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How Artificial Intelligence Computers are Fueling Industrial Autonomy

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Introduction

Artificial intelligence (AI) is transforming just about every industry today as companies look to make their respective operations more efficient and improve areas including productivity, cost, and worker safety. Autonomous systems – underpinned by computers running powerful AI algorithms – are playing a greater role within industrial and commercial processes, allowing companies to reap benefits and gain a competitive advantage in their markets.

The rise of AI and the transformative effects it is having on everyday life is impossible to ignore. Whether its writing an email using generative AI, speaking to your smart speaker, or allowing your car to park itself when you've arrived at your destination, AI and autonomous technologies are all around us.

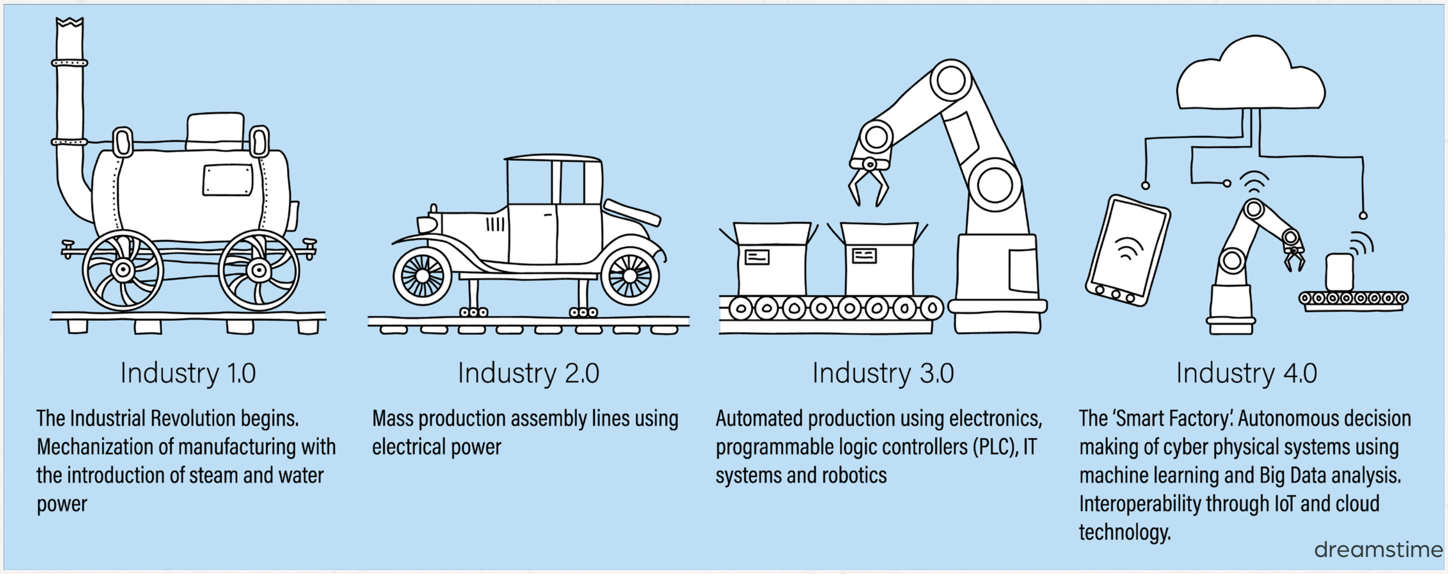
It is not just as our personal lives that are being transformed by AI. Companies and organizations across various sectors are leveraging AI to revolutionize how they manufacture goods, deliver services, and run their operations. The rapid advances in AI and the way that machines can 'learn' without human intervention is also giving rise to more autonomous systems that can sift through large datasets and process unstructured data.

The benefits that AI and autonomous systems bring to any organization can be significant,

including increasing output, optimizing processes, managing resources more efficiently, identifying waste, addressing labor shortages, and increasing safety for personnel.

The latter has been seen in the military space for a number of years, with uncrewed systems able to remove humans from so-called dull, dirty and dangerous missions. For the armed forces, uncrewed platforms now carry out many functions that were once carried out by humans – or there is greater integration with robotics through human-machine teaming – such as IED detection and reconnaissance, while in the intelligence world, AI algorithms are able to sift through vast amounts of data and rapidly identify threats that humans could miss.

