Applying Reinforcement Learning to Modular Cooperative Robotic Systems

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Abstract

This contribution summarizes the work on modular cooperative robotic systems that has been accomplished by our group. We have mainly employed a Reinforcement Learning approach although general Soft-Computing techniques are also applied in order to control and coordinate teams of robots with cooperative and competitive objectives.

1. Introduction

In the last few years our group has been applying Reinforcement Learning techniques for controlling and coordinating modular and multi-robots systems. It is well-known that this kind of systems are composed by teams of robots, which can be homogeneous or heterogeneous, i.e. the design, structure and component of each robot can be the same or the each robot can contribute with a different locomotion system —wheeled or legged robots, conventional, modular or reconfiguting structures— or with a different sensorial system (Duro et al., 2008).

The contributions are related to a research project entitled "*McRobs — A Modular Cooperative Robotic System for Operations in Dynamic Unstructured Environments*" which is been developed with another groups. The objective of this project is the development of modular robot architectures for their operation in highly unstructured environments, such as shipyards and building industry, in which the object to be manufactured or operated over is not placed on a conveyor or production line, but it is the tools that must be brought to it. The navigation space of the team of modular robots may be floors or vertical walls. The aim is to develop methods that guarantee that ensembles of cooperating robots are able to, for example, reach the designated points or densely cover a surface. This goal implies the following sub-objectives under the structural restrictions of the robot: computing the inverse kinematics, stable structural design, introduction of cognitive mechanisms in the mission control which allow the adaptation to changing circumstances, dense trajectory generation, obtaining cooperation strategies automatically.

Reinforcement Learning is been applied to different scopes: robot navigation, modular robots control and robots teams coordination.

2. Robot navigation

In the context of multi-robotics systems we have applied reinforcement learning methods for generating autonomous robots controllers to solve robot navigation problems. The problem of learning control actions from the perceived environment for convetional wheeled autnomous robots is discussed in (De Lope & Martin H., 2007; Maravall & De Lope, 2008). We have also proposed solutions for unconventional robots such as and unmanned aerial vehicles (Martin H. & De Lope, 2009).

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3. Modular robots control

An important concept in multi-robotics systems is the possibility of robots reconfiguration. Some tasks could need or could be solved more efficiently with a different robot structure that, for example, makes easier the robot movements in the environment by allowing the access to specific locations. The control of such robots is not easy by using traditional methods, thus we have applied reinforcement learning in order to control the modular robot movements (Martin H. & De Lope, 2007; Martin H. et al., 2008; Pereda et al., 2008; Maravall et al., 2009).

4. Robots teams coordination

Finally some solutions for robot coordination have been proposed from a reinforcement learning approach. We have successfully solved complex problems as for example multi-robot line-up behaviors (Sanz et al., 2008), surveillance coordination tasks (Maravall & De Lope, 2008; Quinonez et al., 2009) and storing disks with different colors in warehauses (Sanz et al., 2009). The coordination scheme for carring out the proposed task is learned in each case.

5. Concluding remarks and further work

We have empirically verified that Reinforcement Learning methods can be applied succesfully in order to solve tasks in multi-robotic systems domains. The methods enumerated above have been applied to robot control and navigation problems and also to coordinate the actions of several cooperative and competitive robots.

Our current interest deals with the generalization of the diverse proposed methods and also the creation of new models for robot coordination that includes the learning of communication languages emerged from the direct robot interactions.

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