Maracatronics VSSS Team Description Paper for LARC 2022

Vinícius A. Pereira[1], Zilde S. M. Neto, Danillo do N. Santos, Flávio M. C. da Silva, Andre L. P. da Silva, Breno O. Rodrigues, Felipe L. Mororó, Gabriel R. de Oliveira, Lucca M. Gioia, Luís E. M. Alves, Luiz H. de S. Arruda, Maria R. de A. Silva, Pedro S. V. Motta, Rodrigo L. Leandro, João P. C. Cajueiro, João M. X. N. Teixeira, Guilherme N. Melo, José R. de O. Neto

Abstract— **This paper presents the current state of the Maracatronics team as it stands for Latin American Robotics Competitions - Very Small Size Soccer League 2022. This paper contains descriptions of the improvements done at the controller software, the electronical procedures and the mechanical procedures of Armorial Project, the current project to create mobile and autonomous robots of Maracatronics Robotics Team.**

I. Introduction

The Maracatonics team has competed at the VSSS category for 2 years, but this year is the first presential competion for the team. As long as the pandemic period was on the loose, the physical production was very reduced on the previous years, so all the main production and preparation for a physical competition were made on this year.

The improvements of both the electronical and mechanical projects along the years were revised for the main production and also some of the ideas elaborated on the 2021 Tech Challenge were taken into account as we participated at the time being. On the control system, the enhancement of an efficient Path Planning and a PID control were made as these two were two points were listed to be upgrade at the and of the previous LARC.

Thus, this Team Description Paper (TDP) aims to list the electronical and mechanical development as well as the control system enhancements for this year's competition.

II. Mechanical Project

The robots in the VSSS category were based on the model previously presented on Tech Challenger, as seen in [1]. The project's main tool was the SOLIDWORKS [1] software, used to create, develop and design all the design and construction of the robots. Showing a model with a simple and compact shape and with the aim of ensuring agility, efficiency, low cost and ease of controlling and grabbing the ball, as seen in Figure 1

The robot features a dribbling mechanism with a hyperbolic geometry, together with a spiral circular profile, based on studies and research carried out previously, this would be the best way to control the ball, as seen in [2]. To generate the rotation of the hyperbolic bar, a micro DC K30 motor would be used connected to a transmission of $17 : 15$. However, due to new studies, it was evidenced that this transmission

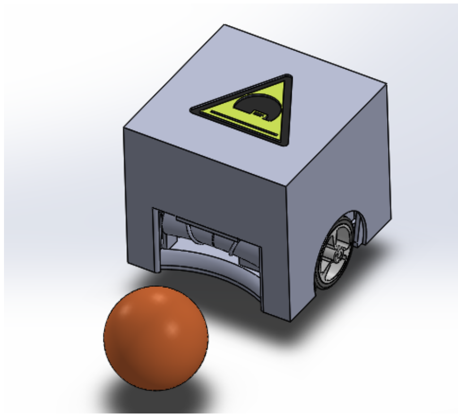

Fig. 1. Projeto 3D do Robô

system would not be enough for the dribbling to present an efficient operation, so a change was made to insert a new transmission $3 : 1$. This new change was implemented because it was verified that the engine with the previous transmission would have a high speed, lower torque and higher battery consumption.

This modification provides an increment in torque and effectiveness. It has two pulleys, one that is fixed on the dribbling bar and the other is on the K30 motor shaft that move through a belt and generate the necessary speed to catch the ball, as shown in Figure **??**.

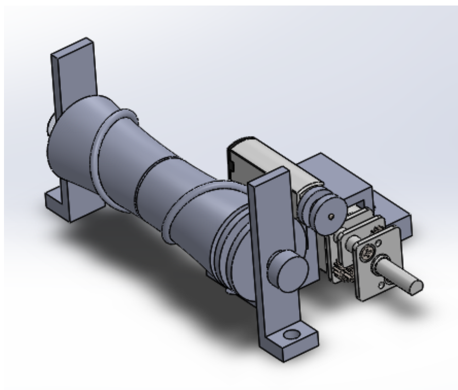

Fig. 2. Sistema de transmissão com polias

[1]All authors are with Maracatronics Robotics Team, at Mechanical Engineering Department, Centro de Tecnologia e Geociências, Universidade Federal de Pernambuco, State of Pernambuco, Brazil maracatronics@gmail.com

III. Electronical System

A. Dribbler system

Compared to the project in 2020, the brushless motor used an *Electronic Speed Controller (ESC)*, changing to a brushed motor and it required the implementation of a locomotion's driver on the *Printed Circuit Board (PCB)*. The driver *L239D (figure 3)* was used for the dribbler system since it is already used on the locomotion system. The entire 3D circuit design is shown in figure 4.

