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CONTROL OF THE MOBILE ROBOT USING NEURAL NET
ŘÍZENÍ MOBILNÍHO ROBOTU NEURONOVOU SÍTÍ

Abstrakt

Článek v první části popisuje školní mobilní všesměrový robot, konkrétně jeho řídicí, lokomoční a senzorický subsystém. Ve druhé části je prezentováno řízení robotu pomocí jednoduché neuronové sítě realizované v programu MatLab a jeho Neural nets toolboxu. Uvedený mobilní robot byl vytvořený na katedře robototechniky VŠB-TU Ostrava a slouží též k experimentům s řídicími systémy, komunikacemi a již zmiňovaným aplikacím neuronových sítí.

Abstract

In its first part this paper describes the educational omni-directional mobile robot on the omni-directional roller wheels, concretely their control, locomotive and sensory subsystems. In the following part the control of this robot, by using simple neural net, is presented. The neural net is realized in the MatLab software and its neural nets toolbox. This robot was developed at the Department of Robotics of VŠB - Technical University of Ostrava and it is aimed for education and research purposes in area of embedded control systems, communication and AI based on neural nets.

Keywords: Robotics, Omni-directional mobile robot, Neural nets, Sonar, Digital compass, I2C, Silab C8051F120, CMUcam, MatLab.

Introduction

The actuation of robot is realized with three gear head MAXON DC motors. The omni directional roller wheels are mounted on output shaft of gear heads.

The main task of the embedded control system is data acquiring and preprocessing of the sensor subsystem including communication with the intelligent digital CMOS camera CMUcam1 and the locomotion subsystem.

Robot's subsystems

The robot is divided into some main parts. The robot's "brain" is in the two-level form. The lower part of the control system which is situated on board is the microcontroller. The present version of the control system is based on the C8051F120 microcontroller which the previous control system with the microprocessor SAB 80C537 was replaced. At present – in March 2007 - it is the most powered microcontroller based on the X51/52 family in the world, which managed 100times higher speed in comparison to the standard x51 microcontroller running on the 12MHz oscillator.

Control subsystem

The C8051F120 device is the member of the family of 8 microcontrollers and disposes the highest power and equipment as the digital and analogue peripherals, connectivity, 128k Bytes FLASH memory and On-chip debug circuitry with breakpoints, single-stepping, watch-points, stack monitor, inspect/modify memory and registers.

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Its task is to provide the interface with other subsystems of the robot as the locomotive, sensory, sensory data acquisition and data pre-processing. Its very important function there is communication with the upper level of control system too. The upper level of the control system is PC with a controlling application. This level ensures analyzing sensory data with the neural-nets as well as learning and training of neural net(s). The present controlling software uses the MatLab with the Neural network toolbox and the Visual Basic. The interconnectivity between booth levels is realized either wireless (via Bluetooth module) or by line.

Locomotive subsystem

The actuation of the robot is realized with three gear head DC motors with the encoders which are mounted on the robot double – deck chassis. Every drive is assembled from the A-max 19, Graphite Brushes, 2.5 Watt Maxon motor with the through shaft, worked on nominal voltage 6 Volt. For reducing speed and increasing the mechanical power, the planetary gear head is added (gear ratio: 84:1). The omni directional roller wheels are mounted on output shaft of gear heads.

Every motor there is controlled with the own autonomy microcontroller ATMEL ATmega8 with the power H-bridge IC L298. The microcontroller solves independent speed control with the P- algorithm. The IRC sensor with 16 pulses per revolution is used for speed feed-back there. The communication with these modules is through I2C bus. It means that microcontrollers are “slaves” in I2C terminology.

