Robo-Erectus Jr-2016 KidSize Team Description Paper.

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Abstract

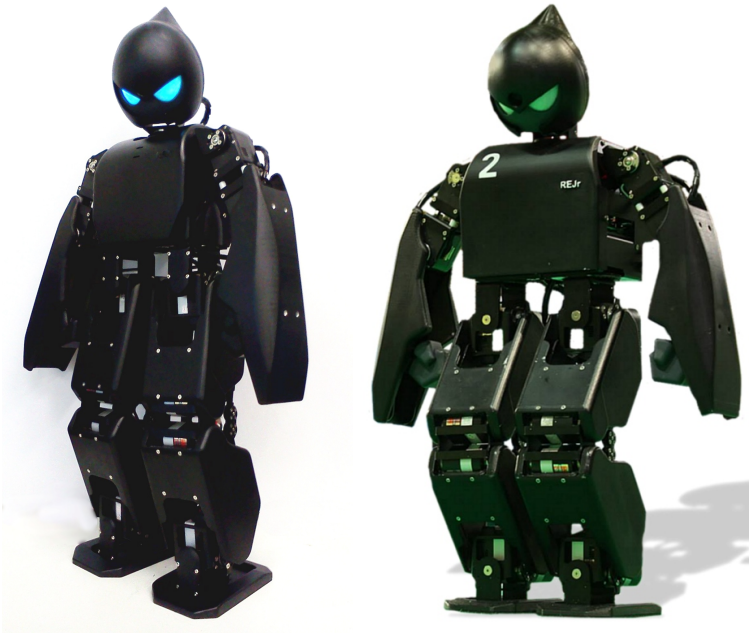
This paper provides the team description of Robo-Erectus Junior (REJr) that is set to participate in the Humanoid League KidSize Soccer Competition of Robocup 2016. REJr are a series of KidSize humanoid developed in the Advanced Robotics and Intelligent Control Centre (ARICC) of Singapore Polytechnic (SP). The latest version of the REJr humanoids are the Bv-MkIII+ and Bv-MkIV.

1 Introduction

Biped locomotion research and development work started in Singapore Polytechnic (SP) in 1996. Since then, SP has been active in the field of biped research and development. In 2002, the work was extended to the humanoid robot with the establishment of the Robo-Erectus project (www.robo-erectus.org) in the Advanced Robotics and Intelligent Control Centre. The aim of the project is to develop a humanoid platform that can be used for research and education [1].

Table 1. Team performance since 2002

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
RoboCup 2015 Humanoid KidSize Tech. Challenge	4^{th} Place



(a) REJr Bv-MkIII+ (b) REJr Bv-MkIV

Fig. 1. Robo-Erectus KidSize Humanoids

Team Robo-Erectus is one of the pioneer soccer-playing humanoid robots in the RoboCup Humanoid League, having participated in Robocup 2002 Fukuoka when the league first begins. Over the years, the team has actively participated in the competition and bagged several awards. Table 1 shows the team's performance since 2002. Last year, our team came in 4th place in the technical challenge and made it to the quarter-finals of the soccer competition.

Team Robo-Erectus would like to commit to participate in the RoboCup 2016 Humanoid League Competition upon confirmation of qualification and securing of travel expenses funding. The team is still in the process of securing sponsorship and funding for the travel expenses. Members of the team are able to volunteer as referees as they have sufficient knowledge of the rules with members having the experience in refereeing in past RoboCup competitions.

This paper is organized as follows. Section 2 briefly describe the robot where an overview of the hardware and software are presented. Following, in Section 3, the major improvement works done for this year RoboCup are highlighted. Finally, in Section 4, the concluding remarks are presented.

