FUJITSU

AI-Enabled Image Recognition System to Revolutionize the Manufacturing Line

Artificial Intelligence (AI) technology is dramatically changing production sites for manufacturing. AI enables manufacturers to automatically generate and revise image recognition system programs, used for assembling parts and various inspections, to respond quickly to changes in part specifications or the manufacturing line. Working hands-on with this technology for five years with Fujitsu Group companies, Fujitsu Laboratories has made visible progress improving the productivity and QCD (quality, cost, delivery) of electronic parts manufacturing.

Image recognition systems have been used in manufacturing lines of electronic products for quite some time. Cameras are used to perform automated assembly and inspections throughout the manufacturing process, from start to finish. They mount and assemble components, inspect soldering, and visually inspect products, among other various tasks.

Taking visual inspections as an example, an image recognition system can detect defects from multiple images of the target as captured under various lighting patterns with an attached camera. In theory, this greatly improves QCD (quality, cost, delivery) as scratches, dirt, foreign matter, and other subtle faults–which, up to that point, had been inspected with the naked eye–can now be caught in a batch inspection.

Even so, the manufacturing industry is changing, and image recognition systems are increasingly becoming a bottleneck. Systems are now expected to respond more flexibly and promptly to changes in part specifications, the start-up or change in manufacturing lines, and other needs. If there is a change to the manufacturing line, the image recognition system needs to be reprogrammed or rebuilt.

Tetsuo Koezuka, researcher for Fujitsu Laboratories at the Research Center for Next-Generation Manufacturing Technology, has spent many years developing image recognition systems at Fujitsu Laboratories. He explains some of the difficulties with this technology. "It takes time to program image recognition systems–the implementation has to be custom-fit specifically for each manufacturing line. The images captured can be affected by everything from the lighting on the manufacturing line to angle of light and camera position. Almost weekly, we have to go onsite to adjust the program when a manufacturing line goes online."

These systems also require constant maintenance; any change to the manufacturing line or part specification means captured images might not be recognized accurately. As Koezuka goes on to say, "Every change requires a developer to go onsite and tweak the programming. Traditionally, we went onsite, assessed the situation, and viewed the images to fix the code. We'd wait for up to a week to make sure everything is running smoothly." Koezuka's teams also faced delays due to start-up of the manufacturing line.

AI to Vastly Improve Precision of Image Recognition Systems

To loosen this bottleneck, Fujitsu Laboratories has been working on automating image recognition systems these last five years. If program generation and onsite adjustments could be automated, it would reduce the time spent on preparing equipment and switching part specifications, which in turn would accelerate turnaround time until safe operation for the manufacturing lines and eliminate the need for developers to stay at the production site. While image recognition systems are only automated in some automated assembly and inspections, this shift will in effect improve productivity and quality for the manufacturing line as a whole.

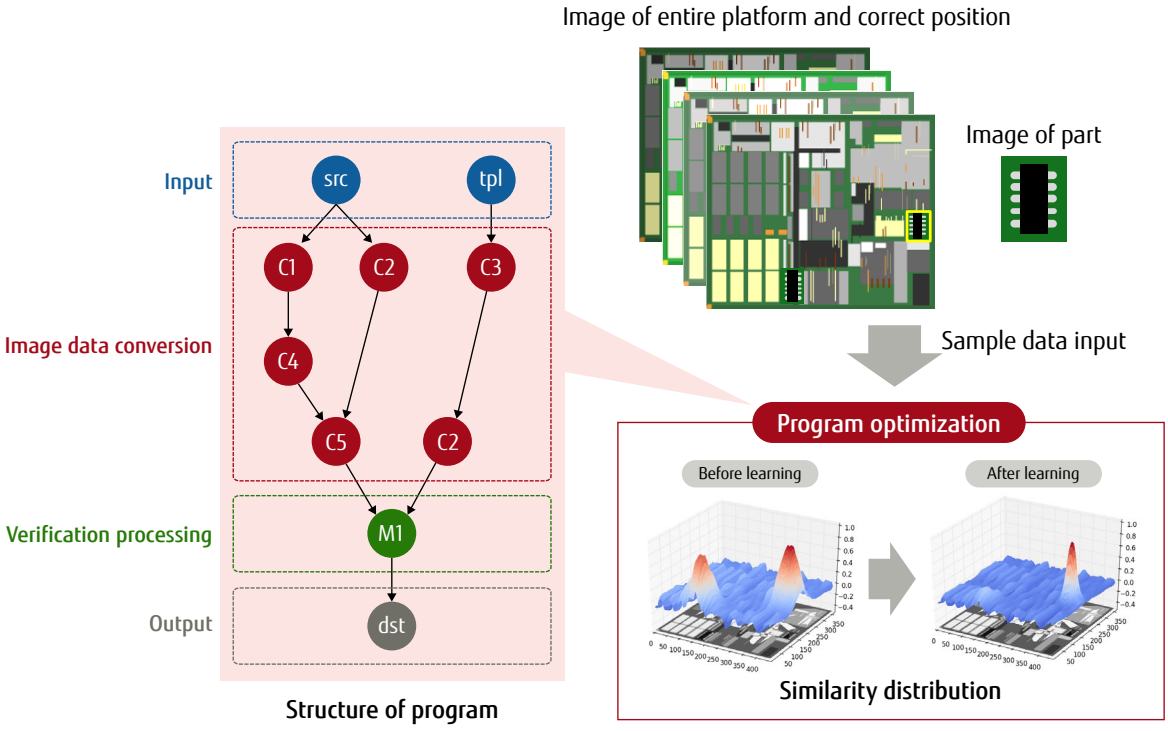

Figure 1: Structure and optimization of recognition program with optional graphics

The inspection program—the crux of image recognition systems—increases the contrast on captured images of products to detect flawed edges with scratches or dents, as well as positioning. The accuracy of inspections could be improved by making the program learn various image data.

