

# MRL Small Size 2008 Team Description

Omid Bakhshandeh<sup>1</sup>, Ali Azidehak<sup>1</sup>, Meysam Gorji<sup>1</sup>, Maziar Ahmad Sharbafi<sup>1,2</sup>,

<sup>1</sup> Islamic Azad University of Qazvin, Electrical Engineering and Computer Science Department, Mechatronics Research Lab, Qazvin, Iran

<sup>2</sup> University of Tehran, Electrical and Computer Engineering Department, Tehran, Iran  
m.sharbafi@ece.ut.ac.ir

**Abstract.** This paper describes MRL Small Size Soccer Team activities in mechanics, electronics, software and Artificial Intelligence. A summary about each part presents in this paper to make reader familiar with our contributions. Locomotion design and kicker system is described in mechanics, wireless communications and controller make the electronic section and software includes interface and decision making. The reinforcement emotional learning based motion control and neural network used in vision are expressed as Artificial Intelligence approaches separately.

## 1. Introduction

Robotics is the center of attention of many researchers these days. The reason is that it can include mechanics, electronics, artificial intelligence, Image processing, control and many other fields of research. Therefore In this paper, we describe our approaches to these different challenges which we would use to participate in RoboCup 2008 small size soccer Competitions.

After two years MRL team was reconstructed with new members with grateful experiences in other RoboCup competitions. In fact this team contains a combination of two groups attaining the first place in Rescue Simulation and Junior Soccer league in two previous RoboCup competitions in Germany 2006 and USA 2007 repeatedly. MRL and Espadana were joined to establish a team with significant quality both in software and hardware areas. Our aim is examining some new approaches especially in Artificial Intelligence and introducing innovative attitudes in this field of research.

This paper is organized as follows: software architecture will be described in section 2. Electronic design which makes the structure of robots' onboard brain is explained in section 3 and in the next section the robots' mechanics skeleton, with the goal of achieving the most favorable characteristics, is illustrated. Using AI in robot motion control and vision will be presented in section 5.

## 2. Software

Starting with software description, our attitude to manage the robots will be presented in this section. Software system divides into four main parts, namely, Interface, Decision Making System (DMS), Vision and Motion Control which two last ones are explained in section 5.

Role of Interface part is transferring data between robots, referee box and software control center. This part gathers the sensor's data, sends them to the managing center and informs actuators from control commands.

All of the commands, required to act by robots, are extracted from DMS as the director of the robots. Regarded to whole situations of robots and actions that can be performed, DMS decides to allocate actions to them. In other words, it designs the strategy of the agents according to their perceptions of the environment.

Decision Making consists of the five parts: World Model, Strategy Module, Planning Module, Action Executer and finally Path planning (Obstacle avoidance).

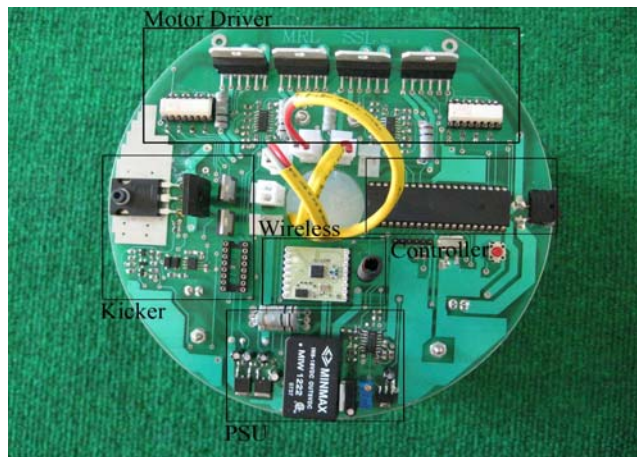
World model module states environmental conditions. Because RoboCup Small Size environment is fully observable, world model perceps all circumstance changes. It has the knowledge of the locations and orientations of robots, including teammates and opponents, and ball position. Next part, strategy planning module, states general game strategy, roles of the robots and targets according to the information comes from the world model. Many coordination algorithms inspired from real world and learning based ones, utilized in soccer 2D make our another approaches [1].

Action Executer generates appropriate actions for robots. And finally models these actions to be understandable for machinery structure of the robots.

We use a simulator to test our algorithms in order to save time and costs. DMS can connect to simulator and robots simultaneously. Currently we use ODE as the physics engine, but in order to handle new tests that require better 3D environment (like cheap kick); switching to Microsoft Robotics Studio will be done in near future.

### 3. Electrical Design

One of the main parts that its reliability has an important role in creating a footballer robot is its electronics' design. Figure 1 shows the elements of the board and different modules are depicted obviously in it. As it can be observed in this schema, the electronic circuit consists of five parts which are Power Supply, Motor Driver, Kicker, Wireless Communication and Controller.



