論 文 の 内 容 の 要 旨 Abstract

論文題目　　Distributed Task Allocation and Path Planning in Dynamic Environment for Multi-robot Guidance System
(動的環境における複数案内ロボットの作業分担決定と経路計画)

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We present a conceptual design and formal definition of a distributed multi-robot guidance system. The ultimate goal of our system is to accomplish an environment that comprehends human intentions and satisfies them intelligently, safely and efficiently. The conceptual design of previous guidance robot systems and ours is introduced. The key problem of the proposed system: distributed dynamical task allocation with moving target is mainly addressed in this study.

Distributed dynamical task allocation with moving target means that the number of targets and targets' position can change before there is assigned robots to execute. For such new domain, we firstly propose an enumeration of moving task allocation (ENOMOTAL) method which is extended from combinatorial optimization and market-based task allocation. Robots bid on targets, transmitting the costs to the other robots. Then robots select targets from the combinatorial cost table based on the objective function. Then another method: dynamical sequential moving task allocation (DYSEMOTAL) method, by implementing multi-round negotiation and body expansion behavior. Every first half time step, robots negotiate sequentially and select targets to perform according to our proposed algorithm. When all robots have finished this first time selection, any remaining unselected robot chooses an unassigned target sequentially at the latter half time step. We set two distance thresholds for robot decision-making to apply body expansion behavior. The advantages of both methods are highlighted by comparison with existing algorithms. Simulations show that minimal costs and maximal efficiency are obtained by the ENOMOTAL method; however this method cause oscillations. Reversely, DYSEMOTAL method is a usable assignment approach.

After analyzing the advantages and disadvantages of proposed two methods, we develop

a hybrid dynamic moving task allocation (HYDYMOTAL) method that combines both. Once robot(s) or target(s) update its position or working state, robots select targets from the combinatorial cost table to minimize the objective function independently. And we use two sample time thresholds for robots decide the conditions of robots and targets, and reallocate targets. The HYDYMOTAL method is expected to improve the previous algorithms to overcome the major disadvantages. Particularly, utilizing the HYDYMOTAL method can obtain minimal costs and maximal efficiency; improve the robustness of the whole system.

This study also develops an effective improved artificial potential field based simultaneous forward search method (Improved APF-based SIFORS method) in known environment; this method is very similar with the path relaxation method. We firstly redefine potential functions to calculate a valid path, and then propose a simultaneous forward search method (SIFORS method) to shorten the distance of planned path. Such path is calculated by connecting the sequential points produced by improved APF method. The simulation results confirm that our proposed path planning approach can calculate a shorter, collision-free and safe path to a destination than the general improved APF can, and consume few computational times.

Finally, we integrate the HYDYMOTAL method and the improved APF-based SIFORS method in a known environment with kinds of complex obstacles. And we demonstrate the robustness of HYDYMOTAL method by simulations.