MOBILE AUTONOMOUS ROBOT

Jaroslav Rozman
Doctoral Degree Programme (3), FIT BUT
E-mail: rozmanj@fit.vutbr.cz

Supervised by: František V. Zbořil
E-mail: zboril@fit.vutbr.cz

ABSTRACT

This paper describes the autonomous mobile robot, created at the Department of Intelligent Systems (DIS). The robot consists of robotic kit, sonars, compass, encoders and camera. It was built to allow students to practically test the algorithms from courses like Artificial Inteligence and Robotics and mainly for their bachelor and masters works.

1. INTRODUCTION

Robotics on DIS is quite new branch established only a few years ago. In the beginning there was a single robot bought from the USA. Students in their works learned how to handle with sensors of the robot, how to create a map of a laboratory and other robotics tasks. The laboratory of robotics was established few years later. It is provided with ten robots and it is used mainly in a new course Robotic and for students' final works. A disadvantage of these robots is that students do not have any chance to change the parts of robots, so their work is aimed only to make the programs which controll the robot via PC. Of course, even so there is a plenty of work they can do. But if they want to learn robotics to its fundamentals, it is necessary to have access to sensors of robot, motors and learn how to program on-board controller. That is why we decided to build another robot.

There are three different approaches to this task. First, we can build the robot by ourselves, including design and manufacturing of chasis and also the on-board desk with microcontroller and I/O circuits. Second approach is to buy a chasis used for example for RC cars and rebuild it to a mobile robot. Last option is to buy some robotic kit and various sensors and to assemble everything together. In the end we decided for the last option as the best one.

2. ROBOT COMPONENTS

Particular parts of the robot are a robotic kit, four ultrasound sonars, four encoders, magnetic compass, camera, accelerometer and a robotic arm.

2.1. ROBOTIC KIT

The robotic kit consists of a chasis, four motors with wheels, three IR sensors, board with processor and I/O pins and board for controlling the motors.

The chasis is made of lexan with aluminum stiffeners. Four motors has extended shaft for connecting encoders and are energized by 7.2V battery pack. The kit is supplied with three IR sensors which measure distance from 10cm to 80cm, but they are reliable only on the beginning of this range, that is why they are usable only as additional sensors. The most important part of kit is BotBoard with a microcontroller. It has 4 analog and 16 digital I/O pins which allow connecting of many accessories. The BotBoard also has three pushbuttons with LEDs, speaker and connector for PlayStation2. The microcontroller in the BotBoard can be Basic Atom, Basic Atom Pro, Basic Stamp and others. This particular robot is equipped with Basic Atom Pro based on processor Hitachi 3664 and programmed by special kind of Basic language developed for this processor. The advantage of this approach is that user can simply handle with I/O pins of the board, I2C interface and can use commands created specially for controlling of the robot. The motors are controlled from BotBoard via Scorpion board, which is dual H-bridge motor controller. From BotBoard are send signals to the Scorpion. According to the length of pulses, which can be from 1ms to 2ms, the motors rotate in one direction (if length is between 1ms and 1.5ms) or opposite direction (if length is between 1.5ms and 2ms), if the length is 1.5ms the motors are stopped. The more the length is to 1ms or 2 ms, the faster are the motors rotating.

Fig. 1: Robotic Kit for Autonomous Behaviour.

2.2. SONAR

Ultrasound sonar is one of the most used sensors in robotic. Robot is equipped with four SRF08 sonars, which allow to measure distance from 3 cm to 6 meters, the duration of measurement is 65ms and the angle of beam is 55°. Sonars are powered by 5V and are connected to BotBoard by I2C interface. Sonars can have 16 addresses therefore it is possible to connect up to 16 sonars and create a ring of sonars around the robot. Sonar has 36 registers and user control it by reading and writing into them. Measuring is started by writing number 80, 81 or 82 into register 0. The results are stored in registers 2 to 35 and are in inches, cm or ms depending on written number, each distance is stored in two registers. Sonar has also light sensor and its result is in register 1. Sonar is capable of measuring up to 17 echoes.

2.3. COMPASS

Because the robot needs to know its direction, it is equipped with compass CMPS03. There are two possible ways how to get direction from the compass. First of them is a PWM signal with length of an impulse from 1ms (1°) to 36.9ms (359°). Second is again the I2C interface. In register 1 is stored a number from 0 to 255 which matches the angle 0° – 359°, and in registers 2 and 3 is a number from 0 to 3599.

2.4. CAMERA

Camera used on the robot is CMUCam2, which was developed on Carnegie Mellon University and uses OV7620 as camera sensor with resolution of the chip of 160x255. The main purpose is the color tracking. It allows tracking of moving objects, or is suitable for a landmark localization, path following and other. To fulfil these tasks the camera can control up to 5 servos. Communication with PC is via a serial port, the speeds can be set from 1.2kbps to 115.2kbps.

2.5. ROBOTIC ARM

Robotic arm LYNX6 can be part of the robot and can be controlled by robot's microcontroller or it can stand alone, because it has its own controller. The controller is SSC-32 and has a microprocessor Atmel inside and allows to control up to 32 servos. The arm has seven servos Hi-Tec and six degrees of freedom. Servos are controlled by length of pulses sent from the controller. The length varied from 1ms to 2ms, which corresponds to the end points of the arm movements. In case the length of the pulse is 1.5ms, the arm is in its mid position. The controlling of servos is similar to controlling of the motors.

Fig. 2: Lynx 6 Robotic Arm.

