Electronic Platform for Small Robots in Education

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***Abstract*— Robotics is a scientific discipline which needs a high level knowledge in the fields of computer science, as well as electrical and mechanical engineering and high-performance modular control systems. This paper reports the first results of a project that uses a previously developed very small Electronic Platform (Miniboard) for small and simple autonomous mobile robots. This board is used in the education program with bachelor students in their third and fourth semester. It should help them to build robots, like Sumos or Line Followers, so they can get first experiences in robotic. We demonstrate the robustness of this approach in controlling indoor mobile robots for the RobotChallenge in Vienna.**

***Keywords*— wheeled mobile robots, WMR, controlling system, robotic hard and software architectures, RobotChallenge**

I. Introduction

Robotics is a scientific discipline which needs a high level knowledge in the fields of computer science, as well as electrical and mechanical engineering and high-performance modular control systems. This paper reports the first results of a project that uses a previously developed very small Electronic Platform for small and simple autonomous mobile robots. Put simply, the Miniboard consists of a single-processor system which handles all tasks by itself.

To easy the students the entrance into the robotic, a full driver library is supported, e.g. for ADC or Motor Control. In bigger robots, like Line Follower or Mega Sumos the Miniboard can be implemented, as well as in very small robots like the Mini or Micro Sumos.

II. Related Work

Much of the recent work in robotics has used embedded systems such as PC 104 [9], Mini-ITX [8] or RNFBFRA-Board [7]. In contrast to the proposed concept, these systems are very big and have more computing power than needed for small robots. To control actuators or sensors, additional boards are often needed, this also increases the necessary space for the electronic.

These are facts to complicate the design of robots for the students or make it impossible, e.g. if the board has bigger dimensions than the robot is allowed to have.

III. Hardware Design

At the beginning of the development of the Miniboard (as shown in Fig. 1 and Fig. 2) was one main point to design a board with dimensions fewer than 5 cm by 5 cm. Because one goal was to implement the board into Micro Sumo robots and these robots have a dimension of 5 cm by 5cm by 5 cm.

On the board the micro controller ATMega644 [6] is used. Because this kind of micro controller is also used at the Modular Electronic System [1] and so the students get to know the ATMega644. The board is designed to be the stand alone control unit in a small robot.

It can deal with:

- up to two DC brushed motors
- up to 14 digital Inputs/Outputs
- up to four analogue Inputs

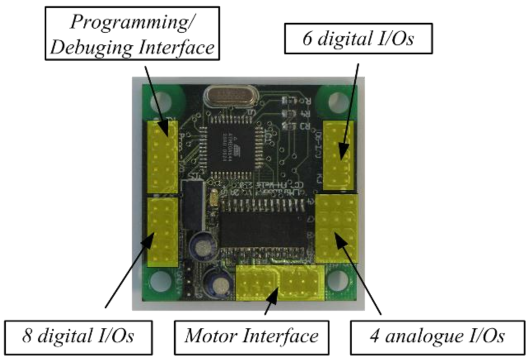

Fig. 1 Miniboard Topview

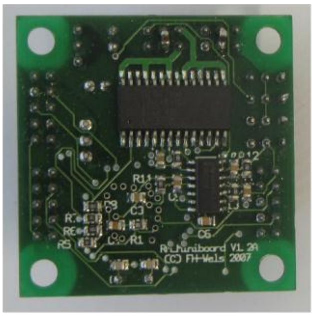

Fig. 2 Miniboard Bottomview

A. Motor Control

The motor board has two full H-Bridges BTS7750G [14] from Infineon to control two DC motors. The BTS 7750G is part of the TrilithIC family and has the following features:

- low RDSon: 70 mΩ high-side switch, 45 mΩ low-side switch
- maximum peak current of 12 A
- full short-circuit protection
- operates from 3.5 V to 42 V
- PWM frequencies up to 1 kHz

Part of the motor control is to manage the speed, the position and the odometric navigation system.

B. Digital Inputs/Outputs

The board supports up to 14 digital Input/Outputs. To these I/Os can be connected various sensors, e.g. infrared sensors to detect a black line in Line Following competition or to become aware of an obstacle or an opponent robot in Sumo competition. Also output interfaces, e.g. LCD interface can be connected.

C. Analogue Inputs

To the board also can be connected up to four analogue input signals. The inputs have a voltage range from 0 V to 5 V and the ADC has a 10 bit resolution. They can be used for measuring the distance to an obstacle or an opponent robot.

These inputs can also be used as digital input or output, if needed.

D. Power Supply

To stabilize the 5 V for the micro controller a LM7805 is used. This kind of voltage regulator can handle an input voltage up to 20 V. The drawback is, at a high difference between input and output voltage the power dissipation is also high.

This is the reason why an additional board was developed. On this board is a step down converter witch can handle input voltages up to 42 V with a power factor from 90 % over the whole input voltage range from 8 V to 42 V. This board can be soldered instead the LM7805.

Usually LiPo accumulators with 7.4 V or 11.1 V are used.

IV. Software Driver

When the students start with there first project, they can use a software library, which set up the whole hardware modules of the ATMEGA644, e.g. the ADC or the timers.

Additional to these low level drivers also high level drivers was developed, e.g. motor control or a cooperative multitasking system. So it is possible to develop software for the main task without dealing a long time to setup the processor or a LCD interface.

A. Motor Driver

The motor driver is divided into different tasks. The first task is to handle the increment encoder and calculate the actual speed and position. Afterwards the software controls the speed and position with a PI-regulator.

