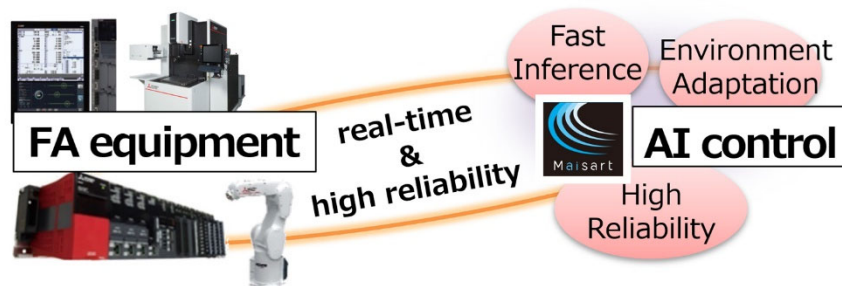


Mitsubishi Electric and AIST Develop AI Technology for Real-time Control of FA Equipment

TOKYO, November 25, 2021 – Mitsubishi Electric Corporation (TOKYO:6503) and the National Institute of Advanced Industrial Science and Technology (AIST) announced today that they have developed an AI technology that predicts changes during automated manufacturing processes and then makes real-time adjustments in the factory-automation (FA) equipment, such as motion speeds, etc., during operation. In addition to eliminating the need for time-consuming manual adjustments, the AI estimates the confidence level of inferences regarding factors such as machining error and then controls the FA equipment based on suitable levels of confidence. The technology is expected to lead to more stable, reliable and productive operations, particularly in agile manufacturing.



AI technology for real-time control of FA equipment during operation

Key Features

1) *Fast: AI achieves high-speed inferences for dynamic control of FA equipment control*

In factories that use FA equipment for agile manufacturing, such as computerized numerical controller (CNC) cutting machines and industrial robots, the movements, operating speeds, acceleration, etc. of the equipment vary during the operating processes. In conventional manufacturing, skilled workers must adjust the operating parameters according to various specifications, such as the required level of accuracy. Mitsubishi Electric has now developed an AI technology that simultaneously performs high-speed inferences and equipment control for real-time FA operation. Incorporating Mitsubishi Electric's expertise as an FA equipment manufacturer, the new low-load AI control technology performs inferences while simultaneously controlling FA equipment. Although the technology minimizes its processing load, it is capable of achieving high-level inference accuracy while simultaneously guiding FA equipment control.

2) *Adaptable: In-process learning to adapt to constantly changing work factors*

The shapes of workpieces change during manufacturing and this can lengthen manufacturing times or lower processing quality. In addition, changes can vary by workpiece, making it difficult for FA equipment to learn in advance. Mitsubishi Electric's new technology, however, allows the AI to learn work factors during FA equipment operation and then make real-time adjustments as needed. In addition, the technology formulates physical phenomena, such as friction, and then incorporates these

mathematical expressions to enable learning during operation, making it possible to adapt to constantly changing processing factors.

3) ***Reliable: AI performs adjustments according to inference-confidence levels***

AI inferences must be reliable to ensure that real-time control of FA equipment leads to stable product quality and efficient processing. Mitsubishi Electric’s new algorithm calculates the confidence level of inferences by learning the machine characteristics of each process and each target device. By using this algorithm to control FA devices, the new AI ensures high reliability.

Collaboration in Developing New AI Technology

Name	Contributions
Mitsubishi Electric	Implementation and improvement of AI control technology for CNC systems, servo systems, electric discharge machines, and industrial robots
AIST	Use of AI for optimization and data analysis

Development Background

Operating needs change frequently in agile production, so optimum conditions, such as FA equipment motion speeds, revolutions, etc., must be adjusted individually for each type of product. Performing such adjustments manually, however, requires labor and time, resulting in decreased productivity. Moreover, declining birthrates and aging populations in many developed countries are resulting in a shortage of skilled workers capable of adjusting FA equipment.

In response, Mitsubishi Electric and AIST have developed a technology that uses AI to predict various changes in manufacturing processes, such as changes in shapes as each workpiece is machined, and then automatically adjusts the FA equipment’s operation in real time. In addition, the confidence levels of the AI inferences are indexed and the FA equipment is controlled accordingly, ensuring high reliability and productivity.

This is the latest deployment of an AIST AI technology in Mitsubishi Electric’s FA equipment since the two entities began collaborating on AI development in fiscal 2017. Going forward, Mitsubishi Electric expects to increasingly incorporate various forms of its Maisart®* AI technology in FA equipment and systems to significantly improve manufacturing productivity.

