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Computational intelligence for structured learning of a partner robot based on imitation

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Abstract

Imitation is a powerful tool for gestural interaction between children and for teaching behaviors to children by parent. Furthermore, others' action can be a hint for acquiring a new behavior that might not be the same as the original action. The importance is how to map or represent others' action into new one in the internal state space. A good instructor can teach an action to a learner by understanding the mapping or imitating method of the learner. This indicates a robot also can acquire various behaviors using interactive learning based on imitation. This paper proposes structured learning for a partner robot based on the interactive teaching mechanism. The proposed method is composed of a spiking neural network, self-organizing map, steady-state genetic algorithm, and softmax action selection. Furthermore, we discuss the interactive learning of a human and a partner robot based on the proposed method through experiment results.

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1. Introduction

Pet robots, partner robots, and entertainment robots have been developed as the next generation of human-friendly robots. The robots require the capability of communicating with humans, as the robots are gradually used in the field of human society. The capability is essential in constructing a relationship or even a friendship between a robot and its human owner. The interrelation between the human and robot is constructed through their actual interaction. For example, when a child begins to play with a pet robot, the child would try to have contact with the robot in various ways. Because the contact pattern is used as sensory inputs for the robot, the child will search for causal relationship between the sensory input and its corresponding robotic action output. Therefore, if a specific structure exists in the robotic action pattern of the related with a certain human contact pattern, the human learns its structure or relationship. At the same time, the robot finds the specific structure in the human contact pattern based on the sensory input to make its corresponding action pattern. Therefore, interactive or mutual learning is very important for their communication based on actions. The communication of a robot with a human requires the continuous interaction with the human, because the human tries to find out the causal relationship between human contact and its corresponding robotic action. Furthermore, the human can construct complicated relationship by expanding or integrating the found or constructed relationships. Therefore, the robot needs to accumulate the mapping structure between its perceptual system and action system through interaction with the human step by step [35,36].

Imitation is a powerful tool for gestural interaction between children [6] and for teaching behaviors to children by parent. Imitation is defined as the ability to recognize and reproduce others' action, and imitation has been also discussed in the research of social learning theory. In general, the social learning is classified into two levels: observational learning and imitative learning [40]. The concept of imitative learning has been applied to robotics [1–10]. Basically, in the traditional researches of learning by observation, a motion trajectory of a human arm assembling or handling objects is measured, and the obtained data are analyzed and transformed for the motion control of a robotic manipulator. Furthermore, various biologically inspired neural systems have been applied to imitative learning for robots [1–4]. Especially, the discovery of mirror neurons is very important [1]. Each mirror neuron activates not only in performing a task, but also in observing that somebody performs the same task. In