Robo-Erectus Jr-2013 KidSize Team Description Paper.

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Abstract

This paper provides a brief description of Robo-Erectus Jr (REJr) that is set to participate in the KidSize category in the Humanoid League of Robocup 2013. Robo-Erectus Jr-Bv are a series of KidSize humanoid developed in the Advanced Robotics and Intelligent Control Centre of Singapore Polytechnic. The latest version of the Robo-Erectus Jr-Bv humanoids are the MkII+ and MkIII.

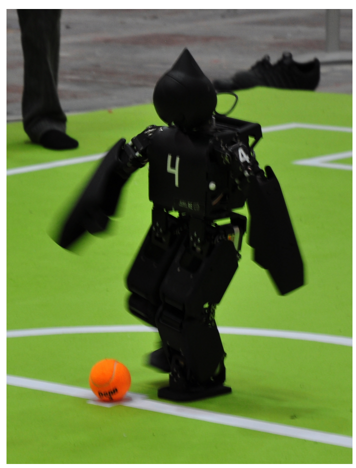


Fig. 1. REJr Bv are the latest series of Robo-Erectus KidSize humanoids

Statement of Commitment

Our team Robo-Erectus is committed to take part in the Humanoid League, KidSize category, at the RoboCup 2013. Our team consists of professional staff and students so that we can perform our best in the competition. Robo-Erectus team commits that a member of the team will be proficient to serve as referee during the KidSize competition. The team commits that the member that will act as referee will be able to act as main referee, assistant referee or Referee Box Controller. Robo-Erectus team also understand the implication of failing to any of these commitments for future participation in the Humanoid League.

1 Introduction

The Robo-Erectus project (www.robo-erectus.org) started as early as 2002 in the Advanced Robotics and Intelligent Control Centre (ARICC) of Singapore Polytechnic. Robo-Erectus (RE) is one of the pioneer soccer-playing humanoid robots in the RoboCup Humanoid League, having participated in Robocup 2002 when the league first begins. In subsequent years, RE actively continue to participate in the humanoid league from 2002 till 2011. Table 1 shows the team performance of the RE project since 2002. This paper is organized as follows. In Section 2, the mechanical and electrical designs are presented. Following, the locomotion control system, image processing, localization and robot behavioural game system are described respectively. Finally, in Section 4, the concluding remarks are presented.

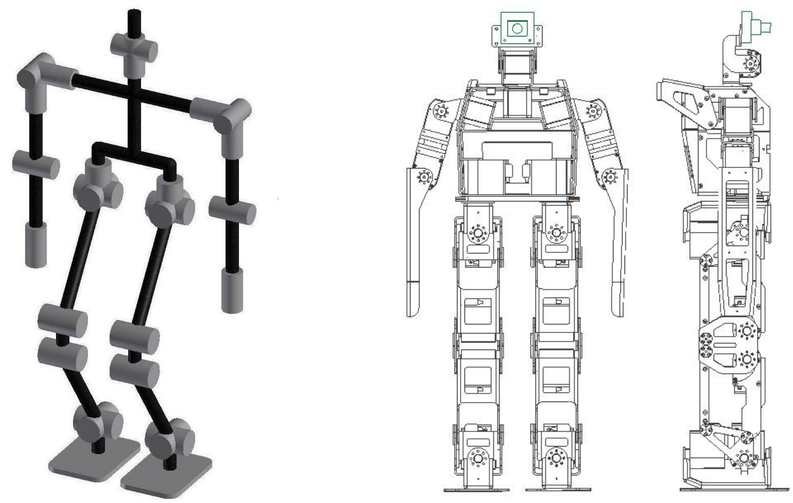
Table 1. Team performance from 2002 to 2011

