Cooperating Multiple Behavior-Based Robots for Object Manipulation
- System and Cooperation Strategy -

ZHI-DONG WANG, EIJI NAKANO, and TAKUJI MATSUKAWA

Dept. of Mechanical Intelligence, Tohoku Univ., Sendai, 980-77 Japan

Abstract

A multiple vehicle robot system for cooperative object manipulation is described. This system consists of a host and several distributed behavior-based vehicle robot agents. A strategy on cooperatively organizing the behavior-based robots which only have limited ability in manipulation is discussed. An extended subsumption architecture, which has some layers for manipulation and cooperation, is built for each vehicle robot. A simulator and some simulation results are shown also.

Keywords: Multi-Agent Robot System, Cooperative Manipulation, Manipulation by Vehicles, Behavior-Based Robots System

1 Introduction

In recent years, there have been many studies focusing on cooperation of distributed autonomous multi-robot systems and robot swarm intelligence [1][2][5][6][10][15][18][19]. Most of them are concentrating on methods in which the cooperation strategy is based on distributed problem solving theory and distributed decision theory. The characteristic of these studies is that each robot gets some information about other robots by communication, then uses the information for making a distributed decision, for example, the studies on dynamic collision avoidance among mobile robots, and on respective tasks accomplishment via multiple robots. Compared with the above, studies on cooperative tasks which have dynamic constraints, such as object manipulation by multiple robots, are few.

On the existence of dynamic constraints, the cooperation among robots should have more dynamic factors than the cooperation for collision avoidance. When a pure distributed autonomous robots system is constructed for object manipulation, some problems make the physical system difficult to realize. The increase in communication quantity required to guarantee the quality of cooperation, and achieving harmony between moving motion and manipulating motion in a robot are amongst the problems experienced.

In this paper the scheme of a multiple robots system, consisting of a host and distributed vehicle robots, for performing a cooperative task (as illustrated in Fig.1), will be discussed.

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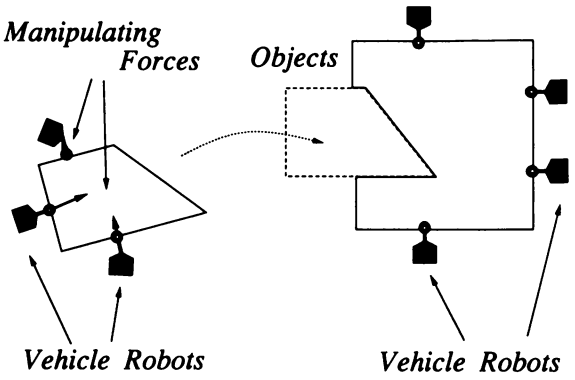

Figure 1: Cooperative Task of Objects Manipulating and Assembling by Multiple Robots

A strategy on cooperatively organizing these behavior-based robots for manipulation will also be discussed. To control this vehicle robot an extended subsumption architecture, in which communicated information is also acting as input (just like the signals from sensors do), will be described. A simulator and some simulation results will be shown.

2 Behavior-Based Multiple Robot System with Host(BeRoSH)

For a multiple robot system, there are two extremes (Fig.2), a centralized robots system and distributed robots system. In a centralized robots system, each robot is only a collection of sensors, actuators and some local feedback loops. Almost all tasks are processed in a host. The communication between the host and robots only involves sending data from sensors to the host and receiving detailed commands from the host. Conversely, in a distributed robots system, each robot plans and solves a problem(task) "independently" while communicating with the other robots. Contents of communication is information which has been processed in each robot.

A multiple robot system which aims at coqperative work, always has some tasks which are common to the whole system rather than to the individual robot, for example, a task for planning of manipulation, or a task for global cooperation, etc. These tasks are fit to be processed in a host rather than in each robot. However, in a centralized robots system, the defects, such as the limitation of processing ability, reliability on fault-tolerant, etc, might become more conspicuous as the system becoming larger, because the processing of all of tasks is performed by the host. Moreover, since each robot is distributed physically, processing of some tasks are suited to be done separately rather than being concentrated at the host. Then, it can be said that centralized processing is not quite suitable to cooperative work via multiple robots.

The trend towards studies in this area seems to indicate that a distributed autonomous robots system is superior to a centralized robots system from the view points of flexibility, robustness and fault-tolerant ability. In a pure distributed system, the processing of a