Omnidirectional Mobile Robots from Team Cyberlords Junior for RoboCup Junior Soccer 2010

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***Abstract*—We describe the evolution of our soccer-playing omnidirectional mobile robots with an emphasis on a description of the mechanical, electronics and software characteristics of the 2010 version that will be presented for competition in the LARC2010 that will take place in São Bernardo do Campo, Brazil.**

I. Introduction

TEAM Cyberlords Junior was founded in the summer of 2008 with a focus on the RoboCup Junior Soccer competition. In September 2008 we took 3^{rd} place in the 1^{st} Mexican RoboCup Open. One year after our first competition, in September 2009, we played and lost the final game in the 2^{nd} Mexican RoboCup Open becoming 2^{nd} place in the nation. A couple of months after that we registered for LARC2009 in Valparaiso, Chile along with three other teams. Among our rivals was the team that had recently defeated us in the Mexican RoboCup Open. We became Latin American champions by playing and winning the final game in LARC2009. As Fig. 1 shows, although many of the mechanical parts of our robots were designed and manufactured by us specifically for the RoboCup Junior Soccer competition, the robots we used in 2009 were still based on LEGO motors, sensors and computing units [2].

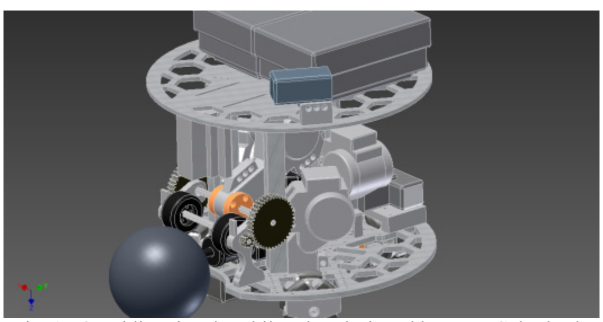

Fig. 1. Omnidirectional mobile robot designed by team Cyberlords Junior for the RoboCup Junior Soccer competition in 2009

Since our first participation, our robots have undergone a series of redesigns. In this paper we describe the mechanical, electronics and programming for our most recent robot development, which was successfully used by our team in the RoboCup 2010 World Championship which took place in Singapore.

For the LARC2010 we intend to participate using a combined robot team integrated by one of our new robots with the 2010 design and one of the old ones using the 2009 design.

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II. Mechanical Design

Our robots are based on an omnidirectional drive mechanism that uses three omnidirectional wheels. The wheels are 4cm in diameter, the same type that we used in our previous design. The omnidirectional wheel used in our robot is shown in Fig. 2.

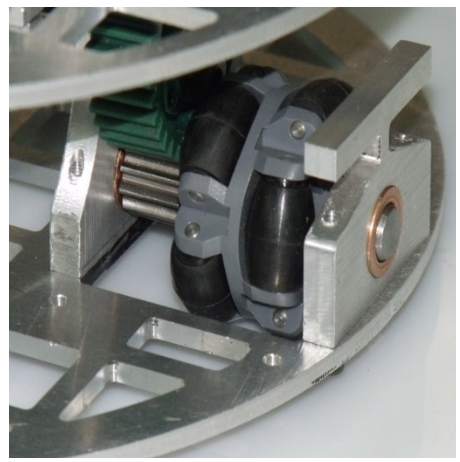

Fig. 2. Omnidirectional wheel attached to our new robot

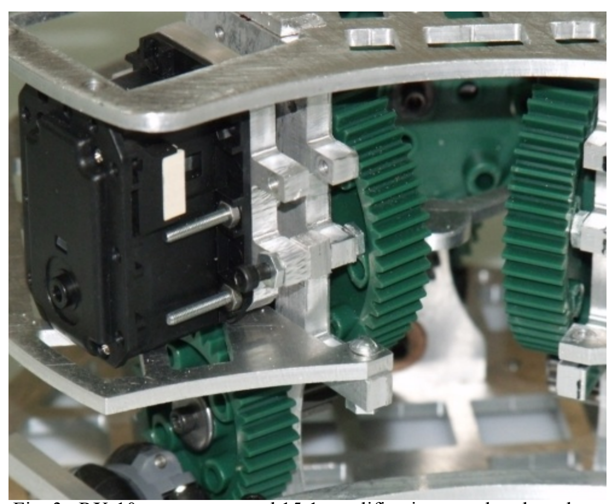

Fig. 3. RX-10 servomotor and 15:1 amplification gear box based on high strength VEX Robotics gears

