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Abstract

KINEMATICS, DYNAMICS AND INTELLIGENT CONTROL FOR NONHOLONOMIC MOBILE MODULAR MANIPULATORS

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A mobile modular manipulator can be defined as a kind of robot combining a mobile platform and an onboard modular manipulator together. This combination extends workspace of the entire robot dramatically. However, kinematic and dynamic modeling becomes complex and difficult to achieve because of the interactive motions between the mobile platform and the onboard modular manipulator. Moreover, the problem to decompose a given end-effector task into motions to be carried out by the mobile platform and the modular manipulator is of great requisite. Furthermore, tip-over stability is another concerning issue since the probability of overturn increases because of the mechanical structure. So, tip-over avoidance without affecting the end-effector motion task is very important. In addition, a mobile modular manipulator may have to simultaneously face up several such dangers as joint limits, singularities, obstacles and tip-over instabilities. Therefore, multiple secondary task performing is an interesting and challenging topic.

In this dissertation, the modular robot concept is introduced and a new integrated modeling method is presented, which takes the following factors into thorough consideration: the interactive motions mentioned above, nonholonomic constraints of the mobile platform and self motions caused by redundancy of the entire robot. A new tip-over stability criterion is proposed on the basis of supporting forces and an effective tip-over prevention algorithm is presented. Neural networks, fuzzy logic systems and neural fuzzy systems are combined with adaptive and robust techniques, and a series of robust adaptive intelligent controllers are devised. Unlike such conventional control schemes as computed torque control, these controllers do not rely on any exact dynamic parameters in advance and can suppress bounded external disturbances effectively. If a mobile modular manipulator has more degrees of freedom than required, it can be called a redundant one. In this dissertation, redundancy of such a robot is utilized to perform such secondary tasks as tip-over prevention, singularities removing and obstacle avoidance. These secondary tasks are achieved via adjusting self-motions in a real-time manner so that the end-effector task will not be affected. To fulfil several secondary tasks together with the primary one in the end-effector workspace, an extended gradient projection method is devised. The effectiveness of the modeling method and the controller design algorithms have been verified via both computer simulations and real experiments.