MRL Extended Team Description 2018

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Abstract. MRL Small Size Soccer team, with more than nine years of experience, is planning to participate in 2018 world competitions. In this paper, we present an overview of MRL small size hardware and software design. Having attained the third place in 2010, 2011 and 2013, second place in 2015 and first place in 2016 competitions, This year we enhanced reliability and achieved higher accuracy. Due to the great changes in the rules, We made major changes to the software. Finally, by overcoming electronic and mechanical structure problems, We promoted the robots ability in performing more complicated tasks.

1 Introduction

MRL team started working on small size robots from 2008. In 2016 Robocup, the team was qualified to be in final round and achieved the first place. In the last competition in Germany MRL team ranked in the top 3 teams. In the upcoming competitions, the team goals is having more dynamic and intelligent behavior. In 2018 competitions the main structure of the robots is the same as last year, see [1] for details Figure 1 shows the MRL 2016 robots.

Some requirements to reach this target are achieved by redesigning the electrical and mechanical mechanisms. Moreover, simple learning and optimization approaches are employed in the way of more dynamic play. Evaluation by software tools, like simple motion planner and Strategy originator based on artificial intelligence.

This paper is organized as follows: First of all, the software contains new visualizer and logger description 2. The Electrical design including ARM micro controller, and other accessories of robots onboard brain, is explained in section 3. Description of new wheels and mechanical structure, which modifies the capabilities of the robots dribbler system, is the subject of section 4.

2 Software

In this part the software main objects are presented. It is shown that how our new modifications provide us a more intelligent and flexible game. In this year

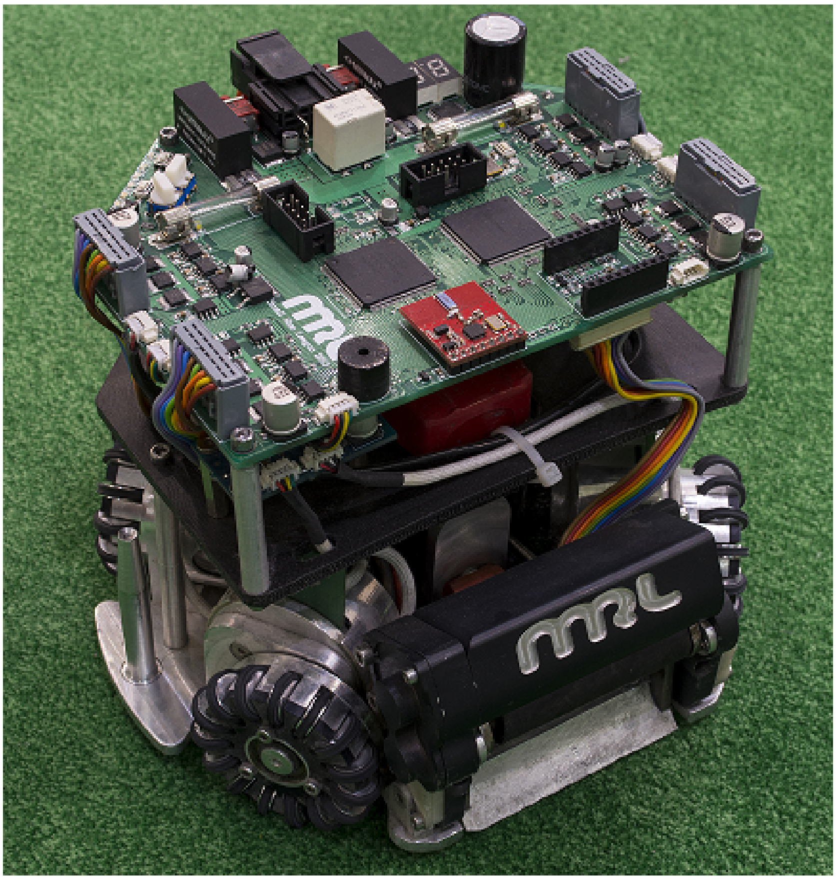


Fig. 1. MRL robot for 2016 competitions

MRL software team has not changed the AI main structure. The game planner as the core unit for dynamic play and strategy manager layer is not changed structurally, but some new skills and abilities are added to the whole system. In this section, after a brief review about the AI structure, short description of the unchanged parts are presented and references to the previous team descriptions are provided. Finally major changes and skills are introduced in details.

