MRL Team Description 2011

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Abstract. MRL Small Size Soccer Team with more than three years experience in different international competitions is planning to participate in 2011 world games. After attaining acceptable performance to reach the third place in 2010 competitions, debugging, increasing the reliability and achieving higher accuracy and speed are the next steps in our modifications for this year. Finalizing our debugging tools like 3D simulator and comprehensive user interface in this year aided us to evaluate whole of the system software from low level control to high level strategies. Finally, redesigning the electronic boards and mechanical structure promoted the robot ability in performing more complicated tasks.

1 Introduction

MRL team started working on small size robot From 2008 and after three years we could qualified to be in semi final round and attaining the third place which means that our last year plan was achieved. The main problem in MRL robot in 2010 competitions was its unreliable behavior. Our main target in this year plan is resolving this problem via redesigning the electrical and mechanical mechanisms.

Another goal of our team is improving the speed and accuracy of the motion. Some requirements to reach this target are satisfied with hardware restricting. Other points are considered in motion control approach. New methods in control are designed using abilities gained by evolution of software tools like online debugging and simulator which is detailed more in [2].

This paper is organized as follows: Firstly, software architecture including our new approaches in high level strategies and tools are described in section 2. A new electrical design based on Arm micro controller beside FPGA, and other accessories of robots' onboard brain, is explained in section 3. Description of mechanical configuration modification for the newly designed robot which elevates the capabilities of the robots' smooth and reliable motion is the subject of section 4.

2 Software

In this part the software main objects are presented. It is shown how our new system debugger helps us to design a robust controller and microprocessor programs. In this year MRL software team has been started a new high level analyser project that will be shown in the next section. Our simulator new features will be presented afterward.

2.1. Online internal debugging

As stated before, to debug onboard control modules such as wheels' speed and controller parameters a comprehensive debugging tool is required. Investigation of the commanded velocities and the robot velocities computed via vision and encoder data simultaneously is desired. By using this new approach we can easily debug and analyze our PID controller, wireless module data or any of our internal components. We've designed an online link between our microprocessor and AI systems in order to enable us to debug and maintain all controllers and speed problems easily and in a time optimal fashion. Fig. 1. shows our internal debugger graphical interface. In this figure the mentioned data are shown. If the desired velocity and robot speed measured by vision are similar, the control performance will be suitable.

