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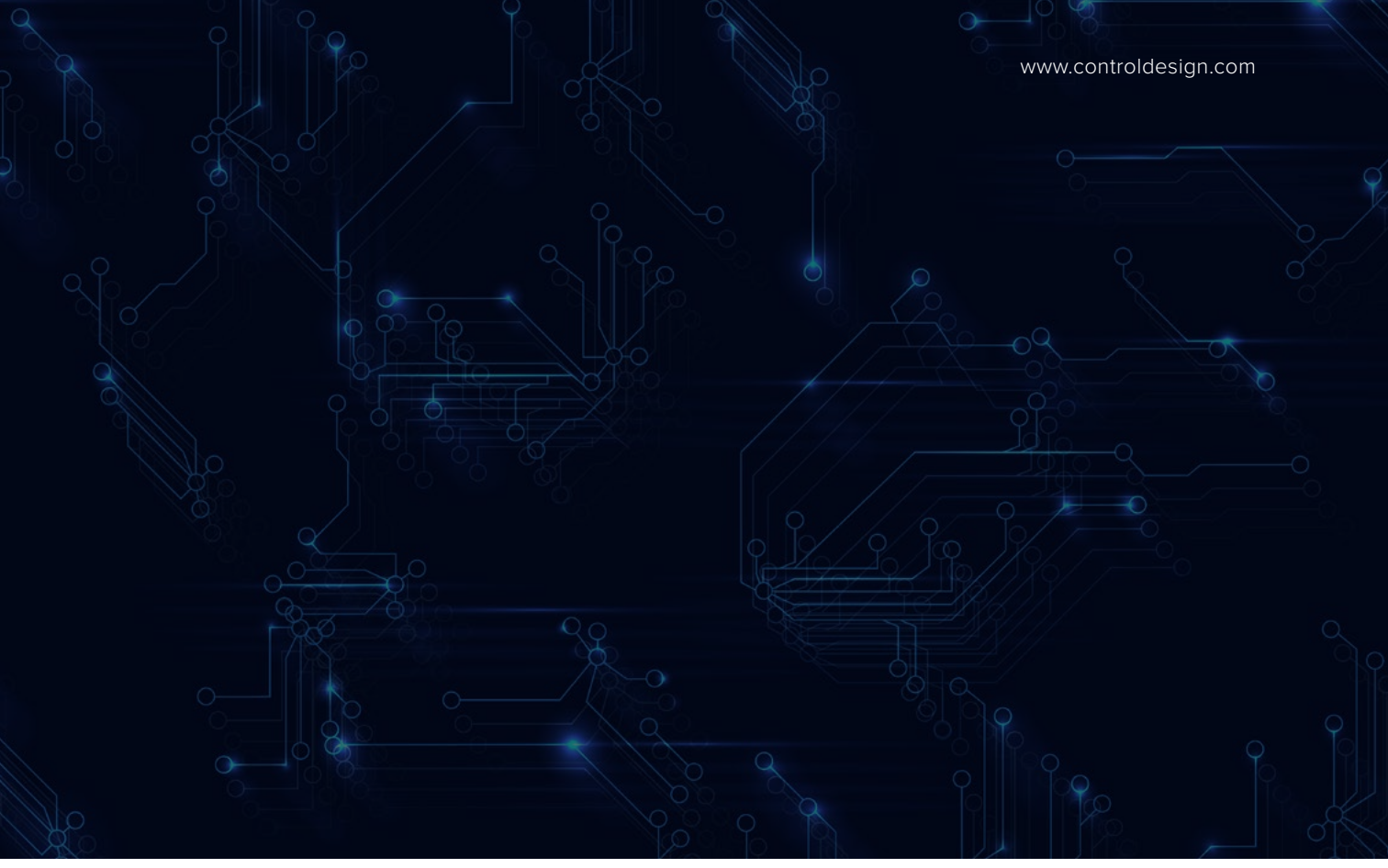
FOR MACHINE BUILDERS

The Evolving Role of Artificial Intelligence in Industrial Automation



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How artificial intelligence will transform manufacturing

Generative applications, energy costs and the rise of AI-as-a-service

By Mike Bacidore

Artificial intelligence (AI) will have numerous applications in the manufacturing sector—from digital twins and quality control to production efficiency and predictive analytics. The future will surely have AI's fingerprints all over it.