Competition Category	Result
RoboCup 2002 Humanoid Walk	2^{nd} Place
RoboCup 2003 Humanoid Free Style	1^{st} Place
RoboCup 2004 Humanoid Walk	2^{nd} Place
RoboCup 2004 Humanoid Free Style	2^{nd} Place
RoboCup 2004 Humanoid Kick H40	2^{nd} Place
RoboCup 2004 Humanoid Kick H80	2^{nd} Place
RoboCup 2007 Humanoid TeenSize	4^{th} Place
RoboCup 2008 Humanoid TeenSize	4^{th} Place
RoboCup 2010 Humanoid AdultSize	2^{nd} Place
RoboCup 2011 Humanoid AdultSize	2^{nd} Place

2 Hardware Design

2.1 Mechanical Design

REJr is a 22 degree-of-freedom (DOFs) humanoid robot with 14 DOFs in the legs, 6 DOFs for the hands and 2 DOFs in the head (Fig. 2a). The pitch, roll and yaw joints in the hip are orthogonal and intersect at a single point in the hip. Both the shoulder and ankle joints have orthogonal pitch and roll joints. The robot adopts a parallel double crank mechanism in the leg structure with double actuation in the knee. Fig. 2b shows the mechanical skeleton assembly of the humanoid robot REJr. The humanoid robot is designed and constructed using aluminium alloy which is light-weight, and able to provide adequate structural strength.



(a) Degree-of-freedoms configuration (b) Mechanical assembly

Fig. 2. Mechanical design of REJr

2.2 Electrical Design

Fig. 3 shows the electrical system architecture of the humanoid. The humanoid is driven by two processors (Table 2), a high level host processor and a low level micro processor, connected to various peripherals. The humanoid task and peripherals are sub-divided and handled by the two processors independently.

Table 2. Specifications of the processors

Features	High Level Host Processor	Low Level Micro-Processor
Processor	fitPC	dsPIC
Speed	1600Mhz	80Mhz

The humanoid is actuated by digital servos coupled to each of the leg joints. Two power rated servos are employed (Table 3); the upper body uses lesser power, lighter and smaller servos in compared to the lower body. The servos are connected using the daisy chain configuration and controlled using half-duplex serial communication. The servos are commanded at a frequency of 50Hz. Four types of sensors are mounted on the robot (Table 4); camera, inertia measurement unit (IMU), rate gyroscope and absolute rotary encoder. The camera is mounted in the robot head to provide monocular vision. The IMU and rate gyroscope are mounted in the body to measure the linear acceleration, angular tilt and rotation. The actuators in each joints are embedded with an absolute rotary encoder for measurement of joints angle.

Table 3. Specifications of the actuator.

Actuator	Torque	Speed
Upper Body	40.8 kg.cm @ 10.8v	0.19 sec / 60 deg @ 10.8v
Lower Body	67.0 kg.cm @ 11.1v	0.22 sec / 60 deg @ 11.1v

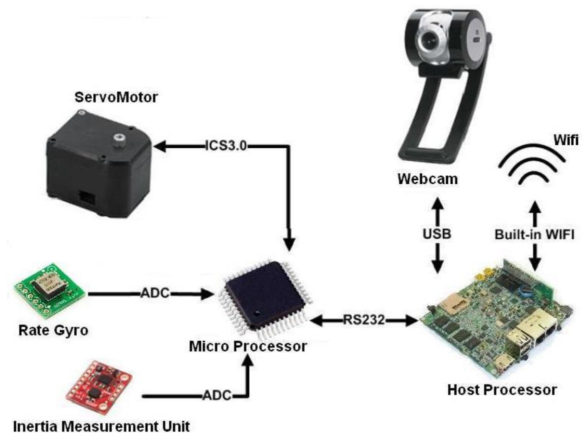


Fig. 3. Electrical system architecture

REJr has a built-in Wifi module that allows wireless exchange of information for communication between the humanoids and with the referee box. A single 2Ah 3-cells high-current Lithium polymer rechargeable battery which allows 15-20 minutes of operation is used to power the humanoid.