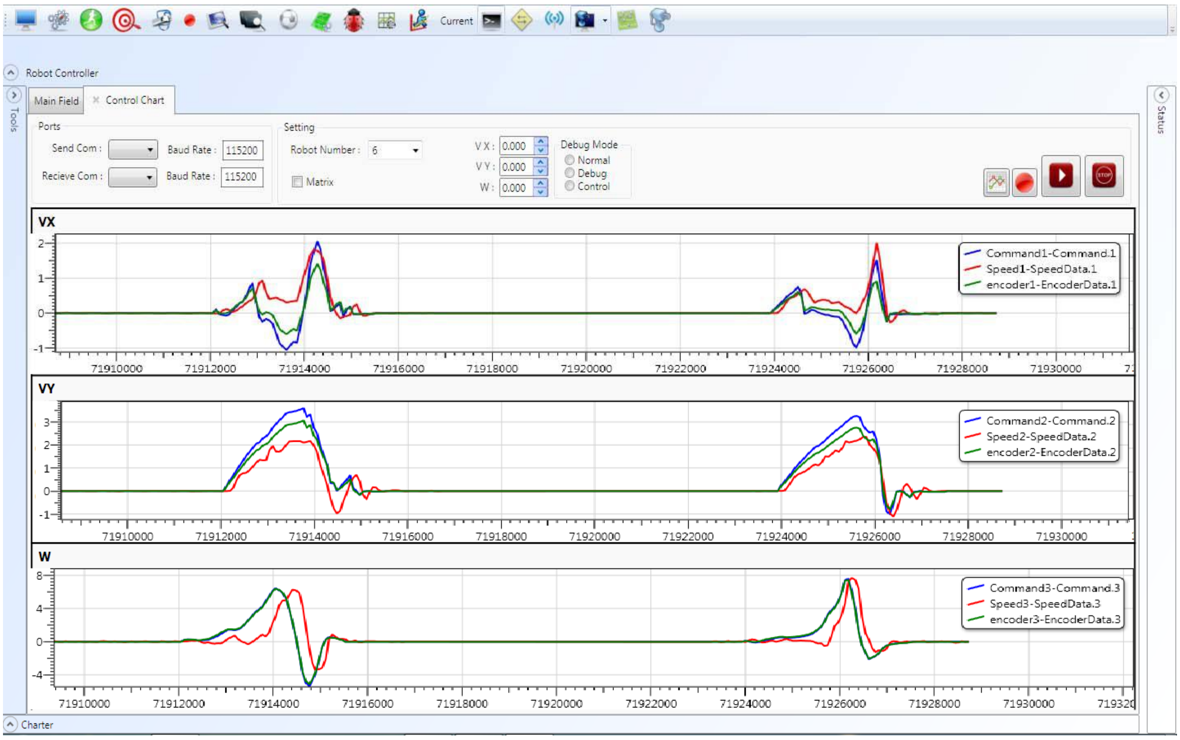

Fig. 1. User Interface of the AI, showing the viewer and settings Box

Previously, we had a unique configuration states for all of the robots without considering differences between them. This year, we have embedded a sub-section to our AI system which stores specific properties of each robot which later would be used for system's calibrations. These properties include controlling issues, kick speed or any kind of configuration parameters.

2.2. High level Analyzer

One of the most significant variations we have made to our MRL2011 team is the implementation of a new decision making layer as a high-level analyser. Log files from SSL Vision of all MRL games should be recorded during a game. The final stage will be extracting the opponent team strategies and finding the best tactic to cope with it. Although, it is too far from implementation, the preliminary steps are under construction. Strategy model consists of different parameters such as the number of robots in each position e.g. defence robots, attackers and free robots. Our goal is distinguishing the best feasible strategy from these models dynamically. For instance, if the opponent team is attacking with one "attacker", one marker robot should be placed to block it. If there are two attackers in non dangerous area (far from penalty area), there should be still one blocker robot. Of course, such high level decision makings can be implemented properly when each task in lower levels could be performed in a perfect manner. Before obtaining such performances a simulator will help the high level designer to evaluate his ideas.

The core system of MRL2011's simulator is the same as MRL2010. One of the significant changes in the simulator is considering noise signals in wireless system. We found that this noise has a close relation with distance. Sometimes data packets aren't properly received by robots. A probabilistic model for data transfer has been introduced to simulate a real wireless system. Measuring lost data compared with the size of sent packets shows a detectable relation with distance between the robot and the wireless transmitter (d). A Gaussian distribution is fitted to the wireless noise with the mean (m) and variance (σ) related to the distance ((1) and (2)). More details about these contributions are explained in [2].

$$m = (1 + \frac{2}{\pi}\arctan(0.4(d-5))) \qquad (1)$$

$$\sigma = 0.03\log(1 + \frac{d}{5}) \qquad (2)$$

3 Electrical Design

The electronic system of MRL team has been designed and developed continuously for more than 3 years. The major changes during the last year are motor driver, wireless communication module and the current sensing system.

Since, the motors have been changed from 24v to 18v - to get higher speed and acceleration – motor driver circuit was changed to make both sections compatible with each other. Also, we have decided to improve our wireless communication because in last year, there were many problems in data transfer. For detecting over current, avoiding motor damage and control usages, current sensors were utilized.

This year, our system consists of a main board and some daughter boards (DB). This approach simplifies the repairing process especially during the matches. Most of the problems came out from the damages happens in Processor Daughter Board (PDB) because of connecting its pins directly to the power systems. To lower these damages, all I/Os were isolated from the power section, using optocouplers [1]. Figure 2 shows the main board and its modules.