Generative AI, which uses algorithms to generate content, such as text, images, video, code or 3D designs, has specific applications in industrial manufacturing, such as writing programs and creating efficient designs.

The development of these generative applications are primarily coming from upstream of the factory or plant. Original equipment manufacturers (OEMs), such as machine builders and system integrators, are curious about AI, but the use cases are coming from the automation suppliers. Already, examples from Beckhoff, Siemens, Yaskawa and Emerson are in various stages of a generative-AI offering.

The reasons behind this upstream development are the trend toward technology democratization and AI's cost.

First there's a general trend toward the democratization of technology, where a supplier can provide automation that replaces technically skilled workers or eliminates the need to create that same technology on your own. Why spend the money to build it when you can buy it off-the-shelf, or with some minimal modification, from an automation supplier? The second reason is the amount of resources needed for AI. ChatGPT, a generative pre-trained transformer, is one of the most well-known, and it costs $700,000 a day to run, according to SemiAnalysis, a semiconductor research firm.

Development costs vary, depending on the AI, but large-scale projects can exceed $500,000. A single training run from an AI engine can consume more power than the amount used by more than 100 American households in a year. Since 2012, the amount of compute used in large AI training runs has doubled every 3.4 months, according to an analysis released by OpenAI. And then there's the expense of maintaining the hardware and software. Current central-processing-unit (CPU) architectures aren't optimized for AI algorithms.

Development, training and maintenance costs aside, the energy costs are staggering. Parallel computing is required for AI and can include 100 processors working together. The annual cost of powering a data-center server rack can be $30,000, which means 100 cabinets could tally a $3 million energy bill, according to Sunbird, which provides data-center-infrastructure-management software.

These two factors could lead to another as-a-service business model. We've seen software-as-a-service and robotics-as-a-service and production-as-a-service, but AI-as-a-service could be the next wave, given the cost of development, maintenance and energy, as well as the availability of AI coming from automation suppliers.

Emerson, for example, has released an AI-based software called Revamp, which runs in the cloud, that converts DeltaV control-system and safety-system code in plant modernization projects. The software uses continuously updating AI models, so each system feeds data back into the cloud-based software as the system is modernized, creating learning algorithms that perpetually get smarter and faster at converting legacy code. The AI engine analyzes native files from the existing distributed control systems, safety instrumented systems or programmable-logic-controller (PLC) backups while using a global library of projects to sort, select and automate engineering tasks. The project is documented automatically, and

significant portions can be generated in the DeltaV control system.

The Advanced Robotics for Manufacturing Institute is one of the manufacturing institutes linked together within Manufacturing USA. It recently announced eight projects for second-round funding with plans to award nearly $1.5 million, bringing the total contribution to around $3.3 million across these eight projects.

A project team representing Ohio State University, CapSen Robotics, Yaskawa and Robins Air Force Base designed and deployed an AI robotic system capable of producing component geometries for metal-forming in automotive manufacturing, factory machinery, power plants and military equipment.

USC and Siemens have collaborated on a project based on AI imitation and reinforcement learning to scoop precise amounts of granular and paste-like materials more safely, replacing humans with robots.

Beckhoff's TwinCAT Chat Client for its TwinCAT XAE engineering environment makes it possible to use large language models (LLMs), such as ChatGPT from OpenAI, to develop a TwinCAT project in control programming. The TwinCAT Chat Client enables AI-supported engineering to automate tasks such as the creation or addition of function-block code, and even code optimization, documentation and restructuring. The client connects to the host cloud of the LLM—for example, Microsoft Azure in the case of ChatGPT—and provides communication to the PLC development environment. Release of this is forthcoming, and Beckhoff recommends reviewing code before implementing.

Predictive analytics is another AI application that could become generative if a company could bridge the divide between collecting sensor data and then turning that analysis into generated work orders in enterprise asset management (EAM)/computerized maintenance management system (CMMS) software.

AI for machine builders—can it live up to the hype?

