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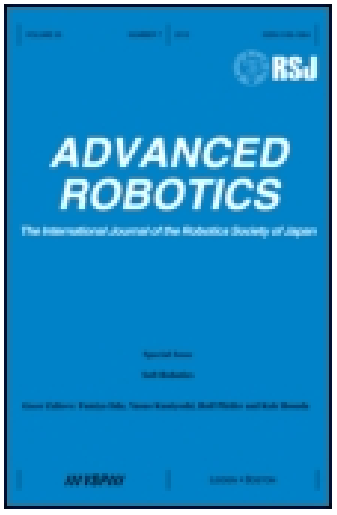


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# Biped-type leg-wheeled robot

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# Biped-type leg–wheeled robot

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*Keywords*: Wheeled robot; leg-wheeled robot; dynamic trajectory control; stairs; under-actuated mechanism.

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There are many types of locomotion such as by wheels, legs, crawlers, etc. Recently, by combining the mechanisms of two or more types of locomotion, mobile robots with the merits of those types have been developed. Among these robots, a typical class is leg–wheeled robots that can negotiate obstacles using legged locomotion and can travel fast on flat surfaces using wheeled locomotion. Many studies of leg–wheeled robots have been carried out. However, most of them use mechanisms that keep the center of gravity low to ensure stability when negotiating rough surfaces (steps, stairs, etc.). Such mechanisms suffer from low energy efficiency and slow negotiating speed because of being a complex system with many degrees of freedom.

Therefore, to allow a leg–wheeled robot to efficiently and speedily negotiate stairs that are typical indoor obstacles, we have proposed a new mechanism and its control scheme. The proposed new leg–wheeled robot will travel by driving the wheels with static stability on a flat surface and can negotiate stairs with dynamic stability by balancing its body on those actively controlled wheels that contact the ground. This type of robot with dynamic stability has a simple structure, because its mechanism does not necessitate static stability. Moreover, the high center of gravity is no disadvantage because the dynamic movement of the center of gravity can be controlled easily, and the energy-efficient wheeled mechanism will be useful for self-contained robots.

The 'biped-type leg-wheeled robot', which we developed as a new prototype of a leg–wheeled robot, is made of two legs connected by an actuated joint. Each leg has two wheels on the same axle. The axle is enough long so that the robot can be statically stable with one leg in the roll direction. A DC servomotor (23 W) is attached to the lower part of each leg for driving the wheels and one to the upper part of each leg for lengthening and shortening the leg. A DC servomotor (11 W) is attached to the middle part of one leg for changing the angle relative to the other leg in the pitch direction. A rotary encoder is

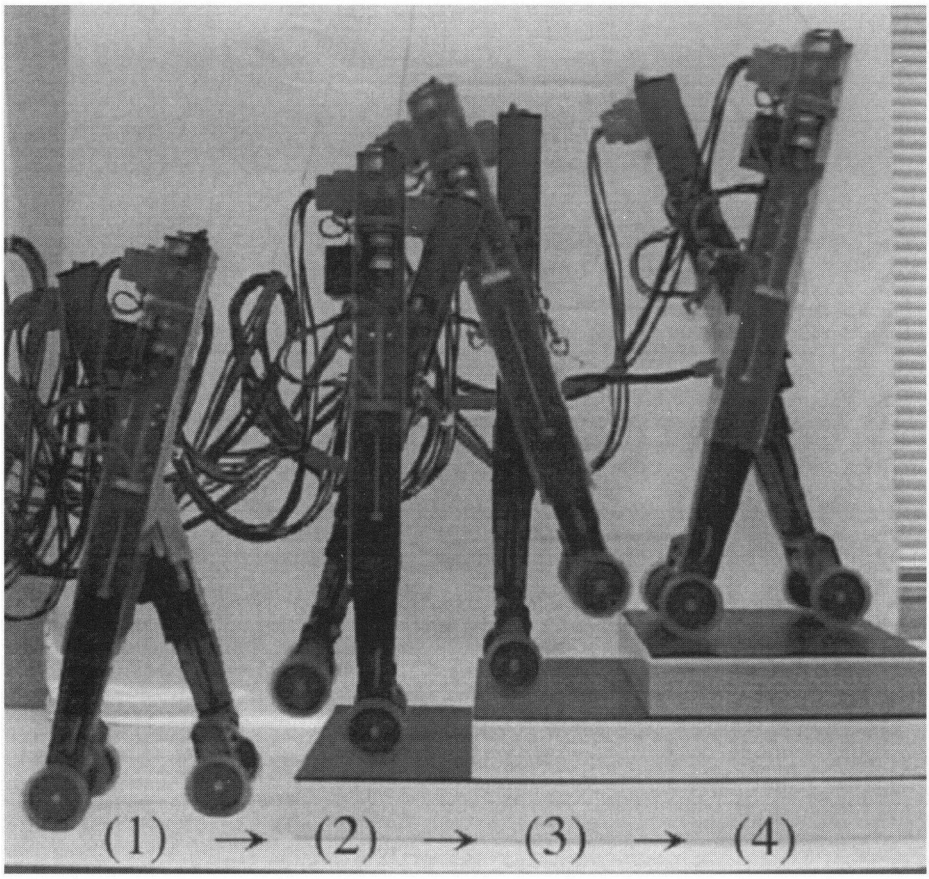


**Figure 1.** Going up stairs by the 'biped-type leg-wheeled robot'.

attached to each motor for sensing the rotation angle of the motor. A rate gyroscope is attached to each leg for sensing its angular velocity in the pitch direction.

In our control scheme, in order to enable fast negotiation of stairs, a dynamic trajectory planning and control method is adopted taking into account the dynamic interference that is inherent to the designed leg–wheeled robot. We also propose a method to connect the dynamic trajectory control motion in the statically unstable state and the structure changing motion in the statically stable state. Using the proposed methods, fast climbing up and down stairs (3 s [per step]) by this robot has been realized successfully (Fig. 1). As the result, the effectiveness of our proposed new mechanism and dynamic control methods for leg–wheeled robots have been confirmed by the successful negotiation control experiment.

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