**Fig 1.** The electronic board schematic.

### **3.1. Power Supply**

Power Supply Unit (PSU) is one of the most significant sections. Using DC/DC converter besides isolating the control and wireless communication sections from power section (PS) increased the reliability of the circuits. PS required voltages are 5 and 12 volts but logic segment needs 2.5, 3.3 and 5 volts. Because of the large area needed to implement it, we used SMD devices. Opto-Couplers are also used for connecting them to each other.

To provide the required energy, Li-Poly batteries were chosen. The most important point about these batteries is ease of damaging. If voltage of battery drops below 3(V) or crosses the limit of 4.2(V), the capacity will be wasted. Therefore voltage monitoring is necessary to protect batteries. Current measurement is required to know the battery charge and to work in the safe area of batteries too. The advantages of this kind of batteries are their low weight, ability to produce high current and speed of charging process.

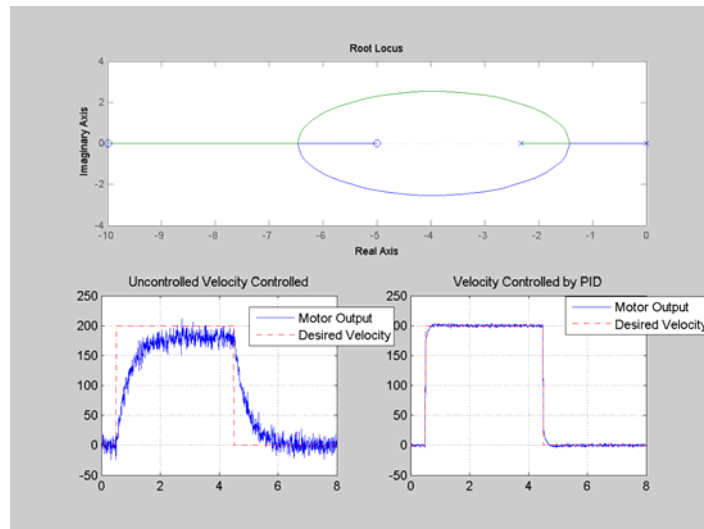
### **3.2. Motor Driver**

To control the motors we used L6203 Power Mosfet Drivers. Using the angular velocity by means of differentiating of the encoder output and designing a PID controller via Ziegler-Nichols method, results in a desirable velocity control of motor. Although noise, saturation and dead zone make some perturbation in velocity control, robustness of PID controller compensates most of it. Figure 2 shows the root locus and step response of our controller for one of the motors. The suitable performance of this controller is observable in this figure.

Current limit is applied to minimize the slips of the robots. As mentioned above all drivers were coupled by opto-couplers.

### **3.3. Kicker**

For kicking the ball by a solenoid we need high voltages and Capacitors that can supply high currents. We use two 1800( $\mu$ f) and 200(volt) capacitors connected series to each other. The charger, charges them up to 350V in 7 seconds and it makes a great kick by a small solenoid. The main problem was heat caused by the charger and it must be cooled down by a big heat sink. For discharging, Power-Mosfet Transistor is utilized and keeping it high for some milliseconds causes different speeds.



**Fig 2.** Root Locus of the motor and controller (top), uncontrolled angular velocity (bottom left), angular velocity controlled via PID (bottom right).

### 3.4. Wireless Communication

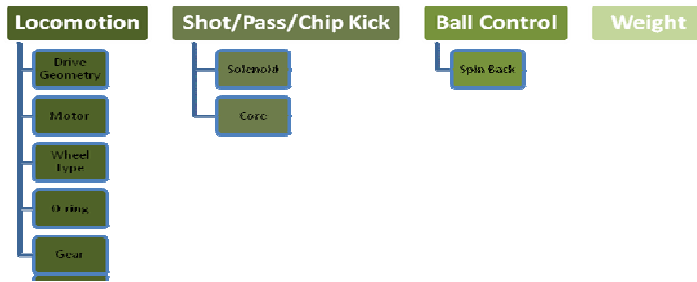
Communication from DMS to robots performed by wireless modules that work in carrier frequencies from 430 to 440 MHz performing multi-channel data transmitting. This Module (RXQ2) directly connects to serial port and behaves like UART. It means you can send data without caring about wireless niceties like CRC, antenna tuning and etc. Only remaining thing is packing data into data packets and throw it.

## 4. Mechanical Engineering Subgroup

Mechanical engineering subgroup is in charge of design, execution and physical improvement of different parts. Figure 3 displays responsibilities of this group.

