Bogobots-TecMTY humanoid kid-size team 2009

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Abstract. This paper describes the specifications and capabilities of the humanoid robots developed by the Bogobots-TecMTY Humanoid Team at Tecnológico de Monterrey, Campus Estado de México for Robocup 2009 competition. It is presented our present version of robots as well as the new design with more capabilities in which we are working now. The main research of the team focuses on stable omnidirectional parameterized walking engine as well as a robust perception systems based on vision to perform path-planning analysis and motion decision based on localization and orientation.

Keywords: Humanoids, stable omnidirectional parameterized walking engine, robust perception systems, decision-making based on localization and orientation.

1 Introduction

Since 2004 Tecnológico de Monterrey started a research project on humanoids. The goal is to have full-autonomous robots with efficient walking abilities, high-sensitive perceptions systems, multiple manipulation-skills and learning-abilities. The RoboCup soccer challenge is a very good opportunity to develop our robot prototypes and focus in our research interests, the last year, we had the opportunity of participate in the RoboCup 2008, where we learn a lot and we could identify our improvement areas, for that reason, we come again with a full new version of our humanoid team robots, which main features are the mechanical design, perception system, processor unit, and gait algorithm, with all this, we are willing to participate in RoboCup 2009.

2 Mechanical-Electronic Designs

Bogobot-1 kid-size humanoids are built with aluminum brackets. The kinematic chains are powered by high-torque servomotors. Each leg has 6 DOF and each arm has 3 DOF [1]-[2].

To provide tilt and pan motions to our vision system [3], we use an aluminum mechanism powered by two micro servomotors directly controlled by the camera, providing object tracking independently from leg or arm motions.

The Bogobot-1's electronic architecture was custom-built and considers a main processor based on DSPic30f4013 with:

- a PWM servocontroller card communicated by RS232.
- CMUcam3 camera connected by RS232,
- Digital compass [4] connected in an analog input.
- IMU electronic device connected in 5 analog inputs,
- Switched power supply connected to two Lithium-Polymer batteries [5].

Fig. 1. Bogobot-1

The servocontroller card receives all requested angular positions of joints from the main processor and sends electrical PWM signals to servomotors.

Object recognition and ball-tracking are processed on the CMUcam3 and this information is sent to main processor for decision-making algorithms.

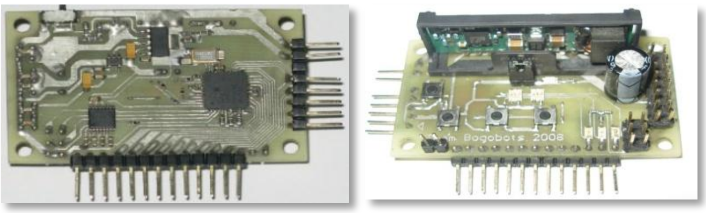

Fig. 2. Custom-built electronic for Bogobot-TecMTY humanoid.

Bogobot-2 kid-size humanoids are in development. This model has been designed to be constructed with aluminum brackets. The articulations will be driven by high torque servomotors. The 21 DOFs of this robot are distributed by the following way: 7 in each leg, 3 in each arm and 1 for the head.

The main components for this robot will be the following:

- 14 Robotis Rx64 servomotors.
- 7 Robotis Rx28 servomotors.
- A USB webcam.
- A digital compass.

- An IMU electronic device.
- A Lithium-Polymer battery.
- An ultra Mobile PC.

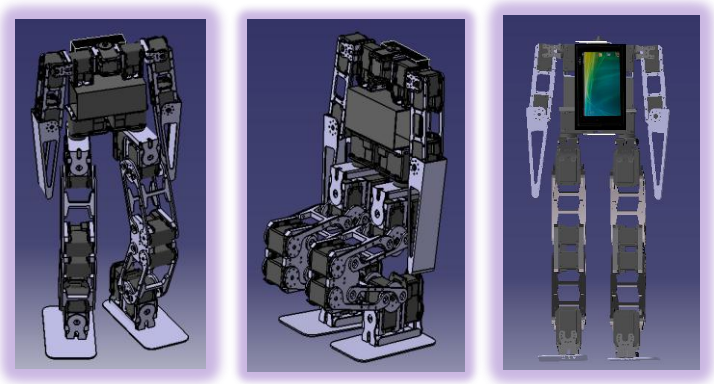

Fig. 3. Bogobot-2 design.

3 Motion algorithms

The movements are implemented in two ways: predefined motion pattern and real-time trajectory computation with inverse kinematics. The first kind is based on interpolated key-frames composed by motor's angles that are off-line specified by programmer and in-line interpolated with numerical methods. This approach is mainly used for instinctive movements like kicks, blocks, recovering from falling down, or transitions among static-postures. The second kind of movements is based on run-time parametric walking-pattern generator that allows robot to walk in different styles, speeds and directions [6]-[9].

This second kind of movement is performed in 3 steps. The first one consists in compute feet paths keeping global momentum always zero by using ZMP techniques. These ZMP-based trajectories are computed with the projection of the Center of Mass on the XY plane. The second step is computing the angular position of the leg's servomotors (joints). Fortunately, this can be done very fast because we could solve inverse kinematics analytically. That is, once the foot position is computed, all the angular position of the joints are calculated by the IK formulas. The third step uses information provided by gyroscope unit, which is filtered by a Kalman filter, to compensate angular position of specific servomotor that helps robot to keep itself in standup posture regardless disturbances by unlevel floor, small bumps, and collisions (see Figure 4).

