Team Description 2006 for Team RO-PE B

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Abstract. The paper describes the two kid size robots RO-PE-III and RO-PE-IV, developed by Legged Locomotion Group from National University of Singapore. The two robots had participated in RoboCup 2005 and ranked 3rd in kid category. With another year on modifications and improvements, they are now ready for RoboCup 2006. The design philosophy, control architecture and some of the research works done on the two robots were also presented in the paper.

1 Introduction

RO-PE (RObot for Personal Entertainment) is an ongoing humanoid robot project in Legged Locomotion Group (LLG), Control & Mechatronics Lab (COME Lab), National University of Singapore since 2001. The objective of the project is building a series small size humanoid robots (RO-PE-I through RO-PE-IV) as test bed for researches in bipedal walking and artificial intelligence due to the growing popularity of humanoids in the robotics research community during recent years. Team RO-PE started its participation in RoboCup humanoid league from 2004, with its RO-PE-II [1], achieving commendable results. And in 2005, RO-PE-III and RO-PE-IV had again done LLG pride by ranking 3rd in kid size category.

2 Mechanical Design

2.1 Leg Design

One of the lessons learned from RO-PE-II in RoboCup 2004 is its mechanical design of legs. Comparing with most of other participating robots, RO-PE-II has a large leg length to height ratio. This causes a higher CG (center of gravity) and in competitions where the robot's walking stability and speed is of primary concern, higher CG is not always desirable. And a longer leg also means a lower natural frequency of walking; it limits the maximum walking cycle achievable for the robot as well. In RO-PE-III and RO-PE-IV, the leg length comparing with the total height has been reduced; enable both robots to walk faster with shorter walking period.

2.2 Arm Design

In a 2v2 game, the goal keeper should be able to dive to the ball when the opponent striker is shooting and get up immediately afterwards to be ready for the next defense. RO-PE-IV is designed with this consideration. With the arm powered by high torque RC servo motors, RO-PE-IV can recover from fallen posture in a short while.

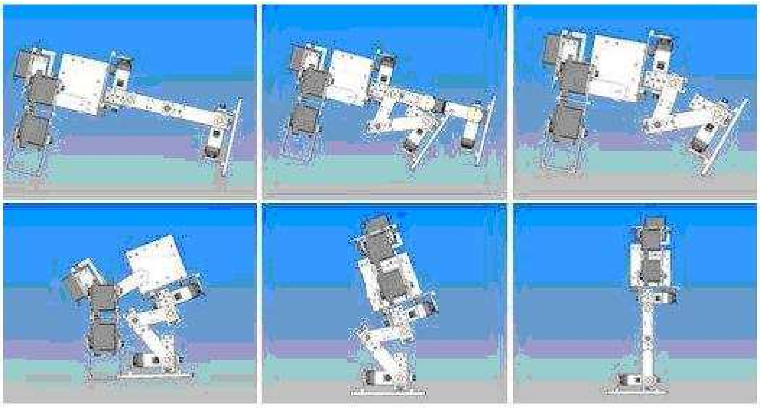


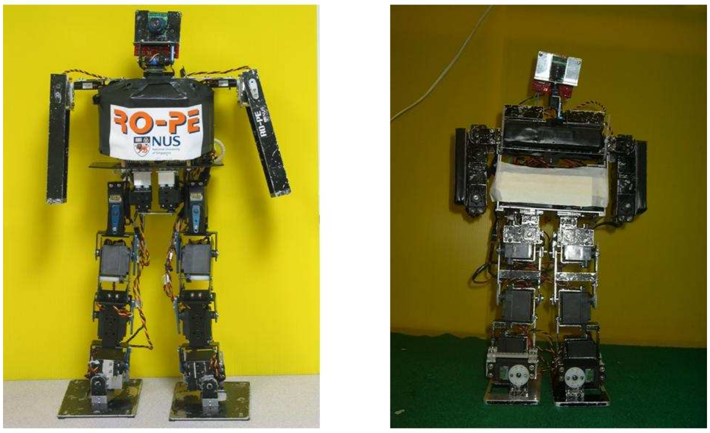
Fig. 1. RO-PE-IV getting up from fallen posture.

