Survey on IEEE Very Small League Robots

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***Abstract*—IEEE Very Small Size is an IEEE Robotics Competition league where teams composed of three small robots, led by a computer to dispute soccer matches. This tournament happens in Brazil since 2003. Nowadays it's disputed during the Latin American Robotics Competition (LARC) and the *Competição Brasileira de Robótica* (CBR), along whit the Robocup Robotics Competition. All the participant teams from all leagues owe to write a Team Description Paper (TDP), and those can be found on Brazilian Robotics Competition's (CBR) page. There is a total of ninety TDPs, from 2013 to 2016, available at the competition site. As this is the first time that we attempt to participate in this competition, we have analyzed key design aspects of the reported designs, like movement, communication, vision, mechanics, sensors, batteries, and processors. Such information can be a useful guide for those beginner teams who is interested in design their own robots in order to participate in the next competitions.**

***Keywords*—very small size league; soccer robot; LARS-SBR;**

I. Introduction

IEEE Very Small Size is a robots soccer championship that happens in Brazil since 2003 [1] and in 2017 the competition will take place in *Curitiba - PR* during the Latin American Robotics Competition (LARC) and the *Competição Brasileira de Robótica* (CBR)[2]. According to the event's rules, all the teams owe to write a Team Description Paper (TDP) with the most important aspects about their design, so that other researchers are able to replicate their system or part of them. On CBR webpage we found ninety TDPs from 2013 to 2016. During those four years, a total of 36 educational institutions have submitted TDPs for the category and some of them, like *Universidade Federal de Itajubá* (UNIFEI) and *Fundação de Apoio à Escola Técnica do Rio de Janeiro* (FEATERJ) have more than one team competing in the same year. Despite being a Latin American competition there is only one non-Brazilian team. As this is the first time that we are joining the competition, so we decide to analyze what the teams have used to build the structure, the mechanics, electronics and vision, movement and strategies algorithms. It's important to understand that these works are published before the competition, so they represent the intentions of the teams, not the final system and we have no guarantee that all of them have competed indeed. On this paper we present some of the championship rules and some details that we found interesting as well as some suggestions for the event organizers.

[1]http://www.cbrobotica.org/?page_id=81
[2]http://www.cbrobotica.org/mostravirtual/?lang=pt

II. Rules

In IEEE Very Small league, teams with three 7.5cm cubical robots compete on a 130cmx150cm soccer field, and these robots must be controlled by a computer, without human interference in running game. For this, each team needs to fix a camera 2m above the field to provide visual information to the computer - wich is owned by the team - in order to feed the strategy and movement algorithm in a closed loop, deciding how each robot proceeds. The overall system is illustrated on Figure 1. Each team has the chance to substitute any robot twice during the game, or as many as wanted during the interval. The game has two periods with 5 minutes each and a 10 minutes interval. As a regular soccer game, the winner is the one with more goals and also there are fouls, free kicks, penalty kicks, goal kicks and free balls. If after the two periods the game is a tie, it goes to 5 minutes sudden death match. The field is black and white and the team colors are yellow and blue. They play with an orange golf ball. The team can differentiate each robot using one additional color as long as it's not orange, white or grey. [1]

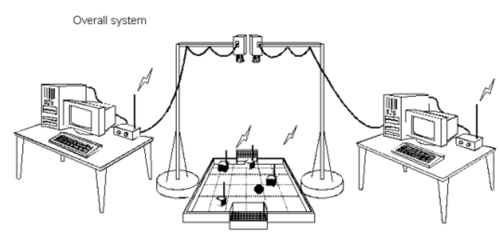

Figure 1. Overall structure - source [1].

III. Structure and Mechanics

There are no specific rules about what the team can or can't use on the robots, although, they must fit on a 7.5cm cubic mold, so they end up having a very simple structure, in most cases divided in layers and equipped with two motors and two wheels. As can be concluded from the data shown on Figure 2, 37.77% of the TDPs don't mention the material that was used to build the correspondent robot structure, but 35.55% of them have used a 3D printer for it, being ABS the most prevalent material, which is the same material used to make Lego ^{TM} blocks. Other frequently materials used are acrylic, aluminum, glass fiber, PVC and wood. Some teams also use two or more of this materials.

Most teams use a pair of motors and wheels, with the axes aligned, but we found three teams, UnBall [2], Ararabots [3] and Red Dragons [4] that use them side by side, which is

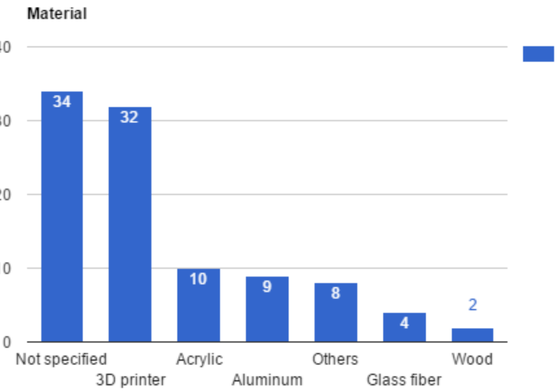

Figure 2. Materials used on the robot body.