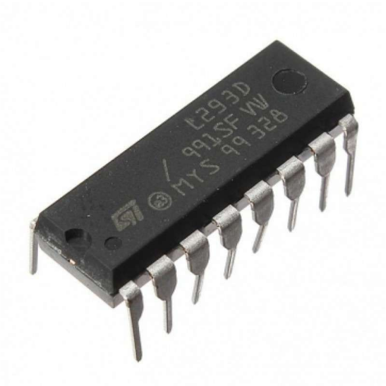

Fig. 3. Locomotion system driver

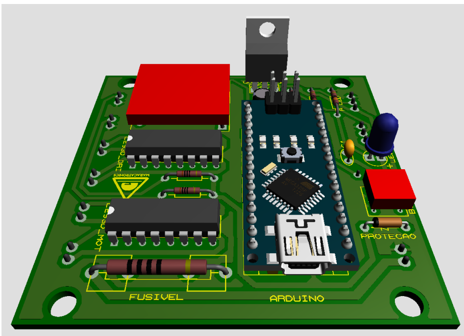

Fig. 4. 3D view of the PCB circuit

B. Future changes

For future changes, it is intended to implement a new microcontroller, *STM32F103C8T6* (Figure 5), which is better for our desired requirements than the Arduino Nano. The *STM32F103C8T6* has access to more connections for peripherals, more PWM ports, more ports for others general uses, it is cheaper, has a debug interface and processing speed increased compared with the Arduino Nano.

IV. Control System Overview

A. Path Planning

The path planning method used by our team was a basic RRT which did not fully match our expectations. With that said, we looked for alternatives and landed on the Univector Field as the one that best fitted what we were looking for. This path planning method had already been used on another teams and it was proven that it worked well on the VSSS category. Besides that, the way the vector field guides the robot mimics a behavior that previously we had to hard code on our players.

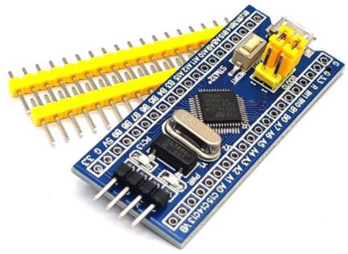

Fig. 5. Microcontroller STM32F103C8T6

In this navigation method the path is determined by hyperbolic and a repulsive field. The resultant field is a combination of these two types. The repulsive field is used to avoid obstacles and the hyperbolic is used to set the goal to the robot and general direction of the movement.

The Univector Field is defined as follow:

1) Hyperbolic Field:

$$\phi_h(\rho, d_e) = \begin{cases} \theta \pm \frac{\pi}{2}(2 - \frac{d_e + K_r}{\rho + K_r} & \text{if } \rho > d_e \\ \theta \pm \frac{\pi}{2}\sqrt{\frac{\rho}{d_e}} & \text{if } 0 \leq \rho \leq d_e \end{cases} \tag{1}$$

where

- θ angle from x-axis at the position p
- K_r adjustable parameter
- ρ distance between the origin and position p
- d_e predefined radius that decides the size of the spiral.

2) Repulsive Field:

$$\phi_r(\rho) = \theta \tag{2}$$

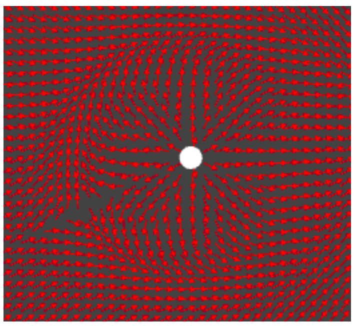

Fig. 6. Repulsive Field

These are the two basic field types, using them we can build a Move-To-Goal field and an Avoid-Obstacle one.