Feet trajectories can have different shapes (e.g. rectangle, ellipse, half-ellipse, etc.) and are defined by a set of parameters (e.g. foot center, step height, maximum forward/sideward step size). Figure 5 shows an example of semi-circular shape. The phases of the two legs should shifted by half a phase in order to guarantee that one foot is in contact with ground while the other foot is flying over.

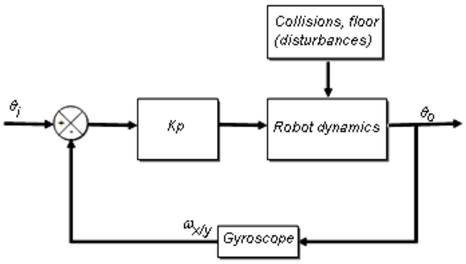

Fig. 4. Feedback compensation for external disturbances.

With this basic idea, we modeled our robot as being a two-wheeled vehicle where we could vary its direction and speed. This idea proved to be very simple and versatile regarding the kind of walks we could achieve.

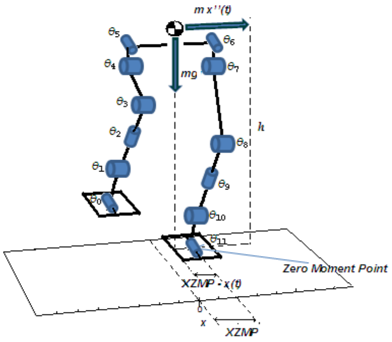

Fig. 5. Foot-path of robot considering Zero-Moment-Point.

We are now adjusting all developed algorithms of locomotion to the new mechanical structure. We are also working on some path planning strategies for better approach the ball given different circumstances and perform different kind of action depending on specific situation of robots on the field.

4 Vision algorithms

The vision algorithms of bogobot-1 were programmed using the vision system CMUCam3 incorporating features like color segmentation algorithms, object recognitions, distance estimation, self-localization and object tracking.

We implemented off-line algorithms of color segmentation in cubic classes and we implement on-line color-based algorithm for object identification [10].

Ball-tracking was implemented in CMUcam3 and provides estimation of relative distance that is sent to main processor for decision of motions towards ball.

We are now developing new vision algorithms in an ultra Mobile PC running in a LabView® environment. Those algorithms are based in color segmentation through rotational ellipsoids. Also, we are now developing a new tool of on-line semi-automatic color segmentation that helps the user to calibrate the key color regions needed for players in only some minutes, with the aid of real-time images taken by the camera. The beta version of this new tool and its results are shown on Figure 6.

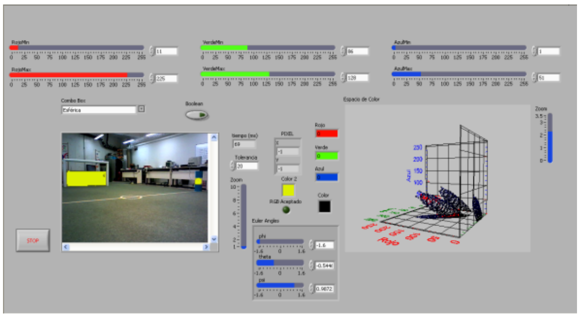
RojoMin 11
RojoMax 225
VerdeMin 86
VerdeMax 128
AzulMin 1
AzulMax 51
Combo Box Esférica
Tiempo (ms) 69
Tolerancia 20
PIXEL X -1 Y -1
Rojo 0
Verde 0
Azul 0
phi -1.6
theta -0.5446
psi 0.9872

Fig. 6. Ellipsoidal color segmentation and Graphic Interface in Development.

We are developing self-localization algorithms by classic methods of triangulation. Basically, we infer robot position on field by the recognition of two landmarks and the relative distance respect to robot. The location of ball on the field is based on relative distance and orientation of ball with robot's position. We will also implement localization algorithms based on lines instead of color. Field lines or edges of objects will be used to find landmarks for localization. We are researching algorithms for color segmentation robust to variant light conditions and noise.

5 Decision Algorithms

The main processor performs three tasks: (1) a walking-pattern generator. Using the analytical inverse kinematics of legs and a parameterized leg-path generator is possible to easily perform omni-directional walking, (2) some simple motions like standup, kick and block are developed with frame-based motion, and (3) off-line decision-making algorithms are run to produce individual player's behaviors.

This year we are using LabView® environment because it is very easy to build interfaces with communication and data acquisition systems. Also we are now focusing in the communication between robots on game through a Game Controller.

Off-line decision-making algorithms are run to produce individual player's behaviors. For example, a player behavior sequence is: (1) find the ball, (2) go close to the ball, (3) get control of the ball, (4) find opponent goal or pass the ball to a teammate, (5) aligning to opponent goal, (4) shoot towards, (5) keep defensive posture.

A summarized graphic version of our decision algorithm is presented in Figure 7.

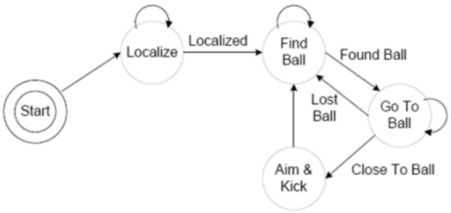

Fig. 7. States based decision algorithm.

6 Conclusion and Future Work

In this paper, we showed the present work of Bogobots-TecMTY team. We take advantage of our previous research results on biped robots to implement them on our humanoids team. Some research done in our Institution about vision systems was also implemented.

This is the second time our team intends to participate in the RoboCup humanoid kid-size league. Our first participation was in Suzhou China 2008. Right now, our team of three robots is fully capable of playing soccer, and now we are working very hard to have the next version of our humanoid robots to RoboCup 2009.

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