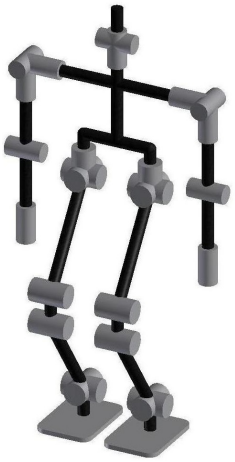
2 Overview

In this section, an overview of the REJr robot is presented. As majority of the improvement to the robot this year pertains to the software, the hardware is

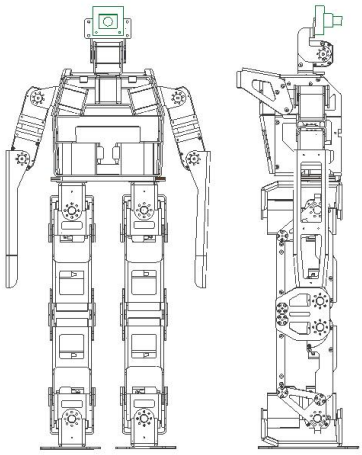
only briefly described. More details of the robot's hardware are available from previous year team description papers [2].

2.1 Hardware Design

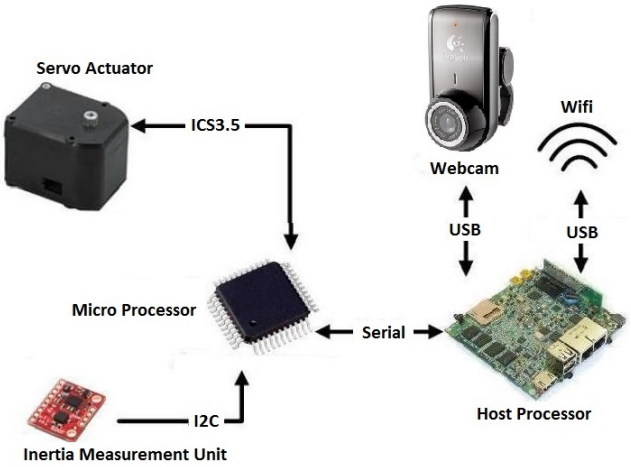
The team will be adopting the same robot from last year's competition. Figure 1 shows the current version of the REJr humanoids for the competition; Bv-MkIII+ and Bv-MkIV. Figure 2 shows the mechanical and electrical hardware of the robot. Detail specifications of the robot is available from the robot's specification papers.



(a) Degree-of-freedoms configuration



(b) Mechanical assembly



(c) Electrical architecture of robot

Fig. 2. Mechanical and electrical hardware of the robot

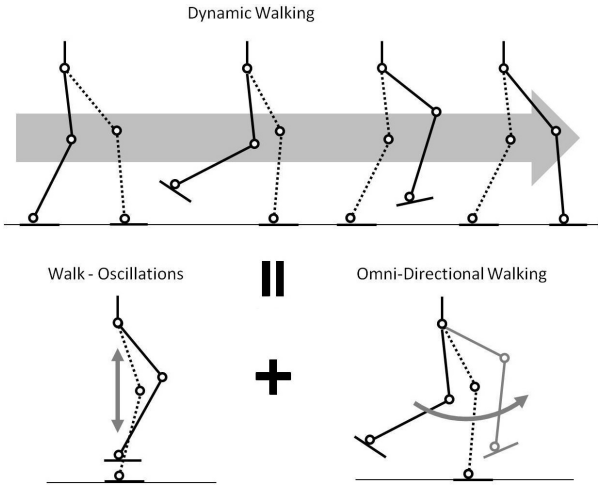


Fig. 3. Gait generation of REJr

2.2 Software Specifications

Locomotion Control REJr adopts a decoupling approach for dynamic walking gait generation(Fig.3) based on the Zero-Moment Point(ZMP) using the inverted pendulum model[3]. The dynamic walk is decoupled into lateral walk-oscillations and omni-directional walking gait generation to reduce the complexity in implementation. A ZMP preview controller[4] is implemented to further enhanced the robustness of the walking gait on artificial grass.

Image Processing Image processing is achieved using edge detection and the YUV colour space on REJr. Scan lines are used to minimize computation time and to generate window of interest for in-depth processing. Postulation of the ball, goals, field lines and junctions are determine from the generated window of interest.

