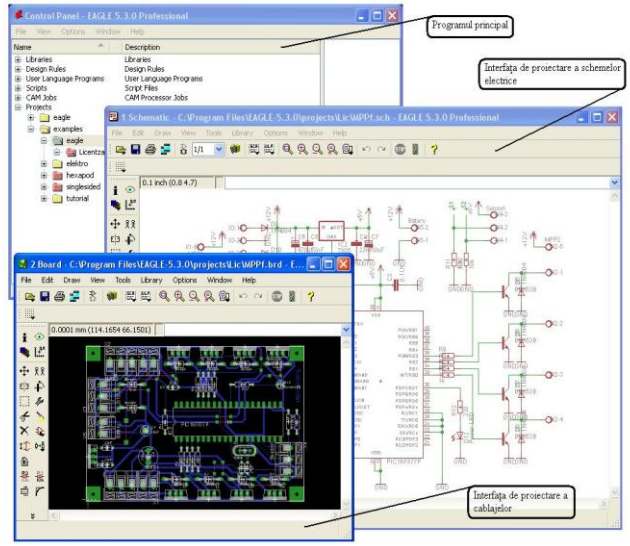

Fig. 13 Eagle Professional Interface (v.5.3.0)

After realized the schematic wiring were results the associated wirings for the two assemblies of the prototype robot. Both electrical and wiring diagrams are related below in Figures 14 and 15.

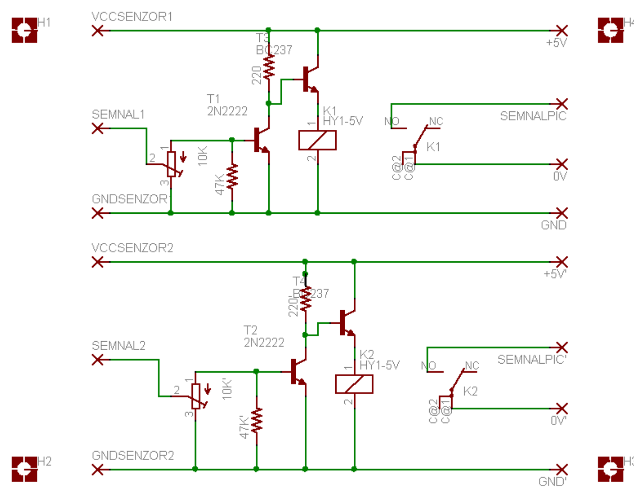

Fig. 14 Diagram of sensors installation

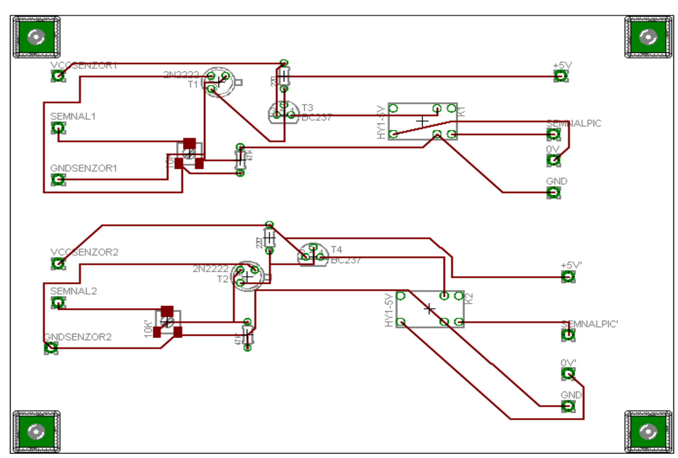

Fig. 15 Sensor wiring installation diagram

One made, first, the electronic assembly sensors because the main purpose was to obtain a range of their work from 0V to 5V, with an amplification and switching in order to successfully control the microcontroller, given that these sensors send a nonlinear voltage.

Fig. 16 Sensor assembly

After one received the proposed outputs from the sensors, one realized the assembly for the installation of the microcontroller, stepper motor control, based on information provided during the displacement.