The software system consists of two modules, AI and Visualizer. The AI module has three sub-modules being executed parallel with each other: Planner, STP Software (see [6]) and Strategy Manager. The planner is responsible for sending all the required information to each section. The visualizer module has to visualize each of these sub-modules and the corresponding inputs and outputs. The visualizer also provides an interface for online debugging of the hardware. Considering the engine manager as an independent module, the merger and tracker system merges the vision data and tracks the objects and estimates the world model by Kalman Filtering of the system delay. Figure 2 displays the relations between different parts. In this diagram, an instance of a play with its hierarchy to manage other required modules is depicted. The system simulator is placed between inputs and outputs and simulates the entire environment's behavior and features. It also gets the simulated data of SSL Vision as an input and proceeds with the simulation.

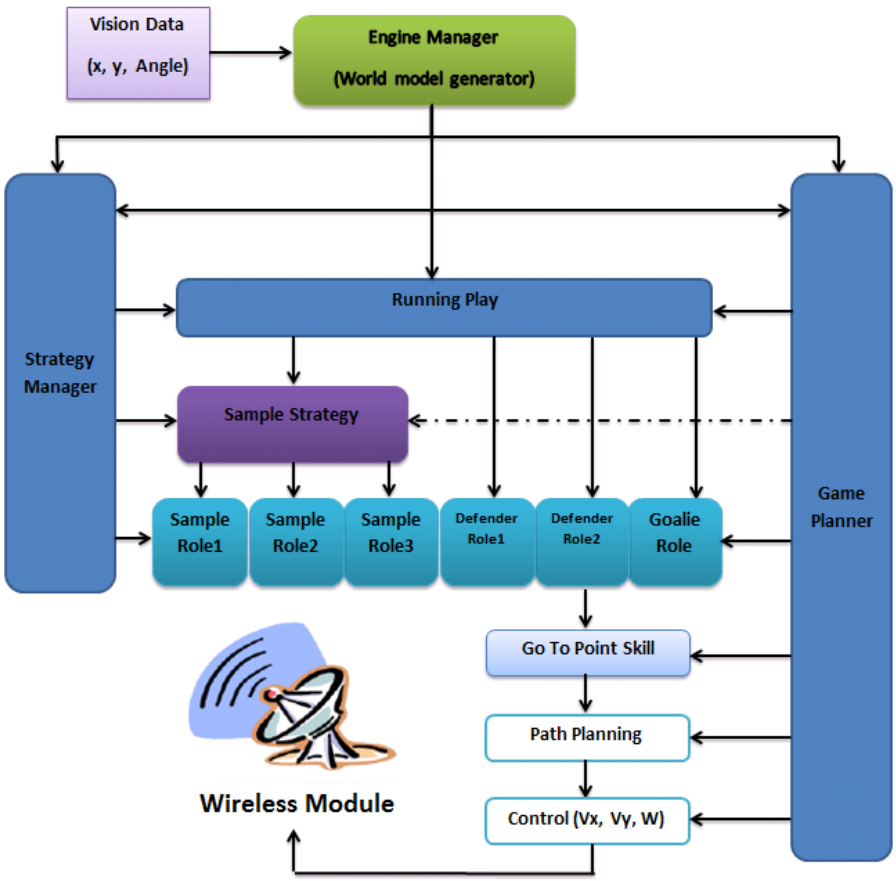


Fig. 2. Block diagram of AI structure

2.1 Simple Motion Planning

according to growing the field size and number of the robots , Our previous system it was not efficient and , less cost effective and more efficient way. A number of previous problems can be found below:

– Due to a lot of processing, we had to use a special GPU (Graphics processing unit) and we could not use this motion planner on any computer.
– Use of old and outdated technology.

