Smart manufacturing moves from autonomous to intelligent

Case Study

Company
Seagate Technology

Location
Normandale, MN

Contact
seagate.com

Industry
Data Storage

Inside Project Athena: Seagate's internal AI edge platform

Key Takeaways

- Seagate has built a working, practical AI platform to improve production line efficiencies and product quality. It could provide up to 20% reduction in new cleanroom investments required for manufacturing and could lead to up to 10% reduction in hours spent on the process.
- Internally codenamed Project Athena, Seagate's system can process millions of microscope photographs every single day.
- By deploying deep learning, Athena has trained itself to identify defects faster and more accurately than a human subject-matter expert.
- Seagate can now resolve irregularities and process problems more quickly and at a lower cost than ever before. Seagate expects to see up to 300% ROI from efficiency improvements and better quality processes.
- The Project Athena technology has a broad range of applications for all of our clients operating in the manufacturing industry. It's a significant first step in smart manufacturing and an example of Industry 4.0 happening right now.

Introducing Project Athena

Seagate has successfully deployed its first ever deep learning manufacturing project in its Normandale, Minnesota, wafer fabrication facility. Wafers—small slices of semiconductor material—are used to create the read-and-write heads on hard drives.

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The Challenge

Seagate factories produce more than one billion recording transducers every year. To maintain the highest standards of quality, these transducers must be analyzed and tested to detect manufacturing defects. But what are transducers—and what do they have to do with wafers and drives? The design starts with the raw material that is, essentially, a thin semiconductor substrate. Over the course of a photolithographic process, the substrate becomes a thin, flat, crystalline wafer. The wafer, when sectioned, and with further processing, becomes a transducer (also known as a slider)—a part capable of reading and writing data onto a rotating magnetic disk recording surface.

The testing process is long, complex, and manually intensive. There are 100,000 sliders in every 200mm wafer that need to be checked. The Normandale factory takes millions of microscope pictures every day, generating 10TB of data that must be sifted to detect potential production defects before wafers are assembled into drives.

Because of the sheer volume of transducers that need analysis, engineers cannot possibly test them all. Even with a lengthy manufacturing process, there simply isn't enough time to check every image. This means that defective units can—and do—escape immediate detection occasionally and are caught later in the process, with much higher cost.

Seagate's teams needed a way to check more pictures in less time. But simply hiring more image analysis experts would still not be enough to process millions of pictures.

The teams had achieved a degree of automation using rules-based image analysis. This approach meant that it was possible to identify some anomalies—as long as the system knew what it was looking for first. The rules had to be built manually, a time-consuming process that had to be constantly tweaked and refined.

The rules-based system was slow to set up, slow to refine, and produced variable results. Aside from generating plenty of false positives, the rules could only detect known issues. This resulted in a potential risk—that faulty wafers could escape detection before being assembled into read-and-write heads.

Thanks to advances in AI, machine learning, and Internet of Things sensors, a new solution eliminates that risk. That's Seagate's Project Athena.

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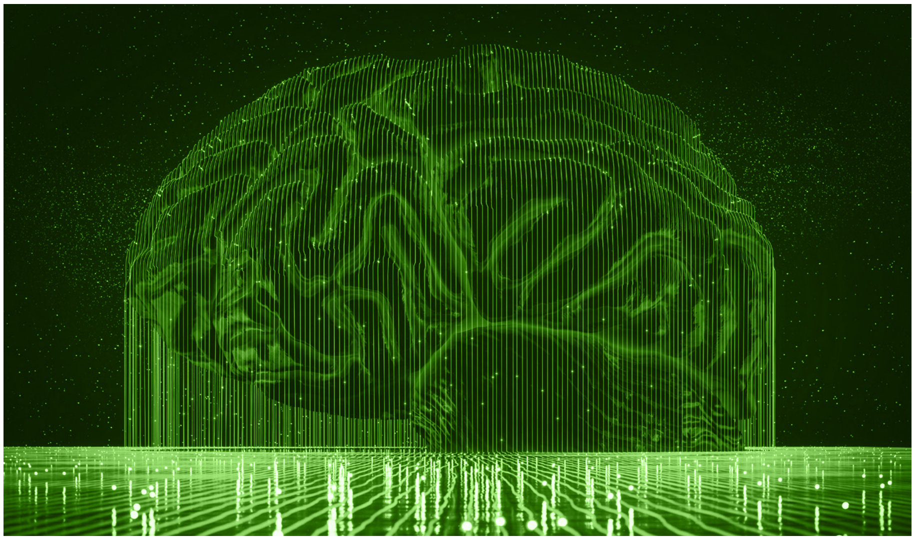
The Solution

The solution had to deal with two main problems: the huge volume of data that needed to be processed every day and the shortcomings of the current rules-based analysis engine. Traditional big data programs operate on a batch process—completely inappropriate for a production line operating 24×7×365.



