

# A new industrial revolution?

## CSU research holds huge promise for manufacturing

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People and industrial machinery suffer the same fate, functioning as both do in an imperfect world.

We know what that means for humans. They can break or age and wear down. But whirling, pumping, lifting, cutting, boring and otherwise power-driven gadgets used to manufacture things face similar challenges. They respond in familiar ways.

Now, though, a professor at Cleveland State University has introduced a fresh approach to

meeting the myriad disturbances that manufacturing devices confront second by second in their daily lives.

The technology that Zhiqiang Gao developed can identify burgeoning errors in machine operations, anticipate their effect and adjust the process before the errors screw up any products. A result is that whatever parts the machines kick out remain as consistent as the manufacturer chooses, despite any friction or power surges that otherwise would throw production out of kilter.

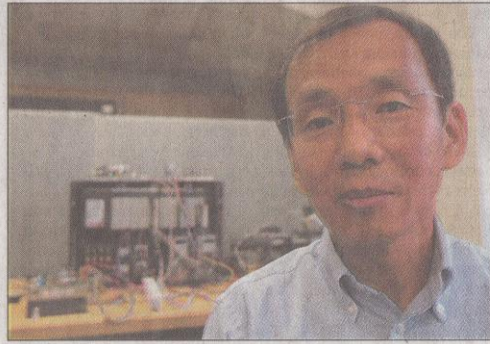
Gao's control system, called ac-

tive disturbance-rejection control, or ADRC, aims to enhance or, eventually, even supplant a control approach that has been the industrial standard since the 1920s. The old approach is called the proportional-integral-derivative, or PID, controller.

As errors slip into machine operations, PID uses a control loop feedback approach to "tune" three factors in the operations.

Gao has toiled over a new approach since the 1980s, when he was studying at the University of Notre Dame, and especially since 1990, when he joined CSU.

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Engineering Professor Zhiqiang Gao, shown in his Cleveland State University lab, has seen his struggle to bring industrial machine control technology into the 21st century begin to pay off in recent weeks. The company that he and a business partner formed received a \$1 million investment from Early Stage Partners in Cleveland.

## WEAR

FROM C1

### Motion-control research holds huge promise

ADRC brings the most sophisticated interplay of engineering and mathematics to bear on anticipating and rejecting problem operations in machines.

The trick is to sense that, for instance, friction may slow a machine, thus disturbing operations of, say, cutting plastic sheets into cell-phone gaskets. The software would compute the scope of the possible disruption and instruct the power unit to compensate before the friction messes up products. "It rejects the disturbance," Gao said, by making a simple adjustment.

Many environmental sources can introduce problems, but ADRC focuses on maintaining consistent output, an essential concern of modern manufacturing, where quality control and cost savings reign supreme.

The software that Gao developed could become what a local entrepreneur calls "a revolutionary approach, a disruptive technology" in the industrial world. One result is that it could help make Cleveland a new center of excellence in tomorrow's manufacturing universe.

Last month, ADRC Technologies Inc., the company Gao and industrial-controls expert Jim Dawson of Hudson started in 2006, received \$1 million in financing from a Northeast Ohio venture capital firm to launch real-world testing on the professor's control system. "That's real money," Dawson said.

Starting in the next few weeks, the technology — software that takes information from sensors embedded in machines and uses sophisticated algorithms to foresee problems — will go under close scrutiny for about six months. It will operate in drill presses, industrial lathes, stamping machines and other mechanized tools on shop floors scattered around the region.

"What we're going to do now is put this technology in settings with actual manufacturers and do controlled tests," said Jim Petras, a founder and managing director of Early Stage Partners, whose investors put up the \$1 million.

"We'll take someone who has a complex process and runs a piece of equipment 24 hours a day, seven days a week with the appropriate maintenance schedule," Petras said, and harvest a wealth of operational data.

