IMPLEMENTATION OF MICROMOUSE CLASS ROBOT

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ABSTRACT

This work summarizes development and implementation of Micromouse class robot. Project has three main parts: construction of robot, development of hardware and implementation of control software.

1. INTRODUCTION

There are static and mobile robots. Mobile robots have ability to move. There are many types of mobile robots depending on their purpose. There are transport, manipulating, scouting mobile robots and many other types. Mobile robots are constructed usually with wheel, belt or walking chassis. Mobile robots become very popular on universities and even in public. Robotic websites with tutorials, theory, news from robotics and helpful manuals are in [1] and [2]. Another theory, information and manuals can be found in [3] and [5]. There are also many robotic competitions with many categories. Eurorobot and Istrobot are two big competitions in our region.

Istrobot competition [2] includes three main categories: Micromouse, Path follower and Mini sumo. Participation in Istrobot 2006 competition in two categories (Micromouse, Path follower) was the main goal of our project.

Micromouse is a category where autonomous robots are solving maze. Goal is to find the fastest route to the centre of the maze within time limit. The maze for the contest contains 16x16 cells. Each cell have 18x18 cm dimension. There is more than one way to the centre. Maximum time for one robot to perform is 10 minutes. The time taken to travel from the start cell to the centre cell is called the “run” time. This time considers penalties for touching the robot and for time spent in the maze. Robot with the shortest run time wins. Exact rules are described in [2].

Micromouse class robot is a small robot mostly with differential chassis and stepper motors. Energy source is NiMH or Li-Pol accumulator battery. As a control system is usually used microcontroller or mini-ITX computer. Control system is programmed in assembler or in some higher programming language for example C language. In the Figure 1 are shown small testing maze with 5x5 cells and Micromouse class robot.

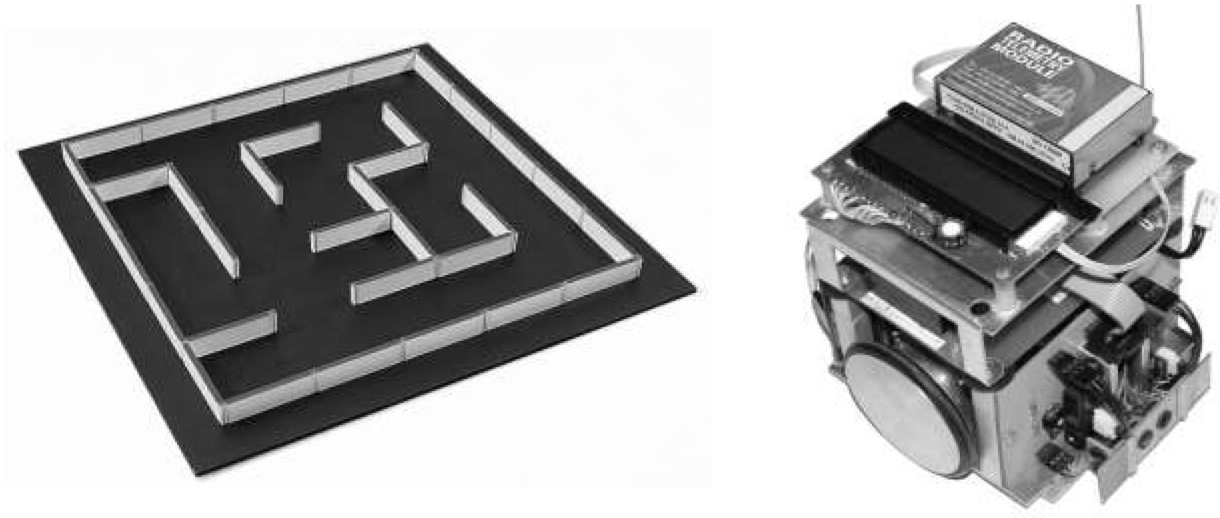

Figure 1: Small testing maze, Micromouse class robot

2. CONSTRUCTION

Micromouse robot is constructed to be suitable for maze. Construction considers maximum dimensions and has ability to maneuver within the maze. Robot is built on differential chassis.

Differential chassis is mostly used solution for Micromouse robots. Chassis has two active wheels. Each wheel has one degree of freedom. This chassis is not suitable for hard terrain, but can turn around on one place and it is easy to control. Block diagram of differential chassis is in the Figure 2.

