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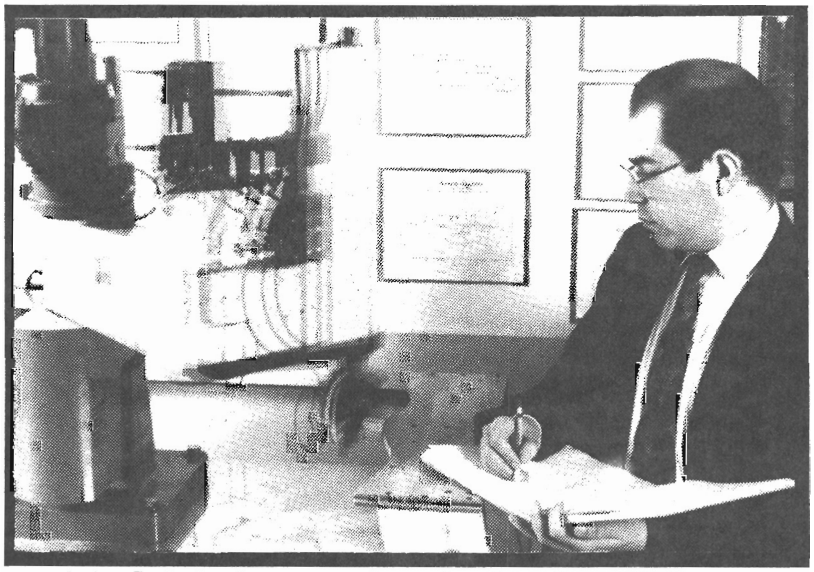
CAN YOU TEACH AN OLD ROBOT NEW TRICKS? SYSTEM HELPS EXISTING AND NEW ROBOTS LEARN FROM MISTAKES, IMPROVE THEIR PERFORMANCE

Improving the performance of older robotics equipment may no longer require expensive hardware changes. Two Georgia Institute of Technology researchers have developed a software-based system that allows robots to quickly improve their performance by learning from their errors.

The system Dr. Nader Sadegh and graduate student Kennon Guglielmo have devised uses algorithms integrated into the robot's learning controller. The algorithms help the machine better its performance in fewer steps than most current controllers.



Dr. Nader Sadegh observes a robot using the software-based system he developed to improve robot learning and performance. (Color/B&W Available)

"Most existing learning controllers require about 100 repetitions of the task to obtain the greatest improvements," Sadegh said. "In our case, it would take about four or five cycles."

Sadegh's system could be less expensive to install in older robots than existing controllers because it does not require major hardware modifications -- just software changes -- and therefore would not greatly increase a robot's cost or complexity, Sadegh said.

The researchers on the National Science Foundation-sponsored project began by developing algorithms similar

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to those found in current robotics literature. A 486 microcomputer samples the robot's optical encoder, which measures the angular motion of each joint in the robot arm and determines how closely the arm's actual movement follows an ideal path -- in this case, one that might be used in arc welding or machining processes.

The researchers successfully tested the software, housed in the 486, on computer simulations. They then began using the system on an IBM 7545 robot with four degrees of freedom. The robot moves its arm under control of the learning scheme and compares its attempted motion with the ideal path. Using this information, the robot modifies its actions for the next cycle. It repeats these steps and improves performance for up to about five cycles, at which point the robot is performing as well as its physical limitations and sensors will allow, Sadegh said.

"The novelty is how it uses the error over one cycle, and the desired trajectory, to come up with an improved control input for the next cycle," he explained. "This is the tip of the iceberg -- a small part of what learning is about."

The robot performs well even at high speeds and under situations in which variables are not known ahead of time--when the weight of the load a robot will pick up is unknown, for example.

"The algorithm we used is practical and appears to be faster and more robust to uncertainty than many others," Sadegh noted.

Such performance is not common -- most similar learning programs are specific to particular robots and do not work well in uncertain situations, Sadegh said.

The system's applications are not limited to robotics. The accuracy and speed of numerically controlled machine tools could be improved with the technology, as well, he added.

While continuing their current work, the researchers are pursuing a related project enabling robots to learn to control the force they exert on objects.

"We want to enable the robot to manipulate objects or control more generally the contact force generated with the environment," Sadegh said.

In addition, the researchers are developing a system that allows a robot to simultaneously improve its arm position and the force it exerts on an object.

A paper on Sadegh and Guglielmo's work, "Experimental Evaluation of a New Robot Learning Controller," was published in association with the IEEE Conference on Robotics and Automation, Sacramento, California, May, 1991.

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