Borregos3D Team Description 2008

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Abstract. This paper shows the description of our team Borregos3D for the RoboCup Simulation 3D league. Last year in Atlanta we used a basic agent architecture based on finite state machines with very simple algorithms for the different behaviors like walk, kick, turn and stand up. The skills are currently being improved by using more complex techniques such as coupled oscillators for walking. Also, we developed an algorithm for computing the center of mass of the robot using quaternions. Moreover, the team has been ported to Java for platform independency and for being able to use several artificial intelligence open source libraries available on the web.

1 Introduction

In this paper, we show the main characteristics of our team, which is named Borregos3D. The team is being developed at Tecnologico de Monterrey in the city of Monterrey, Mexico, by a group of master students working on the Center for Intelligent Systems. We are the first simulation team from Mexico to participate in the 3D simulation league.

Our team Borregos was created back in the year 2004 for the Simulation 2D category and competed in RoboCup Portugal 2004 in the Simulation 2D category with M.Sc. Emmanuel Martinez as the team leader, under the supervision of Ph.D. Ramon Brena [7].

In the year 2006, M.Sc. Carlos Bustamante started developing a new team for the simulation 3D league with spherical agents and was classified to participate in the competitions of RoboCup Germany 2006 in the city of Bremen, under the supervision of Ph.D. Leonardo Garrido. A fuzzy bayesian approach for decision making in RoboCup Simulation 3D was presented in the RoboCup Symposium [5]. Later, a comparison between fuzzy bayesian classifiers and gaussian bayes classifiers was published in [4]. Another student, Cesar Flores, contributed developing the physics models which were used in the goto and dribble behaviors of the agents. This approach was published in [2].

Later, a hybrid monte carlo localization with Kalman filter sensor fusion approach was used for diminishing the effect of noise and uncertainty in the agent self localization process, and was published in [3]. With this approach, Borregos3D participated in the RoboCup Brazil Open 2006 competitions and won the 3rd. place. M.Sc. Carlos Bustamante graduated in december 2007 and his thesis [1] contains a more detailed explanation of all the aforementioned articles.

In july 2007, we participated in the first humanoid simulation competition in Atlanta, USA. The simulation substitutes the spherical agents with humanoid agents based on the Fujitsu HOAP-2 robot as shown in figure 1. In november 2007, we were the organizers of the 3D simulation league in the 3rd. RoboCup Latin American Open celebrated in Monterrey, Mexico.

Our efforts are now focused on developing better walk, kick, turn, strafe and stand up behaviors for the humanoid agent. For such a task, we are developing algorithms for computing the center of mass of the robot and using coupled oscillators for a dynamically stable walking gait.

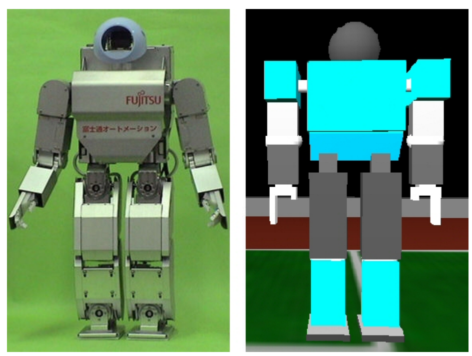


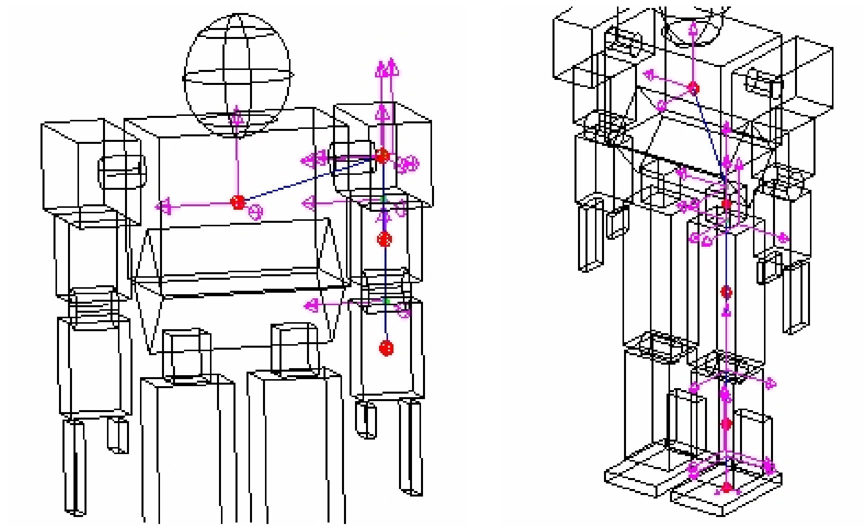
Fig. 1. Fujitsu HOAP-2 Robot (a) Real version (b) RoboCup3D Simulation version.