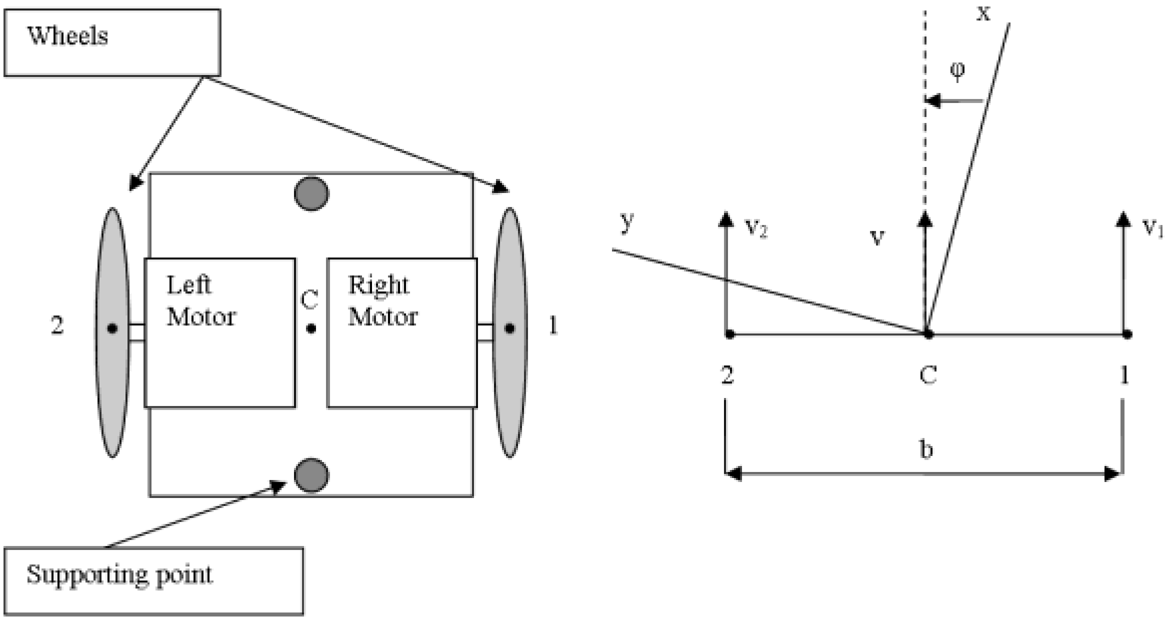

Figure 2: Differential chassis

In the Figure 2 are defined points (1, 2, and C) and velocities at these points. Angle φ is deviation of robot direction from x axis. Wheelbase is defined as b. Wheel radius is defined as r. Rotations of wheels are defined as ω_1, ω_2. Basic equations for differential chassis are shown below.

Velocity of wheels:

$$v_1 = r \cdot \omega_1 \quad [m \cdot s^{-1}]$$

$$v_2 = r \cdot \omega_2 \quad [m \cdot s^{-1}] \tag{1}$$

Center velocity:

$$v = (v_1 + v_2)/2 \quad [m \cdot s^{-1}] \tag{2}$$

Center distance:

$$d = (l_1 + l_2)/2 \quad [m] \tag{3}$$

Angle:

$$\varphi = (l_1 - l_2)/b \quad [rad] \tag{4}$$

Rotation:

$$\omega = (v_1 - v_2)/b \quad [rad \cdot s^{-1}] \tag{5}$$

x axis increment:

$$\frac{dx}{dt} = v \cdot \cos\varphi \quad [m \cdot s^{-1}] \tag{6}$$

y axis increment:

$$\frac{dy}{dt} = v \cdot \sin\varphi \quad [m \cdot s^{-1}] \tag{7}$$

3. HARDWARE

Electronic system of robot is capable of all tasks needed for successful solving maze. Sensory subsystem acquires desired data about walls in maze. Sensory subsystem is made of two analog distance sensors and of three proximity sensors. Control system process data and locates robot in maze. Control system is also responsible for mapping, route planning and motion regulation. The PD regulator algorithm is used for motion regulation within walls of the maze. Microcontroller Atmel ATmega8535 is used as a control unit. Features of microcontroller can be found in [4]. Drivers provide power signals for controlling actuators. These drivers are made of integrated circuits L297 (stepper motor controller) and L298 (power dual H-bridge driver). Actuators are two stepper motors SX16-0503. Motors have resolution of 200 steps per round. This resolution allows good speed regulation with no need of using encoders. Robot is powered by 10 cell NiMH battery. Communication subsystem provides data from robot and achieves basic user interface. Communication subsystem includes LCD display and RF communication module.

Electronic system diagram of Micromouse robot with concrete sensors, drivers and microcontroller is shown in the Figure 3.