Table 4. Specifications of the sensors

Sensor	Details
Camera	640x480 Resolution 30fps.
Gyro (IMU)	$\pm 500°/sec$ angular rate.
Accelerometer(IMU)	$\pm 3g$
Rate Gyro	$\pm 300°/sec$ angular rate

3 Software Specifications

3.1 Locomotion Control

The Robo-Erectus Junior's locomotion uses an approach [1] which decouples the dynamic walk into two components; lateral walk-oscillations and omni-directional walking. The humanoid walk uses a two stage compensation technique and a dynamic support phases generator. Omni-directional walking movements are generated in real-time using sinusoidal functions. The use of compliant joints for foot landing impact and stability criterion measurement is employed.

3.2 Image Processing

The image processing on-board REJr uses the same image processing algorithm [2] developed in previous years with several improvements. Colours are used for identification of the ball, the goals, the field lines and other players in the YUV color space using scan lines. This year, the look-up table is reduced to 64x64x64 from 256x256x256 and the image from 640x480 to 320x240 to speed up processing. A windowing method is used to process the area of interest in the image in higher resolutions.

3.3 Localization

The localization of the humanoid is realized using the Monte Carlo localization (Fig. 4). Based on the field lines and goals, the particle filter determines the position of the humanoid on the field. Gyroscope readings are used to help determine the orientation in relation to which yellow goal is the home and opponent's.

Fig. 4. Monte Carlo localization

3.4 Behavior Control

The behavior control module, consisting of a framework of *hierarchical reactive behaviors*, provides the functioning of the robot in autonomous mode. This structure restricts interactions between the system variables and thus reduces the complexity [3]. The control of the behaviors happens in three layers: skill, reactive, and planning layer.

The skill layer controls the servo, monitors targets, actual positions, and motor duties. The skill layer translate actions from the reactive layer into motor commands and feedback to the reactive layer once the commands are executed.

The reactive layer implements the robot behaviors like walking, kicking, getting-up, and so forth. This layer selects the behaviors based on the desire task that the planning layer send. Corrections behaviors required due to deviation from actual task is also handled by this layer.

The planning layer use the behaviors of the reactive layer to implement soccer skills such as defending and attacking behaviors. The behaviors at the planning layer are abstract goals which are passed to the reactive layer.

3.5 Dynamic Role Assignation

In a robot soccer game, the environment is highly competitive and dynamic. The proposed approach conceived the team as a self-organizing strategy-based decision making system, in which the robots are able to perform a dynamic switching of roles in the soccer game. The changing of roles will be filtered based on three criteria; Strategy, Game Time and Goal Difference respectively [4].

1. Strategy, the strategy to be used for the game will be selected before kick-off and half time of the game. The strategy defines the final objective of the team, and specifies if team should be more offensive or defensive in their play.
2. Game Time, the time of the game, 10 minutes for each half of the normal game, and 5 minutes for each half of extra time when required.
3. Goal Difference, defined as the difference of own team goal score and opponent team goal score.