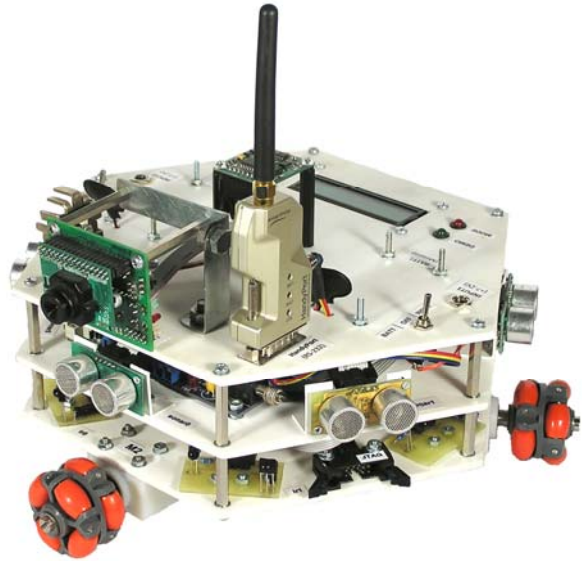


Fig. 3 Omni-directional Mobile Robot

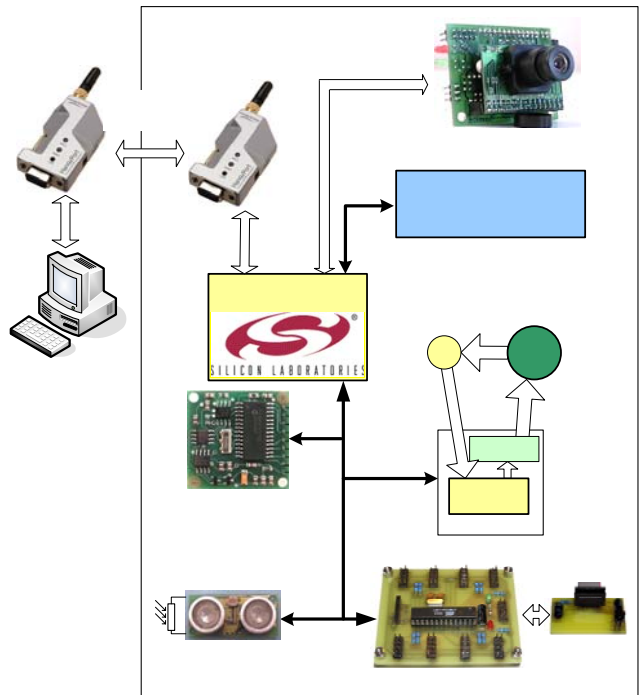


Fig. 3 Robot block diagram

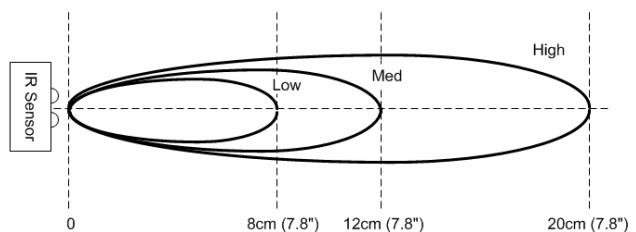


Fig.3 IR near proximity sensor

Sensory subsystem

The most important part of robot is the sensory subsystem. The robot's facility to solve required tasks as obstacle avoidance, learning and repeating path depend on its facilities. The sensory subsystem consists four separate parts.

First are six sonars SRF08 with measuring distance to 6 meters and communicating through I2C bus. Besides it, the sonars are equipped with light sensor too. The sonars are positioned in the middle robot's board – see Fig. 3.

The next part is the module of six near proximity IR sensor, detecting obstacle in three ranges (low - about 8 cm, medium – 12, high – 20 cm) – see in [7]. This module works as I2C “slave” device and communicates through I2C bus too. This module is in the [7] in its right down corner. These IR sensors are placed bellow the sonars - in the bottom board. The advantage of this arrangement there is that obstacles with the various highs can be detected.

The compass module – CMP03 - is used for measuring azimuth angle.

The last part of the sensory subsystem there is the CMUcam1 with the SX28 microcontroller interfaced with an OV6620 Omnicision CMOS camera on a chip [11] that allows simple high level data to be extracted from the camera's streaming video. The picture data are preprocessed in the low level control system – microcontroller C8051F120- and transmitted for analyzing to the upper control level.

Neural network

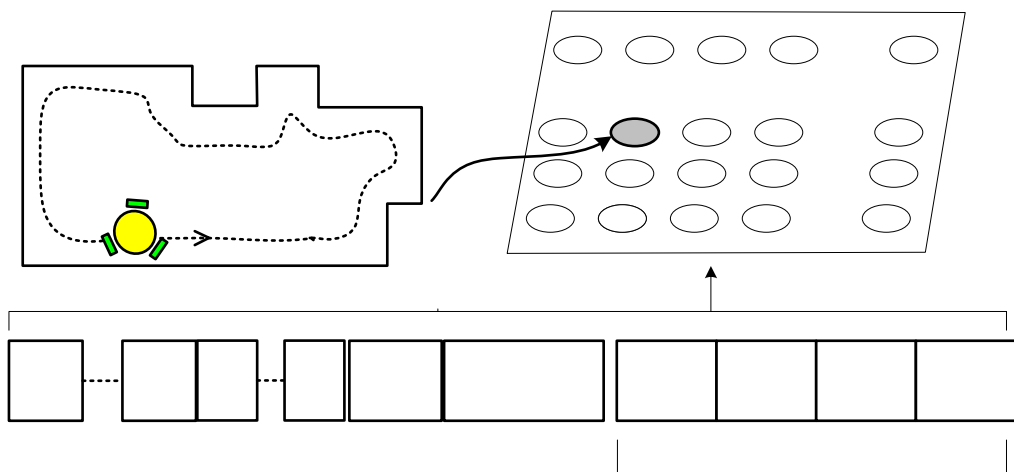


Fig. 4 Input vector for 8 x 8 cells SOFM (with marked a winner neuron of competition)