Militaries that are able to take advantage of AI are more likely to be successful on the battlefields of the future. Similarly, the companies that are able to fully implement AI-based autonomous solutions in their work



processes and take full advantage of the numerous benefits are the ones that are likely to be market leaders and achieve a competitive advantage over the long term.

This is a key tenet of 'Industry 4.0', where companies and organizations leverage technologies such as AI, the 'Internet of Things' (IoT), the cloud and big data.

Autonomous platforms for industrial applications

We can think about the application of AI and autonomy in the commercial world in two ways; one being at an enterprise level for IT operations and infrastructure, which requires computers to function in relatively benign environments – such as data centers that support the cloud or dedicated on-premise facilities. This enables companies to increase efficiencies across a company and improve processes using AI-driven software, such as predicting when equipment needs maintenance or reducing energy consumption across business operations.

The second is the application of autonomy and AI to robotics, particularly autonomous or semi-autonomous platforms on the ground, air and at sea. These platforms use a variety of sensors to scan their environment and use powerful computers to process this situational data to understand where it is, what its current condition is, how its situation relates to the job its required to do, and what actions need to be taken to successfully complete the end goal.

This can include robots that are in-situ or in the confines of a building, for instance those on an assembly line or sorting facility. These AI-enabled robots could offer significant productivity increases for the factories and warehouses that have traditionally relied on humans. Amazon, for example, has automated key elements of its fulfillment process through robots that use AI and ML, and the company has even developed a robot arm that can handle items just like a human sorter would do using "breakthrough" ML capabilities.[1]

Similarly, companies are also looking to develop AI-based sorting solutions that can sift through tons of waste quicker and more efficiently than a human, and with more diligence. This use of AI to identify recyclable materials could reduce the amount of plastic that ends up polluting our environment.[2]

Autonomy in the real world

Potentially the most challenging applications are robotic and autonomous systems that operate unrestricted in the open world, where they have to interact with objects and human beings in an unstructured capacity.

Machine learning – as well as deep learning – algorithms play a critical role here. They are able to process significant amounts of unstructured data in short time frames, which can then aid with either computer-led or human decision making. Take self-driving cars, for example, which have to operate in complex spaces and collect a range of visual and statistical data to ensure the vehicle can function without a driver. This relies on numerous sensors across the vehicle to collect data – such as radar, visual and lidar information – and then process that data to determine the vehicle's location, current status, and next action, whether that is taking a turn, or emergency braking for a pedestrian.

The majority of new cars, while not able to drive themselves in an autonomous way, now have semi-autonomous safety features that enable the vehicle's computer to aid the human driver, whether that is alerting the driver to hazards or applying the brake in an emergency.

Industry is keen to take up the advantages afforded by autonomous or semi-autonomous vehicles that can either replace – or at least act as a robotic companion – for humans, and there are several industries that are now exploring the full potential of this technology to improve productivity and efficiencies in challenging times.

The agricultural sector is one such industry looking to increase the use of robotic vehicles that can augment or even replace humans altogether. Farmers across the world are facing significant economic challenges, including increasing demand for food, rising costs, skilled labor shortages and extreme weather events, so efficiencies that are derived from using autonomous systems would be welcomed.

In 2022, John Deere, the manufacturers of the distinctive green and yellow tractors, announced that it had developed a fully autonomous version of its 8R tractor, specifically to address many of the challenges in the sector.[3] Multiple cameras on the tractor enable 360-degree obstacle detection and calculation of distance, and the AI processing of this visual data determines whether it should stop or proceed.

And it's not just tractors; scientists are also exploring how different types of robots can pollinate plants[4], as well as harvest crops – including fruits such as apples[5] – using advanced AI. The aim once again is to reduce the burden for humans that perform this backbreaking work and increase yields for farmers.

