Description of the Warthog Robotics SSL 2019 Project

Rafael G. Lang, Guilherme C. de Oliveira,
Heloisa J. Barbosa, Nícolas dos S. Rosa,
Adam H. M. Pinto, Anderson H. de Siqueira,
Ivan N. da Silva, and Roseli A. F. Romero

Warthog Robotics
University of São Paulo at São Carlos
400 Trabalhador São-carlense Ave, São Carlos, São Paulo, Brazil
info@wr.sc.usp.br
https://www.wr.sc.usp.br

Abstract. This paper presents the main modifications since the last Team Description Paper of Warthog Robotics and a general explanation of the current project, presenting RoboCup SSL team WR Magic, developed since 2011 by the Warthog Robotics group from the University of São Paulo at São Carlos. This project merges the best features from older projects developed by the groups GEAR and USPDroids. The mechanical structure is a mixed design using aluminum and composite materials and contains four DC motors for locomotion. The system architecture is based on the GEARSystem library, with a new decision tree strategy module, and powered by some filtering algorithms on the vision module. The team presents full game capability with accurate and fast responses to strategy and referee commands.

Keywords: Mobile Robotics, RoboCup, Artificial Intelligence, Embedded Electronics, Warthog Robotics.

1 Introduction

The groups GEAR, created in 2003, and USPDroids, created in 2005, merged in 2011 founding the Warthog Robotics. Now the group join the knowledge of the departments of Electrical Engineering of the São Carlos School of Engineering and the Computer Sciences of the Institute of Mathematics and Computer Science of the University of São Paulo at São Carlos. The group counts with about 110 members students of Computer Science, Electrical, Mechatronic and Computer Engineering and develops robotics technologies, applying most of them at the robot soccer. Unfortunately, the team was not able to participate in the last edition of RoboCup, because we are in a restructuring phase. After the defeat in the final of the RoboCup Latin American Open in 2017, the team was improved, recovering the title in 2018.

The mechanical structure and the electronic boards are the same from the last years, described briefly on this paper, and detailed information can be found in

[1], [2] and [3]. The next sections present the newest modifications of WR Magic features details, most of them on the computer systems (artificial intelligence and computer vision systems).

2 Mechanical Structure

The mechanical structure is the same of the last years: the locomotion system with its four Faulhaber 2342 DC motors, the kicking device, and the dribble device mounted with shock absorber system and linked to another Faulhaber 2342 DC motor. The upper part houses the three electronic boards, the battery and the kick capacitor using glass fiber plates; and the cover is a front cut cylinder with protected wheels and openings for the kicking and dribble devices. All mechanical structure is made of aluminum and composite materials as shown in figure 1.

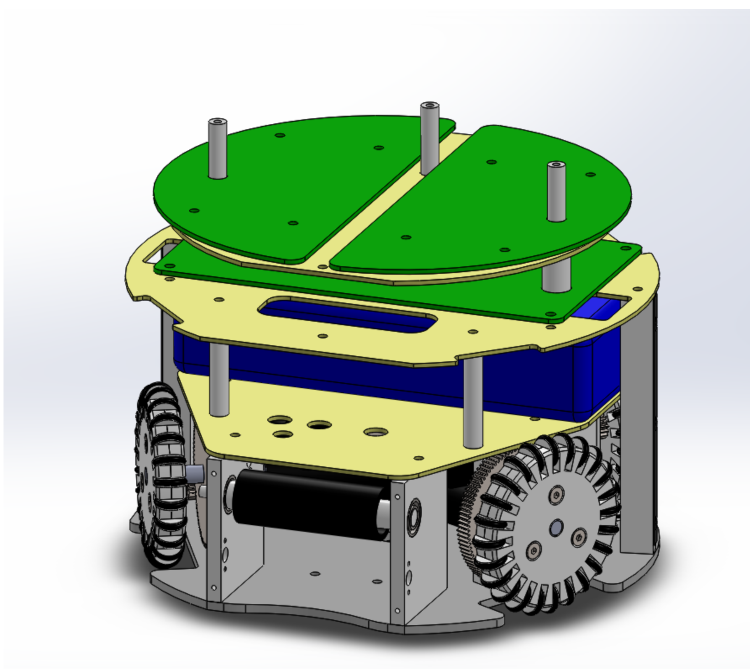

Fig. 1. Internal mechanical assembly of the 2019 Warthog Robotics SSL robot (same of last years).

