Solution Brief

AI Machine Vision
Robotic Arc Welding

intel

ADLINK Enables Automated Arc-Welding Defect Detection with Industrial Machine Vision Edge Solution Toward Industry 4.0

Scalable solution built with the Intel® Distribution of OpenVINO™ toolkit detects porosity defects in real time

ADLINK Leading EDGE COMPUTING

"Intel's unique OpenVINO™–based Edge AI weld algorithm allows automated weld defect detection and robot actuation for manufacturers. The close collaboration between ADLINK and Intel exemplifies our commitment to making deep learning and AI acceleration capabilities available from edge to cloud. ADLINK's Intel-powered, software-enhanced automated weld solution enables SIs and end customers to get to market faster and to continue optimization of the application as their operations evolve."

— Toby McClean, VP, AI and IoT Technology and Innovation, ADLINK

Up to 97% accuracy
detecting porosity defects[1]

OpenVINO™

Robotic arc welding, a critical component of modern heavy machinery manufacturing, is prone to defects involving weld porosity. Traditional manual detection requires highly skilled weld engineers and technicians using visual and auditory indicators. These inspectors are expensive, difficult to find, and face challenges when detecting defects in expansive factory settings.

ADLINK and Intel have created an automated weld-defect detection solution based on ADLINK's EOS vision system with ADLINK Edge IoT software and the Intel® Distribution of OpenVINO™ toolkit action recognition model, capable of automatically detecting porosity defects from video frames in a way not possible with the human eye. Using a neural network–based inference engine, the solution can not only detect defects in real time but also automatically stop the welding process via robot actuation before the defect is prolonged and the part is damaged beyond repair. The model can also be retrained to detect additional types of defects in the welding process. This innovative solution supports a smarter factory, helping to create production lines that are built for Industry 4.0.

Challenges: Detecting defects before they create rework and production delays

The heavy equipment manufacturing industry performs multilayer arc welds on parts that may cost as much as USD 10,000. Porosity defects—caused by the presence of cavities in the weld metal from absorption of nitrogen, hydrogen, and oxygen in the molten weld pool—are the most common type of weld defect. When porosity defects occur during the manufacturing process, they create weaker, less-ductile welds that cannot be shipped or pass inspection. This requires costly rework on the unit or even more costly scrapping of the entire part with the defective weld.

While trained weld engineers can detect porosity with auditory and visual inspection, these engineers are difficult to find. They may also have a difficult time hearing or seeing defects in a crowded factory floor with 50 or more robotic welding stations. Existing automated monitoring systems not based on machine vision experience a high rate of false positives, slowing production and adding to costs.

Machine vision solutions have historically been difficult to create for welding applications. In part, these challenges have been due to an extremely harsh environment that includes smoke, sparks, heat, and splatter hazards and creates difficulties in camera placement and visual detection.

Solution: AI-based defect detection at the edge with Intel® Core™ CPUs, Intel® Movidius™ Myriad™ X VPUs, and the Intel® Distribution of OpenVINO™ toolkit

Automating porosity detection required an integrated, end-to-end system of hardware and software capable of generating insights in real time. The solution consists of a pretrained machine learning model from Intel on the ADLINK EOS-1620 machine vision platform featuring Intel® Core™ i7 processors and Intel® Movidius™ Myriad™ X VPUs. Integrated ADLINK Edge IoT software supports the seamless integration of systems and equipment to capture, stream, process, understand, and act on vision data.

The VPU-accelerated machine vision platform runs the ADLINK Edge implementation of the Intel® Distribution of OpenVINO™ toolkit, incorporating its inference engine into the ADLINK Data River data-sharing platform. This allows analysis and inference capabilities for compute-intense vision workloads from multiple machine vision streams. In order to deliver the right machine vision data to the right place at the right time, the Data River platform supports the ability to plug in modular software and hardware anywhere at the edge to facilitate north-south and east-west data flow.