The mining industry is also facing similar challenges with companies tackling increased costs and skilled labor shortages, all while still trying to maintain profitability. This sector has turned to driverless heavy vehicles – also known as autonomous mining trucks (AMT) – to address these challenges, with companies such as Caterpillar deploying robotic fleets of its monster 793F Mining Trucks. From first deployment in 2013 to 2018, these autonomous trucks have hauled one billion tons of material and increased productivity by 30%.[6]

In the air, uncrewed aerial vehicles – UAVs, or more commonly 'drones' – are also disrupting several industries, either by replacing crewed assets in traditional roles normally performed by helicopters and light aircraft, or creating brand new applications that were not possible before their introduction. Delivery of goods by drones is just one application that is disrupting the market globally, and despite being a nascent industry it was estimated that 2,000 drone deliveries were taking place daily across the globe at the beginning of 2022.[7]

Aerial imagery and data collection by drones is also a booming market, with various sectors employing relatively cheap UAVs to unlock information and insights that was either not possible before, or simply too expensive or unsafe to perform. Drones can be used to collect data for environmental studies, infrastructure inspections, disaster monitoring, surveillance and much more. These intelligent drone monitoring solutions will require a range of sensors and autonomy solutions to perform their functions with relatively little human input.

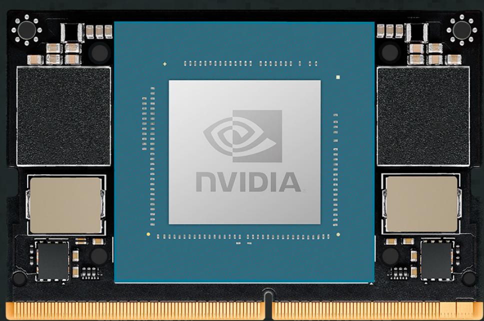
It is not just the operation of the platform itself that AI and autonomous technology enables, however, it can also reduce workload and increase safety for crewed platforms by automating processes that were once carried out by humans.

The "bleeding" edge

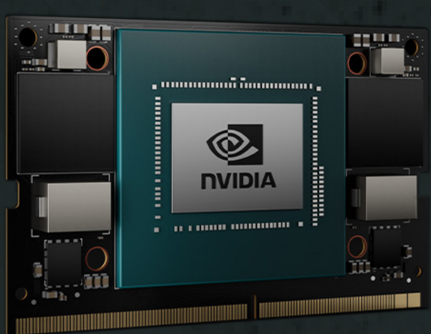
Edge AI compute plays a critical role in achieving industrial autonomy by bringing AI processing capabilities closer to the source of data generation, which is often at the edge of the network in an industrial environment. By integrating AI directly into devices and sensors at the network's edge, edge AI compute allows for real-time data processing, analytics, and decision-making directly on the devices and sensors, reducing the need to transmit data to centralized servers or cloud-based systems for analysis. This offers several benefits for industrial autonomy:

1. Reduced latency: Edge AI compute allows for real-time decision-making and control by processing data on-site, resulting in faster response times and improved system performance.
2. Enhanced reliability: By processing data at the edge, edge AI compute can reduce the dependency on network connectivity, minimizing the risk of system downtime or failure due to network issues.
3. Improved data privacy and security: Keeping data within the local network reduces the potential for data breaches and ensures compliance with data privacy regulations.
4. Scalability: Edge AI compute can be easily scaled by adding more devices and sensors to the network, making it adaptable to changing needs and requirements in an industrial environment.
5. Resource optimization: Edge AI compute can optimize the use of network and computational resources by processing data locally, reducing bandwidth usage and the need for extensive cloud-based infrastructure.

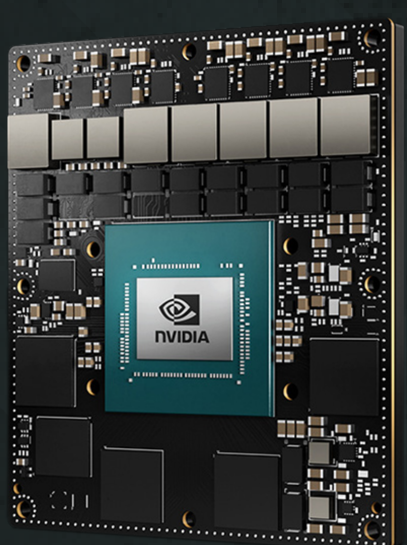
NVIDIA's Jetson Orin Embedded Series



Jetson Orin Nano



Jetson Orin NX



Jetson AGX Orin

NVIDIA's Jetson series of embedded computing platforms are designed for deploying AI and deep learning capabilities on edge devices[8] in various industries, including robotics, drones, smart cities, healthcare, and industrial automation. These platforms combine powerful GPU-based computing, energy efficiency, and a rich ecosystem of development tools and libraries to facilitate rapid development and deployment of edge AI applications.