*Mitsubishi Electric's AI creates the State-of-the-ART in technology



Examples of AI Control Technology Application

1. ***Fast inferences***

As an example of the high-speed inference of Mitsubishi Electric’s AI control technology, the company developed a solution to estimate loads on robotic arms. Various load parameters are utilized to calculate acceleration and deceleration speeds, for which the AI function quickly infers load values using information about the robot, such as motor current, joint angle, etc. Simultaneously, the confidence levels of the inferences are calculated. Finally, acceleration and deceleration are adjusted based on estimated values and confidence levels (Fig. 1-1). To evaluate the effectiveness of this technology, a validation test was conducted to compare differences in robot motion when using and not using load inferences. As

shown in Fig1-2, robot operation time was confirmed to be reduced by 20% when inferences were used. Moreover, more stable operation was achieved by adjusting robot motions only when the confidence level was high.

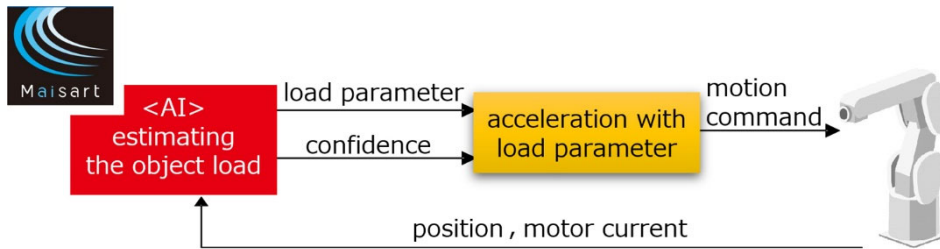


Fig. 1-1 Using AI to estimate load and confidence levels

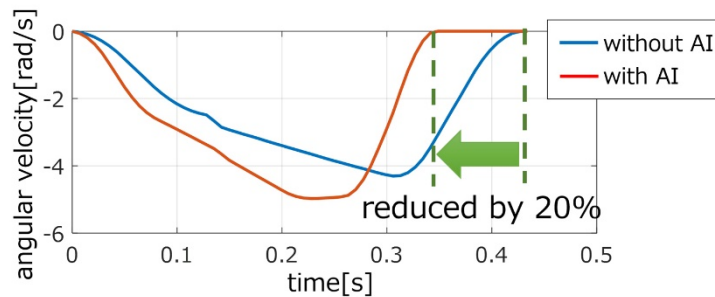


Fig. 1-2 Faster operation using load estimation

2. Adaptation to changing conditions

As an application example of Mitsubishi Electric’s AI control technology that adapts to changing processing conditions, the company developed a solution for automatically adjusting an engraving EDM (electric discharge machine). The EDM positions an electrode close to the workpiece and generates an electric discharge to perform engraving. Debris produced during machining, however, must be ejected with the electrode (Fig. 2-1), and the amount of debris increases as processing proceeds, so the frequency of debris ejection must be increased. In the new solution, AI learns state of debris ejection that is produced and then automatically adjusts the frequency of ejection Tests have confirmed that machining time is reduced up to 23% compared to processing without AI adjustment (Fig. 2-2).

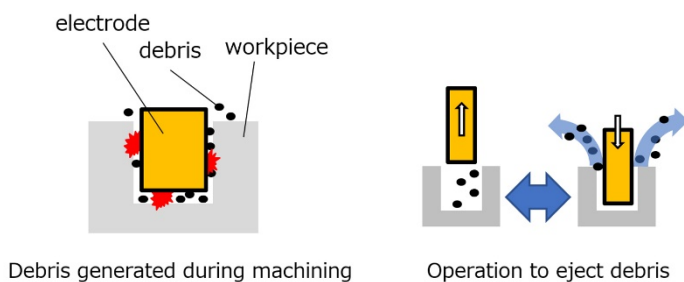


Fig. 2-1 Machining with an engraving EDM

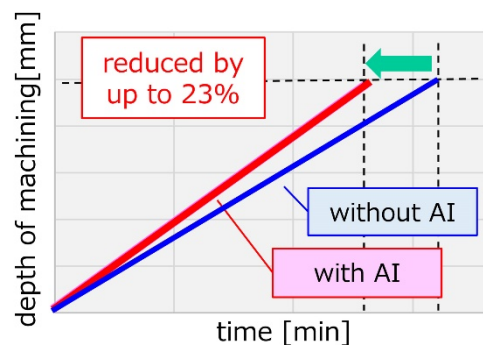


Fig. 2-2 Processing with & without AI

3. Reliability

As an example of the reliability of Mitsubishi Electric's AI control technology, the company developed an AI error-correction solution for CNC cutting machines (Fig. 3-1). The AI estimates constantly changing machining error, or the difference between the cutting machine's current position and the command value, to enable correction even during dynamic machining. Also, the confidence levels of the AI's error inferences are indexed to ensure that error correction is performed only if the confidence level is suitably high. Tests confirmed that machining accuracy is improved by 51% compared to using error correction not supported with AI (Fig. 3-2). Furthermore, low confidence levels can be improved through relearning.

