学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（情報科学）　　氏名　梁　宰誠

学　位　論　文　題　名

Massive Object Transportation by Robots
（ロボットによる重量物搬送）

Robots have been expected to replace human in performing dull, dirty, dangerous, demeaning, and difficult tasks. Transportation of massive object is one of those tasks, which is hard, dangerous, or impossible in some cases for human to do. In space application, a robot manipulator must manipulate highly massive objects such as satellites and modules of a space structure. Space robotic arms are generally operated by a human operator locally from a space vehicle or remotely from the earth. The main problems in the manipulation of a massive object in space by teleoperating a space robot from the earth are communication delay and the unexpected excessive force generated between the space robot and the massive object. On the other hand, in applications on earth, there are a lot of demands for multi-robot cooperative massive object transportation. If an object on earth is too heavy for multiple robots to lift up, the object must be transported by pushing and pulling. The main problem in the multi-robot cooperative massive object transportation is how to exert effective force on the object to push or pull for robots while avoiding slippage between wheels/feet and the ground.

This thesis discusses two types of massive object transportation: massive object transportation in space by teleoperating space robots, and massive object transportation on earth by pushing/pulling by autonomous humanoid robots.

For the massive object transportation in space by teleoperation, force mitigation of the contact force, and a virtual environment considering the dynamics were proposed to solve the large contact force generation problem and the communication delay problem. Hardware-In-the-Loop-Simulations (HILS) were performed with a scenario, in which a space robotic arm was teleoperated to manipulate a massive object of 6,000 kg. The results of the HILS show the validity of the proposed methods.

For the massive object transportation on earth by multiple humanoid robots, a method of generating an optimal robot motion was proposed to effectively exert force on the massive object to push or pull, keeping contacts between the feet of the robots and the ground. In the robot motion generation, frictional force generated at the feet from the ground and reaction force generated at the hands from the object must be estimated in real-time. In order to estimate the frictional and reaction force, a method of attaching virtual masses to the hands and feet of humanoid robots was proposed that improves computational efficiency compared with conventional methods. Dynamic simulations were performed on transportation of various massive objects by two humanoid robots with the proposed method and the conventional PD controller. The results showed that the two humanoid robots could transport a massive object of 200 kg by pushing/pulling without slipping by using the proposed method, while the two humanoid robots could not transport the object by using the conventional PD controller because of the slippage between the feet and the ground.