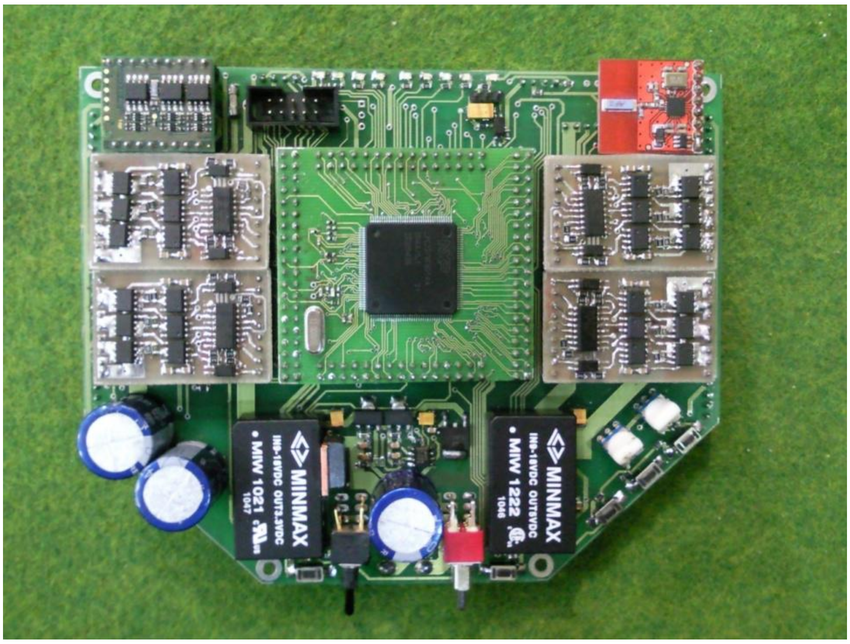

Fig. 2. The electronic main and daughter board

3.1. Processors Daughter Board (PDB)

The same as previous year, we decided to utilize ARM7 microcontroller beside FPGA. It was selected for several reasons such as its powerful debugging capabilities and low-power design of ARM architecture. In addition, the ARM7 with TDMI-S core is one of the best choices for system control. Hence, only real-time tasks such as motor driving are executed in FPGA and all remained parts are implemented in ARM7 microcontroller. Figure 3 represents the relation between ARM and FPGA. According to this figure, the FPGA sends the encoder data and in other side, the ARM microcontroller prepares PWM data for FPGA to drive the motors. The PDB consists of one FPGA and one ARM processor connected to each other. FPGA duty is to control the motors and ARM processor is used to control the FPGA, communicate to wireless, compute control algorithms, debug the entire system and log the data. We used ARM7-TDMI core and developed the project in KEIL software.

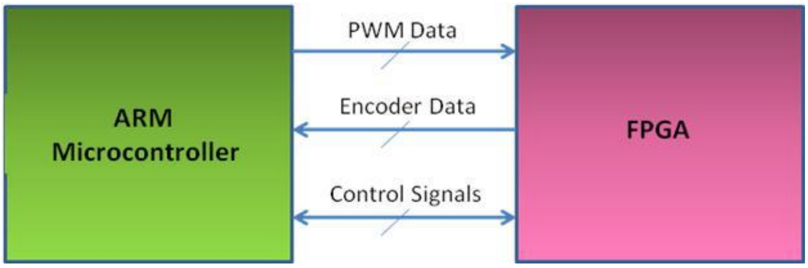

Fig. 3. Communication between Arm and FPGA

3.2. Accessories:

In this section other accessories are described in categorized manner.

1- Wireless Module: The main board receives commands from the AI computer by wireless module. Our communication system is based on the nRF2401 wireless module which is a programmable radio transceiver with a working frequency between 2.4 and 2.52 GHz and a baud rate of 2 Mbit/s. So it decreases the delay of communication to around a few milliseconds.

2- Battery: Each robot uses 4-cells of lithium polymer (LiPo) battery, with capacity of 2200 mAH as a power supply. Robots can run for one game with these batteries. When voltage of batteries reduces, the robot switches to sleep mode and stops working. Of course it was monitored by one LED before reaching to low battery state and by a buzzer to show the critical state.

3- Kicker Board: The kicker board is designed to control the high voltage. It has one MOSFET for charging and two for kicking. An Atmega8 micro controller is used as controller. It creates pulse, limits the charger and communicates with the processor. The board also contains mosfet driver to turn on and turn off the mosfet in nanoseconds which prevents damaging them.

4- Motor & Driver: There are four BLDC (Brushless DC) motors for each robot which is 50 watt Maxon EC45 flat motor and one BLDC motor for the dribbler. Also we use US digital hollow shaft encoder with 360 pulse/cycle resolution to detect the motor speed. All motors except dribbler ones are controlled by FPGA and custom designed driver. For dribbler motor we used MAXON amplifier which is reliable and compact.

5-array sensor: For recognizing the ball position in dribbler and distance of the ball from dribbler, an array of IR emitter and receiver sensors were used. This module is useful when robot tries to get accurately behind the ball.

4 Mechanical Design and construction

The mechanical system of small size robot consists of wheels, kicker, dribbler and motion system. Some problems in the previous design encouraged us to change the materials and mechanical design.