### 4.1. Specifications designed for Robot Motion

Our current robots have 3 wheels and are powered by brushless motors drive system with customized omni-directional wheels. Omni-directional motion can be achieved with three or four wheels which are placed in a triangular or rectangular arrangement. Because of the shortage of time and facilities, three wheels structure was chosen to begin the team activities in other fields (figure 4). Simultaneously we developed four wheels, but unfortunately because of delays in receiving required instruments like motors and encoders we can not switch to them and the description of designs will not be appeared in this section.



**Fig 3.** The mechanical important duties.



**Fig 4.** MRL Small Size Robot scheme

#### 4.2. Structure needed to work with ball

One of the most difficult problems is settling of two kicking mechanisms in a small area. One kicking mechanism serves for kicking hard directly and the second kicking mechanism exhibits a chip-kick effect that allows us to throw the ball over opposing robots. Kickers are settled between four motors.

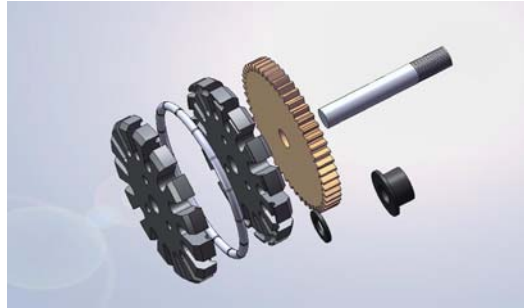
The nature of dribbler spin-back is chosen to have a high friction coefficient so that the robot is able of holding the ball without dropping down it during its movement. To gain this goal, we use a highly flexible plastic tube which is utilized in photocopy machines to take the sheets.

#### 4.3. Wheel

One of the effective parts of the robot structure is its wheels' design. Suitable design of wheel can simplify the motion and improve the accuracy of motion control. The 3D view of each wheel has is displayed in Fig 5. Our omni-wheels consist of inner hubs, with aluminum alloy roller rings which have O-rings stretched around.

Because of goods purchase restriction, we could access only some materials of O-ring. Available Materials are Viton, Polyurethane, NBR and silicon rubber. Most significant factor in selecting O-ring is having good tear resistance at high speed rota-

tion of wheels and high friction coefficient against the carpet. Thus, we tested coefficient of friction in identical state for available materials.

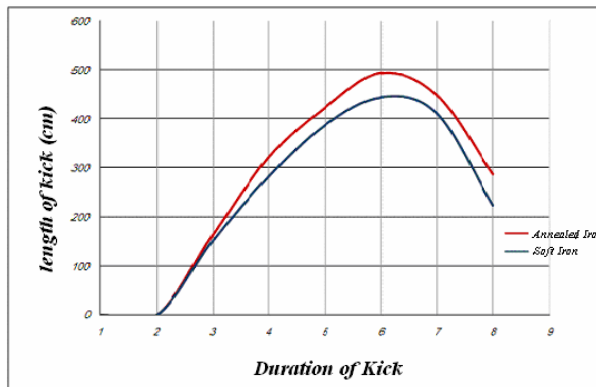


**Fig 5.** The elements make the wheel.

To compare different O-rings, we built a platform which was set against the wall with a single motor and wheel module. The goal of this test was obtaining the voltage at which each wheel slips on the carpet. Examining different types, silicon rubber is selected from mentioned material. In its ingredients, the siloxane backbone different extensively from the basic polyethylene backbone, yields a more flexible polymer. Tensile strength, elongation, tear strength and compression set can be far superior rather than common rubbers. Since more friction between robots and carpet is desirable, it is decided to drill O-rings with thin hot nail. This method yields to friction increase, leads to gain maximum acceleration and makes the robot quick and agile.

#### 4.4. Solenoid

For each kicking system, containing direct and chip kick, a “push” solenoid considered that pushes a soft iron rod. In chip kick system, rod of solenoid pushes a titanium alloy sheet which is jointed to the chassis and the ball is thrown with angle of  $45^\circ$  from the robot.



**Fig 6.** Results of kick power with different solenoid cores

We can improve an impact of rod and speed of ball, by using an appropriate solenoid core. Various materials of core have been compared and the results of two best of them are shown in figure 6. One of them is soft iron and another is soft Iron annealed with Hydrogen. In this experiment the kicker placed with angle  $45^\circ$  and shoots

the ball with different discharge time of capacitors that makes the duration of kick. The distance between position of ball collision with ground and throwing point was measured as length of kick. Figure 6 depicts the preference of the second material from kick power viewpoint.

To pass the ball to teammates, the power of the direct kick can be adjusted by the software. This is done by tuning the duration of kick process. It is clear from figure 6 that changing the duration of kick can affect on the power of kick and make pass with this mechanism.