For these reasons we needed to rewrite the whole motion planner. We decided to use a method that would cost less and find a efficient motion. We prefer to use CPU for motion planning processes. But before using the RRT, we have another way to find the simple path.
At the beginning number of simple paths has been generated in order to a robot and the target which is consisting of a straight line, polynomial curves(up to third degree equation) and also sinus curves. Next each path is being checked by all obstacles in field and in the next stage an optimization finds the best path with respect to our parameters and cost function. If every curve have collision then we start to use RRT(Rapidly Random Tree) otherwise, Velocity and instantaneous acceleration has been calculated by result of first and second derivation of path equation and finally they return as control parameter to low-level control unit. For instance:

$$Y = x^2$$

Speed Constraints are being considered as bellow:

$$V_x^2 + V_y^2 \leqslant V_{max}^2$$

$$V_Y = 2x \cdot V_x$$

$$(2 \cdot x \cdot V_x)^2 + V_x^2 \leqslant V_{max}^2$$

$$4x^2 \cdot V_x^2 + V_x^2 \leqslant V_{max}^2$$

$$V_x = \left(V_{max}^2 \setminus 4x^2 + 1\right)^{\frac{1}{2}}$$

Also acceleration Constraints are being considered as bellow:

$$a_x^2 + a_y^2 \leqslant a_{max}^2$$

$$a_y = 2V_x^2 + 2x \cdot a_x$$

$$\left(2V_x^2 + 2x \cdot a_x\right)^2 + a_x^2 \leqslant a_{max}^2$$

$$\left(4x^2 + 1\right) \cdot a_x^2 + \left(8x \cdot V_x^2\right) \cdot a_x + 4V_x^4 \leqslant a_{max}^2$$

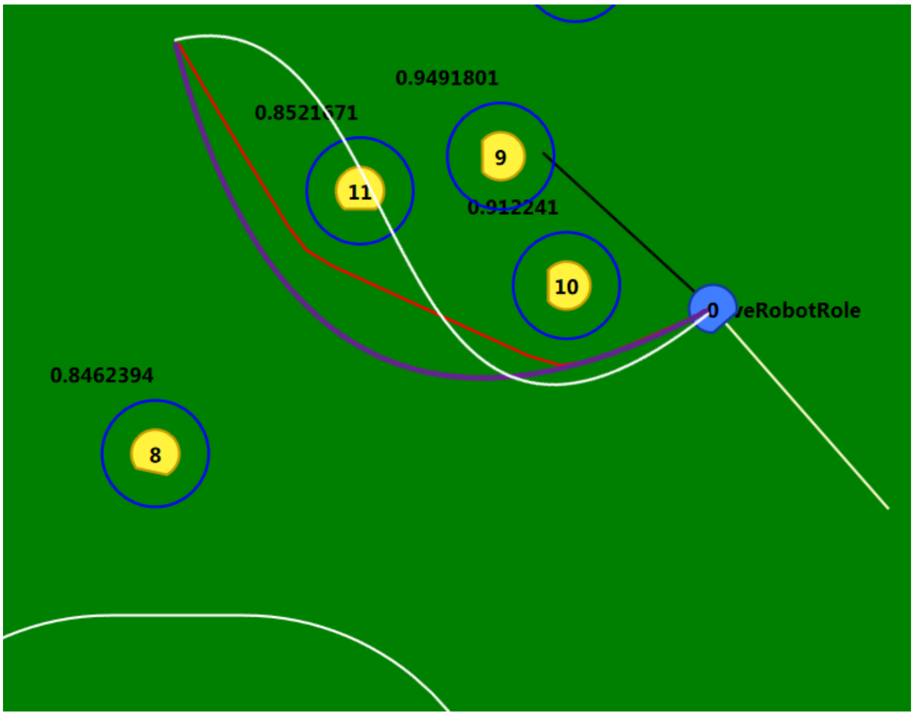
where:

V_x: Linear Velocity of x
V_y: Linear Velocity of y
a_x: Linear Acceleration of x
a_y: Linear Acceleration of y
a_{max}: Maximum Linear Acceleration of Robot
x: Position of x

y: Position of y

Our new motion planner decreases the complexity of processes because it does not have any intermediate points like RRT additionally the improvement increased the speed of robots to move through the pass.

Fig. 3. Comparison between RRT(red curve) and Simple Motion Planning(purple is polynomial second degree and white is polynomial third degree)



2.2 Strategy originator based on artificial intelligence

Strategy originator based on artificial intelligence As the field grows and the number of robots will increases to 11 in the next year, The league is on the way to approaching real football.A learning system designed to attack an opponent team based on their game, that is designed to detect opponent's defense problems using team logs and using artificial intelligence algorithms, produce strategies that are more likely to score. One of the most important advantages is that there is no need to write static strategies.

2.3 Intelligent defenders positioning algorithm

In Small Size League matches (like real soccer games) attacking strategies are very flexible and dynamic. This feature, implies that the defense strategies should be dynamic too. In fact, there are lots of unforeseen states that cannot be considered in advanced. Thus, defenders cannot classify all of them to have suitable react. Between the defense skills, positioning is the most important one. Positioning is the sequence of finding the target(s), selecting the blocking strategy. In this year we are going to add prediction part in our defense that predict the position from last plays of opponents, We give the system some log from latest games of opponent and this new system returns positioning for all defenders for every strategy of opponent, Of course a human must check the result and correct malicious predictions.

3 Electronics

MRL robot electronic consists of an Altera Cyclone FPGA linked to an ARM core the same as previous years. Changes during last year in this section is implementation of parallel motor controllers in FPGA, since calculation of PID controllers in software requires a lot of CPU time. Moreover, moving controllers to FPGA, the ARM processor can be dedicated to other tasks with less interrupts. The other changes are using frequency IR sensor for ball detection and some modifications on the wireless board. For unchanged parts of the electronics see [2] and [1].

3.1 Wireless Board

Last year In order to have a stable two-sided communication we used a new nRF24l+ module but we didnt reach the performance we were looking for, So we designed a new wireless board using a STM32F4 instead of LPC2378 in order to have faster process and a more stable high speed air-data transfer. STM32F405 Micro-controller is featured more than the LPC2378 Micro controller. STM32F746ZG is operating up to 168MHz frequency but the old Micro-controller were operating up to 72MHz. We have also changed the communication between server and wireless board using an FT232 chip (Serial to UART Convertor) and the air-data form so now we can handle more robots faster than before.

3.2 Capacitor Charger Board

Preparing for the new field size, we decided to have longer chip kicks so we had to make some changes in charger board beside the mechanical system and more specific in MOSFET driving and we did so. We have used a more powerful solenoid by increasing the radius and number of turns. Overall, by changing the solenoid and decreasing leakage in MOSFET driving we have better chip kicks.

