Cyberlords LARC 2010 RoboCup Humanoid KidSize Team Description Paper

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***Abstract*— We describe the RoboCup Humanoid KidSize robots developed by team Cyberlords for the RoboCup 2010 competition held in Singapore. The same architecture will be used in LARC2010 to be held in São Bernardo do Campo, Brazil. We emphasize in this article the architectural enhancements for the 2010 version of our robots, which consist mainly of a new computing unit and camera, as well as significant enhancements to the vision algorithms.**

I. Introduction

Team *Cyberlords*, which is part of the *Mobile Robotics and Automated Systems Laboratory* at *Universidad La Salle* México, started working on our RoboCup Humanoid KidSize project in July 2008. The starting point of the project was a pair of ROBONOVA-1 humanoids, which we had to adapt mechanically, interface to several sensors and program to give them the ability to play football autonomously. By September 2008, we had the first functional version of our football-playing humanoids and debuted them in official competition during the *1st Mexican RoboCup Open* where we faced team *Bogobots* and *Pumas UNAM*. Our robots became *2008 mexican champions* by winning the semifinal and final games by a narrow margin of 1:0 in penalty kicks. Figure 1 depicts a practice shot between our striker *Roboldinho* and our goalie *Robo Ochoa*. In 2009 we applied for participation in the RoboCup world championship and, upon our notification of acceptance, we decided to officially join forces with the *Robotics and Artificial Vision Laboratory* of *Cinvestav*, with whom we had been collaborating since January 2009.

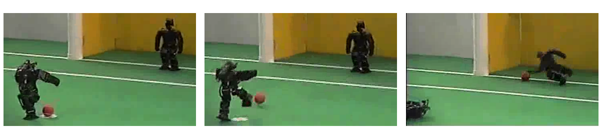

Fig. 1. Practice shot during the *1st Mexican RoboCup Open*

In the RoboCup 2009 world championship we were among the 11 teams that were able to score, and ranked as highest scorer from the American continent. Two months later, at the *2nd Mexican RoboCup Open*, we reaffirmed our scoring leadership among Mexican teams by scoring a total of six goals in four games.

In the RoboCup 2010 world championship, which took place in Singapore, we debuted a new version of our robots. After six games our robots scored a total of six goals. We ranked second from among six teams from the American continent, only behind team Darwin from Virginia Tech.

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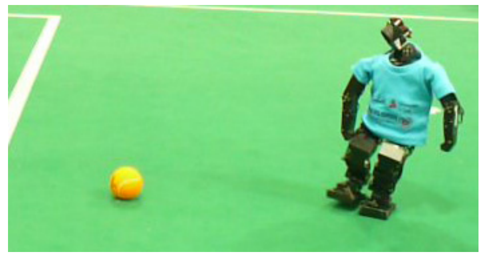

Fig. 2. Robot T1 in action during *RoboCup 2010* in Singapore

For the LARC 2010 competition we intend to bring two of our robots, one of them based on the new 2010 design (named T1) and one based on the 2009 design (our top scorer Benito).

II. General Architecture

The mechanical structure of our design for the 2009 competition was based on the commercial platform ROBONOVA-1 from HITEC, with a few mechanical adaptations. In contrast, our design for 2010 is making significant incremental enhancements to that initial design. Most notably, we are adding a much needed vertical degree-of-freedom (DOF) to the ankles so that our robot can now perform turning motions in a much more efficient way. We are also replacing most of the HS-8498HB leg servomotors with the higher torque HSR-5498SG servos. The head pan-and-tilt mechanism is now actuated by two HS-8498HB, which will give the camera a faster and wider range of motion. This design has a total of 20 DOF and is depicted in Fig. 3.

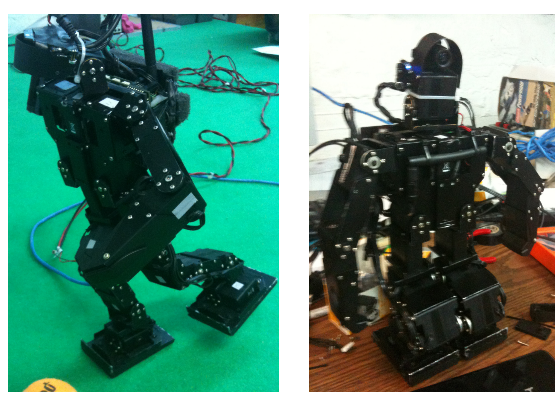

Fig. 3. Structural design for our robot *T1*

In this robot we are using a ROBOARD RB-100 main computer, which is based on the 32-bit x86 VORTEX86DX CPU running at 1GHz with 256MB of DDR2 RAM. This represents about 50 times more computing power than our previous design, which allows us to implement much more complex algorithms. In addition, this computer board includes many peripherals specifically tailored for mobile robotics. Among these ports we have: one RS-485, thirty-two PWM channels, three USB 2.0 ports, one SPI/I^{2}C bus, eight 10-bit ADC ports and one mini PCI socket. The use of this new board has made a significant difference with respect to our original design, since we know that most of the limitations in that design were due to a lack of sufficient computing power. The ROBOARD runs a LINUX operating system and uses a WIFI card for communication with the referee box.

