A Novel Flexible Foot System for Humanoid Robot Adaptable to Uneven Ground

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Abstract: Humanoid robots can walk stably on flat ground, regular slopes, and stairs. However, because of their rigid and flat soles, adapting to unknown rough terrains is limited, moreover, to maintain large scale four-point contact for foot structures to keep balance is usually a key technical problem. In order to solve these problems, the control strategy and foot structures should be improved. In this paper, a novel flexible foot system is proposed. The flexible foot system occupies 8 degrees of freedom (DOF), and can obtain larger support region to keep in four-point contact with uneven terrains; Novel cable transmission technology is put forward to reduce complexity of traditional mechanism and control strategy, and variation of each DOF is mapped to cable displacement. Furthermore, kinematics of this new system and a global dynamic model based on contact-force feedback are analyzed. According to stability criterion and feedback sensor information, a method calculating the optimal attitude matrix of contact points and joint variables is introduced. Virtual prototyping models of a 30–DOF humanoid robot and rough terrain are established to simulate humanoid robot walking on uneven ground, and feasibility of this system adapted to uneven terrain and validity of its control strategy are verified. The proposed research enhances the capability of humanoid robots to adapt to large scale uneven ground, expands the application field of humanoid robots, and thus lays a foundation for studies of humanoid robots performing tasks in complex environments in place of humans.

Key words: humanoid robots, flexible foot, contact force feedback, uneven ground

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