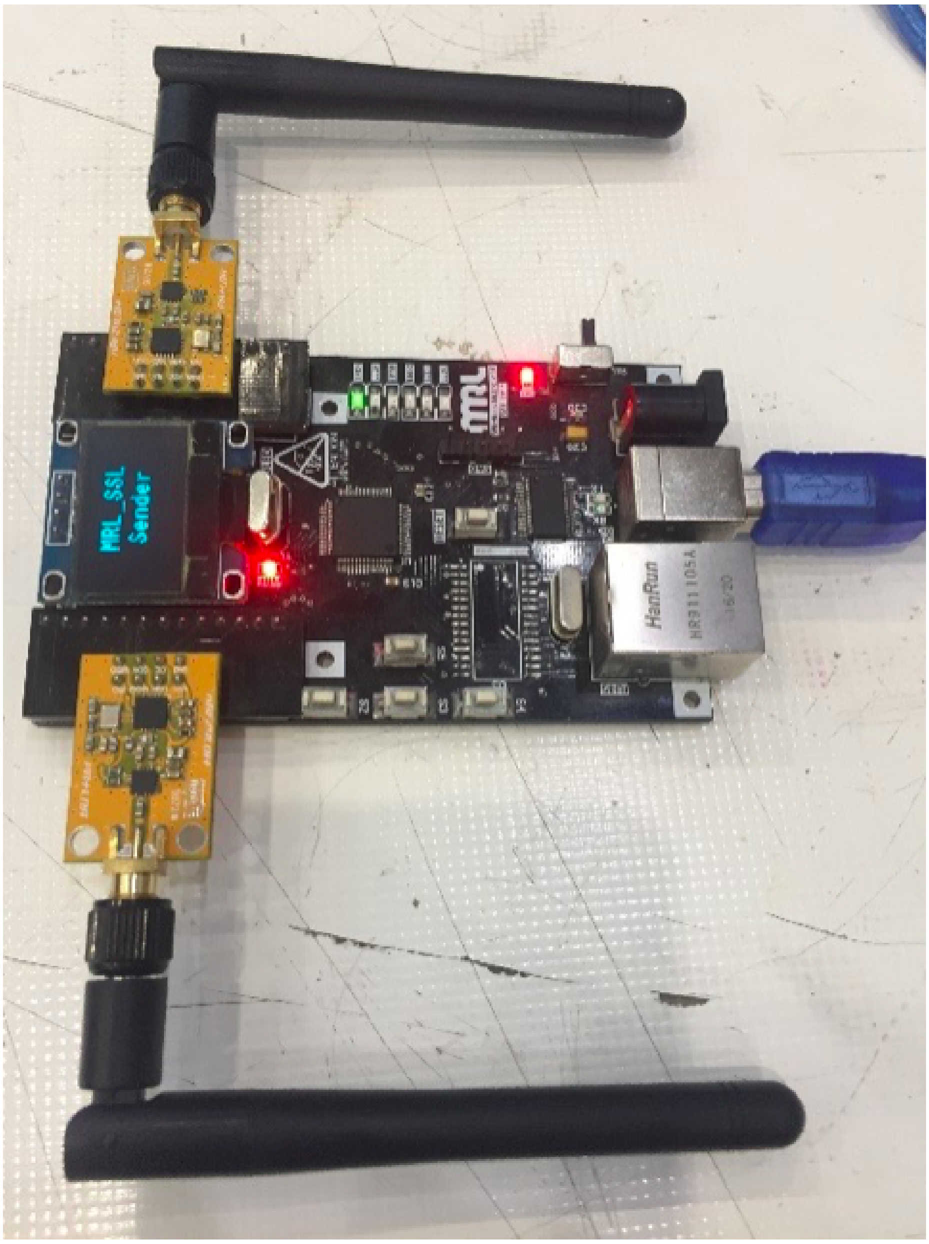


Fig. 4. two-sided Wireless Board

4 Mechanical Design and construction

Typically, the main portions of mechanical structure of a small size robot, include 4 wheels, two kickers, a dribbler and the motion transformer system. Regarding the league rules, diameter of the robot is 179mm and the height is 140mm. The spin back system conceals 20% of the ball diameter in the maximum situation.

Due to some drawbacks in the previous proposed design, we have decided to improve both the mechanical design and the construction materials. Main changes in the mechanical structure of the robot are described in the following paragraphs. The other parts are the same as 2014 robot described in [1].