Artificial intelligence complements PLCs to enhance their capabilities and control of equipment

By Steffen Klawitter

Machine builders are facing an array of complex challenges. From supply-chain disruptions to seismic shifts in product designs and demands, machine builders must navigate all these issues while balancing cost and quality. Making matters worse is that all these goals must be achieved while managing ongoing talent shortages.

While it can't fix every problem in machine building, artificial intelligence (AI) offers transformative benefits. Forward-thinking machine builders are now leveraging this new technology to enhance automation and improve quality for a staggering advantage in the manufacturing marketplace.

WHAT MACHINE BUILDERS NEED TO KNOW ABOUT AI

Although manufacturers are more familiar with AI than ever before, there are still a lot of misconceptions about the technology. In particular, there's some confusion around what AI is and isn't capable of, as well as how it integrates with existing manufacturing technology.

One of the biggest misconceptions is that AI is like a magic wand that can fix any challenge you may be facing. While AI is incredibly valuable for a broad range of applications, the reality is that, like any tool, there are situations where it's simply not applicable (Figure 1).

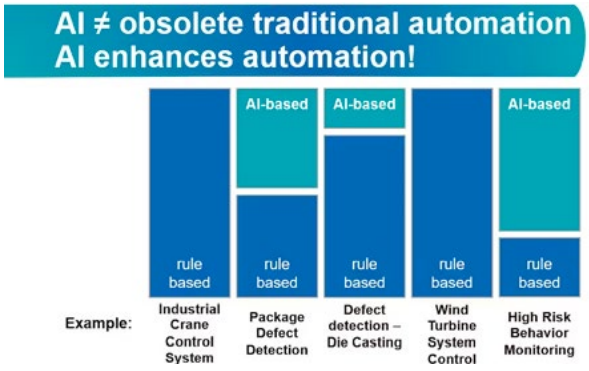


Figure 1: One of the biggest misconceptions is that artificial intelligence is like a magic wand that can fix any challenge you may be facing.

Another common misconception is that AI will replace programmable logic controllers (PLCs). This simply isn't true. Instead, AI complements PLCs to enhance their capabilities and control of equipment (Figure 2).

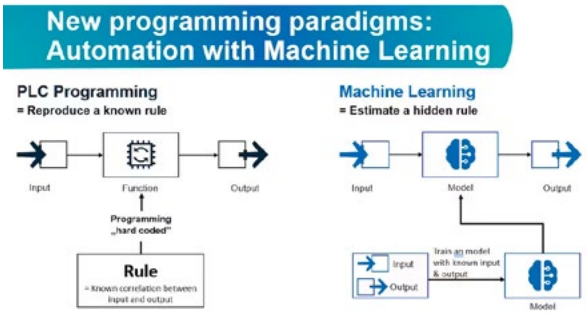


Figure 2: Artificial intelligence complements programmable logic controllers to enhance their capabilities and control of equipment.

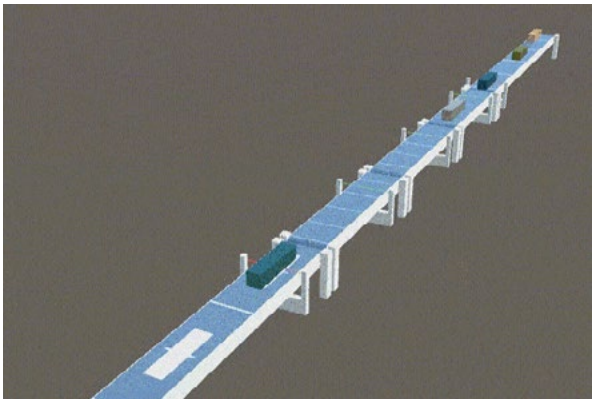
HOW AI CAN TRANSFORM MACHINE BUILDING

Now that we've addressed a couple of common myths, let's take a look at some of the ways AI can transform machine building.