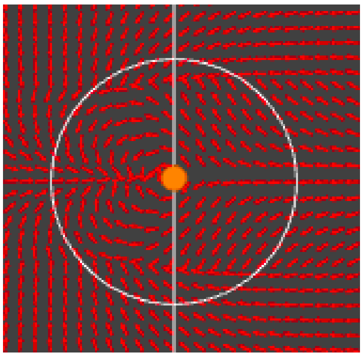

Fig. 7. Move To Goal Field

3) Move To Goal: The Move To Goal field (Figure 7) dictates the general direction on which the team moves, i.e. it defines our side of the field. It does not consider the obstacles in these calculations.

$$\phi = \{ \begin{array}{ll} \frac{y_l N_h(ccw)(p_l,d_e)+y_r N_h(cw)(p_r,d_e)}{2d_e} & \text{if } d_e \leq y < d_e \\ \phi_h(cw)(p_l,d_e) & \text{if } y < -d_e \\ \phi_h(ccw)(p_r,d_e) & \text{if } y \geq d_e \end{array} \tag{3}$$

where

$$N_h(p,d_e) = [cos\phi_h, sin\phi_h]^T \tag{4}$$

- y_l = y+d_e
- y_r = y-d_e
- p_l = $[x, y - d_e]^T$
- p_r = $[x, y + d_e]^T$
- cw = clock wise
- ccw = counter clock wise

4) Avoid Obstacle: To calculate the repulsive field, a virtual position based on the obstacle velocity is defined and the field is set on this position.

$$\phi(p) = \phi_r(p - P'_{obstacle}) \tag{5}$$

$$P'_{obstacle} = \{ \begin{array}{ll} P_{obstacle} + \vec{s} & \text{if } d_e \leq d \geq |\vec{s}| \\ P_{obstacle} + \frac{d}{|\vec{s}|}\vec{s} & \text{if } d < |\vec{s}| \end{array} \tag{6}$$

$$\vec{s} = \vec{V}_{obstacle} - \vec{V}_{robot} \tag{7}$$

where

- $P'_{obstacle}$ virtual obstacle's position
- $P_{obstacle}$ real obstacle's position
- d distance between robot and obstacle
- $\vec{V}_{obstacle}$ obstacle's velocity vector
- $\vec{V}_{robot}$ robot's velocity vector.

B. PID

The PID control system first planned on 2021 was unable to be implemented at the previous time. At the current year, new searches were made to finally have a real operational implementation.

There were two main properties planned to be upgraded since the end of the previous LARC: The final speed and the acceleration impulse. The reason for this was the robot speed of our robots seemed to be low compared to other teams and that was the main objective to implement a PID control at first thought.

For a true implementation, it first took a few tests with the main code without any PID control, so we could see some properties that would be interesting to upgrade. A curve of velocity vs. time at this situation is shown at Figure **??**.

Based on **??**, the final speed estimated is xxx and it takes around xx milliseconds for the robot reach the peak. For the current moment, the team chose an reduction on the peak time of zz% and a velocity increase of xx%. To attain these requirements, a basic PID implementation was made and a classical control technique was used to calculate the desired properties. A few tests were taken with the PID constants defined and the curve shown at Figure **??** was taken.

The Figure **??** compares both curves at Figures **??** and **??** and it can be concluded that the requirements were met (or not met???). With this, it can be concluded that the team gained the know-how about using a PID control and it can be used to attain to any requirements desired for different situations.

V. Conclusions

The team has implemented a bunch of new features, most of them based on the Tech Challenger 2021 to be a more competitive team among the others Brazilian teams. All the tests were tested to validate the application of improved changes and enhanced features.

References

[1] D. S. S. Corp., “Solidworks student,” https://www.solidworks.com/sw/education/6438_ENU_HTML.htm, 2020.

[2] J. E. A. Araújo, M. E. A. de Lima, C. M. A. Montarroyos, L. H. S. Arruda, P. J. L. Silva, A. H. M. Pinto, J. D. T. Souza, and J. P. C. Cajueiro, “Dribbler and kicker systems to small size soccer league robots: A study and project to latin american robotics competition,” in *2020 Latin American Robotics Symposium (LARS), 2020 Brazilian Symposium on Robotics (SBR) and 2020 Workshop on Robotics in Education (WRE)*, 2020, pp. 1–6.