CYRUS 2014 Team Description Paper

Eslam Nazemi[1], Pouya Payandeh[1], Bardia Nadimi[1], Navid Nouri[2], Sina Raeessi[2], Javad Amiryan[3]

{nazemi, ppayandeh , bnadimi, nnouri, sraeessi, amiryanj} @robocyrus.ir
http://www.robocup.sbu.ac.ir/

[1] Department of Computer Engineering of Shahid Beheshti University
Velenjak, Tehran, Iran
[2] Department of Electrical Engineering of Shahid Beheshti University
Velenjak, Tehran, Iran
[3] Department of Computer Engineering of Sharif University of Technology
Azadi av. Tehran, Iran

Abstract. In this paper the current state of Cyrus robotic team is described. Our mechanical designs have provided sufficient speed and accuracy for robots while electrical boards are redesigned to obtain more reliability. In the software system the main changes are done in motion planning module. The new proposed method for generating smooth, safe and short motion plans is described in section 4. Moreover a *robotic team manager application* has been developed for Android devices which can be run on tablet computers and bring some useful tools for team coach.

1 Introduction

We`ve gained many experiences by participating in national and international tournaments and each year many related technologies have been imported to the team [1]. This year as previous years, some improvements are applied in both hardware and software systems. The mechanical parts are redesigned in order to achieve more accurate robots while some changes to electrical boards have been done to get more reliability and performance. In the following section, the changes in mechanical system will be mentioned. Afterward the FPGA-based main board will be proposed. In section 4, new software architecture would be surveyed and also some explanations about our robotic team manager application will be presented.

2 Mechanical design

In mechanical design the main parts are driving system, kicking system and dribbling system. Currently, we are using Maxon EC45 flat brushless motors and Maxon GS45 gear heads in our robots which enable them to have adequate acceleration and speed. Each robot is 179mm in diameter and 146mm in height and at most covers 20% of the ball. A view of mechanical system is shown in Fig. 1.

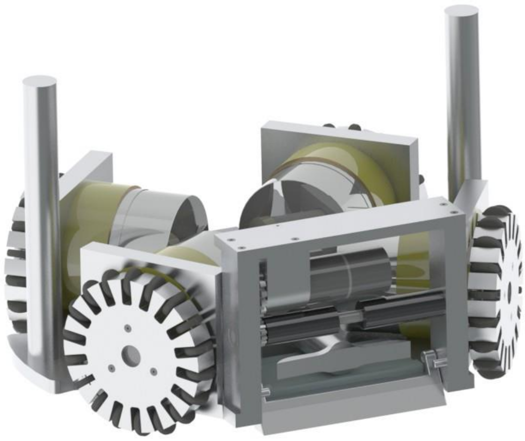


Fig. 1. Robot Mechanical Design

3 Electrical design

In electrical design we focused on reliability of the boards and also the capability of precise control of driving motors. So a new FPGA-based main board is designed and implemented. Furthermore the kicker board which was one of our major troubles was redesigned and a more robust board one increases system provides the controlling signals to the driving system and kicker module and consists of two separate boards called the main board and the kicker board, respectively. The main reason for separating these parts is to reduce the effect of electrical noise caused by boosting and kicking functions of the kicker board on the other parts.

3.1 Main board

The main board has the duty of receiving data via wireless module, analyzing it, and controlling the motors. It also sends commands to the kicker board as to determine the time and power of kicking. Our redesign of robots from 2009 to 2013 involves a completely new electrical subsystem. In 2010 we utilized ATMEGA16 MCU from AVR family microcontrollers. In 2011 we replaced our main microcontroller with ARM7 family - AT91SMA7X - and then in 2012 and 2013 Iran Open competition we designed our main boards based on ARM LPC1768 which provides many better features. 100MHz clock speed in comparison to our last 50MHz clock speed and a cortex-M3 arm processor provides faster PI calculations for the controller division. In this case one of the board's advantages is the ability of easy programming which can be done by an onboard USB 2.0 port. Moreover in new design we have implemented the ability of programming the board wirelessly via our Xbee modules more easily. We have also changed our motor driving system from the old L298 IC ones to the MOSFET bridges ones which provide more efficiency and reliability. This new design has the ability to drive both brushed DC and BLDC motors.