In addition to detecting porosity defects with up to 97.14 percent accuracy,[1] the solution automatically shuts down the weld robots with a stop command once welds have been identified as defective. Workers can also be notified of defects as they occur, so the defective weld can be corrected before parts are rendered unusable.

Within the solution, ADLINK Edge IoT software supports real-time data connectivity and communication between over 150 types of equipment, enabling plug-and-play capabilities across a large number of environments using different types of machines. The solution captures multiple image data streams and applies high-performance processing power to support machine learning and inferencing at the edge, with workload consolidation that allows multiple compute processes to operate simultaneously. It can be easily deployed at scale across many welding robots, requiring only touch-up training to take new environmental conditions into account.

Offering a prebuilt, ready-to-deploy configuration, including a ruggedized camera and its placement and interfacing, the solution also allows easy development, retraining, and redeployment of its base model to detect additional defects. The solution offers the capability to connect to any off-the-shelf ruggedized camera, for fast and easy changes with no vendor lock-in. It can also be used across a range of Intel®-based hardware based depending on the compute requirements, ensuring scalability. All software components seamlessly interact within the solution independent of where they are deployed. This provides the flexibility to bring in additional compute or to move or add software components in the future without impacting the existing system.

Benefits of the ADLINK solution include:

- Automated defect detection to alleviate skilled-workforce shortages
- Weld porosity detection helps stop bad welds in real time
- Workload consolidation for multiple camera inputs and actuation of multiple robots
- Easy model deployment on ADLINK Edge IoT software with an integrated inference engine from the the Intel® Distribution of OpenVINO™ toolkit
- Use of nearly any connectivity protocol, cloud service, and camera interface
- Easy workload distribution on the factory floor
- Scalability for system integrators and end customers using any type of weld equipment or weld environment
- Reduced delays, wastage, and costs, and increased production uptime[2]

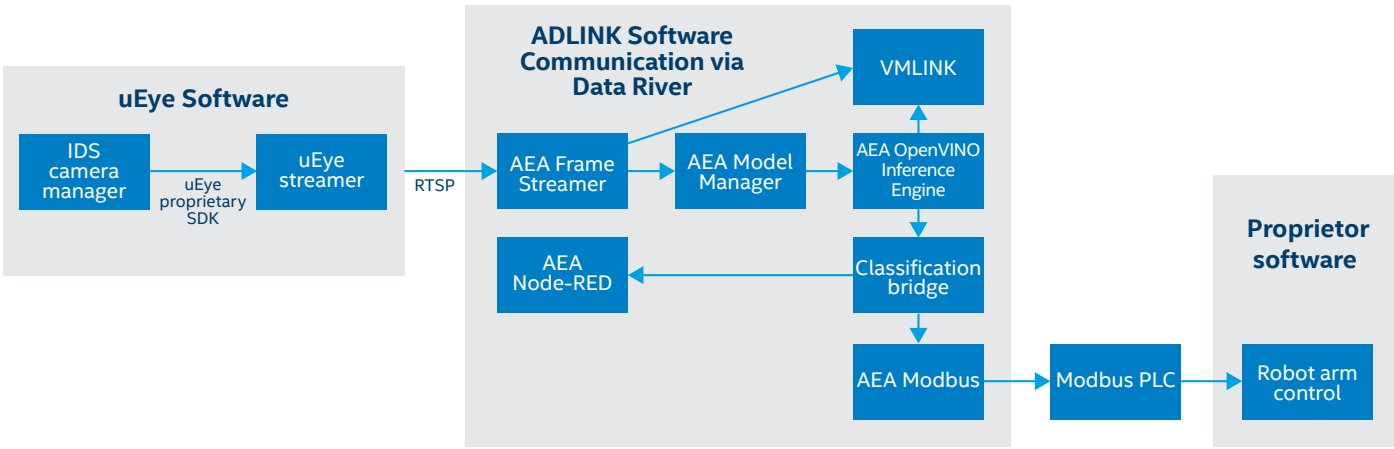
How it works

At the heart of the system is the neural network–based AI action recognition model that is trained on good welds as well as welds with porosity defects. This trained model was based on the action recognition model from the Intel® Distribution of OpenVINO™ toolkit training extensions and is now publicly available for download through the OpenVINO Model Zoo.

