Balancing and Walking Control for a Torque-controlled Humanoid Robot

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1 Introduction

Samsung Electronics Co., Ltd. has been developing humanoid robots for years. Roboray, the latest developed humanoid robot in Fig. 1, has many different characteristics from the previous robots, e.g. Mahru series [1]. The main difference is that Roboray can be torque-controlled with torque sensors at all joints in the lower limbs. There exist some released biped robots which have torque/force controlled joints, like DLR biped [2], M2V2 [3], CB [4], and PETMAN. These robots showed their good performance on balancing, push recovery, stepping or walking on uneven terrain, and so on. In this study, we have tried several new ideas and developed walking and balancing algorithms for Roboray. Therefore, the purpose of this paper is to introduce one of our walking algorithms, which shows the characteristic of torque-controlled hardware well.

Figure 1: Torque-controlled humanoid robot - Roboray

2 Approach

We propose the virtual gravity and the damping control for each joint. They are the main balancing and walking control framework for dynamic bipedal locomotion. Gravity and friction (damping) forces are the most important factors for the robots locomotion. Especially in bipedal locomotion, it is impossible to walk on the earth without these physical forces. Our proposed method is focused on how to use these forces for the stable locomotion. First, we compensate the hardware friction of joints in order to eliminate the nonlinearity. This not only improves the joint controller performance, but also makes the joint to control with the linear friction we want. In addition, the gravity compensation based on the global coordinate system is realized. Next, the virtual gravity control torques and the damping control torques are added to the final input torques with respect to the state of control framework. The basic idea for balancing can be explained simply with an inverted pendulum model. The inverted pendulum would not fall down easily if its joint is controlled with upward virtual gravity force and very small damping. According to the size of the gravity vector and the damping control, the system would adapt itself or stand against the external forces. The proposed method is applied to Roboray, which has 6 DOF in each leg and the pitch joints of legs are composed of tendon-driven compliant actuators. Through the characteristics of the hardware and the control method, our robot is able to balance on inclined slopes or walk on rough terrains with bounded variations. Detailed algorithms and results will be presented in the poster.

3 Open questions

1. Can we use vision data for the stability of biped walking robots? (not for foot step planning nor localization)
2. Which is more important for biped walking robot between unbreakable hardware and never-falling algorithm?

References

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