Currently, we are utilizing FPGA Spartan III family - Xilinx XC3S400 chip - as the only processor on the main board to generate all control signals for all parts such as wireless communication, kicking force, driving and so on. This chip is chosen because of its low power consumption, its high number of available pins and its huge logic gate numbers in comparison with other similar products. The Xilinx Spartan III, with its IP core provides significantly faster computation, when compared to the previous robot MCUs; besides Using FPGA, in addition of real-time benefits, would considerably reduce the number of components on the board and makes the debugging procedure much easier. Fig. 2 represents the relation between FPGA and other units:

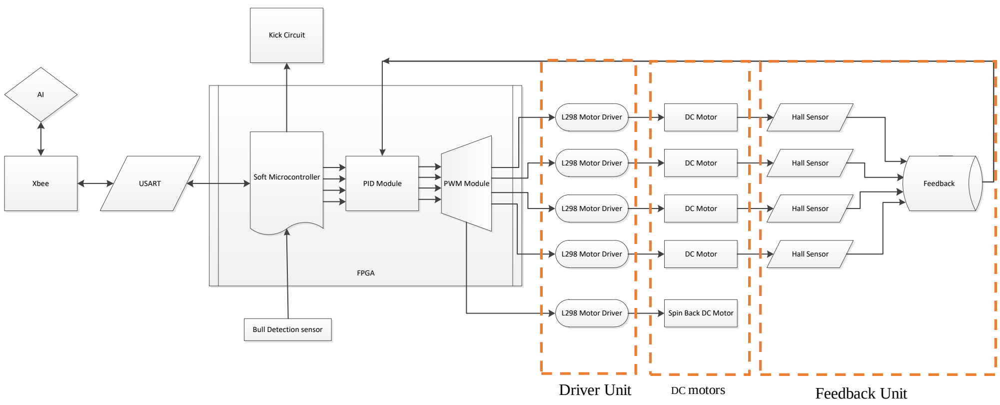


Fig. 2. FPGA-based Electrical Design

3.2 Kicker board

We have used advanced boost circuit topology with a current and voltage feedback on our robot's kicker board. The booster charges three paralleled 1600 µF-250 V capacitors up to 240 Volts using a voltage feedback to measure the capacitors' voltage and a current feedback to adjust the switching duty cycle. The change that has been made here is that we increased the PWM frequency in order to have a higher efficiency and reduce the loss of energy in inductors. We also used opto-couplers in order to isolate the control and power parts.

4 Software System

Software system that we use includes two distinct units. The main processes for decision making are carried out in server program which is responsible for all decision making levels in a small-size team. The other unit, namely Team Manager is designed to visualize and monitor the output data of each module in the server program, during decision making process. The main idea for separating these programs is to run graphical processes of this application, on another computer to avoid unnecessary CPU loads on server computer. Using network communication, we can utilize two separated computer to run the programs. The architecture of the software system is depicted in Fig. 3.

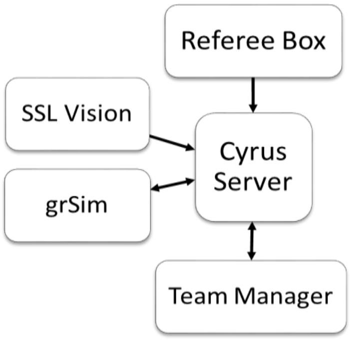


Fig. 3. Architecture of Software System

We have also developed a mini-app to help the team coach during a game or in test times. The information like robot position, robot target and the path which is planned to run are displayed by this application. Moreover, informing the coach about the fouls in game like double defender or exceeding ball speed limit is another feature of this tool.