This model allows for easy retraining and scaling of deployment for future Intel® hardware, reducing application redevelopment time. By accelerating AI workloads with its function and kernel libraries—as well as providing pretrained models covering a wide range of real use cases—the toolkit simplifies the development of machine vision solutions.

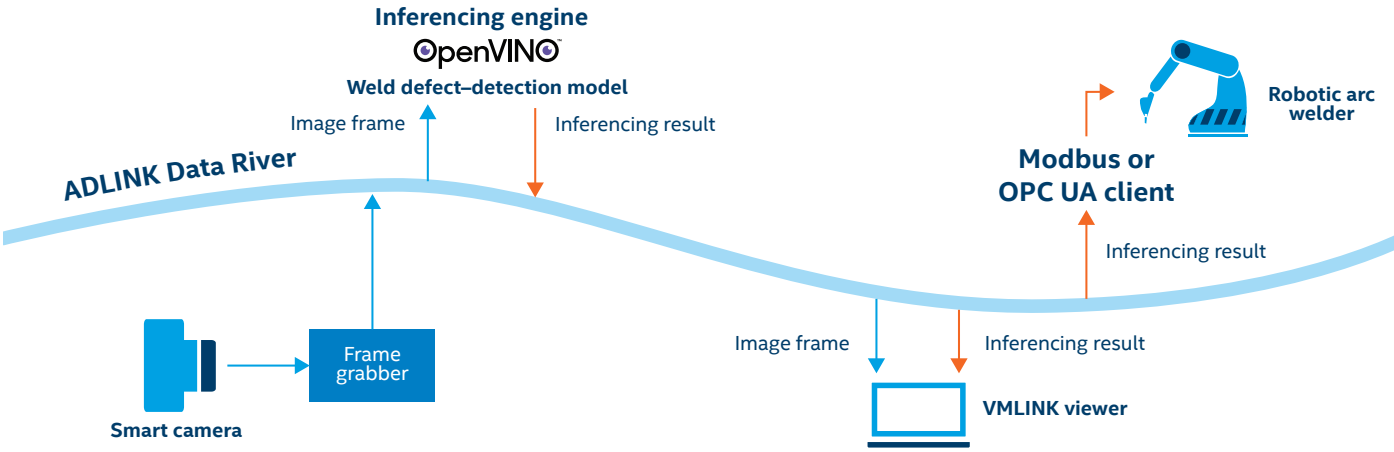
To detect porosity defects in real time, earlier than human inspectors, Intel and ADLINK put a camera where no human could go: on the welding gun, just 12 to 14 inches away from the actual weld. Using video frames from cameras positioned on the welding guns, a 2D classification network is applied to frame processing, followed by temporal aggregation that averages the responses.

The trained AI model is then stored in the AEA Model Manager and the ADLINK Profile Builder applies it to the OpenVINO inference engine for examination of the streaming video frames. When defects are detected by the AI model, the solution is able to instantly switch off the robot in real time using a stop command over Modbus or OPC UA.



Because accuracy of machine vision solutions can be impacted by ambient conditions like light, angle, and resolution, this solution uses light from the weld sparks without relying on any external light sources, making it weld-environment agnostic. This enables greater portability across various types of welding stations without impacting the overall accuracy of the AI model. This stand-alone solution has no dependency on any third-party power supply or the weld robot model, making it truly scalable.