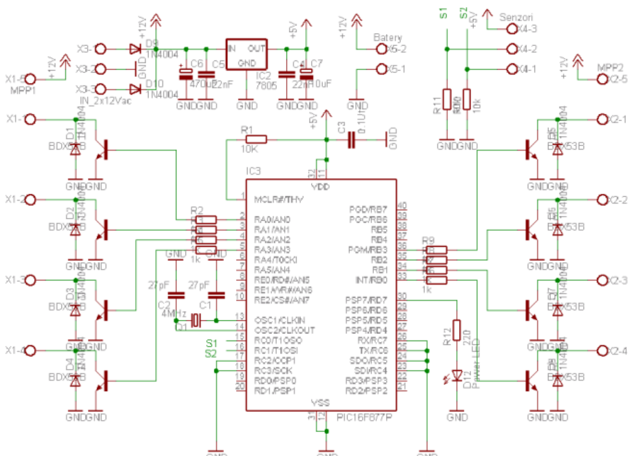

Fig. 17 Scheme for electrical installation of the microcontroller

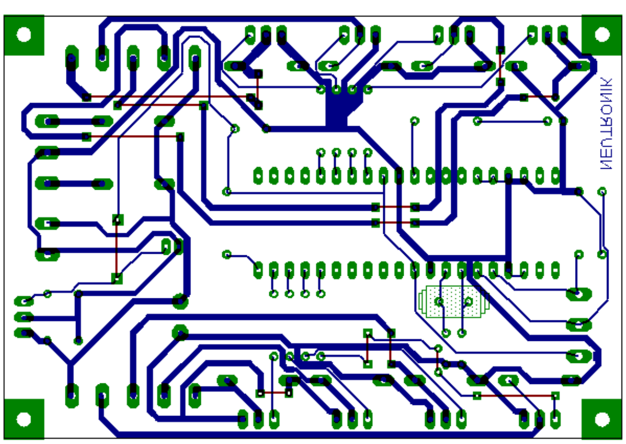

Fig. 18 Wiring installation for the microcontroller

After development, through the photolithographic method, we obtained physical wiring which one drilled according with the circuit scheme. Physical cabling is shown in the figure 19 from below:

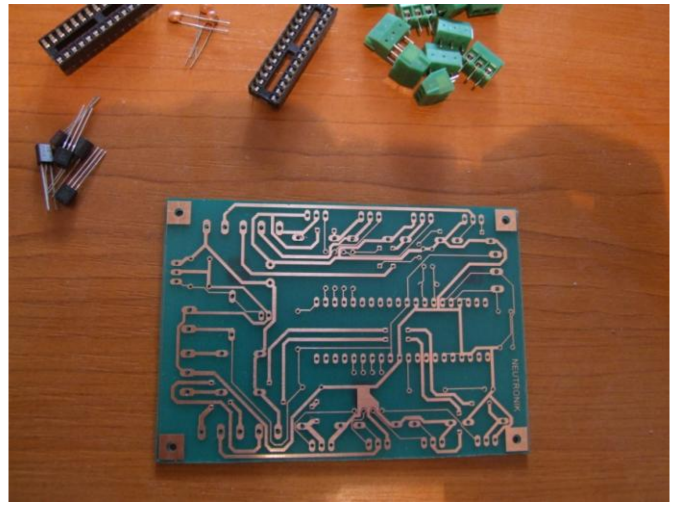

Fig. 19 Wires obtained after the developing

Then, one glued electronic components mounted on board and one obtained the skeleton board prototype robot with sensor assembly, connecting the motors, sensors and feeds according to the schemes, then we connected with the transformer the output feeds [5].

V. Microcontroller prgramming

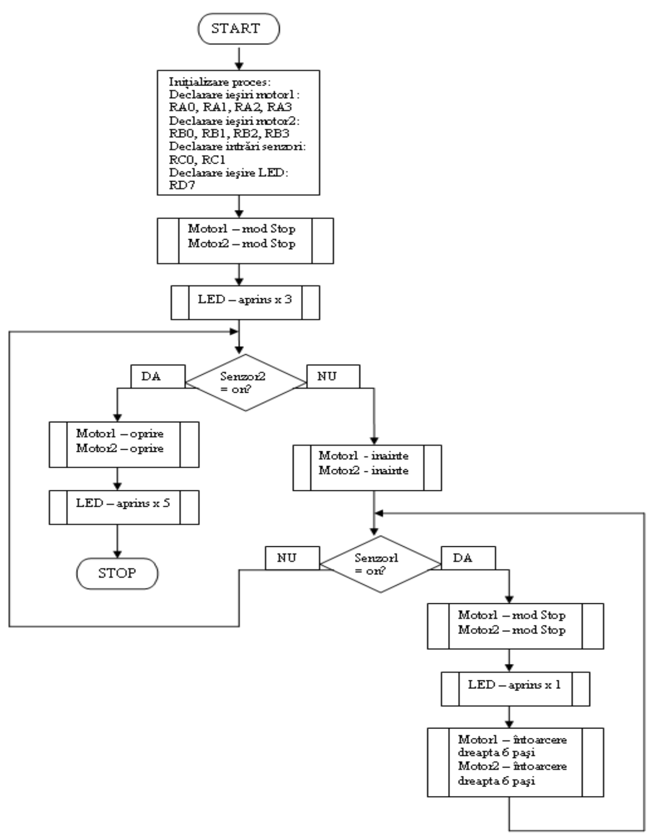

Fig. 20 Logical scheme of the control system

The first step is to initialize a process that includes:

- First engine output declaration;
- Second engine output declaration;
- Input of the first sensor declaration (the sensor placed at the top);
- Input of the second sensor declaration (the sensor placed bellow);
- Output of the green LED declaration.