3 Electronic Devices

The electronic devices are the same of last years, composed of three electronic boards: MainBoard, MotorBoard and KickBoard and detailed information can be found in [1], [2] and [3]. The architecture of the embedded electronics is shown in figure 2.

- The MainBoard is responsible for receiving commands, decoding them and sending commands to the requested actuators (motor board, dribble device and kick board); and for measuring information to send them back to the telemetry system. All communication is done by the transceiver nRF24L01+.
- The MotorBoard receives commands from the MainBoard and controls the motor speeds using the 512 lines per revolution Faulhaber IE-2 encoders as a feedback of a discrete PID controller that drives the motors using the L298 IC.
- The KickBoard controls the kicking device, charging the capacitors and discharging them in a custom solenoid when requested. The charging module follows the boost topology with a digital control system.

All boards are powered by a four cells LiPo battery of 2.6 Ah, that provides an autonomy of about 30 minutes to robot in a game-like ambient.

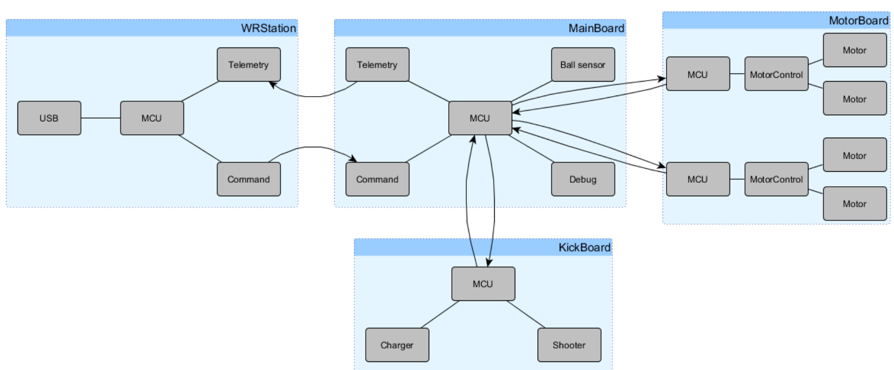

Fig. 2. Block diagram of the embedded electronic systems of the 2019 Warthog Robotics SSL robot (same of last years).

4 Computer Systems

The WR Magic Project software is based on five sub-projects developed by the group: the GEARSystem library, the WRBackbone server application, the redesigned WRCoach strategy application, the WREye vision filtering application, and the WRStation radio communication application.

4.1 GEARSystem

To provide communication and distributed execution between system modules it is used the GEARSystem distributed library [10]. It is built over CORBA and is the same as used last years with minimal bugs extraction and improvements.

The library architecture is minimalist, based in four elements: Sensor, Controller, Actuator and Server:

- **Sensor** creates and set teams, players and ball information (position, orientation, velocity, etc.);
- **Controllers** reads these information and send the commands to the actuators;
- **Actuators** reads, decode and execute these commands (move, kick, dribble, etc.);
- **Server** connects all those elements

This architecture allows the easy development of new software based on these main modules, and detailed information can be found in [1] [2].

In the current implementation of the team, the Sensor module is the WREye, responsible for receiving the data from ssl-vision and inserting it on the system. This module is composed by filters (Kalman, Noise, Loss and Multi Object) and more detailed explanation can be found in [2]. The Server module is WRBackbone, connection all modules on the GEARSystem architecture. The Actuator module in the WRStation, sending commands via USB (using QtSerialPort [13]) to a custom station board that reproduces the commands wireless.