One major change to our mechanical design for 2010 was the introduction of Dynamixel RX-10 servomotors to drive the omnidirectional wheels of the robot. These motors have ample torque to move the robot; however they are not very fast. This is why we decided to design a gearbox that wouldamplify the speed while reducing the torque that reaches the omnidirectional wheels. Figure 3 shows how one of these Dynamixel motors is attached to the omnidirectional wheel through the gear box. We used standard high strength VEX Robotics gears to achieve a 15:1 gear box ratio.

All mechanical parts and assemblies were designed by us using Autodesk Inventor. Figure 4 shows a rendering of our robot's 3D model.

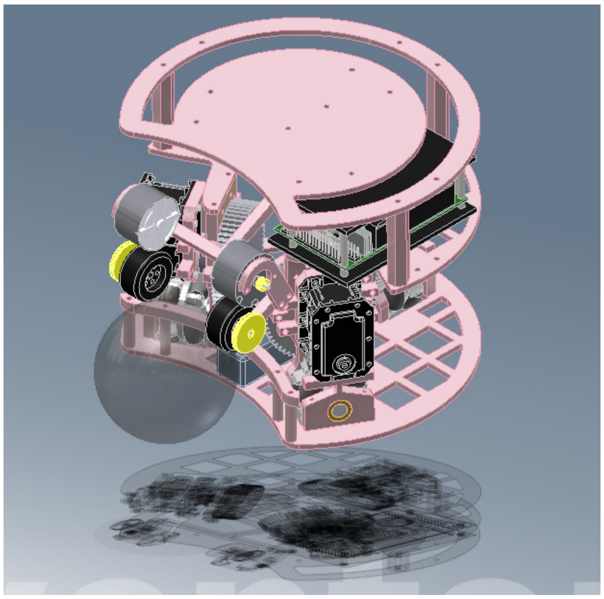

Fig. 4. Omnidirectional mobile robot designed by team Cyberlords Junior for the RoboCup Junior Soccer competition in 2010

The manufacturing of all aluminum parts that integrate the body of the robot was also all done by our team members in the workshop of the School of Engineering at Universidad La Salle. Some of these parts were machined in the CNC available in our workshop under the supervision of certified operators. Figure 5 shows some photos from the manufacturing process.

Fig. 5. Manufacturing process of aluminum parts

A photograph of the finished mechanical body of our 2010 robot design is sown in Fig. 6. The only mechanical devices that are missing in this photograph are the dribbler and kicker.

III. Electronics Design and Low-Level Control

Our robot uses three kinds of sensors. First of all, it uses an Infrared Seeker V2 from HiTec to detect the location of the infrared ball with respect to the robot. Second, it uses a LEGO ultrasonic sensor to estimate the distance to the walls. And, third, it uses a digital compass based on the Philips KMZ51 magnetic field sensor. The information from the compass is used by the robot to orient itself with respect to the field. This digital compass is significantly better than the LEGO NXT compass since it provides much higher accuracy.

Another major upgrade to our robots in the 2010 design was replacing the LEGO NXT programmable brick with a RoBoard computer. This computer is based on the Vortex86DX processor running at 1GHz with 256MB RAM. The RoBoard is an x86 compatible computer capable of running Windows XP or Linux. The computer has all the I/O ports we need to control the robot and communicate with the development platform. It has an Ethernet port that we use for program upgrading, an I^2C port for communication with the sensors, an RS-485 for Dynamixel motor control and it even has a VGA card and USB ports for the occasional in-board debugging.