Gao will analyze quality, efficiency, cost of operation and

### Active disturbance-rejection control

There are plenty of disturbances that can make industrial machines decline over time.

**VARIABLES:** Shifts in temperature, moisture and air pressure. Friction, wear and fatigue. Flow of power and speed.

**INDUSTRIAL CONTROLS:** Aim at detecting those forces and counteracting them. They have been in place since the

first governor on a steam engine during the dawn of the industrial revolution in the late 18th century.

**OLD METHOD:** The old feedback loop approach can't correct a problem that a machine experiences until it disturbs the consistent flow of products, said Cleveland State engineering Professor Zhiqiang Gao.

maintenance required of the machines compared with equipment lacking the new technology. He and the businessmen are confident they have a winner on their hands.

The engineer's years of computations and tests suggest a machine with his technology could perform at least 15 percent more efficiently, using less power and operating with more precision and predictability while generating fewer errors. The net result, according to Jim Dawson, a career industrial-controls expert and president of the new company, "will be double-digit savings for manufacturers. We're sure of that."

The approaching field tests, Dawson said, could position the company, now just an office in Hudson, as "a major technology supplier to all kinds of manufacturers around the globe." And Gao said he would not be surprised if the company's presence here, combined with the research emphasis at the control center he runs at CSU, brings other companies focused on advanced control technology to the region.

"Cleveland is the only place I could have done this, where this kind of focus on industrial controls actually makes sense," he said in his lab. He has worked with labs and manufacturing companies with facilities in Northeast Ohio since the mid-1990s, sharing information with and receiving support from NASA Glenn Research Center, Rockwell Automation, the Cleveland Clinic and many others.

In the '90s, he shifted his research from highly theoretical issues to "dealing with the kinds of practical problems you find in factories," he said.

His third-floor lab reflects that practical turn. The big room is filled with computers, of course, but also industrial simulations. They include a pair of electric motors connected to one another by a rubber drive belt and plugged into a refrigerator-sized

set of controls and a desktop computer.

Graduate student Gang Tian, who is working on a doctoral degree in engineering and is a native of northwest China, explained the unit.

One motor runs the belt and a smaller one introduces disturbances too tiny for the eye to see. Gang turned on the whirring motors, then examined the color

**NEW TECHNOLOGY:** Because tolerances can be set precisely, disturbances are detected before they affect operations.

**THE FUTURE:** Jim Petras, managing director of Early Stage Partners, which recently invested \$1 million in ADRC, predicted that the company could have sales "in the hundreds of millions within the next couple of years."

— Frank Bentayou

watched the display intently.

Later, standing with Dawson and the research assistants and graduate students, Gao smiled and agreed that after two decades of toil, "things are moving pretty fast."

Experts in the field of motion control say his technology has the potential to replace another whose theoretical basis hasn't changed in 85 years.

During that time, and especially very recently, manufacturing has focused far more on precision, efficiency, speed and consistency, as well as operating with fewer employees. These are all factors that play into the economics of making goods inexpensively for worldwide markets, a competitive requirement today.

Manufacturers are grasping at every opportunity to streamline processes, another way of saying "cutting costs." Petras insists that the reason ADRC is a great early-stage investment is that the company expects virtually to guarantee the double-digit savings the venture capitalist loves to talk about.

"And here's a system that not only can industrial machine makers incorporate into their manufacture of new equipment, but it's easy to retrofit it, too," into existing machines, he said.

That's an important consideration, as nearly half the nation's manufacturing machines have been in use for a decade.

Gao said "the light bulb went on" when he began connecting with the cluster of manufacturing companies nearby and talking with practitioners about what they confront, using a control model developed in 1922. "Everybody said, 'Yeah, it's a problem, but we don't know how to solve it.'"

From his early days at CSU, the university supported his efforts to dive into the question corporations didn't have the time or energy to answer: What's the basis for the next generation of industrial controls?

The question is now getting a lot of attention.

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