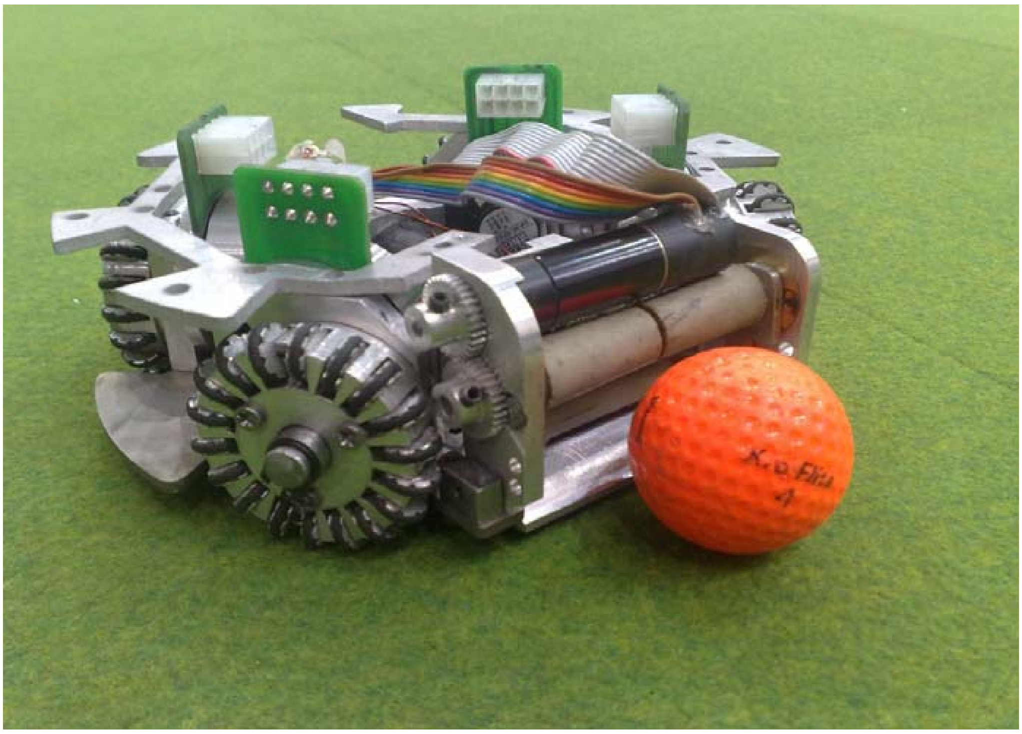

Fig. 4. Robot 2010 mechanical structure

After changing the motors, the optimal radius of the wheels will vary. Calculating it for our new robots resulted in 29 millimeters for which are made from aluminum alloy. Thus, more O-rings can be used to make the omni directional characteristics of the wheels made from Neoprene. Each wheel has twenty rollers. Other data about the motor wheel structre are as our previous verion [4].

The robot uses dribbling system to improve the capability of ball handling, dribbler is a shaft covered with Silicon tube and connected to high speed brushless motor shaft, Maxon EC16 Brushless, with 1:1 gear ratio. The MRL2011 robot has ability to kick the ball up to speed of 12m/s . The robot has also the custom-made flat solenoid for chip kick system which is attached to chassis, under the main solenoid. The chip-kick has a 45 degree hinged wedge which is capable of kicking the ball up to 4m before it hits the ground.

Fig. 5. Wheels of (Left) MRL2010, (Right) Designed wheels for MRL2011

References

1. A. Azidehak, M. Hoshyari, M. A. Sharbafi "Design and Implementation of Minimal Components Brushless DC Motor Driver for Mobile Robots" 2011 IEEE International Conference on Mechatronics, Istanbul, Turkey, (2011).
2. Bakhshandeh, O., M., Sharbafi, "Modeling and Simulating of Omni Directional Soccer Robots" 2011 IEEE 3rd International Conference on Computer Modeling and Simulation (ICCMS 2011), Mumbai, India, (2011).
3. Sharbafi, M. A., Hoshyari, M., Esmaeelpourfard, S., Bakhshandeh, O., HaajSeyedjavadi, E., Esmaeeli, D., MRL 2010 Team Description, In Proceedings of the 14th International RoboCup Symposium, Suzhou, China, (2008).