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Abstract

This work is the first part of a project that is intended to develop a control strategy for multiple heterogeneous robots oriented to the assistance in situations of search and rescue. The project is presented from two perspectives that run simultaneously but in different time scales, the first is the real time heterogeneous robots control perspective in charge of the robots task execution studied mainly through the perspective of artificial potential functions and the second the task allocation problem in charge of the optimization of the number of people helped. This paper is intended to present the advance of the project in the area of real time control focused in the task of exploration considering the heterogeneity of the velocity of the robots, its limitations in communication range and the obstacles evasion. The algorithm presented allows the robots to explore a non-convex scene without losing the network connectivity, without presenting collisions between robots or between obstacles and introducing a simple network reconfiguration algorithm intended to make more flexible the network structure.

Keywords

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Exploration with Heterogeneous Robots Networks for Search and Rescue

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Abstract: This work is the first part of a project that is intended to develop a control strategy for multiple heterogeneous robots oriented to the assistance in situations of search and rescue. The project is presented from two perspectives that run simultaneously but in different time scales, the first is the real time heterogeneous robots control perspective in charge of the robots task execution studied mainly through the perspective of artificial potential functions and the second the task allocation problem in charge of the optimization of the number of people helped. This paper is intended to present the advance of the project in the area of real time control focused in the task of exploration considering the heterogeneity of the velocity of the robots, its limitations in communication range and the obstacles evasion. The algorithm presented allows the robots to explore a non-convex scene without losing the network connectivity, without presenting collisions between robots or between obstacles and introducing a simple network reconfiguration algorithm intended to make more flexible the network structure.

Keywords: Networked robotic system modeling and control, Mobile robots, Autonomous robotic systems.

1. INTRODUCTION

Motivated by big disasters occurred in the last years such as the World Trade Center terrorist attack, the Fukushima nuclear disaster and more recently the Ecuador earthquake the development of the rescue robotics has been widely developed by the international community. This interest is motivated given that the personal destined to the attention of the disaster may not be enough for handle the scale of these kind of events or even when they are capable enough, the attention of the situation may be dangerous or harmful for the humans and the robots may execute some of the search and rescue task while the humans are safe.

Nowadays there are many efforts made in this field such as the Work of Gunn and Anderson (2015) where it is presented schemes of heterogeneous robots teams formation, the work of Turner et al. (2015) where it is shown algorithms for the task allocation problem in the robotic search and rescue scenario, the work of Nam and Shell (2015) where it is analyzed the robots task allocation problem with costs uncertainties for different situations, and the work of Chand and Carnegie (2013) where it is presented an hierarchical exploration algorithm using heterogeneous robots (they differ in sensing and computation capabilities). These works present detailed frameworks for the task allocation problem with high level instruction but do not consider the lower level control schema for the robots of multiple robots for different kinds of tasks (including the exploration). These works consider the real time control problem but are focused mainly in the homogeneous case and do not consider the connectivity constrains nor the obstacles avoidance.

This paper presents an algorithm of exploration for heterogeneous networked robots teams considering restrictions of the communication links, static obstacles evasion, and the possibility of reconfigure the network in order to avoid some non-desired stable equilibrium points in the exploration tasks. The algorithm proposed implements the algorithm DisCoverage presented by Haumann et al. (2013) and extends it to the heterogeneous case using non uniform Voronoi partitions based on the minimum arrival time to each point instead of the minimum distance. It also employs the ideas presented by Zavlanos et al. (2011) to analyze and maintain the network connectivity using artificial potential functions combined with a simple reconfiguration algorithm based on the proximity of the robots and the evaluations of the second eigenvalue of the Laplacian matrix of the network for checking the connectivity. The artificial potential functions are used also for guarantee the statics obstacles evasion and the avoiding of the collisions between robots with determined security radius. The algorithm is tested in non-trivial simulations in a simple convex space and in a more complex non-

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> *Citation Excerpt :*
>
> …In a MRS, multiple robots cooperate to achieve a common goal by means of local objectives within a shared environment [1], with particular interest in dynamic fully-unknown or semi-unknown environments, where unpredictable external events may happen and change the environment state. Generally, a MRS overcomes the performance of a single robot in tasks that have critical characteristics, such as searching and rescuing operations [2–4], minefield mapping [5], planting and spraying [6], surveillance [7], hazardous environment exploration and

manipulation [8] and others. These mentioned tasks have common requirements that involve the cost to achieve their goal....

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