III. PERCEPTION AND LOW-LEVEL MOTION CONTROL

For the purpose of giving our humanoids some degree of autonomy two kinds of exteroceptive sensors were interfaced to them:

1) A single IDS UI-1226LE-C USB 2.0 camera for monocular vision, which is mounted on a 2 DOF mechanism above the shoulders of the robot,
2) a 6 DOF inertial measurement unit (IMU) based on ST's LPR530AL and LY530ALH gyroscopes plus ANALOG DEVICES' ADXL335 triple-axis accelerometer which allows the robot to prevent falling to a certain degree plus allows it to know the sequence of motions necessary to get up in case of a fall, and

All servomotors and sensors, including the camera, are directly interfaced to the RB-100, which is the only programmable computing unit on-board the robot. HITEC servomotors are interfaced to the RB-100 through the PWM ports, so there's no need for an external interface unit that would only add weight to the robot. The IMU outputs are interfaced to the RB-100 using six of the ADC input ports. The UI-1226LE-C camera uses one of the three USB 2.0 ports available on the board.

Using a *Robot Pose Editing* software tool developed by Andrés Espínola in our lab we are able to generate a sequence of *key frames* for robot gaits. These *key frames* are then interpolated in realtime inside the robot in order to achieve smooth motions.

Self localization of our robots within the field is performed by inverse-pose estimation of the camera based on instantaneous observations of well known features of the field, such as the goal posts, the landmark poles and penalty marks. It should also be noted that the camera being used this year gives a significantly higher resolution image than the CMUCAM3 used in our design the previous years. This allows our robots to perceive features that are further away, including the ball.

Feature extraction from the predefined and controlled environment of the RoboCup field is an essential step towards achieving self localization. The vision system of our robot uses as landmarks the four corners of the goal posts (two at the bottom and two at the top) and the colored segments of the poles located to the sides of the center line of the field. The first step is to perform color segmentation on the captured image. Images are segmented into five colors: blue, yellow, green, white and orange. Figure 4 shows a sample image segmented in the HSV space. The methods developed in our lab to extract relevant features from the field will be the subject of an upcoming publication.

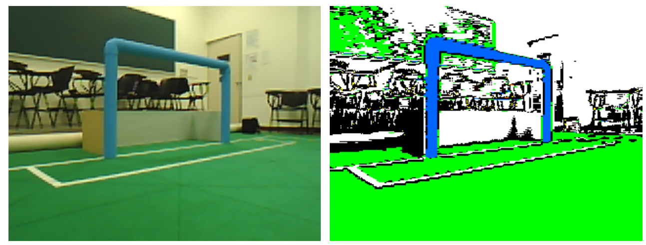

Fig. 4. Color segmentation in the HSV color space

IV. ROBOT BEHAVIOR CONTROL

The behavior control architecture for our robots is based on a hierarchical finite state machine (FSM). There is a high-level FSM which implements one state for each high-level action to be performed by the robot, such as GetUp, Walk, FindBall, AdjustOrientation, and so on. Each of these high-level states may in turn execute a lower-level FSM. For example, the high-level FindBall state is implemented by a low-level FSM that moves the head in a predefined sequence testing for the presence of the ball at each step.

The FSM transitions from one state to another triggered by a set of crisp conditions that depend on sensory information. These include AccelFallen, BallFound, ShotFilter, CompassDisoriented, BallFar, BallFoot, and so on. More than one condition may be triggered at any one time, so a conflict-resolution strategy is needed. Our approach is to give priorities to each condition so, for example, AccelFallen would have a higher priority than BallNotFound (or any other state for that matter) and BallNotFound would in turn have a higher priority than CompassDisoriented. Within each state, conditions are tested in the order of their priority, so whenever more than one condition applies only the highest-priority condition is taken care of, while the rest are not even tested. This makes sense since, for example, whenever the robot falls over it doesn't matter whether it knows where the ball is or not, the only thing that matters at that point is getting up.

Another special contribution from our team is the implementation of the ShotFilter condition inside the goalie's FSM. This condition is responsible for detecting a shot towards the goal, which in turn triggers the goalie's diving action in the appropriate direction (left or right). The ShotFilter condition uses the proprioceptive information from the pan-and-tilt head servos that is generated while the vision system tracks the ball. Whether the ShotFilter will be triggered or not depends both on the speed and location of the ball relative to the goal line. However, the relationship between these two ball-motion state variables and the head-servos angular positions is non-linear and it is not immediately obvious what set of conditions should trigger the diving action taking into account that there is a delay between the start of the reaction and the moment the goalie's arm actually reaches the goal line. Our solution to this problem is based on a parametric non-linear filter that we adaptively fine-tune by using experimental data.

V. Conclusion and Future Work

We have described the details of the structural and sensory details of the new humanoid robot architecture used by team Cyberlords in the RoboCup 2010 world championship. The general design of the behavior control for this robot is also described.

Acknowledgements

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