Obstacles Avoidance Method for an Autonomous Mobile Robot using Two IR Sensors

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Abstract: ***– The paper presents a local navigation method for mobile robot, based on sensorial information given by two IR sensors. These types of sensors are simple and relatively low-cost sensing modalities to perform navigation tasks in environments with obstacles. On the other hand, IR sensors may be preferable due to their faster response time and can be integrated in structure with microcontroller.***

Keywords: ***mobile robot, IR sensors, behaviors, obstacles avoidance.***

I. INTRODUCTION

Very often obstacles avoidance tasks rely on ultrasonic sensors where the measuring data of the sensors are first used to gain a local representation of the environment in order to afterwards control the robot accordingly [1]. In this context we have distinguish between two fundamentally different types of representation: grid-based representation [2],[3], where the environment is divided into a number of cells which can be occupied or free to a certain degree, and feature-based representation [4], for example the environment is modeled by a set of points, lines and planes.
In [5], image processing is used to detect perspective lines to guide the robot along the center axis of the corridor. Other authors have proposed to use optic flow to guide the robot through corridors.
IR sensors are simple, commonly employed, and relatively low-cost sensing modalities to perform the wall-following task. Sometimes, IR sensors may be preferable to ultrasonic sensors due to their faster response time, narrower beam width, and lower cost. Unfortunately, the intensity of the light detected depends on several parameters including the surface reflectance properties, the distance to the surface, and the relative orientation of the emitter, the detector, and the surface. Due to single intensity readings not providing sufficiently accurate information about an object's position and properties, the recognition capabilities of simple IR sensors have been underused in many applications. Although these devices are inexpensive, practical, and widely available, their use has been mostly limited to detection the presence or absence of objects in the environment (proximity detection) for applications such as obstacle avoidance, counting or wall-following.
There are many papers which propose IR sensors for autonomous mobile robot navigation. In [6] is described the reactive exploration/discovery behavior which was applied to a mobile robot through computer simulation in the UMBRA simulation framework. The mobile robot chosen for this simulation study was a two wheel differential drive vehicle. This robot used eight infrared sensors to detect the surrounding walls, and a compass was simulated to help the robot turns to the desired orientations and travel in a straight line.
The paper [7] describes an incremental evolutionary approach used in the development of a suitable neural controller for achieving robust obstacle avoidance behavior, which is then further fine-tuned towards a wall following one for a simple mobile robot. Obstacles avoidance is based on data acquired from 8 IR sensors.
In [8] is proposed a homing system based on cheap IR sensors that allows docking a mobile robot at the docking station, for automatic recharging or another operations. The homing system is composed of an infrared transmitter and an infrared receiver. The former is located at the center of the docking station and latter at the center of the robot.

II. PRESENTATION OF THE OBSTACLES AVOIDANCE METHOD

An autonomous mobile robot (MR) equipped with two IR proximity sensors is considered. The IR sensors (LS in the left, RS in the right) are mounted in front of the robot, having the orientation like in Fig. 1. The sensors are composed from IR emitter and receiver, and can be controlled so that their covered distance is on three levels (L1, L2, L3 and R1, R2, R3 respectively). On time of the robot moving, that distances will be alternatively set up, in increasing order.

Practically, the robot moving algorithm is based on data acquired from the sensors. In order to plan the mobile robot actions, the flowchart presented in Fig. 2, is used. If neither sensor detects an obstacle then the robot moving will be at maximum speed. When one (or both) sensor detects one (or more) obstacle, at level L3 and/or R3, then the robot moving will be at medium speed. When one (or both) sensor detects one (or more) obstacle, at level L2 and/or R2, then the robot moving will be at slow speed. If one (or both) sensor detects one (or more) obstacle, at level L1 and/or R1, then the robot will turn left or right, depending on the obstacles position and their mission.

Some possible situations are presented in Fig. 3. Depending of the obstacles position the robot will sets its speed to maximum, medium or minimum. When the obstacles is very closed the robot, it will turn left or right, in order to avoid it.

A more detailed presentation of the robot behaviors, which must be activated, depending on possible situations, is presented in Table 1.