> **...the most challenging applications are robotic and autonomous systems that operate unrestricted in the open world...**

The latest Jetson series is called Orin and features the Orin Nano, Orin NX, and AGX Orin embedded modules.

1. Jetson Orin Nano: Up to 40 TeraFLOPS (TOPS) of AI performance with power options between 7W and 15W. Available in 4GB and 8GB versions.
2. Jetson Orin NX: Up to 100 TOPS of AI performance with power configurable between 10W and 25W. Available in 8GB and 16GB versions.
3. Jetson AGX Orin: Up to 275 TOPS of AI performance with power configurable between 15W and 60W. Available in 32GB and 64GB versions.

NVIDIA provides a comprehensive software stack for Jetson platforms, including the JetPack SDK, which comprises an Ubuntu-based OS, CUDA, cuDNN, TensorRT, as well as other essential tools for developing and deploying AI applications, including Isaac SDK for robotics and automation development; and DeepStream SDK for developing AI-powered video analytics applications.

Systel, headquartered in Sugar Land, TX, integrates Jetson technology into rugged computer hardware solutions, engineered for harsh environments, and purpose-built for mission critical autonomous applications. Its Kite-Strike II mission computer for example is built around the Jetson AGX Orin module and is fully rugged and size, weight, and power (SWaP) optimized for edge deployment.

Hardened for survival

Industrial automation involves the integration of various systems and equipment, such as sensors, control systems, and robotics, to perform tasks without human intervention. As these systems are subjected to harsh conditions, including extreme temperatures, vibrations, dust, and moisture, the hardware must be ruggedized to withstand these elements and ensure reliable performance. Rugged computing systems offer improved durability, resistance to environmental factors, and robust construction, which allows industrial autonomous systems to operate with minimal interruption, thus ensuring continuous production and reducing costly downtime.

Industrial autonomy requires computer hardware that can be easily adapted and scaled to meet the changing needs of an organization. Rugged computer hardware offers modularity, allowing for easy integration with existing infrastructure and seamless upgrading or expansion as needed. This adaptability ensures that autonomous systems can evolve with industry trends and advancements, maintaining their efficiency and productivity.

Furthermore, rugged hardware is designed to be interoperable with a variety of software and devices, which simplifies the implementation of automation and increases compatibility across different systems. This versatility is crucial in industrial autonomy, as it enables organizations to streamline their operations and reduce complexity in managing multiple systems.

Systel's military-proven rugged computers are adaptable to industrial requirements. While a fully military-spec computer – designed to survive explosions and other military threats – is often not what is required for these industrial applications, reliability in an unpredicatble environment is paramount particularly as downtime can negate any productivity gains made through AI.

There are many crossovers in terms of the technology required between military and industrial applications. The military's need for heat-proofed, fully-sealed, powerful computing systems can just as easily apply to a dirty, dull and dangerous commercial task – such as waste management or mining, for example – as it can a military one.

And just as a small form factor computer lends itself for integration into a SWaP-optimized military-grade UAV or UGV, it can also benefit being used in a delivery drone that will be used to deliver parcels or small robots used for picking apples in an orchard.

As of the publishing of this white paper, Systel is in development of an ultra-small, ultra-light edge AI processing device called Sparrow-Strike, integrating the NVIDIA Orin NX module. Sparrow-Strike is targeted towards uncrewed aerial systems (UAS) and unmanned ground vehicles (UGV) with multiple rugged build options for both industrial and defense verticals. Utiliziing a modular design approach with options such as alternate chassis materials and connector types can lead to size, weight, and cost savings for industrial applications that do not require military grade ruggedness but are still subject to harsh environmental conditions.

