報告番号	※ 甲 第 11053 号

主 論 文 の 要 旨

論文題目 Planning for Smooth Robot Motions with Task-dependent Constraints （タスク依存の拘束に基づくロボットの滑らかな動作計画に関する研究）

氏　　名 SUNG Changhyun

論 文 内 容 の 要 旨

The increasing complexity of mechanisms and environments for robots is making it more difficult to generate smooth robot motions efficiently. This is known as the problem of motion planning, which refers to finding a movement trajectory for a many-degrees-of-freedom robot to achieve a given task. Additionally, a variety of constraints, such as collision avoidance and the robot's joint limitations, must be considered for the entire duration of the motion. A successful method for tackling the problem is to parameterize the trajectory and formulate motion planning as an optimization problem. Constrained optimization has the potential to deal with the constraints for the entire duration of the motion. In this research, we introduce an effective framework for planning and optimizing robot motions in the joint space using via-points. In motion planning for robots, a via-point representation can be used to assign sufficient conditions to satisfy constraints of the movement. Furthermore, the via-points are connected using fifth-order polynomials describing the minimum jerk criterion. Therefore, the smoothness of an overall trajectory is always guaranteed. This research focuses on two aspects; one is single task planning and the other is a sequence of multiple tasks. For a single task, we present a planning method to deal with various conditions in achieving the task. Furthermore, we develop a rapid optimization algorithm to plan smooth robot motions with small computational cost. Moreover, an initialization method for generalizing a motion-planning framework is also proposed to take into account the complexity of the task and efficient gradient-based optimization. Next, we solve a motion synthesis problem to achieve continuous robot motions and formulate the planning of smooth transition motion between individual tasks. Each method was evaluated through simulations and real-world experiments using different scenarios and considering various conditions for achieving the task. We applied our framework to generate a whole-body motion for a humanoid robot, walking motion for a wearable walking-assist robot, and reaching movement for a redundant robot arm. In the

case of whole-body motion, specifically kicking motion, we confirmed that the humanoid robot could successfully and rapidly score a goal on various courses created by changing the location of an obstacle. Furthermore, it was possible to deal with varying conditions in the walking motion such as stride length and foot clearance. For reaching movements using a 7-DOF robot arm and a 16-DOF humanoid upper body model, we confirmed that the robot could reach the target without violating any constraints such as collision avoidance, even with increased complexity of the task. In addition, we synthesized humanoid whole-body tasks such as kicking and walking motions. We showed that the robot could achieve a given task by executing a series of whole-body motions. In particular, the robot was able to kick a ball quickly without stopping between sequential motions, and with greater stability in maintaining its balance. These results indicate that our methods can efficiently generate feasible and smooth robot motions with improved the articulation of movements.