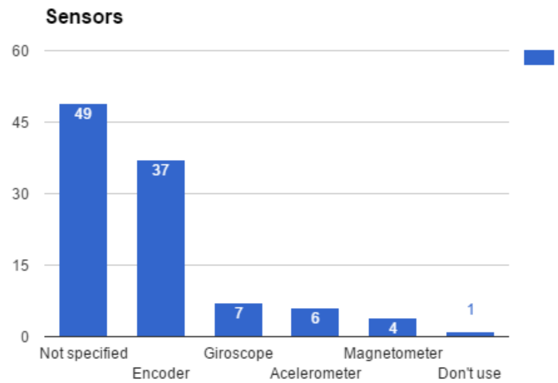

Figure 3. Sensor used on the robots.

appropriate to use motors with attached encoders, although they don't say that this is the motive. Another different option is to use three wheels, like Ultrabots [5]. UFABC [6] also have made a project with three wheels, but they concluded that wasn't enough space inside the robot for this. Some teams even use four wheels, like Poti [7] and Jerimum [8] that use two of them as freewheels to assure equilibrium, so they use only two motors. A team named *Fuzzy Control* [9] choose to keep four motors, to equip omni-directional wheels, allowing them to move easily in any direction.

IV. Electronics

The electronics is responsible for communication and control of robots. The basic components are communication modules and processing, however there are other components that can assist in locating and movement, such as sensors. In this section we present the sensors, communication and microcontrollers used by the teams.

A. Sensors

The most common sensor found in the robots is the encoder, present on 41.11% of the TDPs, and they can be magnetic or optic. But, as we can conclude with the data shown on the Figure 3, 54.44% of the TDPs don't specify if they use some, or any kind of sensors. Another thing to notice is that from the ninety TDPs, only seven use different sensors than encoders, so they are used as a set. Red Dragons[10][4] use inertial measurement unit (IMU) composed of three gyroscopes, three accelerometers and three magnetometers, but on their 2016 project [11] they haven't included them. NoSoccer[12] on its single participation at the competitions build a system using an accelerometer with gyroscope also as Autobotz [13] did. However Autobotz didn't use such kind of sensors in the following year [14]. Drumonsters team [15] suggests the idea of using one GY-80 with accelerometer, magnetometer and gyroscope together. And Jerimum [8] use gyroscope combined with magnetometer. It could be observed teams stopped using the sensors but unfortunately they don't argue if these sensors could be useful or not.

B. Communication

For the communication between the host and the robots, as we can see in Figure 4 is very common to use Xbee since it's easy to program and have a good range and reliability, but it's also very expensive. An inexpensive alternative commonly used by the teams is the nRF24l01 radio, although is not so easy to use as the Xbee. RoboK B [16] RoboK Yellow [17] and RoboK[18] actually uses both devices, as in year 2014 they complained about interference issues with the Xbee. Although, it's not clear if they were able to change the main communication via software or if it was needed to open the robot to do this, however, the TDPs state clear that both communications don't work simultaneously. Pequi Mecânico has joined the competition from 2013 to 2016 with different communication devices, in [19] they used Bluetooth, [20] was made with nRF24l01 and [21] using Xbee, but unfortunately they do not discuss the reasons for this design changes.

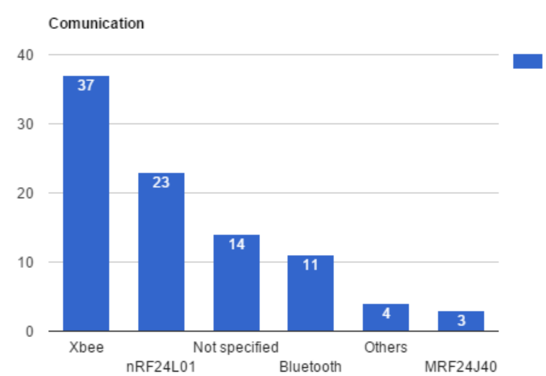

Figure 4. Communication used on the robots.