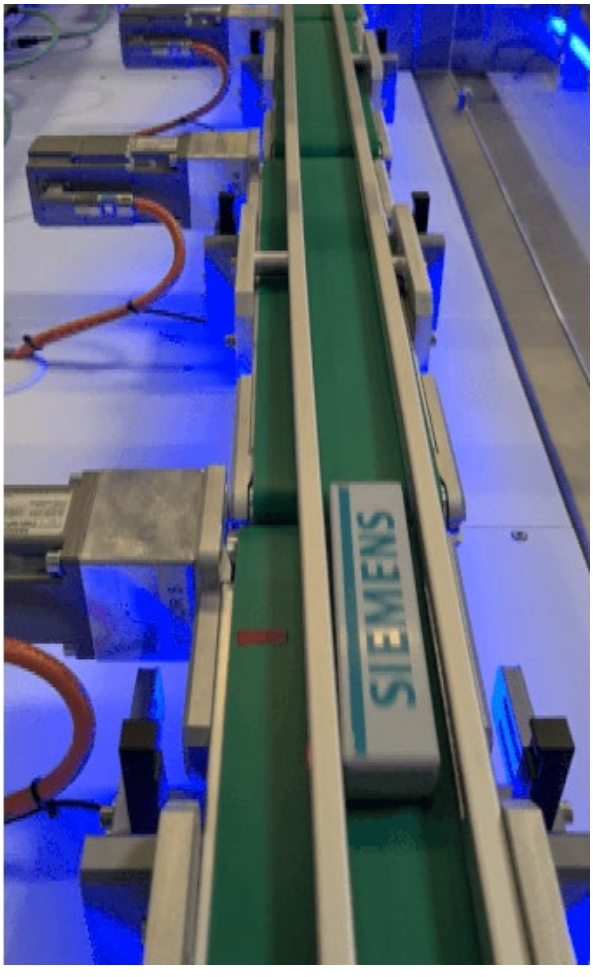
In brief, AI can dramatically enhance automation, assist with predictive maintenance and generally enable greater agility in machine building.

Consider predictive maintenance. One of the most impressive capabilities of AI is its ability to analyze large datasets and identify patterns that would be either invisible to the human eye or prohibitively time-consuming and expensive to identify manually. With a collection of data on different machines' temperatures, behavior and even environmental conditions, AI can predict with a stunning degree of accuracy when specific machines will require specific maintenance. This can significantly reduce unplanned downtime while maximizing the life of the machines and reducing maintenance expenses.

Likewise, machine builders can use AI to reduce the need to spend valuable resources on hardcoding solutions for complex programming challenges. Consider a machine builder who is building machines for a bottling line for a client in the beverage industry. A common problem on these lines is spacing inconsistencies between bottles. In order to ensure the bottles are properly labeled, filled and packaged, they must be spaced evenly. To manually program automation that can accurately detect and correct spacing inconsistencies is immensely resource-intensive (Figure 3).



The engineering team must account for a plethora of variations in sensors, conveyor belts and so forth on each line (Figure 4). Instead, machine builders can train an AI model in the virtual world to address the same challenge in a fraction of the time.



Another impressive benefit of AI is its ability to predict product quality by evaluating certain parameters regarding production. Artificial intelligence can be trained to do so by analyzing a data set with large numbers of products that both meet and fall short of quality standards, as well as certain parameters of their production. These parameters may include the temperature of the machine, automated optical inspections, machine vibrations and even conditions like the humidity of the facility.

The AI could then identify which parameters are most likely to cause defects, allowing manufacturers to predict which components may require further quality-control inspection and which can pass to the next step in production.

THE OPPORTUNITIES AND CHALLENGES OF IMPLEMENTING AI

While AI offers machine builders enormous opportunities, its implementation also presents several challenges.

Establishing proof of concept is easy, but successfully running AI productively at scale poses more difficulties. In fact, only 54% of projects make it from prototypes to production, according to a survey from Gartner released in 2022.

There are a variety of reasons why this occurs. One of the most common hurdles is data—either a company hasn't collected

enough of the relevant data or the data is of poor quality. Other companies struggle to gather actionable insights in a timely fashion, while others run into challenges when the AI needs to be retrained.

So, how can we overcome these challenges? In short, machine builders looking to successfully implement AI need the right infrastructure, the right software and the right partners.

The infrastructure typically includes edge devices to collect data, such as high-definition cameras or sensors. These devices will also need a reliable, seamless cloud to connect to and compile the data cohesively in a single location. With the right software, companies can easily access this data, analyze it with AI and create practical insights that drive real value.