## 5. Artificial Intelligence

Artificial intelligence can be applied widely in robotics. The DMS is the main part that can utilize the benefits of AI, but in this section we only describe vision and motion control with this attitude. In the following two subsections, we present a summary about the problems specifications and then our approaches to them.

### 5.1. Vision

Three Basler cameras for their high performances (speed and quality of images) are used as our main vision instruments. The cameras send data by a Fire Wire IEEE 1394 cable to the vision computer and a 3.6 GHz Intel CPU supports our software.

After receiving the images, identification of the objects should be done. RGB data converts to HSL to calibrate easier and after passing the color detecting module, different clusters are determined by C\_means. Our color detecting box is an artificial neural network (ANN) that is trained in the first day of competition to tune for that condition. Multi Layer Perceptron (MLP) with 10 neurons in hidden layer is our ANN method. Figure 7 shows the block diagram of the explained object detection module.



**Fig 7.** Block diagram of object detecting

After segmentation different objects such as the ball, teammate and opponent robots can be distinguished. Data fusion of the blobs of each robot can show the position and orientation of robots. This is the application of vision in small size competitions.

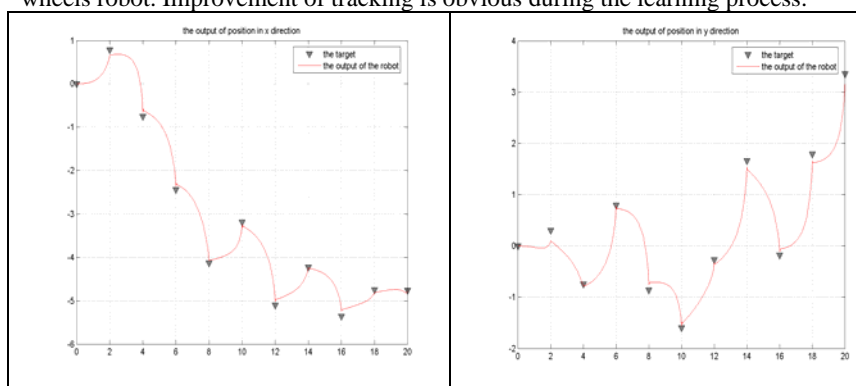
### 5.2. Robot Motion

The common motion control method in most of competitors in RoboCup is via robots sensors like encoders, compass and gyroscope. In this part we want to express a summary about our learning based motion control besides the classic approaches, that has many advantages. In other words we have a combined method based on odometry and Reinforcement Learning (RL).

Navigation via sensors data can be found in literature frequently; so we only describe our learning based method. The detail of our approach is explained completely

in [2]. Because of the uncertainty of the robots in real world, the pre-designed controllers may cause many difficulties, and using learning is one way to adapt it to real robots which may have different parameters. Our approach consists of three levels; first step is gathering the data from robot and identifying a model for the motion considering all uncertainties. Secondly a learning based controller is designed and the parameters will be updated in simulated model and finally the controller will be implemented in robot and fine tuning results in accurate coefficients for each robot.

For the first step we use LoLiMoT (Locally Linear Model Tree) to identify the robot's dynamic because of its special characteristics like accuracy and velocity of the operation in control applications [3]. For the next step we propose a direct BELBIC (Brain Emotional Learning Cased Intelligent Controller) controller which its applications are extended recently [4, 5]. Here we have added the goal of keeping the control effort as low as possible to the usual goal of tracking the set point so as to implement control that is not cheap [4]. Figure 8 shows the quality of this method for three wheels robot. Improvement of tracking is obvious during the learning process.



**Fig. 8.** The position of robots with BELBIC controller (left) x direction, (right) y direction. The triangles are the target points.

## 6. References

1. Stone, P., Veloso, M.: Multiagent Systems: A Survey from a Machine Learning Perspective. *Autonomous Robotics*, vol. 8, no. 3 (2000)
2. Sharbafi, M.A., Lucas, C., Mohammadinejad, A., Yaghubi, M.: Designing a Football Team of Robots from Beginning to End. *International Journal of Information Technology*, vol. 3 no. 2, pp. 101—108. (2006)
3. Nelles, O.: Orthonormal Basis Functions for Nonlinear System Identification with Local Linear Model Trees (LoLiMoT). in *Proc. IFAC Symposium on System Identification*, Kitakyushu, Fukuoka, Japan, (1997)
4. Lucas, L., Shahmirzadi, D., Sheikholeslami, N.: Introducing BELBIC: Brain Emotional Learning Based Intelligent Controller. *International Journal of Intelligent Automation and Soft Computing*, vol. 10, no. 1, pp. 11--22. (2004)
5. Moren, J., Balkenius, C.: A Computational Model of Emotional conditioning in the Brain. in *Proc. workshop on Grounding Emotions in Adaptive Systems*, Zurich, (1998)