The **1** logical signal indicates presence of one (or more) obstacles and 0 logical signal is considered like a free way in that area.

The algorithm can be adapted for situation in which the robot must be moving toward a target, avoiding the obstacles. Of course, in this situation the robot must be equipped with a global navigation system.

III. TESTING OF THE ALGORITM

For testing of the algorithm, the miniature mobile robot Robby RP5 (see Fig. 4) was used [9]. As can be seen in the image, it is equipped with two IR sensors, for obstacle detection, each of them composed from an emitter and a receiver.

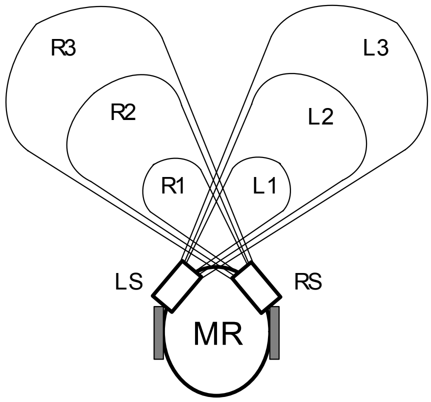

Fig. 1. The positions of IR sensors.

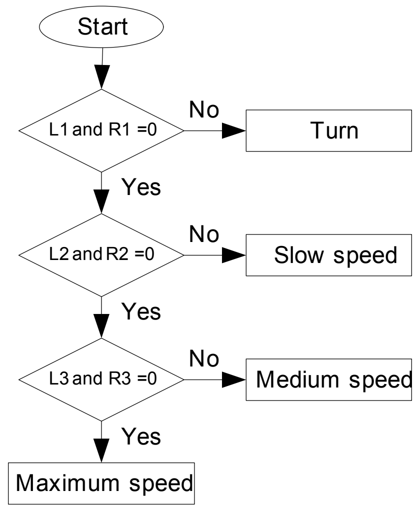

Fig. 2. The actions of the mobile robot.

The distance of area covered by the sensors can be set up on three levels: 30, 60 or 100 cm, respectively.

The locomotion system of the robot is composed from two symmetrical trays. Both of the c.c. motors and the spur gear transmissions are integrated therein. The wheel axles and drive shafts are supported in sintered bearings. Two independently controllable electric motors ensure highest mobility of the chassis.

The robot uses the D/A converters, in this case better referred to as PWM outputs, to switch the drive motor voltage, so that, the speed and direction of each track is freely controllable.

The command system of the robot is presented in Fig. 5.

The microcontroller on the robot is a computer of the C-Control series. This compact unit features universal capabilities for measuring, controlling and steering as well as serial data communication and data storage.

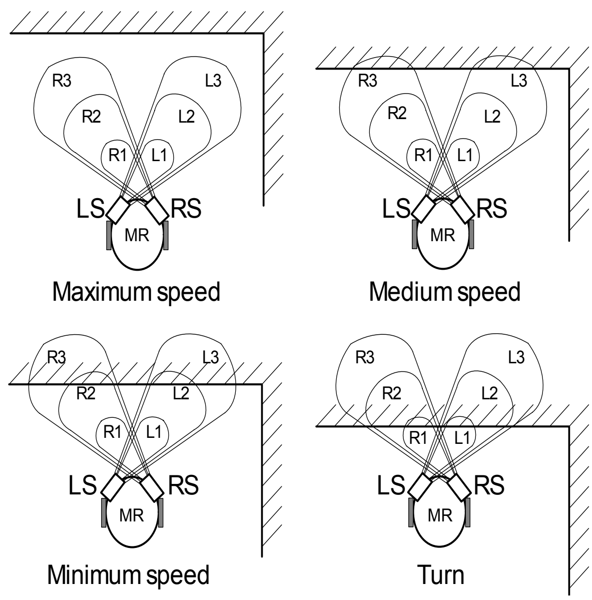

Fig. 3. Example of possible situations.