The commands sent by WRStation is generated by WRCoach, the Controller module on GEARSystem architecture and one of the most improved modules, since it contains the team's strategy.

4.2 WRCoach

The coach responsible for setting the strategy to the team: Understand the world model, navigation, obstacle avoidance and behavior selection. A simplified diagram of the software architecture is presented in figure 3. The subsequent paragraphs describe the Coach architecture; a full description of the software is available in [2] and in Brazilian Portuguese at [12].

As WRCoach is software that has been improved since 2016, its current version is pretty stable, but it always requires optimization and bug fixes. In [3] it was presented two main corrections: NAN (not a number) removal and the attacker behavior.

The NAN bug occurred because the WRCoach's final output is a float that represents speed in x,y and theta axis and some mistakes, as division by zero, resulted in a not a number being send to software or propagated to robot firmware. The routine added solved this problem.

The new complex attack behavior select the best time to shoot or pass the ball, choosing which has a clear path to goal or an free attacker in condition to

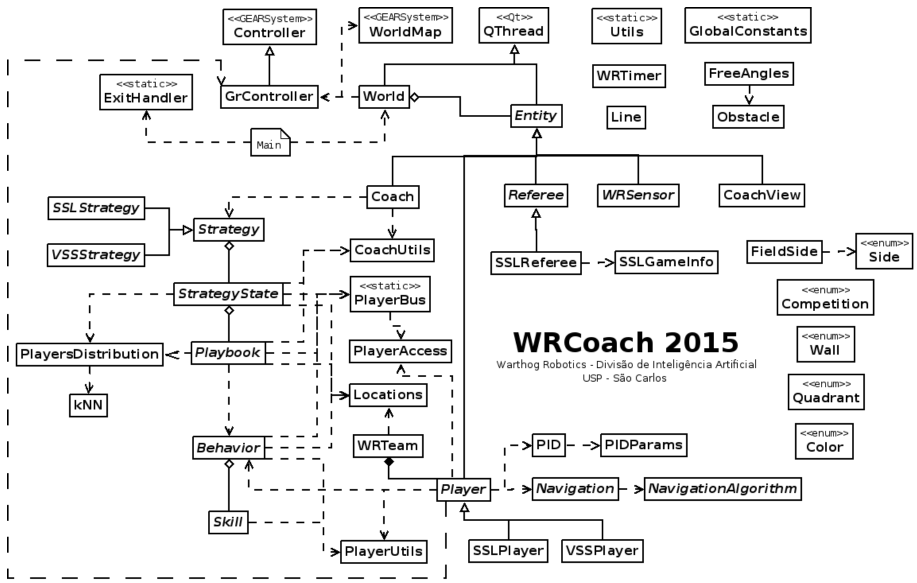

Fig. 3. Simplified diagram of the modules of the WRCoach software.

trap the ball. This behavior improved the chances of goal of the team, avoiding some kicks that would be easily blocked by the rival team.

With the evolution of the attacker, the focus of improvement this year was on defense. Dynamic marking situations were added to the decision tree, where defenders positioned themselves to prevent kicking and clear passes. This behavior is even more important in cases where you play with a smaller number of robots. With a robot is kicked out, or even in maintenance during the game, the team needs to adapt to a more defensive condition in order to avoid the opposing goal. The goalkeeper's algorithms were also improved considering this dynamic marking. The goalkeeper needs to be more precise in recognizing the attacker's orientation, and act quickly to block the goal.

Some other skills have been added and are being tested, such as new indirect kick routines considering opponents robots (including the goalkeeper) and new studies for positioning players who are not directly participating in a current play. With this, robots need to consider, in addition to the free angles, better positioning within the quadrants, making better use of available space in the field.