2.6. COMMUNICATION

Communication between the robot and a PC is via two Bluetooth modules HandyPort HPS-120 connected to the serial port. The range of communication is 100m and the transmit rate can be set from 1.2kbps to 115.2kbps.

2.7. ENCODERS

Encoders, together with sonars, are the most important sensors on the robot. They allow to find out the distance moved by the robot and with sonar they can create the map of the robot environment. Encoders send pulses on channels A and B and, based on their sequence, controller finds the direction of the robot. Disadvantage of this approach is increasing error of position. That is why it is important to check often the position with sonars or with different sensors, which can measure the position of robot.

3. PROGRAMMING

The work on the robot consists of two parts, programming of the microcontroller on robot (and of course assembling of the robot and all wiring) and creating of the program in the PC. Program in the robot has to be made first, because without it, any program in PC would be useless. However, what has to be created first are programs, which will test particular components (as described in Chapter 2) of robot.

The program in the robot consists of infinite loop in which sensors are being read, pulses to the motor sent and data sent to PC. Robot has four sonars which should be fired in a sequence, otherwise sonars would interact with each other. Measurement of every sonar lasts for 65ms, so for four sonars it is 260ms at least. Between this 65ms the pulses to motors has to be sent, because the pause between two pulses for motors should be 20ms. The pause could be longer, but not much, because motors would stop working. The most problematic part is reading from encoders, because each reading consumes time of processor and the procesor can't do anything else at that time. Moreover, from each encoder there are two signals so we have to read eight signals and, because we can't read all four encoders in same time, we have to split it between writing and reading of the sonar. So the sequence of commands in the loop is following (Fig. 3) – writing to the sonar1, sending a pulse to the motor, counting from encoder1 for 20ms, a pulse to the motor, counting from encoder2 for 20ms, a pulse to the motor, counting from encoder3 for 20ms, a pulse to the motor, counting from encoder4 for 20ms, reading from sonar1. This sequence is repeated for all four sonars and after it the measured values are sent to the PC. Except of the values from the sonars and encoders there are values from IR sensors, compass and the state of the battery. But reading of these values consumes minimal time of the processor, so their performing is not critical.

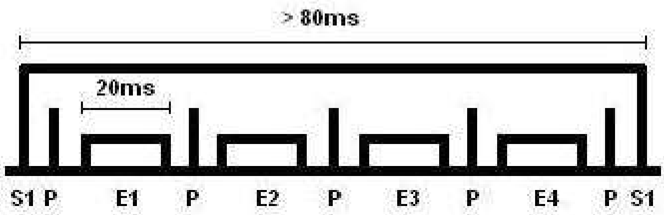

Fig. 3: Timing of measurement of sonar and encoders. Leftmost S1 is start of Sonar 1, P indicate pulse to motors and E1 to E4 are measurements from encoders. Leftmost S1 is end of measuring of Sonar 1.

The program in the PC simple reads values sent by robot via serial port. These values will be used for various tasks, one of them could be map making or path planning. Except from the various sensors the robot is equipped with a camera, which was planned to be used mainly for teleoperation. But, together with the encoders and compass or accelerometer, the camera can be used for map making instead of sonars. Camera would take a picture of robot surroundings and then robot would move a bit, e.g. 30cm, then camera would take another picture. Because the robot didn't move about a big distance, the corresponding objects in both images changed their position only a little, so it should be quite simple to find them and to calculate their coordinates relative to the robot.

4. CONCLUSION

The main purpose of this robot is its use in education of students. They should continue to work on the robot as part of their final bachelor and master project and in the new course - Robotic. The idea is, that they improve the on-board program of the robot and make programs for various tasks, which the robot can execute. Other task is to make program in the controlling PC, which will control the robot and which will be used for map making, localization and path planning or mobile agent systems. Also this program will control the camera and will receive and draw the images from the camera. Part of future work will also be changing the BotBoard for FITKit and re-programming of the camera. The camera can also be used in courses which deal with a computer vision.

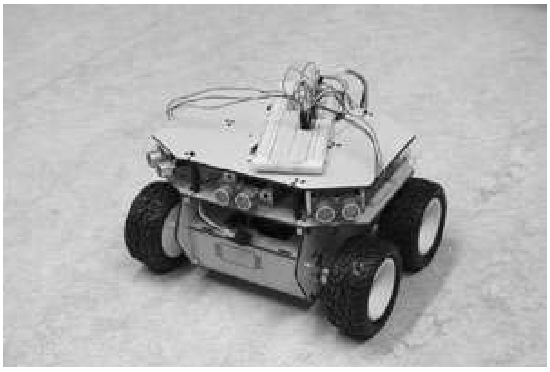

Fig. 4: Mobile robot in laboratory.

ACKNOWLEDGEMENT

This work was supported by the Czech Ministry of Education, FRVŠ project No. 2818

REFERENCES

[1] *Lynxmotion Robot Kits* [online]. c2006 [cit. 2006-03-01]. Available from WWW: <http://www.lynxmotion.com/>

[2] *Total Robots* [online]. c2003 [cit. 2006-03-01]. Available from WWW: <http://www.totalrobots.com/>

[3] *The CMUcam2* [online]. [cit. 2006-03-01]. Available from WWW: <http://www.cs.cmu.edu/~cmucam2/>

[4] *OmniVision* [online]. c2007 [cit. 2006-03-01]. Available from WWW: <http://www.ovt.com/>

[5] *Basic Micro* [online]. C2004 [cit. 2006-03-01]. Available from WWW: <http://www.basicmicro.com/>

[6] *Handy Wave* [online]. c2007 [cit. 2006-03-01]. Available from WWW: <http://www.handywave.com/>