There are tested various neural nets on this mobile robot. The neural nets are running under the MatLab program. For development, training and debugging of 8 x 8 cells Self-organizing feature map (SOFM) the Neural Network toolbox for MATLAB as map building and orientation is used there. The 8 x 8 cells SOFM works with input vector which consists of 18 items. All items are in one byte integer form. Three items of motor speeds are in signed integer form, whereas the rest of items (sonars, compass and camera) are in unsigned form – see Fig. 4. Number of weights is 1152. The SOFM output is one activated neuron “winner of competition” which represents some of learned robot position in its surroundings.

A linear one-level net was tested as the following model of Neural net. Using this net the mobile robot has been controlled in the autonomy mode. In this case the input vector consists only the data of sonars of the sensory subsystem, which were pre-processed in significantly way

during testing. For example, sonar data were averaged, distances of obstacles measured with sonars were divided into eight regions (0 – 80 cm). Then the converting this data into binary form followed. Then the vector (18 items) is set to net (the net was learned earlier). Outputs are converted to one number from 0 to 7 with specific means, where 0 means robot forward, 1 – robot to left slowly, 2 – robot to left fast etc.

Summary

In this paper the omni-directional mobile robot for education purposes was described. Its several subsystems described as locomotive and sensory were presented. The second part of this paper presents the implementation of the two neural networks models as robot control unit. At first the 8 x 8 cells Self-organizing feature map (SOFM) and subsequently the linear one-level net were tested. Using this second net the mobile robot has been controlled in autonomy mode. During testing both neural nets the pre-processing of the input vectors was very important. Applying only sensory data in raw form isn't suitable. Proper sensory data pre-processing is the „know-how“.

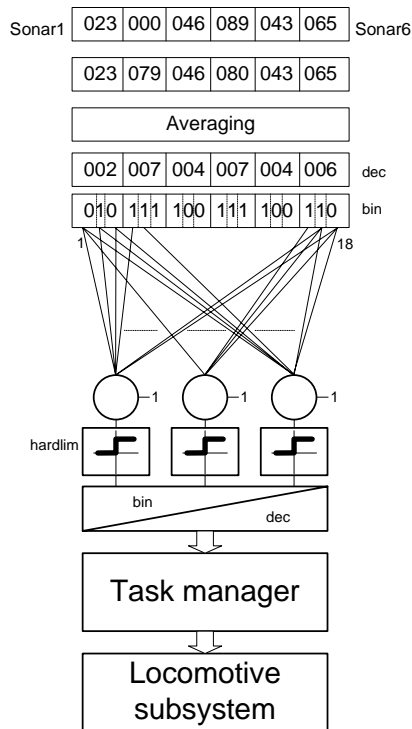


Fig. 5 Input vector for 8 x 8 cells SOFM

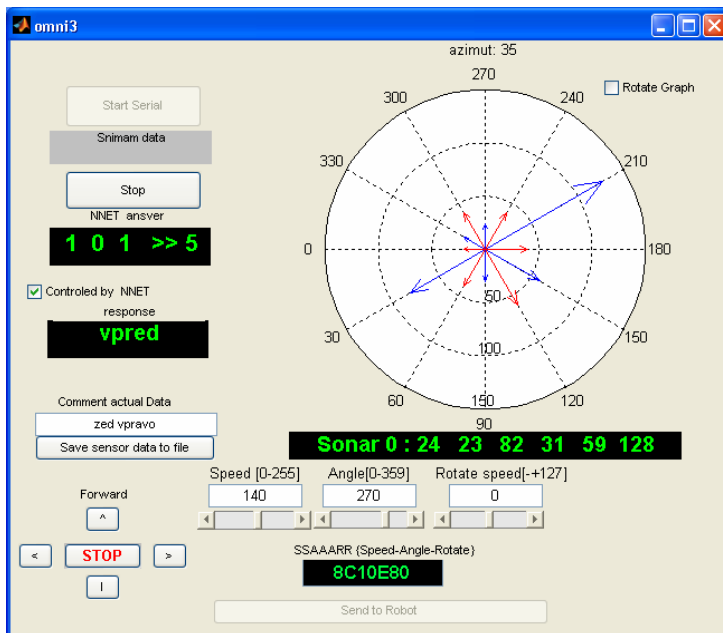


Fig. 6 Robot control software with neural net - MatLab

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