5 Improvements for 2019

The mechanical and electronic projects are the same from 2015 and are considered stable. The improvements in the embedded software (telemetry system) are still in beta version, but the faithful model of robot made possible research about quantity and quality of controllers applied, in a paper available only in Brazilian Portuguese Language [11].

The WRCoach structure, completely new in 2017, is now stable and the focus are in improvements in high-level strategy. The best testing platform is the competition itself, but it is believed that software improvements have made the robot more competitive considering the games at the Latin American Open. It was proved that this new structure allow more control over AI components, and the coding execution and debugging.

6 Conclusion and Future Work

In computer system, the improvement of the coach described in [2] and [3] was a great change in the strategy of the WRCoach and turn it more complex. The algorithm are more stable and efficient, with the cost of the defeat in 2017 and non-participation in the world cup in 2018, but now the robot is really competitive

The developed hardware is robust, reliable and provides an excellent platform to the strategy systems, and the improvements were focused in the embedded software as show in this paper, like the controller of the robot.

Future works will be focused mainly in those areas, improving the software WRCoach and the embedded software of the robot like the controller.

7 Acknowledgments

The authors would like to thank all Warthog Robotics team for the help and friendship; the University of São Paulo for the facilities and financial support; the Embraer, OSG Sulamericana, Griffus and SolidWorks companies for the technical sponsorship; and all others that helped us during the project.

References

1. Lang, R.G., Bernardo, A.M., Oliveira, G.C., Menezes, H.B.B., Ramos, L.C., Roque, L.G.S., Silva, I.N., Romero, R.A.F.: Description of the Warthog Robotics 2015 project. In: 2015 RoboCup (2015)
2. Lang, R.G., Oliveira, G.C., Menezes, H.B.B., Rosa, N.S., Correa, R.A., Gomes, V.H., Silva, I.N., Romero, R.A.F.: Description of the Warthog Robotics 2016 project. In: 2016 RoboCup (2016)
3. Lang, R.G., Oliveira, G.C., Barbosa, H.J., Rosa, N.S., Cepeda, B.H., Siqueira, A.H., Silva, I.N., Romero, R.A.F.: Description of the Warthog Robotics 2017 project. In: 2017 RoboCup (2017)
4. Nordic Semiconductor: High Frequency 2.4 GHZ Wireless Transnciever. Data Sheet (2007)
5. Olivera, V.A., Aguiar, M.L., Vargas, J.B.: Sistemas de Controle - Aulas de Laboratório. EESC-USP, Brasil. (2005)

6. Aguiar, M.L.: SEL359 - Controle Digital,2015. EESC-USP, Brasil. (2015)
7. Pressman, A.I.: Switching Power Supply Design. McGraw-Hill. (2003)
8. Mohan, N., Undeland, T.M., Robbins, W.P.: Power Electronics - Convertes Application and Design. Wiley (2002)
9. Tse, C.K.: Complex Behavior of Switching Power Converter. CRC Press. (2003)
10. Lang, R.G., Romero, R.A.F., Silva, I.N.: Development of a Distributed Control System Architecture. In: 2014 Latin American Robotics Symposium. (2014)
11. Furlan, M. S., Silva, I.N.: Comparação de Controladores PID em Sistema de Malha Dupla em Robôs Omnidirecionais. In: 2018 Simpósio Internacional de Iniciação Científica da Universidade de São Paulo. (2018)
12. WRCoach v2 documentation. Division of Artificial Intelligence - Warthog Robotics, available at `https://www.assembla.com/spaces/warthog-dia/wiki/WRCoach_v2`.
13. Qt Company: QSerialPort documentation, available at `http://doc.qt.io/qt-5/qtserialport-index.html`.
14. Wikipedia: PID Controller, available at `https://en.wikipedia.org/wiki/PID_controller`.
15. Control System Labs: Discrete-time PID Controller Implementation, available at `http://controlsystemslab.com/discrete-time-pid-controller-implementation/`