2.3 Modification

Lessons were also learnt from RoboCup 2005 on RO-PE-III and RO-PE-IV. And it several areas in their structures were identified to be problematic. Thus, quite a major modification was done on the robots and Fig.2 shows the two robots after modifications.

3 Hardware

This section provides a brief explanation of the hardware system, including the actuators and sensors as well as the control systems.



(a) (b)

Fig. 2. (a) RO-PE-III and (b) RO-PE-IV in their standing positions.

3.1 Actuators and Sensors

All sensors and actuators are off-the-shelf components that are widely available in hobby shops. This enables us to build our robot with relatively low cost. Below is a list of all the sensors used in RO-PE-III and RO-PE-IV.
1. RC Servo motors - The primary actuator source for the two robots are Hitec RC servo motors. Various types with different output/weight ratios are used in different joints of the robots to achieve necessary actuation.
2. CMUCam II - CMUCam II [2] are used for both robots for multi-color detection and tracking. With a frame buffer, CMUCam II has provided much more functions than the CMUCam I which was used for RO-PE-II last year.
3. Force Sensor - Force sensors is equipped with RO-PE-III to roughly measure the center of pressure on the foot, provided by FlexiForeces.
4. Gyro - The gyro, by Silicon Sensing System, is used to sense the information of angular velocity. And after integration of the angular velocity, we get the heading angle of the robot. Despite the drifting effect of the gyro, it works reasonably well for short period.

3.2 Control Systems

RO-PE-III and RO-PE-IV adopt different control architectures. While RO-PE-III with PC-104 computer system has a full computation power on board, RO-PE-IV is control by a micro-controller based control board we developed in LLG.
1. PC-104 System - This option provide the maximum computation power. PC-104 is small size PC (3.6" X 3.8") with RTLinux installed. All the sensor reading is acquired through the PC-104 compatible DAQ card. And with the sensor

information, the walking trajectory is then calculated online in the PC-104. It can also playback the pre-planed trajectory.
2. Micro-controller System - This option enables the robot to be compact in size and energy saving. The walking trajectory can also be either calculated online or pre-planed beforehand.

4 Control Architecture

The control of the robot is realized in a modular manner. A series of actions is broken down into modules such as walking one step or turning left. We then have different sub-routines as the building block of the basic movements. These sub-routines can either be generated online by inverse kinematics [3], or pre-planned offline and later playback in the robot. The main program loops, make decision based on the sensor information and hops around different sub-routines.

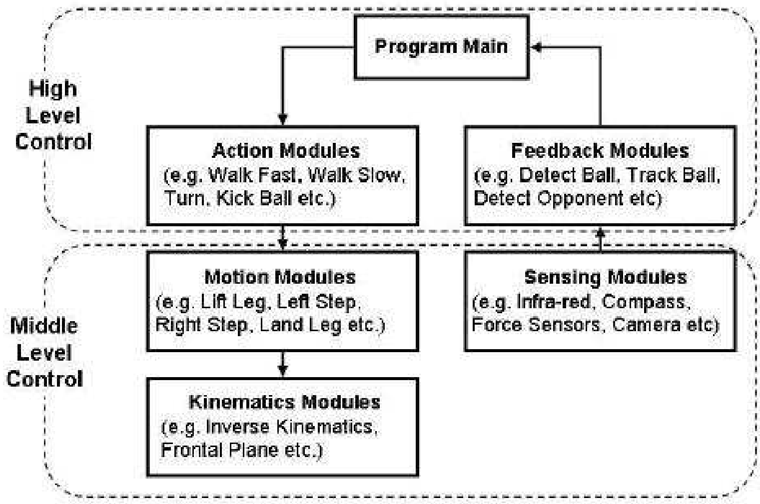


Fig. 3. Control Architecture.