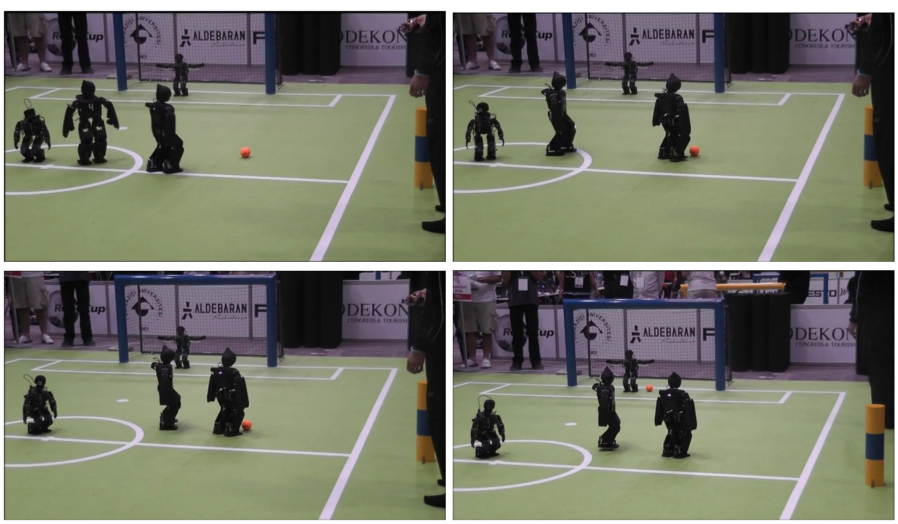


Fig. 5. Ball approaching and team coordination during RoboCup2011 games.

At several points during the robot soccer game, the robots need to communicate with one another. This may involve informing agents of events or responses, asking for help or information, and negotiating to iron out inconsistencies in information or to agree on a course of action. Negotiation will be necessary when changing of roles is required. In review of the dynamic roles design, the ball approach method should be taken into consideration. Team formation change may be based on the positions of the three robots. This could be useful when two robots required negotiating for a particular role. The proximity and approach to the ball could be used to determine which robot would get the role. Besides, the ball approaching and ball possession is important to coordinate the robots during the game.

Figure 6 presents a situation where robot A and robot B are disputing for the role of striker and defender. There are two criteria employed to solve this problem. First, the robots should evaluate if they are attacking or defending. This is evaluated by determining if the opponents are close to the ball, in that case it is considered that the team is defending; otherwise, it is considered that the team is attacking. Second, the robots will evaluate the distance to the ball. If the robot believes that its distance is shorter than that of the other robot, it will approach to the ball and win the role, i.e. defender when the team is defending or striker when attacking.

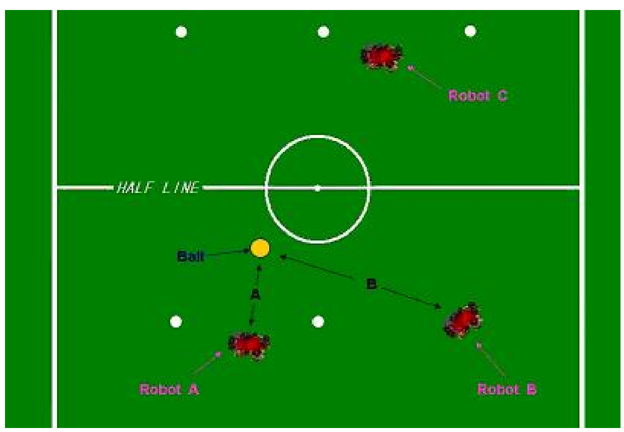


Fig. 6. Negotiation of roles for two robots based on distance from the ball and the strategy of the game.

During a game there could be situations where a team must play with substitute robots, and occasionally the team must play with fewer players. To deal with these situations, the proposed formations roles with priorities. These priorities indicate which roles must be filled first. Figure 5 presents the approach to ball and team coordination with two robots. Since both robots have striker role, both will try to approach the ball. However, once one striker reach the ball and takes possession of the ball, the second striker will keep a distance. This coordination has been further explore to pass the ball.

Table 5. Formations and priorities of the roles per formation.

Formation	Highest	High	Low
Defensive	Goalie	Defender	Defender
Normal	Goalie	Defender	Striker
Offensive	Goalie	Striker	Striker
Super Offensive	Defender	Striker	Striker
All Out	Striker	Striker	Striker

4 Conclusion

In this paper, we introduced the state-of-art of the Robo-Erectus Jr humanoid robot. In compare to its predecessors, the latest version of the Robo-Erectus has significant improvements to its speed, stability and reliability and is prepared for the Robocup 2013 competition. For more detailed information about the Robo-Erectus, please refer to the team's website www.robo-erectus.org.

Acknowledgments

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