

Abstract

Hossam El-Deen H. Mahmoud Sallam

A Navigation Approach for Configuring Hexagonal Metamorphic Autonomous Mobile Robots

Abstract During the last twenty years, many of the research efforts focused on the field of distributed robotic systems, especially Self-Reconfigurable Robotic Systems (SRRSs), which is inspired by rather simple biological organisms with the aim of understanding and implementing basic survival-related behaviors in robots. The spread of these robotic systems has increased significantly due to the many challenges, difficulties and potential issues that cannot be solved by humans in different environments and which require special capabilities. Many of the different software and hardware implementations of SRRSs, which are accomplished at different levels of abstraction, are presented in this thesis with regard to their classifications, abilities and limitations. Metamorphic Robotic Systems are a sub-category of SRRSs. This type of robotic systems is composed of a set of homogeneous robotic modules. All modules have the same size, shape and capabilities. Each module can autonomously change its locations and connect and disconnect to from other modules to achieve the required tasks. This thesis focuses on a 2-D planar for a hexagonal metamorphic robots which can navigate autonomously in different unknown environments. All Hexagonal Mobile Robots (HMRs) embedded in the system are separated from each other, are randomly distributed in different locations and move individually. In our work, an algorithm is proposed to address the navigation problem of HMRs to achieve the required configuration in different environments. The proposed navigation algorithm consists of two parts. The first part, the centralized part, is used by the Global Robot, Leader, to communicate with the Local Robots to Select the closest robot to the target location. In the second part, each local robot makes use of the decentralized part of the proposed algorithm to optimize the Selection of the optimum empty cell, which is nearest to the goal location in the movement path. All local robots use local feedback information, provided by its sensory system, to generate sub-goals which are empty and adjacent. Local robots move to fill the sub-goals cells along its trajectory to reach its final goal locations without collisions deadlock. In general, the desired configuration is achieved while each local robot reaches its goal location and connects to the other local robots to act as a single unit. The main objective of our proposed algorithm is to minimize the required number of robot movement and iteration through the navigation process in the presence of obstacles and avoiding collisions to achieve different desired configurations in an optimal manner while enforcing several constraints and assumptions. Additionally, we improve the performance of our proposed algorithm by making a modification to solve avoiding obstacles problems. The 2D HexaAgentSystem simulator is used as the evaluation methodology to show the benefits of utilizing the proposed navigation algorithm for metamorphic robotic systems. The simulator is adopted for modeling the behavior of self-reconfigurable robots in different virtual environments. Extensive simulations are conducted to compare and show the performance achievements and the effectiveness of utilizing the proposed navigation algorithm. Keywords: Self-reconfigurable Robotic Systems, Hexagonal Metamorphic robotic Systems, Centralization, Decentralization, Autonomous Mobile Robot Navigation.