Distributed Ant Colony Clustering Using Mobile Agents and Its Effects

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Abstract. This paper presents a new approach for controlling mobile multiple robots connected by communication networks. The control mechanism is based on a specific Ant Colony Clustering (ACC) algorithm. In traditional ACC, an ant convey an object, but in our approach, the ant is implemented as a mobile software agent that controls the robot which is corresponding to an object, so that the object moves to the direction ordered by the ant agent. In this time, the process in which an ant searches an object corresponds to a sequence of migrations of the ant agent, which is much more efficient than the search by a mobile robot. In our approach, not only the ant but also the pheromone is implemented as a mobile software agent. The mobile software agents can migrate from one robot to another, so that they can diffuse over robots within their scopes. In addition, since they have their strengths as vector values, they can represent mutual intensification as synthesis of vectors. We have been developing elemental techniques for controlling multiple robots using mobile software agents, and showed effectiveness of applying them to the previous ACC approach which requires a host computer that centrally controls mobile robots. The new ACC approach decentralizes the mobile robot system, and makes the system free from special devices for checking locations.

Keywords: Mobile agent, Ant Colony Clustering, Intelligent robot control.

1 Introduction

Ant colony clustering is one of the clustering methods that model the behaviors of social insects such as ants. The ants collect objects that are scattered in a field. In ant colony clustering, artificial ants imitate the real ants and gradually form several clusters. The application we have in our mind is a kind of intelligent carts.

When we pass through terminals of the airport, we often see carts scattered in the walkway and laborers manually collecting them one by one. It is a laborious task and not a fascinating job. It would be much easier if carts were roughly gathered in any way before the laborers begin to collect them.
For example, in order to achieve such clustering, we can take advantage of Ant Colony Clustering (ACC) algorithm which is an Ant Colony Optimization (ACO) specialized for clustering objects. ACO is a swarm intelligence-based method and a multi-agent system that exploits artificial stigmergy for the solution of combinatorial optimization problems. ACC is inspired by the collective behaviors of ants, and Deneubourg formulated an algorithm that simulates the ant corps gathering and brood sorting behaviors [1].

We previously proposed an ACC approach using mobile software agents [2]. In the approach, a mobile software agent traverses all the robots that are corresponding to objects, collecting the information of their locations. The mobile software agent conveys the location information to a host computer, where the ACC algorithm is performed to determine the locations of clusters to which robots are supposed to move. Each robot has certain pheromone value so that if the strength of the pheromone is strong, it means a substantial number of robots form a cluster and the robots nearby are supposed to move toward the cluster. Also the robots in the cluster are locked to prevent being moved. This mechanism contributes to stabilizing the clusters and giving them relatively monotonic growth.

Although the previous approach yielded favorable results in preliminary experiments, it required a host computer for centrally managing locations of robots and executing ACC algorithm. Therefore, there is some time lag until the robots were clustered, and it could prevent the robots from dynamically reflecting changes of the circumstance.

In this paper, we propose a new pheromone base ACC approach using mobile software agents. In our new approach, called distributed ACC, the host for centrally controlling robots is not necessary. Some Ant agents, which is mobile software agents corresponding to ants, iteratively traverse robots (intelligent carts). Furthermore, the pheromone is also implemented as a collection of mobile software agents. We call them Pheromone agent. Each Pheromone agent is created on a robot included in a cluster. Once it is created on the robot, it migrates to other robots within the scope. It has a datum representing strength and direction, which is used for guiding Ant agents. Multiple Pheromone agents reaching the same robot are combined into one single agent with the synthesized strength and direction.

These features of our distributed ACC algorithm provide the following contributions:

1. dynamically reflecting circumstances, and
2. saving energy consumption because robots without Ant agent consume very little energy.

We also show that the number of Ant agents can be decreased without sacrificing efficiency of clustering in our experimental results.

The structure of the balance of this paper is as follows. In the second section, we describe the background. The third section briefly describes the traditional ACC algorithms. The fourth section describes the mobile software agent system that performs the arrangement of the multiple robots. The agent system consists of