"When a manufacturing line or part gets changed, the image recognition system also needs to be refined. With limited image data for validation, however, developers get stuck onsite through a lengthy trial-and-error process. We figured that AI technology could be applied to the process to get optimal solutions from small amounts of image data." (Koezuka)

The company decided to use specialized genetic programming. Genetic algorithms are a form of the evolutionary algorithms proposed by the University of Michigan in 1975. While difficult to implement when initially discovered, these can now be implemented on a regular PC with modern advancements to ICT.

This concept would produce major results. When tested on a part assembly line at a Fujitsu Group company, the image recognition system automatically generated the code used for inspection and achieved an almost 100 percent recognition rate. On top of that, the system generated the program in a mere eight hours. Conceivably, you could enter the system commands in the evening to code a program overnight. Compared to the seven days it takes developers, this was a breakthrough. The Fujitsu Group took this success and started using AI technology at production sites immediately.

Specialized Genetic Programming – Producing Results at Production Sites

Koezuka says, "There are major differences between specialized genetic programming and deep learning. By limiting the purpose, you can achieve a high recognition rate without the large volumes of data needed for learning. They say we are now in the third AI boom. Specialized genetic programming was in the limelight during the second AI boom as a program that incorporated the strengths of expert systems."

Tetsuo Koezuka

Senior Expert
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The target and purpose of the program used in the image recognition system of manufacturing lines are established beforehand. However, the amount of image data available prior to operating the manufacturing line is limited. Deep learning could generate an original algorithm with large amounts of data, but a completely different approach was needed here.

With automated manufacturing machines operating based on image data, having a mostly correct recognition rate is not good enough. If the judgment criteria become a black box, then operation can't improve nor is there accountability at the production site. Such requirements aren't conducive to deep learning; genetic programming, whose judgment algorithms can be traced, is more suitable.

Specialized genetic programming can be configured with specialized templates to shorten processing times and achieve a high recognition rate. For example, the template could narrow it down to three processes: enhancement, threshold process, and binary image handling. Reconfiguring this template allows it to handle various other issues other than image recognition.

The program can evolve automatically by preparing training data from normal and defective images to make pass/fail judgments. Because it resembles the evolution of living beings, the term genetic is used.

Naturally, programs are developed in the lab, not the production sites. To gain a high recognition rate, the computer itself must repeat its trial-and-error process onsite and evolve the program automatically on its own. "It won't surpass deep learning or achieve anything extraordinary, but the system is reliable and delivers results," says Koezuka.(Figure 1)

Start of External Consulting Services

Fujitsu Laboratories has used specialized genetic programming jointly with the manufacturing division of Fujitsu to produce major results at production sites.

Now, the system can distinguish a part regardless of its shape and location during the process of inspecting implemented part for misalignment. The time required to develop the program for pass/fail inspection processes has been reduced by 80 percent. As mentioned above, our part assembly machines can now relearn without specialist adjustments and still maintain recognition rates of 97 percent or higher. Variations in positioning were cut by half, shortening work hours by 33 percent.

Koezuka points out the potential: "We've developed programs for more than 100 image recognition systems already. We use different programs with the same purpose, experimenting to determine which are better. We can even see the relative advantages during a review, which leads to further improvements."

Building on the Fujitsu Group's efforts, Fujitsu has started offering consulting services for utilizing AI infrastructure at production sites. With this service, Fujitsu will design and build a learning database for each product and work process at a production site, creating a system that continuously improves accuracy by incorporating AI methods.

Other planned applications include supporting printed circuit board design in electrical design, finding similar 3D model parts in structural design, and more. These image recognition system programs can be repurposed from manufacturing lines to other applicable fields.

Advancing Cloud Technology and Transforming Manufacturing

Koezuka says, "Image recognition systems have gone from an idea created in the lab to achieving actual results at production sites. They've already evolved by responding to onsite needs and should be able to evolve even further by handling various non-Fujitsu projects. We already have quite a number of inquiries from the automotive industry."

Fujitsu image recognition technology began with recognizing simple images such as straight lines, and has widened its applicable range to complex objects such as round protrusions. Fujitsu engineers are current working to develop visual inspection technology that can be used not only for electronic equipment, but a wide variety of other manufacturing lines as well. If they are successful, it would grant the entire manufacturing industry access to efficient visual inspections.

With this research and development, Fujitsu is drawing up its vision: a manufacturing line that automatically determines the reason for a defect and feeds that back to the preceding process. If we can achieve that, everything can be automated, from design stage to manufacturing line.

For the future, Fujitsu's strategy is to offer the image recognition system as a cloud service. Image recognition programs would be automatically generated, sent to each factory via the cloud, then installed and implemented at each manufacturing line with Fujitsu support.

"There are two paths we are considering for cloud services. One is to create a database of image data, learning data, and programs to improve our support capacity. In addition to the SaaS (Software as a Service) platform, the other is to provide PaaS (Platform as a Service) so that customers can utilize the service as a part of their own system. We have conducted individual trials so far, but we really want to transform manufacturing as a whole with cloud," Koezuka explains with enthusiasm. The applications of image recognition systems on production sites still have plenty of room for growth.

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