The resulting solution is an end-to-end integrated system that enables AI at the edge, connects to new and existing weld equipment, captures multiple compute-intensive image data streams, and deploys machine learning models to edge devices with easy continual improvement. With the Edge AI Machine Vision Weld Solution, manufacturers gain insights needed to drive action on the factory floor. This automates the QA process to improve quality, reduce costs, and increase factory throughput.[2] It brings intelligence to the edge for fast decision-making and reduced latency, with easy upgrades and scaling as needs evolve.



Summary: Automated arc weld defect detection powered by Intel® technology

Heavy equipment manufacturing requires precision arc welding that is prone to porosity defects. Porous welds result in brittleness and weakness that cannot pass inspection and may require expensive parts to be reworked or scrapped. To detect and correct these welds at an earlier point in the manufacturing process, ADLINK collaborated with Intel to develop an automated defect-detection solution. This machine learning solution used the Intel® Distribution of OpenVINO™ toolkit, ADLINK Edge IoT software, and ADLINK's EOS-1620 machine vision platform featuring Intel Core i7 processors with Intel® Movidius™ Myriad™ X VPUs, providing a ready-to-deploy solution for manufacturers and an easy-to-scale offering for system integrators.

With the new machine vision solution, ADLINK and Intel make it possible for manufacturers to see welds up close in a way never before possible with manual inspection: frame by frame, allowing defects to be detected and acted upon in real time. With these new capabilities and an easy, flexible machine interface, the solution helps manufacturers automatically monitor and helps stop the welding process and enable revisions before a part requires scrapping.

Designed to be flexible and scalable from the start, the arc-welding solution aids additional defect detection with fast and simplified model retraining. Using the solution, manufacturers can reduce delays, wastage, and costs, and increase productivity.[2]

"ADLINK's plug-and-play EOS series of ruggedized industrial PCs with ADLINK Edge IoT software and 9th Gen Intel® Core™ i7 CPUs, integrated GPUs, Intel® Movidius™ Myriad™ X VPUs, and four-channel GbE camera interface offers a great platform for easy workload distribution and customization for an AI weld solution based on the Intel® Distribution of OpenVINO™ toolkit, making it easier for system integrators and end customers to deploy the solution based on their unique real-time requirements."

— Jonathan Luse, Sr. Director, Industrial Solutions Management, IOTG, Intel

Learn more

Discover how the ADLINK arc-welding solution can simplify defect detection in the factory:

Download the solution ›

Learn about ADLINK Edge ›

See the weld porosity model in the Intel® Distribution of OpenVINO™ toolkit ›

Intel® Distribution of OpenVINO™ toolkit

The Intel® Distribution of OpenVINO™ toolkit is free software for developers that accelerates performance, deep learning, and computer vision inference from edge to cloud. It supports heterogeneous processing and asynchronous execution across multiple types of Intel® processors.

Introducing Long-Term Support

Developers can now choose between standard support releases or Long-Term Support (LTS) for the Intel® Distribution of OpenVINO™ toolkit. Standard releases provide new versions of the toolkit every quarter, ideal for early-stage projects and developers looking to take advantage of the latest innovations in deep learning. LTS offers long-term maintenance and support, a great choice for later-stage developers focused on leveraging the toolkit's existing features and functionality.

Long-Term Support benefits:

- Focuses on deployment and is designed to be taken into production
- Includes critical bug fixes for one year and security patches for two years, postrelease
- Enables shipping applications with reliability in existing capabilities and compatibility

Learn more ›

About ADLINK

ADLINK Technology is a global leader in edge computing with a mission to effect positive change in society and industry by connecting people, places, and things with AI. This is achieved through the delivery of leading-edge solutions addressing customers' critical business and technology challenges. Offerings include robust boards, modules, and systems; real-time data-acquisition solutions; and application enablement for Artificial Intelligence + Internet of Things (AIoT).

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1. Source: Internal ADLINK testing data.
2. Based on internal ADLINK data.

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Intel® technologies may require enabled hardware, software, or service activation.
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