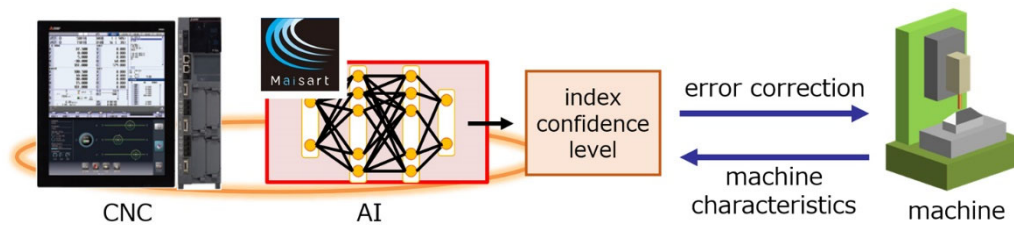


Fig. 3-1 AI error correction in CNC cutting machine

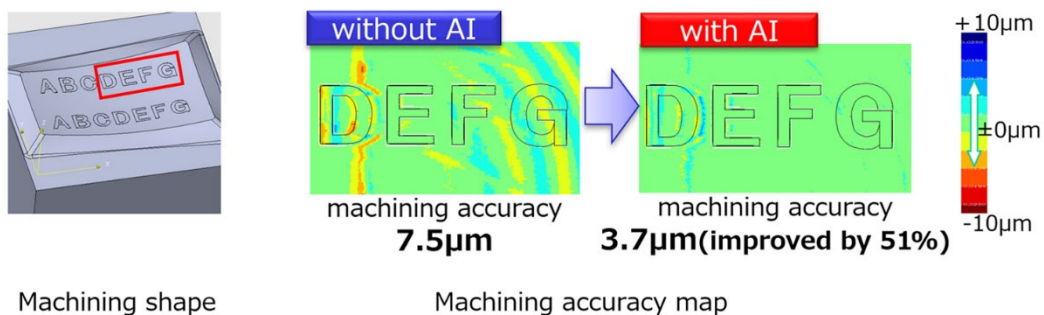


Fig. 3-2 Better results with AI-supported CNC cutting machine

About Maisart

Maisart encompasses Mitsubishi Electric's proprietary artificial intelligence (AI) technology, including its compact AI, automated-design deep-learning algorithms and extra-efficient smart-learning AI. Maisart is an abbreviation for "Mitsubishi Electric's AI creates the State-of-the-ART in technology." Under the corporate axiom "Original AI technology makes everything smart," the company is leveraging original AI technology and edge computing to make devices smarter and life more secure, intuitive and convenient.

Maisart is a registered trademark of Mitsubishi Electric Corporation.

Inquiries

Media Inquiries

Public Relations Division
Mitsubishi Electric Corporation
prd.gnews@nk.MitsubishiElectric.co.jp
www.MitsubishiElectric.com/news/

Public Relations Department
National Institute of Advanced Industrial Science and Technology
hodo-ml@aist.go.jp
www.aist.go.jp/index_en.html

Customer Inquiries

Advanced Technology R&D Center
Mitsubishi Electric Corporation
www.MitsubishiElectric.com/ssl/contact/company/rd/form.html
www.MitsubishiElectric.com/company/rd/

Artificial Intelligence Research Center
National Institute of Advanced Industrial Science and Technology
<https://www.airc.aist.go.jp/en/>

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About Mitsubishi Electric Corporation

With 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Mitsubishi Electric enriches society with technology in the spirit of its “Changes for the Better.” The company recorded a revenue of 4,191.4 billion yen (U.S.\$ 37.8 billion*) in the fiscal year ended March 31, 2021. For more information, please visit www.MitsubishiElectric.com

*U.S. dollar amounts are translated from yen at the rate of ¥111=U.S.\$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2021

About National Institute of Advanced Industrial Science and Technology

The National Institute of Advanced Industrial Science and Technology (AIST) is one of the largest public research organizations in Japan and has a history of almost 140 years. AIST focuses on the creation and practical realization of technologies useful in Japanese industry and society, working to bridge gaps between innovative technological seeds and commercialization. As pioneer and still core player in Japan’s national innovation system, AIST manages some 2,300 specialists engaged in research and development at 11 research bases across the country. For more information, please visit https://www.aist.go.jp/index_en.html.