C. Microcontroller

About the microcontroller, thirty seven of the TDPs use Arduino (Duemilanove, Micro, Nano, Pró-micro, pró-mini and UNO), two use Alevinos, four use Seeduino and one uses Wemos, that are prototyping boards, ready for use. As a considerable part of the TDPs, that specify the microcontroller, set up their own hardware, we choose to count only the microcontroller. According to the data shown on the Figure 5 54.44% of them use Atmel ATmega328. On this count there are three teams claiming to use more than one, Autobotz [14] uses one ATmega328 for the robot and one Arduino UNO for the communication, NoSoccer [12] uses different type of sensors so in order to deal with too many libraries they decided to use one ATmega328 to control the sensors and one ATmega32u4 for the H-bridge and communication. The other one, ITAndroids[22], uses three 18F PICs, one for communication and one for each wheel.

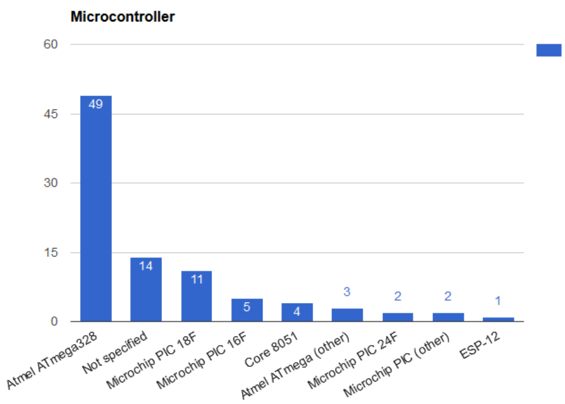

Figure 5. microcontrollers used on the robots.

V. Vision, movement and strategies

The vision system is based on the images received from the camera, 56.4% of the TDPs use the OpenCV library to process the images. SirSoccer [23] has developed a graphic interface for the vision and a simulator based on the OpenCV library, their software is hosted on Github [3] and is open source. We also have Fuzzy Control [9] and SirSoccer[24] that uses the SSL-Vision [4], a software for the RoboCup Small Size League, although they didn't use them in the following years. The movement and strategies used are really difficult to analyze, as the teams don't have a good description on this part and most of them are superficial. For the decision taking and movement, 46.66% of the TDPs don't specify how it's done and many of them use some confusing approaches to do this, some of them claim to use artificial intelligence, some potential fields, some uses both. Surprisingly some say that potential field is a kind of artificial intelligence. About strategies, is common to divide the robots between goalkeeper, defender, and attacker. As the positions are dynamic, they are usually determined by how far the robot is from the goal, the ball, and the other robots. Some teams, uses two distinct modes, offensive when they have the ball and defensive when the ball is with the adversary, and some even have a neutral mode, when nobody has the ball. Working with proportional–integral–derivative controller (PID) could be really useful, as it helps to reduce the error on the speed control, so we decided to include this information on our analysis, 36.70% of the teams use the PID controller, the rest don't specify.

[3]https://github.com/SIRLab/VSS-Vision

[4]https://github.com/RoboCup-SSL/ssl-vision/wiki

VI. Missing parts

When we started to analyze the TDPs we also considered batteries and motors, but we've concluded that they don't present enough information to get something really interesting on this topic. About the battery, some of them specify the components used and others we deduced by images present on the TDPs. We concluded that the most prevalent battery is LiPo type, but 48.88% of them missed this information. Relating to the motors, they are the most unspecified component, the majority of TDPs that tells something about them just mention the gear reduction, which is an inconclusive information without the nominal motor speed. Another detail that we wanted to analyze was the ranking achieved by the all teams in the competitions, in order to relate the performance to the hardware and software of each team, but on the event page it's only shown the first and second positions.

VII. Conclusion

On our search for information about the event's history we couldn't find as much as we wanted, like dates. During the research we ended up finding the CBR page with the ninety TDPs, but still being confusing because it's not possible to apply filters on the search and sometimes there are multiple TDPs for same teams in same competitions. With the readings we conclude that the size of the robot proved to be a great challenge for the teams, making the cubic form with two motors and wheels a standard. The electronics is also pretty simple, the communication varies between Xbee and nRF24l01, ATmega is the most used microcontroller and for the ones using sensors, encoder is the most prevalent choice. We can notice how difficult is to find some unique aspects. Unfortunately, many of the changes made by the teams along the years are not discussed. We understand the idea of asking for the TDPs before the competition, but with this, it's frequent to read about some ideas without any conclusion if it worked or not and can't even know if the teams have participated in the competitions. Thus, we would like to suggest a final review of the TDPs after the competitions and feed the page with a ranking with all teams. After reading all the TDPs we also suggest the event organizers to be more rigorous about the submissions. As we can conclude by all data presented in this paper, most teams don't specify important aspects of the hardware and software used. Many of the TDPs expend a big effort on explaining the rules, which isn't really relevant. We also have noticed that many of the TDPs are pretty much similar and some are even the same.

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