4.1 Decision Maker

As mentioned before, decision maker is designed based on STP Architecture which is proposed by CMDragons in [2]. In the head of this system there are two UDP sockets to make connection with vision and referee systems. After filtering the vision data with Kalman filter the World Model will be updated. As you can see in Fig. 3 in the test mode the vision data is captured from grSim (ssl simulator) [3].

For task allocation, we have built a set of strategy files, each one in a script file. A strategy determines the set of robot roles and their parameters. The role assignment is done based on these roles to join each role to a physical agent. Finally each role calls a specific skill for its own agent. The skills which need the robot to travel a free-obstacle path call the motion planner module.

4.2 Motion Planner

Motion planner is responsible for providing smooth, safe and efficient actions for robots. Among many solutions for dealing this problem Artificial Potential Fields (APF) APF is a simple and computationally low cost method which keeps the robot away from the obstacles in environment. However, this approach suffers from trapping in local minima of potential function and then fails to produce motion plans. In this approach the force sources are either repulsive or attractive [4].

$$F(s) = \hat{F}^{att}(s) + \sum_{i=1}^{m} \hat{F}_{ob_i}^{rep}(s)$$

However the attractive force alone, in this method is not sufficient for directing the robot toward the goal state in every complex configuration space. This is the key idea for defining a new source of force in the space that directs robot to the goal region through some sub-goals. To arrive the main goal the robot must try to look just at the next sub-goal in its way. This idea results in declaring the directive force.

We have proposed a novel approach which employs a *prior path* between origin and goal configuration of the robot. Therefore, the planner guarantees to lead the robot to goal area while the inherent advantages of potential fields remain. For path planning stage a well-known approach Rapidly-exploring Random Trees (RRT) is applied.

In our definition, directive force is determined based on a prior path which is previously generated by RRT planner. This simple plan divides the configuration space into some cells. Each cell belongs to the nearest segment of the prior path. So within each cell the directive force is applied in the direction of that segment. This is shown in Fig. 4.

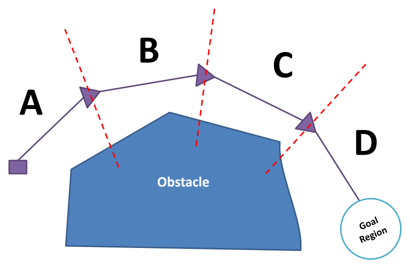
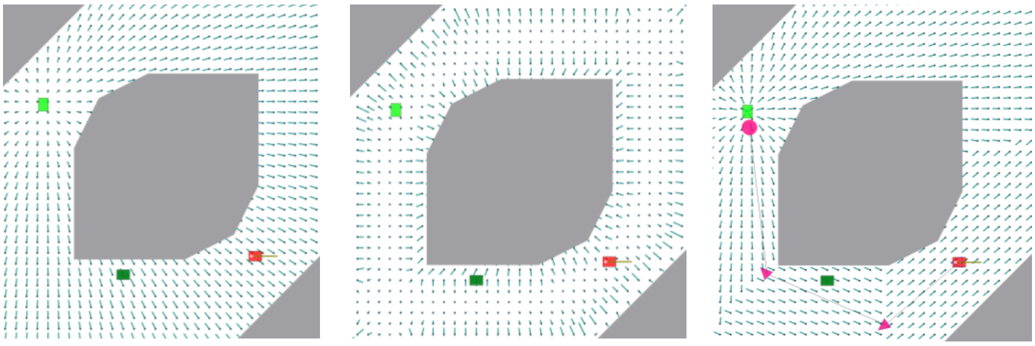


Fig. 4. Dividing the space into distinct cells using a path between the origin and the goal region

The resultant force is calculated by summation of these three force sources.

$$F^{new}(s) = \hat{F}^{att}(s) + \sum_{i=1}^{m} \hat{F}_{ob_i}^{rep}(s) + \hat{F}_{l_i}^{dir}(s)$$

In Fig. 5 these forces are displayed by small vectors in the space.



a) Attractive Force b) Repulsive Force c) Directive Force

Fig. 5. Three types of force sources in APF planning approach

The final plan for above forces is depicted in Fig. 6.