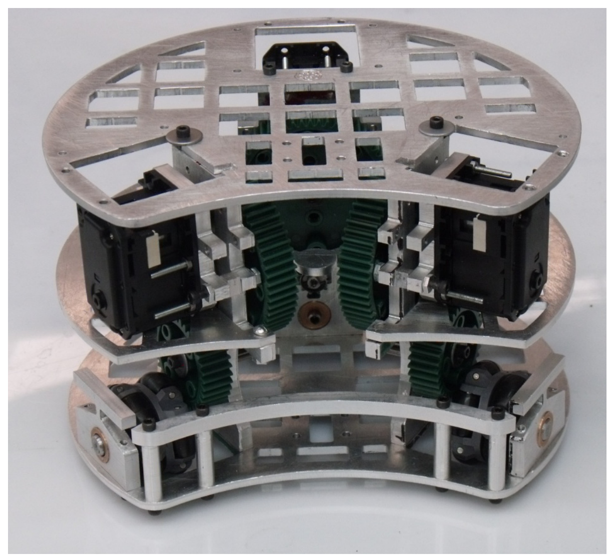

Fig. 6. Assembly of the mechanical body of our new robot

For power, the robot carries a set of four LiPo batteries in series for a total of 14.8 V. This voltage is used to power both the motors and the RoBoard computer, which in turn powers the sensors.

The RoBoard computer installed in our robot runs a Linux operating system on top of which the robot control software runs. All software was developed in C++ and compiled using gcc.

In order to achieve locomotion of the omnidirectional mobile robot in a specified direction and spin rate it is important to regulate the speed of each of the wheels. The theory of operation behind the locomotion of this kind of robot is based on a vector sum that is depicted in Fig. 7.

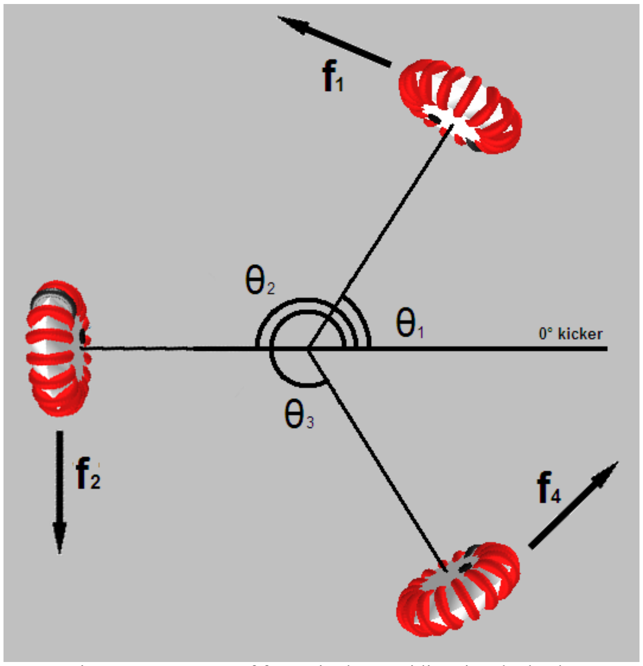

Fig. 7. Vector sum of forces in the omnidirectional wheels

IV. Behavior Control

The behavior, or high-level control, of the robot is programmed using the state-machine paradigm.

A. Goalkeeper

In the initial state of the state machine seeks the ball. If the ball is too far then it checks the compass while it moves. Once the ball is within range it checks the ultrasound sensors and moves laterally until the ultrasound sensors indicate it is within the range of the goal. The next state is to find the ball. If it is close then it attempts to catch it. If it manages to catch the ball then it attempts to shoot using the information from the compass.

B. Striker

As with the goalkeeper, in the initial state of the state machine the striker robot seeks the ball. If the intensitiy of the IR Seeker sensor is below range then it starts seeking the ball. Once it has the ball, it uses the information in the compass sensor to orient itself towards the oppontent's goal and attempts to shoot.

V. Conclusion and Future Work

Our new design represents a significant upgrade compared to the 2009 version of our robots. However, there are still many opportunities for improvement. Through our previous work in our robots we have learned lots of things and for our next version we plan to change our Dynamixel servos for Maxon motors as well as adding artificial vision using cameras in order to recognize the robot opponents and the goals. We are also designing our own ball-seeking sensors.

Acknowledgment

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References

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