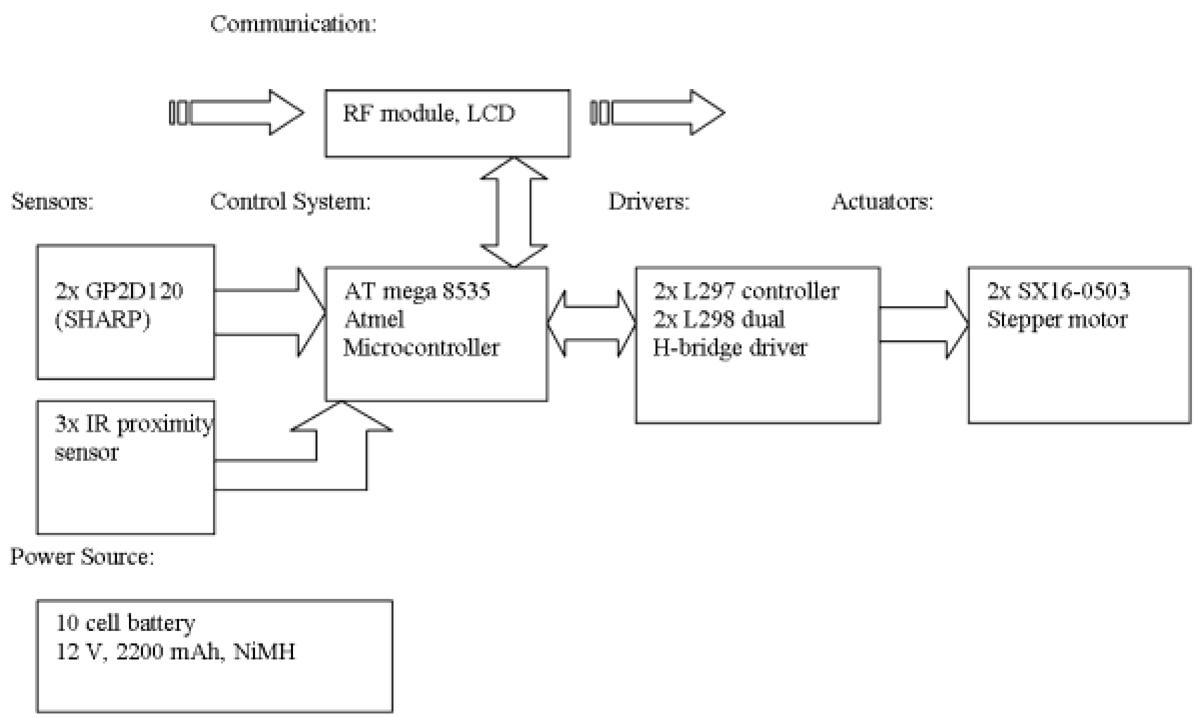

Figure 3: Block diagram of Micromouse robot

4. ALGORITHM

Control program must use some suitable algorithm for solving the maze. Common algorithms for solving the maze are Left hand, Right hand and Flood-Fill. Left hand and Right hand algorithms do not make the map of the maze and do not find the shortest way. These algorithms are not effective in exploring the maze. Some mazes cannot be solved by these algorithms. Flood-Fill is used in our robot because of its features and benefits. Flood-Fill always finds the centre of the maze and finds the shortest route. This algorithm uses mapping.

Basic idea of Food-Fill looks very simple. Flood-Fill assigns value to each cell of the maze. The value is the distance from actual cell to the centre of the maze. Of course we must consider walls. Following Figure 4 shows small maze with filled values. Now we can find the shortest way to the centre of the maze. We start with the value of the start cell. Every time we move to the cell which value is by one less than actual cell value. The way ends in the centre which value is 0. Shortest way is marked with light gray color.

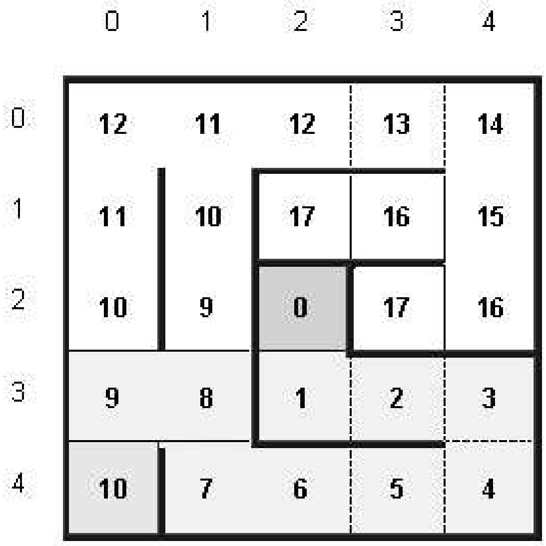

Figure 4: Maze with values

5. CONCLUSION

This project was part of my diploma thesis. I was responsible for algorithm and implementation of control software. My colleague worked on hardware. The product of this thesis was two functional mobile robots. Robots successfully participated in Istrobot 2006 competition. Results were 3rd place in Micromouse category and 4th place in Path follower category. It was quite success because there were about 40 robots in the competition.

This project goes on and these robots are now used for educational purposes such as students' projects. These projects include for example design of new sensory, control, power subsystem or programming new software.

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