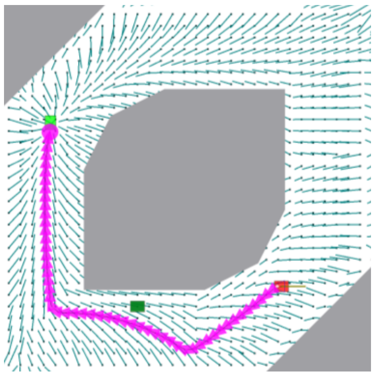


Fig. 6. The output plan of customized APF motion planner

We have also designed a fast adaptation procedure for evolving the motion plans towards optimal solution. Multi-objective optimization is applied to find smoother, safer and shorter plans.

4.3 Calculating Motor Velocities

Experiences show that, a noticeable issue in robot navigation is that the mechanical elements are not ideal i.e. the asymmetric forces between the robot wheels and ground result in imprecise movement of robot. For this problem we have proposed a new algorithm in which the mechanical system is assumed as a deterministic but predictable system. So a Takagi-Sugeno fuzzy method is used to estimate the effect of each motor on robot motion [5].

For example in forward direction the plot is like Fig. 4. The different slopes for 4 lines show that the motors have not identical influence on robot movement in this special direction. We use this data to modify the motor voltage with a coefficient in order to achieve the best motion in each state of the robot.

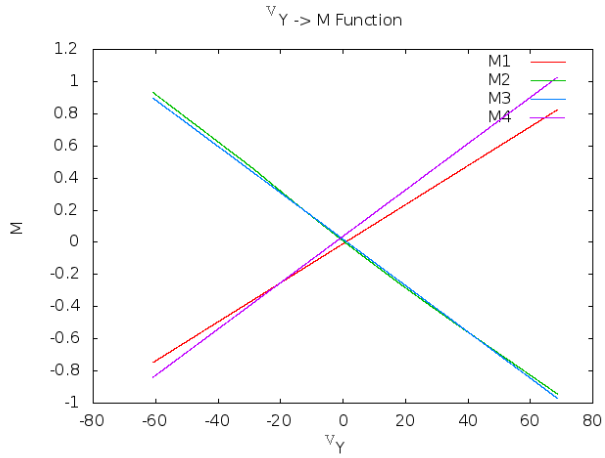


Fig. 7. Relation between Motor velocities and Vy, when Vx=wz=0

References

1. Nazemi, B., Raeessi, S., Amiryan, J., JafarzadehPour, A., Mohammadzadeh, Sh., Nikoukar, A., Aali, A., Eskandari, N. (2014) CYRUS 2014 Team Description.
2. Browning, B., Bruce, J., Bowling, M., & Veloso, M. (2005). STP: Skills, tactics, and plays for multi-robot control in adversarial environments. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 219(1), 33-52.
3. Monajjemi, V., Koochakzadeh, A., & Ghidary, S. (2012). grSim–RoboCup Small Size Robot Soccer Simulator. RoboCup 2011: Robot Soccer World Cup XV, 450-460.
4. Warren, Charles W. (1989). "Global path planning using artificial potential fields." Robotics and Automation, Proceedings., 1989 IEEE International Conference on. IEEE, 1989.
5. Nazari, Mostafa, Javad Amiryan, and Eslam Nazemi. "Improvement of robot navigation using fuzzy method." AI & Robotics and 5th RoboCup Iran Open International Symposium (RIOS), 2013 3rd Joint Conference of. IEEE, 2013.