Novel method for robotic manipulation

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A simple, linear robot is easy to control. With known goals and a clear understanding of variables, a controller tells the robot the rules to follow. If button A is pressed, for example, the robot picks up an item from the conveyor belt. The item can either be moved to a different belt, or disposed of completely.

A more complicated, nonlinear robot is more difficult. The rules change when neither the goals nor the variables are understood.

"The knowledge of system dynamics is completely unknown and system states are not available... therefore, it is desirable to design a novel control scheme that does not need the exact knowledge of system dynamics but only the input and output data measured during the operation of the system," said Dr. Zhijun Fu, a researcher in the department of mechanical engineering at Zhejiang University, China.

Fu and his research team published a paper describing this novel control scheme in *IEEE/CAA Journal of Automatica Sinica* (*JAS*).

The scientists first had to determine the system states in order to figure out how to control them. They implemented a neural network—an artificial brain capable of quick assessment and learning—to observe the system at multiple time scales and to update its information as it studies.

"We cannot apply existing actor-based methods to unknown nonlinear systems directly," Fu said, explaining the appeal of an observer-based method. An actor must be told what to do, while the observer watches

the system to learn the requirements for optimal control.

Optimal control is the goal in most robotic systems. It's the budget of the system—how to achieve the goals at the lowest cost possible.

"The proposed method may be used [in] industrial systems with 'slow' and 'fast' dynamics due to the presence of parameters such as small time constants," Fu said.

Such variable dynamics can typically cost a system a lot, in terms of energy and resources. An observer-based method takes into account each type of parameter and adjusts ideally.

This method also accounts for a common system control problem: the overwhelming of actuators with information. Actuators, the physical sensors in automated machines, can become saturated with information and stop working properly. Since this control method accounts for input constraints (since only the input and output data are measured), the actuators avoid saturation.

Not all of the system control problems are solved, though.

"[In this paper,] we don't consider the state constraints problem," Fu said, referring to potential limitations that scientists may need to apply to a robotic system in some situations. "Future research will be dedicated to solving this problem."

More information: Z. J. Fu, W. F. Xie, S. Rakheja, and J. Ma, "Observer-based adaptive optimal control for unknown singularly perturbed nonlinear systems with input constraints," *IEEE/CAA Journal of Automatica Sinica*, Vol. 4, no.1, pp. 33-42, Jan. 2017.