Development of small mobile robot for manipulation of heavy object

Adopting robots to replace human labor in the manipulation of heavy loads laying at home, in offices or in other environments, human could be emancipated from such kinds of heavy works. However, big scale of transportation robots used in factories are not appropriate be applied as such environments are narrow generally. On the other hand, robots that are designed for certain kinds of manipulation cases may not be practical as objects and environments in the manipulations are various. In this way, we aim to realize the manipulation of heavy objects by small scale of mobile robots.

In order to manipulate the heavy load, it is necessary to exert a sufficient large force on the object to some extent. Anyway, in the case of a small robot, the possibility exists that the robot may flip over due to the reaction force when it exerts relatively large force to the object. Once the robot flip over, it would be extremely difficult to continue the manipulation, so such cases should be prevented. If the robot flipping over could be prevented, then the manipulation of object with all the above-mentioned difficulties could be realized. Furthermore, with cooperation of multi small mobile robots, such as tilting the objects and inserting carts to the bottom[1], then a variety of manipulations would be able to be conducted.

In this research, the mechanism of manipulator shown in Fig 1 is proposed[2], which could exert large scale of force while preventing the robot flipping over. The manipulator is actuated by a linear motor, and works with its two tail ends, which are fixed with passive joints, contacting with the object and the floor. In this way the reaction force acts in the opposite direction of actuating force so that the moment that makes the robot flip over would not occur. Therefore, the robot does never flip over regardless the scale of output force. Furthermore, a compact mobile robot equipped with this manipulator is also developed in this research (Fig 2) [3].

Since the manipulator joints are passive, the robot could not adjust the output position and direction of force in manipulation. Therefore, it is important to properly plan the manipulation for object before conducting the manipulation. In this research the planning method is proposed to determine the manipulation for an object with known dimensional and weight parameters. Firstly, the force exerted on the object is analyzed, and then the number of robots needed for tilting manipulation is determined. In the case of only one robot engaging in the manipulation, the conditions to tilt object without sliding could be obtained through the force analysis for robot. In the case that two robots engaging in the manipulation, adopting the second robot to support the object and with the condition that the robots do not slip as a constraint, the optimal manipulation planning with minimum force could be obtained. Applying the above mentioned method, an object with the weight of 40.0*kg* is tiled actually, as shown is Fig 3[3].

Keywords: mobile robot, large force, pushing manipulation

Reference

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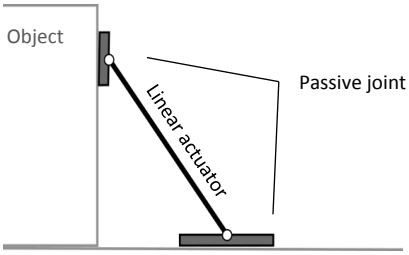

Fig 1. Mechanism to prevent robot flipping over with reaction force

Fig 2. Small mobile robot

Fig 3. Tilting manipulation for heavy object with 2 mobile robots