4.1 Dribbling system

Dribbling system last year we had some problems with our dribbling system. The problem was that the robot could not able to carry the ball on all kind of carpets. So we decide to design a suspension system for it. Now our dribbling system has a suspension that shown in Figure 5in this new system we can easily change the height of the dribbler and fix it in our desire position based on the carpet. As it is shown in Figure 5, dribbler is a steel shaft covered with a rubber and connected to high speed brushless motor shaft, Maxon EC16 Brushless. Since the spin back motor is in the front side of the robot, it is exposed to the strikes caused by the collision with the ball or other robots. To solve this problem, we took the spin back motors position a little back and designed a shield for it. To improve the capability of spin back to control the ball, we made a construction in which the amount damping is controlled.

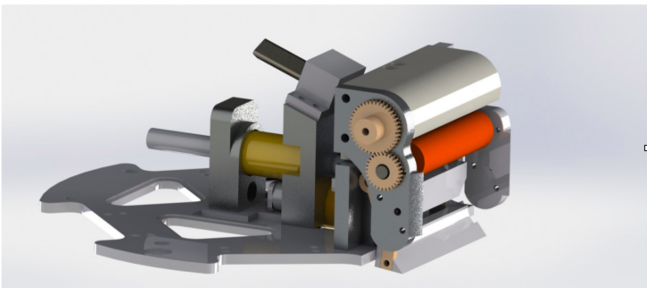


Fig. 5. Dribbling system and kicker

References

1. Ganjali Poudeh, A., Beik Mohammadi, H., Hosseinikia, A., Esmaeelpourfard, S., Adhami-Mirhossein, A.: MRL Extended Team Description 2014. Proceedings of the 17th International RoboCup Symposium, Jao Pesoa, Brazil, (2014).

2. Ganjali Poudeh, A., Asadi Dastjerdi, S., Esmaeelpourfard, S., Beik Mohammadi, H., Adhami-Mirhossein, A.: MRL Extended Team Description 2013. Proceedings of the 16th International RoboCup Symposium, Eindhoven, Netherlands, (2013).
3. Adhami-Mirhosseini, A., Bakhshande Babersad, O., Jamaati, H., Asadi, S., Ganjali, A.: MRL Extended Team Description 2012. Proceedings of the 15th International RoboCup Symposium, Mexico city, Mexico, (2012).
4. Ahmad Sharbafi, M., Azidehak, A., Hoshyari, M., Bakhshande Babersad, O., Esmaeely, D., Adhami-Mirhosseini, A., Zareian, A., Jamaati, H., Esmaeelpourfard, S.,: MRL Extended Team Description 2011. Proceedings of the 14th International RoboCup Symposium, Istanbul, Turkey, (2011).
5. Zarghami, M., Fakharian, A., Ganjali-Poudeh, A., Adhami-Mirhosseini, A.,: Fast and Precise Positioning of Wheeled Omni-directional Robot With Input Delay Using Model-based Predictive Control. Proceedings of the 33th Chinese Control Conference (CCC), pp. 7800–7804, Nanjing, china, (2014).
6. Browning, B., Bruce, J.; Bowling, M., Veloso, M.M.: STP: Skills, Tactics and Plays for Multi-Robot Control in Adversarial Environments. Robotics Institute, (2004).
7. InvenSense Inc: MPU-6000 and MPU-6050 Product Specification Revision 3.4, 2013.
8. Utilizing a Vishay IrDA Transceiver for Remote Control. Application Note by Vishay Semiconductors, Doc. No. 82606, (2014).
9. Nordic Semiconductor: nRF24L01+ Product Specification v1.0,(2008)
10. LLC Allegro MicroSystems: A3930 and A3931, Automotive Three Phase BLDC Controller and MOSFET Driver, A3930 and A3931 Datasheet
11. LLC Allegro MicroSystems. A3930 and A3931 Automotive 3-Phase BLDC Controller and MOSFET Driver, A3930-1 Demo board Schematic/Layout