The table below shows some of the common and widespread military and industrial rugged standards, all of which are imperative for edge AI computer hardware to meet to ensure reliable operation for mission-critical autonomous applciations.

Criteria	**Military Standards**	**Industrial Standards**
Temperature Resistance	MIL-STD-810H (Method 501.7, 502.7)	IEC 60068-2-1, IEC 60068-2-2
Shock Resistance	MIL-STD-810H (Method 516.8)	IEC 60068-2-27
Vibration Resistance	MIL-STD-810H (Method 514.8)	IEC 60068-2-6, IEC 60068-2-64
Dust Resistance	MIL-STD-810H (Method 510.7)	IEC 60529 (IP5x, IP6x)
Water Resistance	MIL-STD-810H (Method 506.7, 512.7)	IEC 60529 (IPx5, IPx6, IPx7, IPx8)
Humidity Resistance	MIL-STD-810H (Method 507.7)	IEC 60068-2-30, IEC 60068-2-78
EMI/EMC	MIL-STD-461G, 464C	IEC 61000-4-3, IEC 61000-4-4, EN 55032
Radio Frequence Devices		FCC Part 15
Drop Resistance	MIL-STD-810H (Method 516.8)	ISTA 2A, IEC 60068-2-31, IEC 60068-2-32
Salt Fog Resistance	MIL-STD-810H (Method 509.7)	IEC 60068-2-11, IEC 60068-2-52
Altitude Resistance	MIL-STD-810H (Method 500.7)	IEC 60068-2-13
Power Requirements	MIL-STD-1275E, 704F	IEC 61000-4-5, IEC 61000-4-11

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Case Study: Meeting the Challenges of Edge AI Compute for Cubside Waste Management

A Fortune 500 industrial company contacted Systel to be its hardware partner for refuse collection vehicle automation. The company aims to automate curbside waste cart location, identification, and lift by utiliizing an AI-based recognition technology. This helps cycle times, training time, safety, predictable scheduling and maintenance.

The challenge the company faces is reliably deploying this technology in the field. The computer will be exposed to harsh and unpredictable conditions, including extreme temperature variations, dirt and fluids (including vehicle washdowns), and severe vibration. Additionally, the computer needs to provide enough processing and interface capabillities to capture data from a 360 degree vision system, run the AI-algorithm in near real-time with low latency, and interface to other peripherals on the vehicle. And of course, there are critical size and weight requirements – there isn't room for a data center rack server; the computer needs to be a small form factor system. Finally, there is a low dollar threshold requirement – industrial autonomy has many similarities to military autonomy but often with a much tighter budget.

Systel's solution is Badger-Bite, a clean sheet design that meets all of the requirements for successful edge AI compute for curbside waste management.

Badger-Bite is an edge AI industrial rugged compute solution.

Integrating an NVIDIA Jetson Xavier NX embedded module, Badger-Bite is engineered for "dirty" operation under austere conditions, is SWaP-optimized, and features robust IO. Badger-Bite helps transform the everyday garbage truck into an advanced AI machine.

- NVIDIA Jetson Xavier NX. Up to 21 TOPS. 384 CUDA cores and 48 Tensor cores.
- Robust IO including GbE, CAN, Wifi/Bluetooth. Modular design with upgrade path to Orin NX.
- -40C to +65C operating temperature; IP67 sealed; composite two-wheeled trailer vibration profile

Conclusion

Industrial autonomy has revolutionized the way organizations operate, leading to increased efficiency, productivity, and overall competitiveness. Rugged artifical intelligence computer hardware plays a vital role in enabling the successful implementation and maintenance of autonomous systems in harsh industrial environments.

By offering improved reliability, performance, adaptability, and data security, rugged computer hardware allows organizations to fully embrace the benefits of industrial automation and adapt to the ever-changing demands of the global marketplace.

Endnotes

1 https://www.amazon.science/latest-news/pinch-grasping-robot-handles-items-with-precision
2 https://techcrunch.com/2022/08/12/trashbot-uses-ai-to-sort-recyclables
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