After initialization, both engines are supplied, but the outputs of the microcontroller is kept zero, because the engines are not moving. Once with the supply of the engine, the green light specific initialization by lighting repeated three times [11].

After this, the first is interrogated the second sensor. If it does not detect the surface displacement is entering into the engine shutdown procedure, after which the LED flashes five times, and the whole system stops. If the surface movement is detected, the procedure goes forward one step, and then proceeds to query the first sensor.

If it does not detect the obstacle, the program continues with the query of the second sensor. If it detects the obstacle is passed to the procedure to maintain the engines stopped, then the LED flashes once and goes to a left turn procedure to six steps, then repeat the query on the first sensor.

Creation of the software application

The software used to realize of program that is implemented in the microcontroller is MikroPascal. MikroPascal is a development application tool for PIC microcontrollers. This software has a rich set of hardware libraries and is an easy way to program the PIC microcontrollers.

MikroPascal is a high level language, as is the MikroC or MikroBasic, which simplifies programming, allowing the writing to a row or several rows of what would require many lines of assembly language program.

Its interface has integrated a compiler and changing of variables and development of the program can be easily followed. The program, after it is completed, is compiled both in the specific format, *. ppas and, also, in traditional programming formats, like *. asm and *. hex.

The following figure 21 is presented MikroPascal interface programming environment.

After the program success compiling in *.hex format, one used IC-Prog (v.1.05.c), in Figure 22, software interface to make possible the loading the program into the PIC16F877A microcontroller.

Programming with this environment software is relatively easy, being necessary to choose the type of component which be programmed, and then to be open the *.hex file to be loaded. The programmer is first connected to the PC and microcontroller is in socket programming [16].

Thus, for programming it choose the "Program All" command, and then to check whether the data were correctly written in memory of the microcontroller it will be selected the "Verify" command.

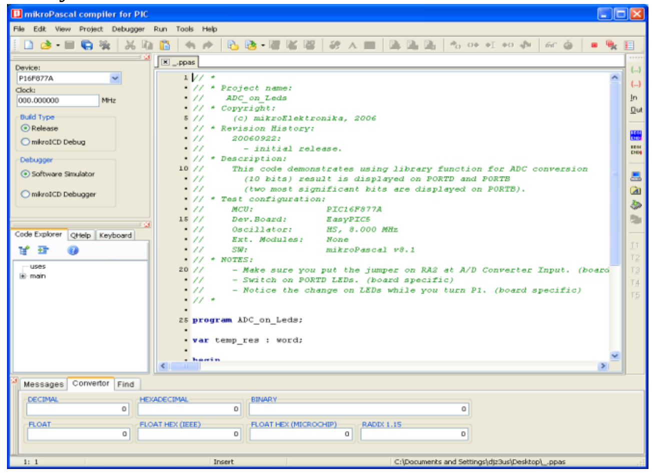

Fig. 21 MikroPascal programming software

Verification can also be accomplished automatically, after writing, if performed a setting into the program options.

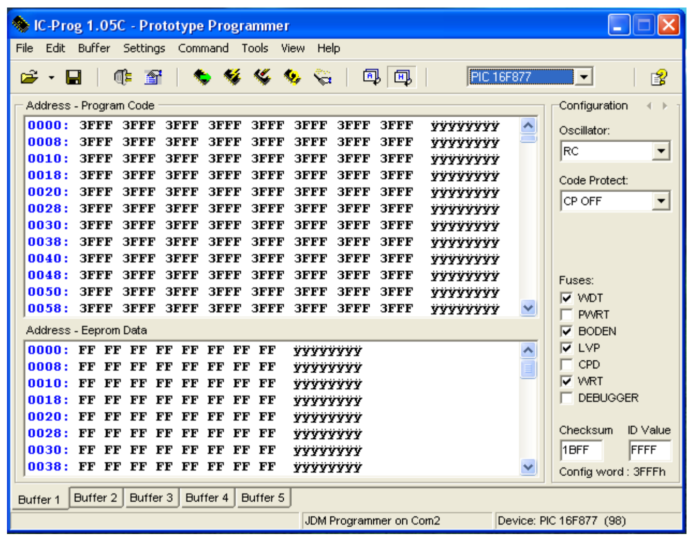

Fig. 22 IC-Prog (v.1.05.c)

VI. Conclusion

Through this work we proposed to achieve an autonomous mobile robot to simulate movement in an unknown environment. With specialized documentation and follow some practical examples, one made the prototype model robot, which is an application with a didactical and scientific goal for the some laboratories. Among the improvements that can be made to the autonomous mobile robot, it lists:

a. Attach an LCD to display in real time: speed, distance to an obstacle that is the direction that he executed the maneuver of return, the real capacity of the power supply;

b. Attaching of a further two sensors to detect the lateral distance between the robot and permanent walls for lateral movement without physical contact between it and the moving environment;

c. Creation of a wheel in the back, and allowing travel on a bumpy road;

d. If one want to switch the automatic control, on manual remote command, using a module guide and on the robot platform being mounted a camera with a microphone to play both images and sounds from the environment travel. On long term the mobile robot autonomy, whatever the environment when they are moving, is constrained by available energy and by the efficiency movement.

