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Chapter XII

Fuzzy Coach-Player System for Controlling a Robot Manipulator

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Abstract

Natural language commands are information-rich and conscious because they are generated by intelligent human beings. Therefore, if it is possible to learn from such commands and reuse that knowledge, it will be very effective and useful. In this chapter, learning from information-rich voice commands for controlling a robot is discussed. First, new concepts of fuzzy coach-player system and sub-coach for robot control with natural language commands are proposed. Then, the characteristics of subjective human decision-making process and learning from such decisions are discussed. Finally, an experiment conducted with a PA-10 redundant manipulator in order to establish the proposed concept is described. In the experiment, a probabilistic neural network (PNN) is used for learning.

Introduction

In recent years, there has been increased interest on research related to human-robot interaction. Even socially interactive robots who can demonstrate human-like behavior through natural language communication, understanding gestures, and so forth have received attention (Fong, Nourbakhsh, & Dautenhahn, 2003).

Among recent related works, two lines of research, both of which are equally important in achieving true human-like behavior, can be identified. This is a result of having two viewpoints for the same problem (i.e., human-robot cooperation).

The first line of research concentrates on embedding robots with more human-like cognitive capabilities. For example, Oates, Schmill, and Cohen (2000) presented an unsupervised learning method that allowed a robotic agent to identify and represent qualitatively different outcomes of actions. They used human experience to evaluate the method. Roy (2003) presented a computational model which was able to learn words from multisensory data. In a more recent interesting work presented in Roy, Hsio, and Mavridis (2004), they proposed a set of representations and procedures that enable a robotic manipulator to maintain a "mental model" of its physical environment by coupling active vision to physical simulation with the view of creating an interactive robot which could engage in a cooperative task with a human. Ballard and Yu (2003) and Yu and Ballard (2004) presented a multimodal interface that was able to learn words from human users in an unsupervised manner in which users perform everyday tasks while providing natural language descriptions of their tasks. This line of research is very important, however, due to extremely demanding technical requirements and theoretical developments, such systems still have a long way to go in order to be applied in practical domains.

The other line of research concentrates on controlling ordinary robots by human-friendly means. Here, ordinary robots are the robots which are controlled by conventional methods and are already being utilized for useful work. For example, Lin and Kan (1998) proposed an adaptive fuzzy command acquisition method for controlling machines using natural language commands such as "move forward at a very high speed." In Pulasinghe, Watanabe, Izumi, and Kiguchi (2004), similar commands were used to control a mobile robot handling out-of-vocabulary words. Pulasinghe, Watanabe, Izumi, and Kiguchi (2003) demonstrated a complex human-robot cooperative assembly task using a robot manipulator controlled by natural language commands. The advantage of this line of research is that it enables us to develop human interfaces for existing robotic systems. Some of the potential areas for such applications are nursing and aiding, helping humans in complex tasks such as surgery, and implementing space-restricted systems where other input-output devices are not feasible.

The work presented in this chapter is different from both of these views. It is related to the second one in the sense that it concentrates on controlling ordinary robotic systems by human-friendly means rather than developing a robot with human-like cognitive capabilities.

In natural language communication, encountering words and phrases with fuzzy implications is inevitable. Therefore, any system which accepts true natural language commands should be able to understand their fuzzy meanings. On the other hand, being generated by experienced humans, natural language commands are inherently information rich. Therefore, they can be very usefully and efficiently employed in machine control fine-tuning the performance of the machine. For example, a command like "move slowly" may concisely convey information