Making Robots Learn

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During Richard Longman's sabbatical in 1984 he initiated research in three new fields, becoming one of the very early contributors to each. With support of ex-doctoral student Robert Lindberg at the Naval Research Laboratory, an Egleston Medal recipient, he started research on robotics in space. The shuttle arm can handle a load of mass similar to the shuttle, and this creates a question: Which end of the arm is the base and which is the load? Two of his early papers appeared in the first book on space robotics produced by the Carnegie Mellon Robotics Institute.

With German collaborators, he started research on time optimal control of robots, something that challenges numerical solution methods. One research focus was a press chain on the Mercedes production line near Stuttgart. The objective was to increase productivity by making the slowest robot get its job done faster. A series of publications progressed from idealized investigations to ones including detailed hardware constraints. Similar productivity problems appear in the production of semiconductor chips.

When a robot is commanded to follow a trajectory, it will repeatedly follow a somewhat different path. Robots often do the same operation hundreds of times a day, making the same errors each time. Longman considered this a bit stupid—can't we make a control system that learns from its experience to do what we ask? He started work on this at the University of Newcastle in Australia. Since then, this problem has developed into the fields of iterative learning control (ILC) and repetitive control (RC).

Longman has produced some 250 publications in this area, and is known for advancing the theory in a way that produces improved real-world performance. Experiments on a robot at NASA improved tracking accuracy by a factor of 1000 in just 12 iterations for learning. The methods can apply to a very large number of feedback control systems, creating high precision motion by improved algorithms instead of higher precision hardware.

At Seagate Technology, experiments reduced the repeatable error in computer disk drives by 98 percent. Similar experiments improved paper handling in copy machines at Xerox. Experiments also demonstrated improved beam focus at the 8 GeV (one thousand million electron volts) accelerator at Jefferson National Accelerator Facility. Longman is currently working on similar experiments at the Naval Postgraduates School on jitter control in laser optics on spacecraft.

ILC and RC aim for high precision motion and optimal control aims for fast motion. Longman is working to develop a marriage between these research areas to simultaneously get the benefits of both—aiming for higher quality products created with improved productivity.

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