2 Center of mass

We have developed an algorithm for computing the center of mass (CoM) of the robot. First, we find the center of mass of all the parts of the humanoid model (head, torso, arm boxes, leg boxes and feet) as shown in figure 2, using direct kinematics by means of quaternions. Then we compute the position of the center of mass with respect to the robot's torso with this simple formula:

$$PCoM = \frac{\sum p_i m_i}{m_T} \tag{1}$$

where p_i is the center of each humanoid part, m_i its mass and m_T the total mass of the robot. Although quaternions are not easy from a conceptual point of view, they represent a computationally efficient tool in comparison with homogeneous matrices.



(a) Arms (b) Legs

Fig. 2. Reference frames for computing the center of mass of (a) the arms and (b) the legs.

Computing the center of pressure (CoP) relative to the robot's torso is very simple. We just add another frame in the center of mass of the foot, because the server sends the relative position of the CoP with respect to the CoM of the foot in the force resistance perceptor as shown in figure 3.

3 Walking gait

Developing stable and reliable walking patterns is one of the fundamental problems in humanoid robots. It is said that a statically stable pattern is that in which the Center of Mass (CoM) relies on the supporting area of the robot when walking. A dynamically stable pattern is that in which the Zero Moment Point (ZMP) is within the supporting area. The supporting area is the convex hull of the robot's feet. Developing a dynamically stable gait is harder, but can lead to faster walking behaviors.

We are focusing on developing a dynamically stable walking behavior but with two major modifications. First of all, we use the Center of Pressure (CoP) instead of the ZMP, which is provided by the soccer server with the force resistance perceptor. We are looking forward to compute ZMP in a near future and see if it is worth in terms of computational time versus the advantages it brings to the walking gait.

Second, we are using a method for walking which consists on coupled oscillators for controlling the joint trajectories during walking. This approach is

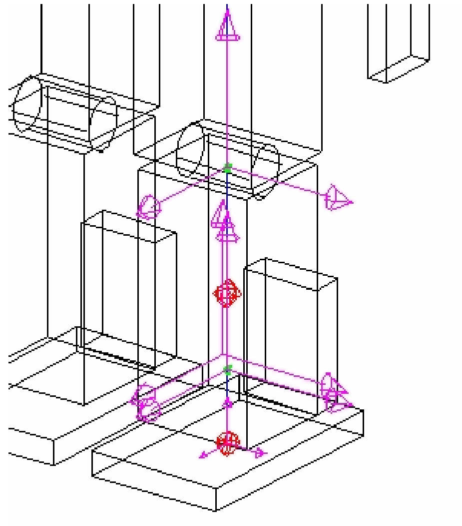


Fig. 3. A frame in the foot for computing the center of pressure relative to the robot's torso.

similar to Central Pattern Generators (CPGs) and it has been applied in the real HOAP-2 robot in [6]. In a near future, we plan to combine the center of mass with the coupled oscillators to get even better results.

In the aforementioned approach, the rhythmic component of the walking gait is described by a system of coupled oscillators modelling the controller phase (ϕ_c) and the robot phase (ϕ_r) with the following equations:

$$\dot{\phi}_c = \omega_c + K_c sin(\phi_r - \phi_c) \tag{2}$$

$$\dot{\phi}_r = \omega_r + K_r sin(\phi_c - \phi_r) \tag{3}$$

However, the robot natural phase ω_r and the coupling constant K_r are unknown as they depend on the robot dynamics. The robot phase is detected with the position C and velocity $\dot{C}$ of the center of pressure:

$$\phi_r = atan2(\dot{C}, C) \tag{4}$$

The center of pressure is scaled into the range $[-1, 1]$ where -1 indicates that the robot is standing in its right foot, 1 indicates that the robot is standing in its left foot and the numbers between them indicate a transition from one foot to the other.

The desired trajectory for each joint is a peudo-sinusoidal wave with phase ϕ_c and phase differences depending on the current state of the walking gait. Thus the trajectories are computed with the numerical integration of $\dot{\phi}_c$ and the joints are moved with PID controllers. The amplitudes of the sinusoidal waves are currently hand tuned, but we are planning to use genetic algorithms for searching the parameter space for better amplitudes.

4 Conclusions

We presented our research work planned for our Borregos3D RoboCup Humanoid Simulation team. We have participated in RoboCup Simulation competitions since 2004. We are currently working on better low-level behaviors such as walking, using coupled oscillators and computing the center of mass of the robot. We expect to combine ZMP, CoM and coupled oscillators in a near future.

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