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Complex Engineering Systems

Editorial

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How to deal with the complexity in robotic systems?

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Within the context of complex engineering systems, this editorial is dedicated to understanding some fundamental characteristics of complex robotic systems by reviewing some recent publications in the current issue of the journal.

Complex engineering systems (CES) have proven their ability to describe a wide range of practical applications: logistics, transportation systems, smart grids, communication networks, networked robotics networks, *etc*. An inherent feature of these systems is the interaction of multiple independent systems, which can be exhibited as a system of systems[1] (SoS) at large. For instance, within the context of smart grid, the paper entitled *A distributed electricity energy trading strategy under energy shortage environment*[2] puts forward a new power dispatch strategy based on the aggregative game theory and Cournot price mechanism for the grid network. The purpose of this dispatch strategy is to enhance the resilience of electric power, in particular, solving the power shortage problem using a distributed algorithm. The distributed algorithm can provide privacy protection and information safety and improve the power grid's extendibility[2]. Recently, robotic systems are frequently used to automate the inspection of distributed or decentralized power infrastructure, which enhances the system's reliability and decreases the operation and maintenance costs.

The main characteristics of CES, including[3] adaptation, self-organization, and emergence, make it so that CES is generally modeled in terms of a set of interconnected systems whose global behaviors are somewhat difficult to predict or manage. In this aspect, emergence in robotics can be realized through human-robot

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interaction or increasing robot autonomy by developing machine learning algorithms.

Considering that there is dynamical interaction among subsystems of a complex engineering system, system evolution or emergence can be exhibited through adaptation and self-organization of interconnected subsystems. Therefore, complexity in robotic systems can be interpreted as finding patterns via the collective action of many subsystems, including robot components, human interaction, environment interaction, *etc*.

In the following, some characteristics of complex robotic systems addressed in the current issue are addressed.

1. PATH PLANNING FOR ROBOTS

Considering that robots often perform tasks in workspaces in the presence of obstacles, it is required to plan collision-free motion based on the workspace geometry. This is mainly classified as offline planning or online planning in accordance with the workspace geometry information[4]. This topic has attracted much attention in the robotics field, and the existing path planning methods are mainly divided into three categories: graph-based, sampling-based, and intelligent methods. For instance, the A* algorithm is a traditional graph-based search method based on known environmental information for the path planning method.

The paper entitled *An improved A star algorithm for wheeled robots path planning with jump points search and pruning method*[5] proposes an effective method for global path planning of wheeled robots based on the A* algorithm. Within this graph-based search method, a jump point search method is adopted by adding only the nodes with special properties to the open list during the process of node expansion. Besides, simulation results are provided to verify the effectiveness of the proposed algorithm.

2. MOTION CONTROL IN ROBOTS

The motion control of robots is related to the movement of objects and can be defined on the basis of an integration of robot automation, robot dynamics, actuation mechanism, and embedded sensors in real time. Emerging technologies for robot motion control deal with the complexity of robot tasks, safety, and environments. Within the context of offshore robotics, the paper entitled *Reinforcement learning-based control for offshore crane load-landing operations*[6] studies the motion control of the offshore crane system, such as the load-landing or -lifting operations in interconnection with a vessel under environmental conditions. During the crane motion, the impact between the loads and the vessels is to be minimized and controlled to avoid serious injuries and extensive damage.

Owing to both system and environment complexities, artificial intelligence and machine learning algorithms have been successfully applied for model learning in robotic control systems. Therefore, machine learning algorithms could play a crucial role in multiple offshore crane operations, including load-landing operations. Specifically, the authors[6] attempted to utilize reinforcement learning (RL) algorithms for crane motion control. More specifically, they used the Q-learning algorithm to develop optimal control sequences for the offshore crane's actuators to minimize the impact velocity between the crane's load and the moving vessel.

Within the context of classical robot control methodologies, it is known that impedance control or admittance control is suitable for stiff or soft environments, respectively. Therefore, a hybrid impedance/admittance control mechanism can provide an adaptive behavior to the robot in order to interact with different environments. The paper entitled *Improved impedance/admittance switching controller for the interaction with a variable stiffness environment*[7] aims to satisfy the continuity of the interaction force in the switching from impedance to admittance control when a feedforward velocity term is present. In addition, the switching parameters are adapted to improve the performance of the hybrid control framework to better exploit the properties of both impedance and admittance controllers.

In summary, according to the above-mentioned discussions, dealing with the complexity in robotic systems is highly related to the amount of information that is needed to describe robot dynamics in interaction with the environment or humans.

DECLARATIONS

Authors' contributions

The author contributed solely to the article.

Availability of data and materials

Not applicable.

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Conflicts of interest

The author declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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