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Handling of a large object by multiple autonomous mobile robots in coordination

YASUHISA HIRATA [1], KAZUHIRO KOSUGE [1], HAJIME ASAMA [2], HAYATO KAETSU [2] and KUNIAKI KAWABATA [2]

[1] *Department of Machine Intelligence and Systems Engineering, Tohoku University, Aoba-yama 01, Sendai 980-8579, Japan*

[2] *Biochemical Systems Laboratory, The Institute of Physical and Chemical Research (RIKEN), Hirosawa 2-1, wako, Saitama 351-0198, Japan*

E-mail: hirata@irs.mech.tohoku.ac.jp

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When we would like to move a large and heavy object, we carry it in cooperation with other people. It is a natural extension of our behavior to the robot to use multiple robots in coordination. Multiple robots in coordination can execute tasks which could not be done by a single robot. Many control algorithms have been proposed for the handling of a single object by multiple robots in coordination.

We have proposed the decentralized motion control algorithm of multiple mobile robots for handling a single object in coordination based on the compliance motion control of each robot. In this algorithm, each robot is controlled so as to have a decoupled impedance around a common compliance center attached to the object as shown in Fig. 1.

The force/moment applied to the object is usually calculated from the force/moment detected by a force/torque sensor attached to each robot. This calculation involves a term concerned with a vector cross product relating to the distance between the robot and the compliance center. When a large object is handled, this term leads to the amplification of the sensor noises included in the force/moment information detected by a force/torque sensor attached to each robot.

In this research, we propose a control algorithm of multiple robots for the handling of a large object in coordination so as to lessen the effect of sensor noise included in the force/moment information. In this algorithm, each robot is controlled so as to have a decoupled impedance at its grasping point as shown in Fig. 2. The algorithm is efficient to lessen the effect of sensor noises caused by force/moment transformation, since a decoupled impedance at its grasping point is not affected by the distance between the robot and the compliance center.

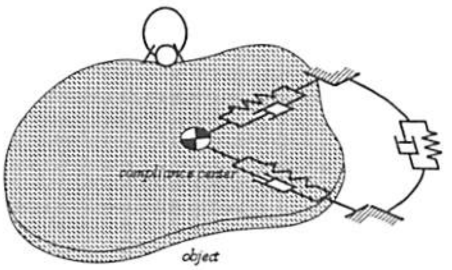

Figure 1. Conventional algorithm.

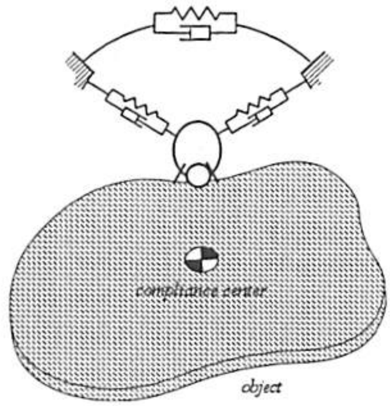

Figure 2. Proposed algorithm.

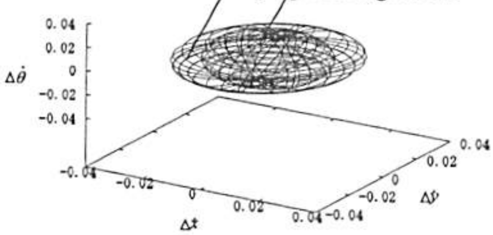

Figure 3. Effect of noise for the mobile robot.

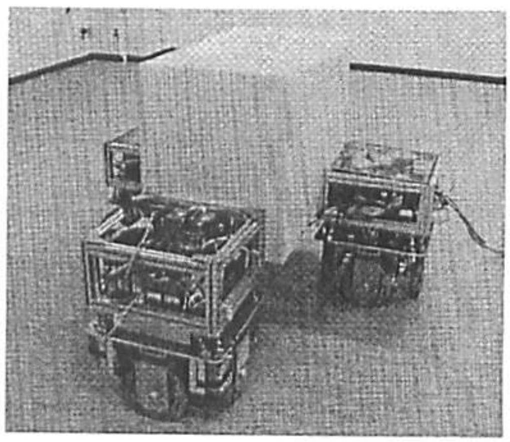

Figure 4. Experimental system.

We could also specify the apparent impedance of the object completely under the assumption that the compliance center is located at the centroid of the system of n mobile robots.

The effect of sensor noise on the mobile robot velocity is shown in Fig. 3. The velocity ellipsoids show that the proposed algorithm decreases the effect of sensor noise included in the force/moment information.

We extend this algorithm to the decentralized control algorithm of multiple robots handling a single object in coordination. The motion command of the object is given to one of the robots, referred to as a leader. The other robots, referred to as followers, estimate the motion of the leader by themselves through the motion of the object to handle the object in coordination with the leader based on the estimated motion.

The proposed decentralized control algorithm is experimentally applied to the omni-directional mobile robots to handle a large object in coordination. One of the experimental results is shown in Fig. 4 using the autonomous omni-directional mobile robots, ZEN, developed by RIKEN. Three mobile robots manipulated a large object in coordination successfully with the proposed method.