R3	L3	R2	L2	R1	L1	Obstacles avoidance
0	0	0	0	0	0	Very fast movement
0	1	0	0	0	0	Fast movement
0	1	0	1	0	0	Slow movement
0	1	0	1	0	1	Turn left 45°, then slow movement
1	0	0	0	0	0	Fast movement
1	0	1	0	0	0	Slow movement
1	0	1	0	1	0	Turn right 45°, then slow movement
1	1	0	0	0	0	Slow movement
1	1	1	0	0	0	Slow movement
1	1	1	0	1	0	Turn right 45°, then slow movement
1	1	0	1	0	0	Slow movement
1	1	0	1	0	1	Turn left 45°, then slow movement
1	1	1	1	0	0	Slow movement
1	1	1	1	0	1	Turn left 45°, then slow movement
1	1	1	1	1	0	Turn right 45°, then slow movement
1	1	1	1	1	1	Turn left 90°, then slow movement

Tab. 1. The robot behaviors depending on obstacles position, in case of the obstacles avoidance task.

The microprocessor allows programming in the well-known BASIC programming language. Through a few lines of BASIC (simplification variant CC-BASIC) source code the computer is able to handle a task like the "brain" of a small autonomous mobile robot.

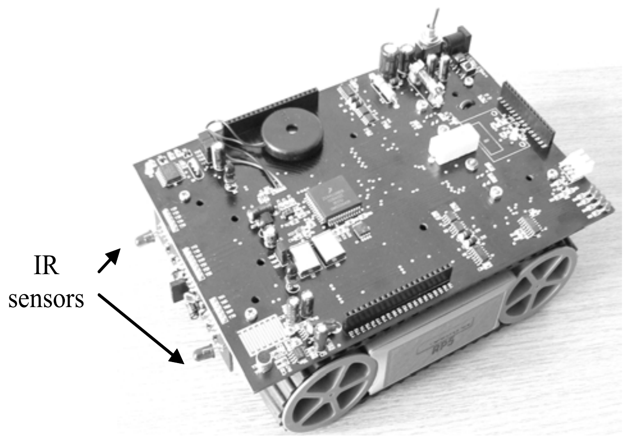

Fig. 4. The mobile robot Robby RP5.

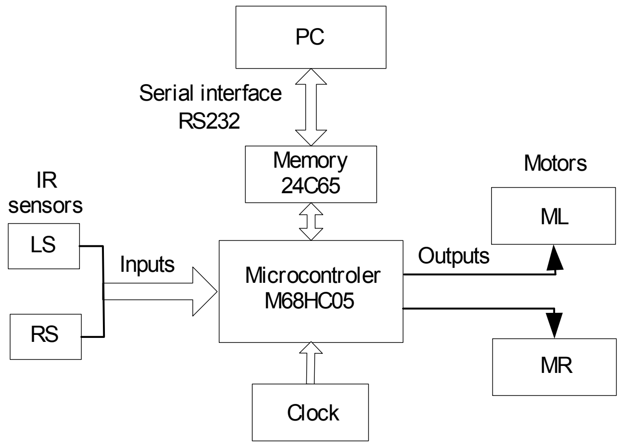

Fig. 5. The command system of Robby RP5.

To communicate with its environment, it has eight analogue inputs, two analogue outputs and sixteen digital port lines randomly usable as inputs or outputs.

The signals given by IR sensors (LS and RS) are directed to microcontroller inputs and the signals commands are used for speed control of DC motor drive. In the same time these signals can be used to turn the mobile robot with different turning radius.

There is an Integrated Design Environment (IDE) for the development of application programs for the robot. The IDE is equipped with a standard mouse-controllable graphical user interface with drop-down menus and allows the development of source code (Editor), translating into machine language (Compiler) and uploading the C-Control program to the robot (Loader).

The developed BASIC program, determining the actions and reactions of the robot, will be translated into a sequence of command bytes by the compiler. The commands and the related parameters may then be transferred via serial interface to the microcontroller, and stored into the EEPROM memory (24C65). The interface connection between PC and robot is only necessary while uploading the program. When the robot is programmed (the program was transferred or uploaded into robot memory), it may be disconnected before starting the robot.

There are commands, as part of the program, whose execution depend on data received from LS (L1, L2, L3) or RS (R1, R2, R3), respectively. Based on these data the mobile robot activates one of the behaviors presented in Table 1 or 2, for tasks like: moving along right (or left) wall or moving toward a target, avoiding the obstacles.