The first step was to build a deep neural network (DNN) that could generate insights to improve automation and detection of transducer failures. Neural network processing was built using Nvidia V100 and P4 GPUs*, and high performance Nytro® X 2U24 storage to underpin the deep learning and AI elements of the Athena system.

Wafer images were then fed into the DNN to train the AI system to distinguish between "good" and "bad" wafers. Athena learns in exactly the same way as a human engineer does—by examining thousands of photographs. But thanks to the raw processing power of the DNN, Athena can learn much faster—and more accurately than a human.

Over time, Athena has acquired the ability to spot potential process defects. The AI assistant flags anomalous images for manual assessment by a subject-matter expert. Athena can build and refine its own rules based on anomalies detected during the image analysis operation.

Most importantly, Athena accepts and analyzes images generated by the electron microscope in real time. The DNN is capable of processing every picture as it is created. Seagate is now able to process the three million images generated every day—and can identify tiny defects that may otherwise be missed by a human engineer.

Real-time processing also allows the teams to identify and correct manufacturing issues early. The quicker problems can be identified, the more effectively Seagate can minimize their impact on the production process and costs.

"This is a game-changing first step in smart manufacturing and a foundational architectural piece that can be expanded across the rest of our factories."

—Jeffrey Nygaard

EVP, Operations, Products, and Technology

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about Seagate's end-to-end solutions at labs.seagate.com

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The Future

Project Athena may be excellent at identifying defects, but it does not—and cannot—completely replace factory subject-matter experts. The most powerful upshot of Project Athena is the way it opens up new opportunities for Seagate's wafer experts to innovate and remedy larger problems.

Athena provides a template for solving a far wider range of problems beyond the factory. Its ability to detect anomalies in a faster, more adaptive, and more meaningful way can extend beyond the smart factory and prove useful in domains as varied as public safety, autonomous vehicles, and smart cities.

"We expect to deploy Athena across all of our manufacturing facilities in due course," says Jeffrey Nygaard, Executive Vice President of Operations, Products, and Technology at Seagate. "And, as the cost of microscopic cameras and IoT sensors falls, the same technologies can be used for other applications, too. This is a game-changing first step in smart manufacturing and a foundational architectural piece that can be expanded across the rest of our factories."

Seagate's manufacturing tools each contain between 30 or more sensors, each of which records machine health and other measurements every second. This information represents an important opportunity to better understand low-level operations. Fed into the Athena DNN, the data helps to identify production issues earlier. This offers the chance to take proactive action in repairing and preventing failures.

Project Athena is not purely for Seagate's benefit either. Similar smart factory technologies can be deployed across the manufacturing industry, allowing Seagate's clients to realize many of the same benefits that Athena provides. The use cases are different, but the underlying principles—deep neural networks, artificial intelligence and machine learning—are identical.

Customers need a solid technology platform for AI projects—and Seagate's solutions can meet those needs.

Powered by the Edge

Project Athena requires a huge amount of data processing to work effectively—10TB of daily wafer picture data needs to be processed rapidly in order for anomalies to be detected quickly.

Athena exists as part of a trend that will see global levels of data creation skyrocket in the coming years. According to IDC forecasting sponsored by Seagate, the global datasphere will grow to 175 zettabytes by 2025.

The demand for speed in this new data-intense world requires a new kind of solution. Edge computing, one of Gartner's ten strategic technology trends for 2018, is a reaction to demands for reduced latency and the rise in applications that demand real-time critical processing. It delivers services faster to the end user by moving computing closer to the source of data.

If data is processed closer to the source, real-time insights can then be generated closer to the end user, greatly reducing the load on network resources and opening up a whole world of potential new applications. In this model, data center technologies—the compute and storage model—are moved to the edge of the network to enable a new generation of applications.

For Project Athena, processing data in the smart factory itself allows anomalies to be identified in real time.

* Nvidia V100 and P4 GPUs were used inside an HPE EdgeLine system and Apollo server

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