For the offline trajectory generation, Yobotics! Simulation set is used. The dynamics of the robot is modeled in the simulation environment and after applying the controller to the robot, joint trajectory can be retrieved. A software called RS_Servo developed by LLG is then used to convert the trajectory into

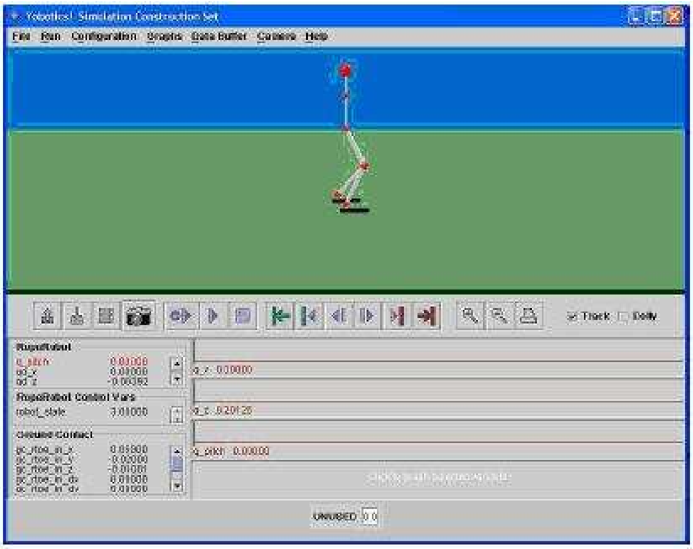


Fig. 4. Yobotics simulation of RO-PE.

a series of servo commands and upload to the host computer (either PC-104 or micro-controller).

5 CONCLUSIONS

RO-PE-III and RO-PE-IV had participated in RoboCup 2005 and achieved rather good results. With the experience gain from the competition, and a year of modifications and improvements, The two robots are bound to perform even better in RoboCup 2006.

References

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3. 3. Huang Q., Yokoi K., Kajita S., Kaneko K., Arai H., Koyachi N. and Tanie K.: "Planning Walking Patterns for Biped Robot," IEEE Transactions on Robotics and Automation, 2001, Vol. 17, No. 3, pp. 280 - 289.

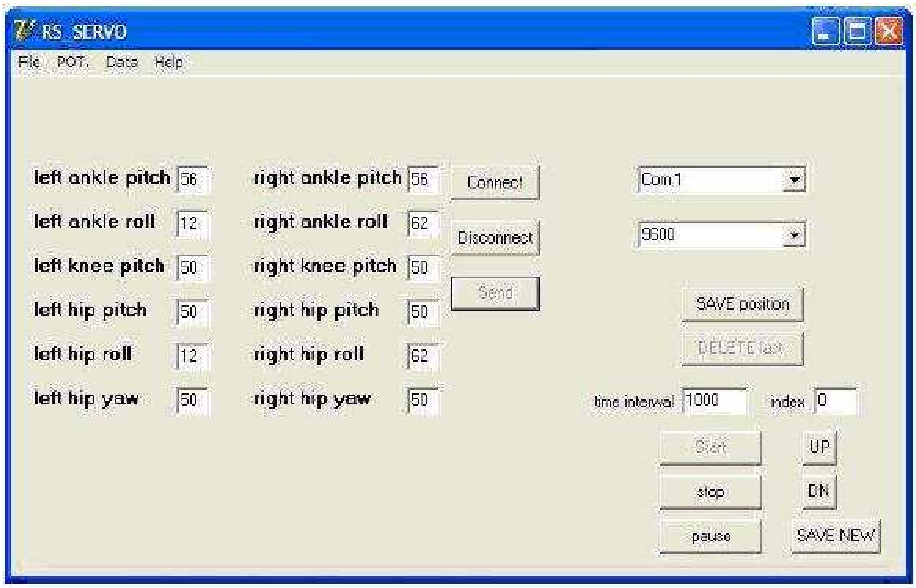

Fig. 5. RS_Servo interface.