To set up the motor controller only the speed and the position have to be set.

B. Multitasking System

To perform more jobs at one time a high performance and self developed cooperative multitasking system [2] is implemented. It provides:

- only 320 byte of code
- only 26 byte RAM per task
- event-triggered tasks
- cyclic tasks
- communication between the tasks with mailboxes

V. Experimental Results

The Miniboard is used in a lot of robots, e.g. Line Followers or Mini Sumos. In this chapter three of them will be introduced.

A. Arrow [3]

Arrow (see Fig. 3) is a Line Follower and participated in 2009 at the RobotChallenge in Vienna.

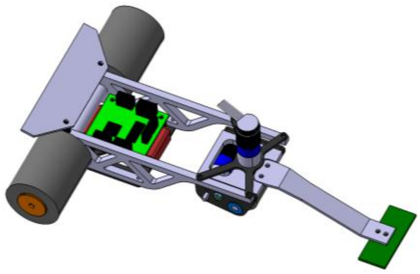

Fig. 3 Line Following robot "Arrow"

It uses both motor ports, one to direct and one to actuate the robot. In the front of the robot is a Printed Circuit Board (PCB) with five infrared sensors to detect the black line. This board is connected to the digital inputs.

B. Dark Knight [4]

Dark Knight (see Fig. 4) is a Mini Sumo robot and participated in 2010 at the RobotChallenge in Vienna.

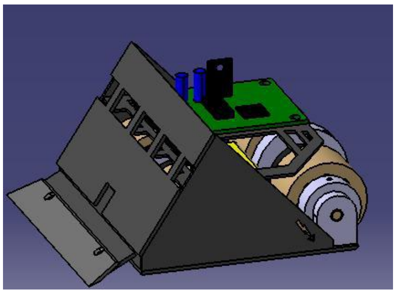

Fig. 4 Mini Sumo robot “Dark Knight”

It uses both motor ports to drive the robot. In the front of the robot are four infrared sensors to detect the opponent robot. These sensors are connected to the digital inputs. The students place a DIP switch on the robot to choose different start scenarios as shown in Fig. 5.

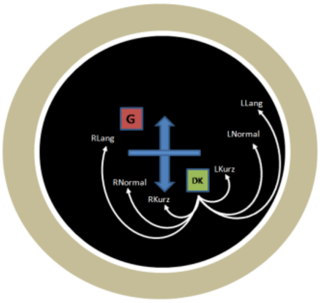

Fig. 5 different start scenarios

C. Dozer [5]

Dozer (see Fig. 5) is a Mini Sumo robot and participated in 2011 at the RobotChallenge in Vienna.

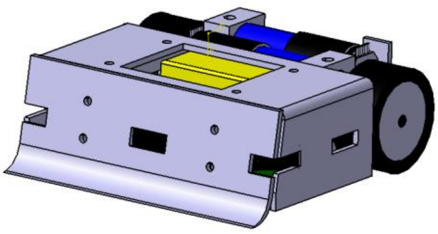

Fig. 6 Mini Sumo robot “Dozer”

It uses both motor ports to drive the robot. In the front of the robot are three and on each side is one infrared sensor to detect the opponent robot. These sensors are connected to the digital inputs.

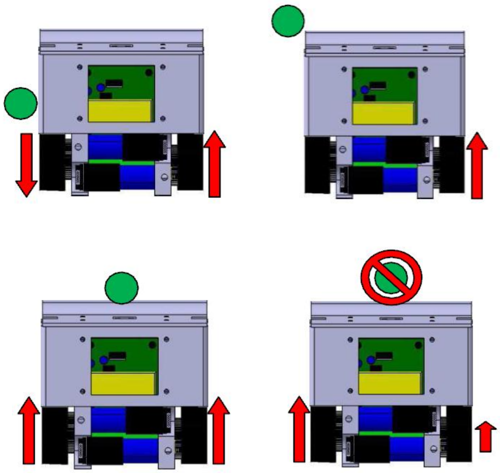

Fig. 7 searching algorithm

Depending on which sensor is detecting an opponent robot, “Dozer” moves hard left, left, forward or right, as shown in Fig. 7.

VI. Further Work

The board works very well and the students were very successful with there robots. A big advantage is the small size of the board, so it can even easy implemented in small robots.

It was developed in year 2007 to participate at the Robot Challenge [11] in Vienna. Students built a Mini Sumo robot that won the first price in Mini Sumo competition and in Slalom Enhanced competition.

Since these time a lot of new electronically parts have been launched, e.g. more efficient micro controller or motor driver.

In the next generation it is planned to use the new micro controller Xmega [12] from Atmel. This controller has 32 MIPS instead of 20 MIPS the ATMega644 has. It also has three full QDEC implemented and lots of other features. It is also planned to use a new motor driver, because the BTS7750G has a maximum switching frequency from 1 kHz. The new type has a frequency from up to 100 kHz.

VII. Conclusions

The Miniboard for the construction of small autonomous robots has turned out to be very useful with a lot of I/Os to connect sensors, actuators or LCD module. With this system it is possible to process tasks at the same time. A LCD module enables the user to carry out changes in the robot, without changing the program and so a connection to an operator station is not necessary. Moreover, important information about the state of the robot is displayed on such a module. The introduced system offers an amount in possibilities to build robots in short time with wide activity field offers for adaptations.

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