The speeds for motors, in program, are between 0 and 255, so these were set up as following:

- Maximum speed (speed_L=255, speed_R=255);
- Medium speed (speed_L=150, speed_R=150);
- Minimum speed (speed_L=50, speed_R=50);
- Turn 90º (speed_L(R) =255, speed_R (L) =50, t);
- Turn 45º (speed_L(R) =255, speed_R (L) =100, t).

The algorithm was tested in a room having different type of corners and different start positions for the robot (see Fig. 6).

Fig. 6. Experiments with the robot.

When the robot is moving perpendicular toward the second wall it can avoid safety (Fig. 7.a). Some problems can arrive in another situation, when the moving direction is not perpendicular to the wall (Fig. 7.b).

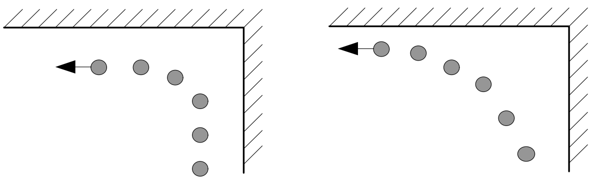

Fig. 7. The robot guidance in corners.

IV. CONCLUSIONS

The resulting time for a complete experiment is relatively short. This is one of the advantages of this algorithm.
But, when the algorithm was practically tested, same errors were registered, due to the signals emitted from one sensor which were received by the other sensor. A solution for that problem is using encoded signals like a remote control uses, so it is possible to know which LED is emitting the sensed signals.
Also, due to the function principle of IR sensors, there are situations when a small or thin object can't be detected. For eliminating this disadvantage a more type of sensors or more IR sensors can be used, but in this case our algorithm must be modified.

REFERENCES

[1]. P. van Turennout, G. Honderd, L. J. van Schelven, ″Wall-following control of a Mobile Robot″, IEEE, International Conference on Robotics and Automation, pp. 280-285, May, 1992.

[2]. J. Borenstein, Y. Koren, ″The Vector Field Histogram – Fast Obstacle Avoidance for Mobile Robots″, IEEE Transaction on Robotics and Automation, Vol. 7, No. 3, pp. 278-288, June, 1991.

[3]. R. Dillmann, J. Kreuzinger, F. Wallner, ″PRIAMOS: An experimental platform for reflexive navigation″, Robotics and Autonomous Systems, Vol. 11, No. 3-4, pp.195-203, Dec., 1993.

[4]. Ben J. A. Krose, Kai M. Compagner, Franciscus C. A. Groen, ″Accurate estimation of environment parameters from ultrasonic data″, Robotics and Autonomous Systems, Vol. 11, No. 3-4, pp. 221-230, Dec., 1993.

[5]. R. Frizera Vassallo, H. J. Schneebeli, J. Santos-Victor, ″Visual navigation: combining visual servoing and appearance based methods″, Proceedings of the International Symposium on Intelligent Robotic Systems, SIRS"98, Edinburgh, Scotland, July, 1998.

[6]. R. Clark, A. El-Osery, K. Wedeward and S. Bruder, ″A Navigation and Obstacle Avoidance Algorithm for Mobile Robots Operating in Unknown, Maze-Type Environments″, Proc. International Test and Evaluation Association Workshop on Modeling and Simulation, Las Cruces, NM, December 2004.

[7]. Dhiraj Bajaj, Marcelo H. Ang Jr., ″An Incremental Approach in Evolving Robot Behavior″, Proceedings of the Sixth International Conference on Control, Automation, Robotics and Vision (ICARCV'2000), Singapore, 5-8 Dec, 2000.

[8]. K. H. Kim, H. D. Choi, S. Yoon, K. W. Lee, H. S. Ryu, C. K. Woo, and Y. K. Kwak, ″Development of Docking System for Mobile Robots Using Cheap Infrared Sensors″, 1st International Conference on Sensing Technology, Palmerston North, New Zealand, November 21-23, 2005.

[9]. www.c-robotics.com.