These considerations are very important for mobile robots located elsewhere, such as those that are posted on the surface of another planet or in deep oceans, where the recovery or power are impossible. While battery technology is of major interest for mobile robots, but is not reliable over time, are some strategies for energy storage (fuel cells and micro fuel cells), and strategies for harvesting energy from the environment in various forms (solar cells, ocean current temperature, wind powered battery and, also, bio battery), and energy management using sophisticated control techniques to improve power supply costs.

By making an electronic assembly, and designing of a computer program, we proved that a robot can be oriented in any dedicated spaces. In addition, it can avoid colliding with any obstacle that comes in the space of motion. The movement within the maze was an example, but with further research, we can develop the application, useful for practical cases, namely, the movement of the mobile robot in museums, hospitals, gardens etc.

References

[1] Borenstein, J., Everett, H.R., and Feng, L., *Where I am? Sensors and methods for mobile robot positioning.* (J. Borenstein (Ed.)), University of Michigan, 1996.

[2] Bräunl T., Embedded Robotics. *A Mobile Robot Design and Applications with Embedded Systems*, Second Edition, ISBN-10 3-540-03436-6 1. Edition Springer Berlin Heidelberg New York, 2006.

[3] Jong-kyu Kim, Seung Kyu Kim, Hwan-Jung Son, Kwon-Hee Lee, Young-Chul Park, *Structural Design Method of a Control Arm with Consideration of Strength*, Proceedings of the 9th WSEAS International Conference on Applied Computer and Computational Science, ACACOS '10, April 11-13, Hangzhou, China pages 149 - 152, 2010.

[4] Munteanu O. – Robotics – *The Basis of the Un-industrial Robotics*, Transylvania University, Publishing House, Brasov, 2003.

[5] Niola V., Rossi C., Savino S., Strano S., *Robot trajectory Planning by Points and Tangents*, 10th WSEAS International Conference on Robotics, Control and Manufacturing Technology (ROCOM '10), Hangzhou, China, April 11-13, 2010, ISBN 978-960-474-175-5, ISSN 1790-5117, pp. 91-96.

[6] Patic P. C., Ardeleanu M., Popa F., Pascale L. - *Study Regarding the Establishing of Automatic Control Drilling on Micro-robots*, International Conference of the Institute for Environment, Engineering, Economics and Applied Mathematics: Circuits, Systems and Signals" (CSS 2010), La Valetta, Malta, September 15-17, 2010, ISBN 978-960-474-217-2, ISSN 1792-4618, p. 122-127.

[7] Patic P.C., Popa F., Ardeleanu M. - *Control of Automatic Drilling Operations with Micro-Robots*, 10th WSEAS International Conference on ROBOTICS, CONTROL and MANUFACTURING TECHNOLOGY (ROCOM '10), Hangzhou, China, April 11-13, 2010.

[8] Rădoi Constantin – *Electronics and industrial informatics – Practical applications*, Technica Publishing House, Bucureşti, 1997.

[9] Stareţu Ionel – *General Association of Romanian Engineers: "Robotics – Challenge of the third millennium"*, 2008.

[10] Vladareanu L., Tont G., Ion I., Velea L., M., Gal A., Melinte O., *Fuzzy Dynamic Modeling for Walking Modular Robot Control,* Proceedings of the 9th WSEAS International Conference on Application of Electrical Engineering, AEE '10, March 23-25, Penang, Malaysia, p.163-170, 2010.

[11] Zaides E. P. - *Sensors and transducers*, Macarie Publishing House, Târgovişte, 1997.

[12] http://prime.jsc.nasa.gov/ROV/history.html

[13] http://inventors.about.com/od/historyrobots/The_History_of_Robots.ht m

[14] http://www.robots.com/robot-education.php?page=history

[15] http://robotics.ucv.ro/carti/MC/c1.pdf

[16] http://www.ic-prog.com/index1.htm/Ic-Prog.v.1.05.c

[17] http://www.acroname.com/robotics/info/articles/sharp/sharp.html#e8#e8

[18] http://www.datasheetarchive.com/.