Distributed Task Allocation and Path Planning in Dynamic Environment for Multi-robot Guidance System

その他のタイトル	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
学位授与年月日	2014-09-11
URL	http://doi.org/10.15083/00007691

博士論文（要約）

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）

李　光輝

Chapter 1 introduced this study background and the field of service robot; the applications of guidance robot system were detailed, and discussed problems of those applications.

Chapter 2 presented a conceptual design and formal definition of the proposed distributed multi-robot guidance system. The ultimate goal of this study proposed novel multiple guidance robots coordination system was to accomplish an environment that comprehends human intentions and satisfies them intelligently, safely and efficiently. The study convinced that a useful guidance system for an intelligent exhibition, museum and shopping mall could be achieved utilizing current technology assisted by proper system integration. The conceptual design of previous guidance robot systems and the proposed guidance robot system were introduced. The two key problems of the proposed system: distributed dynamical task allocation with moving target and path planning were mainly addressed in this study.

Chapter 3 presented a kind of distributed dynamical task allocation with moving target method. Moving target means targets' position can change before robot guiding. For such a new domain, this study firstly proposed a method, called enumeration of moving task allocation (ENOMOTAL) method which was extended from combinatorial optimization and market-based task allocation. Robots bid on targets, transmit 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 was proposed, 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. This method sets two distance thresholds for robot decision-making to apply body expansion behavior. The advantages of both methods were highlighted by comparison with the conventional repeated auction algorithm. Simulations shown that minimal costs and maximal efficiency were obtained by the ENOMOTAL method; however this method caused oscillations. Reversely, DYSEMOTAL method was a usable task assignment approach.

Chapter 4, after analyzing the advantages and disadvantages of proposed two methods, we developed a hybrid dynamic moving task allocation (HYDYMOTAL) method that combining the ENOMOTAL method and DYSEMOTAL method. 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 was expected to improve the previous algorithms to overcome the major disadvantages. Particularly, utilizing the HYDYMOTAL method obtained minimal costs and maximal efficiency; improved the robustness of the whole system.

Chapter 5, considered an effective improved artificial potential field based simultaneous forward search method (Improved APF-based SIFORS method) which could obtain a shorter distance path efficiently without local minima and oscillations in a known environment. This chapter redefined potential functions and used wall-following method to eliminate oscillations, local minima and non-reachable target problems. Because the planned path by improved APF was not the shortest trajectory, we developed a simultaneous forward search method (SIFORS method) to shorten the planned path. The re-planned path was calculated by connecting the sequential points produced by improved APF. The simulations demonstrated that the improved APF method easily escapes from local minima, oscillations, and non-reachable target problems. Moreover, the simulation results confirmed that our proposed path planning approach could calculate a shorter distance path to the destination than the improved APF. Results proved our improved APF-based SIFORS method’s feasibility and efficiency for solving path planning, which constitutes an NP-hard problem for mobile robot.

Chapter 6 integrated the proposed HYDYMOTAL method and the improved APF-based SIFORS method to deal with the distributed multi-robot guidance system in a known environment with kinds of complex obstacles. The simulation results demonstrated that the proposed task allocation method and path planning method in this study were very suitable for distributed multiple robots guidance system. And this chapter demonstrated the robustness of HYDYMOTAL method by simulations.

Chapter 7 introduced the summary of this study, and presented the future works of this study.