Dependable Escorting a VIP with Collective Robots in the Unstructured Environments

JaeSeon Lee¹, Sang-Hoon Ji² and Byoung-Tak Zhang³

¹Department of Computer Science and Engineering, Seoul National University, Seoul, South Korea
²Convergent Technology R&D Division, Korea Institute of Industrial Technology, Ansan, South Korea
³Department of Computer Science and Engineering, Seoul National University, Seoul, South Korea

*Corresponding: jslee@bi.snu.ac.kr

Abstract – This paper deals the collective behavior based multi-robot system in unstructured environments and describes VIP-Escorting problem using the combination of behaviours, although previous works are focus on designing and maintaining the formation. This approach is robust and useful in unstable and unstructured environments. Even though the status of robots or surrounding environments are changed, the combination of collective behaviours can provide proper solutions.

Keywords – behavior based multi-robot systems, escorting, formation control.

INTRODUCTION
The research of collaborative multi-robot systems has gradually gained interest in recent years, mainly due to their possibilities in redundancy, efficiency of resource usage, large-scale coverage, fault tolerance, flexible reconfigurability and spatially diverse functionalities, optimization to complete missions in comparison to the individual robot systems [1], [2], [3]. Although there are various applications using multi-robot systems for cooperative missions, this paper focuses on the problem of VIP escorting in unstructured environments. The escorting problem is one of the most popular applications in multi-robot systems and there are many researches on it. Mas et al. suggested cluster space control methods for entrapment/escorting and patrolling missions [3] and showed the architecture to escort a moving target with obstacle avoidance. According to Annelli et al., the escorting problem consists of two tasks such as surrounding a moving target and maintaining a formation around a target whose movements are unknown [2]. Previous escorting methods focus on making and keeping the formation of multiple robots around a target. However, this paper suggests how to find a VIP whose location is unknown and to escort to his/her destination through safe and shortest paths in unstructured environments. In addition, context-aware reconfiguration methods of collective behaviors of multiple robots are provided for more efficient and reliable robot-control. This paper is organized as follows. In the second section, the proposed escort method is described. Then the expected results and conclusion are followed in the last section.

METHODOLOGY
As shown in Fig. 1, the VIP escort mission is consist of several sequential tasks such as expedition, distribution and escorting, and each task includes the combination of one or more collective behaviors. Each task has a temporal priority and there are conditional transitions between tasks such as finding a target and optimized route to destination. These combination of behaviors can be changed according to the current environmental status. In this section, each task is described and the integration of multi-robot behaviors is also presented.

Fig. 1: The Overview of the VIP Escorting Mission

2.1 Behaviors of Multi-robot
According to behavior-based systems, actions of the robot are designed from various abstraction level and these actions can be generated from a simple combination of basic behaviors or sequential group of behaviors [4]. In Fig. 2, each behavior is triggered by its own activation conditions and its corresponding action is generated as the results. After that, the final action is implemented by the combination of one or more actions

Fig. 2: A general schematic of behavior-based system [4]

In this paper, the new classification of categories of collective behaviors is introduced. Fig. 3 shows that composite behaviors are generated from the combination of basic behaviors of multi-robot. This approach enables to represent the task of multi-robot system through the group of behaviors. In addition, these behaviors are based on multi-robot system, not individual robot system. Therefore, each multi-robot behavior can be composed of one or more behaviors of the individual robot. However, this paper deals with collective behaviors not individual ones.
2.2 Expedition task

In the VIP escorting mission, expedition task aims to accomplish two behaviors such as searching and coverage until specific conditions are satisfied. Searching behavior controls robots to find a target (= VIP) while coverage behavior is performed to scan whole unstructured areas without overlap between robots (see Fig. 4). These behaviors can be executed at the same time or separately. The goal of this task is to find a VIP and to discover the best route to escort the VIP to the destination fast and safely. At the beginning, all mobile robots perform coverage behaviors until any robot encounter a candidate for the VIP. If the candidate proves to be a VIP, some robots that are near the VIP stop their current behaviors and surround the VIP for escorting task. On the other hand, other robots try to find possible paths from the current position of the VIP to the destination. Although there could be various routes for the escorting task, the most safe and fastest route is selected. After the optimal route selection, this task is done and all robots are ready for the next task.

2.3 Distribution task

Distribution task is to secure safe and fast route in unstructured environments, where it is possible to lose paths partially or entirely, and consists of two behaviors such as deployment and exploration. Therefore, it is necessary to distribute robots along the route to secure the route and distribution is reconfigurable according to the changes of the route as shown in Fig. 5. In this Figure, the deployment of multi-robot has been reconfigured when the environments are changed. After the distribution of all robots is finished, they stop their behaviors and they function as kinds of markers to represent the route.

Fig. 5: Deployment behaviors in unstructured environments

2.4 Escorting task

Escorting task performs a certain collective behavior (= escort) that consists of a group of primary behaviors such as formation, target tracking. The shape of formation can be changed according to geographical feature of paths. For example, a line formation is suitable when they move through a narrow passage (see Fig. 6).

Fig. 6: Escort behaviors

CONCLUSION

In this paper, the process and scheme for task completion in the behavior based multi-robot system are suggested. It suggested that the proper combination of collective behaviours can perform multi-robot tasks more robustly. The experiments will be implemented shortly and the results of simulation will be added soon.

ACKNOWLEDGEMENT

This work was supported in part by Ministry of Science, ICT and Future Planning of Korea Government through Original Industrial Technology Development Project for Collective Intelligence Robot (#10037352).

REFERENCES