Localization As per previous year, the Monte Carlo localization is adopted to determine the position and orientation of the robot on the field. The particle filter utilizes key landmarks such as field lines, line junctions and goals. Orientation of the robot with respect to the home or opponent goal is determined using a complementary system that infuses data from the gyroscope and vision.

Behaviour Control The function of the humanoid in autonomous mode is supported by a framework of *hierarchical reactive behaviours*. Three layers:skill, reactive and planning[5] determine the control of the behaviours of the robot. Restriction placed on the interactions between the system variables by the framework reduces the complexity in the behaviour control for optimum performance.

Fig. 4. REJr walking towards the ball in RoboCup 2015

3 Major Improvements

In this section, the major improvements made to REJr are described. The improvements are built upon or extension of accomplished work presented in Section 2.

3.1 Gait Generation

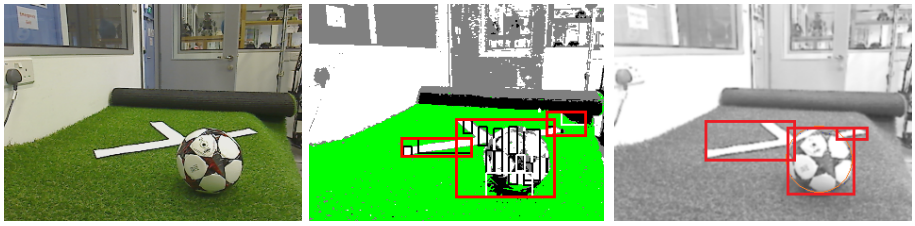
The introduction of the artificial grass play field was a key challenge to many teams in last year competition. Although, REJr was able to omni-walk, the robot was not able to attain its' top walking speed as the artificial grass was softer than expected.

This year, the work[3] using compliant joint sensing in the knee for ground reaction force estimation and foot landing in REJr is extended. Based on [6], an adaptive foot and ground contact model is implemented to alter the walking speed without changes to the gait pattern for adapting to different stiffness properties(softness) walk surfaces.

3.2 Image Processing

Despite the introduction of the new rules for RoboCup 2015, REJr mainly relies on colour for image processing in last year competition. Primarily, the use of colours is still computation efficient and inexpensive. However, reliability and effectiveness is subjective to conditions of the environment.

For RoboCup 2016, REJr adopts an improved image processing algorithm to reduce the reliance on colours. Gaussian blur is applied to the image to reduce noise before segmentation. Blob segmentation is performed to generate window of



(a) Original image (b) Colour segmentation (c) Luminance segmentation

Fig. 5. REJr's image processing (*Red box:window of interest*)

interest based on luminance rather than colour as per previous implementation. This reduces blob splitting due to non-homogeneity and varying lighting (eg. shadow) of the object's colour; Figure 5 shows the difference in the window of interest generated using the two different approach. Edge detection performed in the window of interest is extended to colour and shape detection to increase the likelihood estimate of identifying the objects.

3.3 Game Play

One of the major issues the team faced in last year competition was the lack of game play. In particular, the inability to search for the ball in the large playing field of 9m x 6m. Each robot has a limited vision range of 2m and this often results in the lack of game play as the robots are unable to determine the ball position once the ball moves out of all robots' vision range.

Ball localization is implemented in REJr to address the problem in lack of game for this year competition. A simple rolling ball prediction model and particle filter is implemented to postulate the position of the ball based on the vision inputs from all the robots on the play field. Once the ball is missing, the robots will search and move towards the likely position of the ball determine by the ball localization algorithm.

4 Conclusion

In this paper, the team have presented the overview of the robot and highlighted the major improvements for this year competition. The team is currently focusing on the robot software and aims to put up a better performance for RoboCup 2016. For more detailed information about the Robo-Erectus, please refer to the team's website www.robo-erectus.org.

Acknowledgements

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