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A NEW BIPED MECHANISM WITH TWO 7-DOFS LEGS AND A DOUBLE SPHERICAL HIP JOINT

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Abstract. *The conventional biped mechanism is uniquely fixed when its poses of feet and waist have been specified, and the humanoid robot with it has to walk with bending knees. To overcome these disadvantages, this paper proposes a new biped mechanism with two 7-DOFs legs and one double spherical hip joint. There are two primary advances compared with the conventional one. First, the humanoid robot with two 7-DOFs legs can adjust the lower limb in a manner similar to what human does even that poses of feet and waist have been set. Second, the double spherical hip joint can implement the functions of both hip and waist without introducing waist joint, which means that it is possible for humanoid robots to act knee-stretch walking. In this paper, kinematic analysis and motion pattern generation of the proposed biped mechanism are discussed in detail. And the effectiveness of this new mechanism has been validated by experimental results.*
Keywords: Humanoid robot, 7-DOFs leg, Double spherical hip joint

1. **Introduction.** Since the first full-scale biped humanoid robot WABOT-1 was created at Waseda University [1], the humanoid robot has been developed rapidly compared with other robots [2,3]. As the humanoid robot is similar to human beings not only in the shape but also in the mode of motion, it is much easier to fit the human beings' living environment and serve people.

The reasonable arrangement of degree of freedom (DOF) is significant for humanoid robots to achieve high mobility like human beings. Nowadays, almost all the humanoid robots adopt conventional 6-DOFs biped mechanism, which consists of a 3-DOFs hip, a 1-DOF knee and a 2-DOFs ankle. For example, HONDA developed humanoid robots P2, P3 and ASIMO [4,5]; the Japanese National Institute of Advanced Industrial Science and Technology and Kawada Industries, Inc., jointly developed HRP-2 [6]; the University of Tokyo constructed H6 and H7 [7,8]; the Intelligent Robotics Institute at Beijing Institute of Technology developed the BHR series of humanoid robots [9-11].

However, as to the humanoid robots mentioned above, it's difficult for them to fit the diversity of environments where human beings live. This is because that the structure of conventional biped mechanism is uniquely fixed when the poses of feet and waist are specified, which leads to that the humanoid robot can't change the orientation of its lower limb. Takanishi et al. [12,13] proposed a biped mechanism with 7-DOFs to avoid this situation and made the humanoid robot adaptable for more environments. But this biped mechanism has to walk with bending knees if there are no waist joints. Conventional humanoid robots have to bend knees for walking in order to achieve high control ability of the centre of gravity (COG) and avoid singularity. It causes high energy consumption, and requires high power actuators in knee joints. Recently, the waist joint is tending to