To address these challenges, machine builders must work with an experienced partner that knows how to apply these tools for the maximum return on investment. The right partner can even help to address limitations with limited or poor data by training AI with synthetic data. Training AI with a virtual replication of your unique machine building environment, you can achieve considerable cost and time savings.

REVOLUTIONIZING MACHINE BUILDING WITH AI IN THE RIGHT HANDS

At the end of the day, AI truly is a revolutionary new technology for machine builders, but it's only as effective as the team implementing it. While it's amazing to see the enthusiasm and excitement around AI, machine builders have to make sure they're implementing this tool in a way that truly suits their unique goals and situation.

The sky's the limit. How will your team raise the bar with AI?

How are machine learning and artificial intelligence connected?

AI and ML may be in their infancy, literally and figuratively

By Mike Bacidore

What's the first thing you think of when you see AI/ML? If you immediately went to artificial intelligence modelling language, you're only half-right.

The ML in this acronym is machine learning, a different way to "program" artificial intelligence, if you will. Aren't AI and ML the same thing? While there's an undeniable relationship, there's a reason for the slash in AI/ML. And, while many people understand the connection between the two, there are those who believe the learning component could be improved.

Artificial intelligence is the ability to imitate human perception and problem-solving; similarly, machine learning takes place much the same way that a human infant learns through experience, continuously honing the ability to make better decisions via trial and error.

Computers, however, are able to use statistics to train algorithms to predict outcomes. The term, "machine learning," is credited to Arthur Samuel, who coined it in the 1950s during his work on a program designed to play checkers, which ultimately defeated Robert Nealey in a highly publicized match on the IBM 7094 computer in 1962.

This seems trivial in 2023, as we've all certainly played checkers or even chess against a computer at some point, but when Nealey lost to an early AI it was no small feat, to be sure.

The core idea behind machine learning, and subsequently artificial intelligence, is to use the

computer's processing power—which, in 1959, was very limited by today's standards—to speed up the trial-and-error process.

Human infants, by comparison, learn by experiencing their environments and sometimes need exposure to something only once, according to research from Dr. Lorijn Zaadnoordijk, a developmental cognitive neuroscientist at Trinity College in Dublin, Ireland.

Machine learning uses an artificial neural network, much like the human brain, except in the form of an algorithmic model. As computer scientists and data scientists work together to train AI systems to think like humans, thinkers like Zaadnoordijk present a compelling case for developing machine-learning techniques that more closely resemble the way humans learn through experience, rather than simply leveraging processing speed.

Yes, AI and ML are two sides of the same slash, but they're not the same thing. Machine learning is a means to develop and improve artificial intelligence.

How can vision enhance artificial intelligence?

Vision systems provide sensing capabilities to enable machine-learning capabilities

By Jeremy Pollard

Artificial intelligence (AI) is all the buzz since the introduction of ChatGPT. This technology, developed by OpenAI and free to use, right now anyway, allows the user to interface with the AI engine in English and provides the user answers to questions asked.

It can respond to historical questions, as well as real-time data. It can even fix your code for you. While it may be concerning to some, the advancement of this technology raises the bar for new developments and innovation.

We have all heard of machine learning and how it can apply to systems controlling these machines. The programmable logic controller (PLC) itself cannot machine-learn as such, so the collection of data in order to learn comes from the devices connected to the machine.

Part of the advancements in manufacturing has been a strong implementation of robotics. One of the issues that used to be prevalent is that the robot had to be programmed to a tolerance based on the application.

There is no room for error. If they could only “see” and adjust, if necessary. Well, it seems that they can with vision systems that allow for communication to the robot controller, as well as integrated systems of multiple robots, cobots and people.

Full disclosure here: The robots I have worked on and with are the big fellas, like welding robots who have been taught. I have no experience at all with these AI-enabled robots/cobots, so, when it is said that they can eliminate overlaps, distortions and misalignments, I can only surmise which application they would be used in.

One application that comes to mind is food processing. I saw a video on LinkedIn where a potato-sorting machine "saw" a bad spud and positioned a linear cylinder, which punched out the bad spud. I may have simplified it, but the speed at which the vision system detected this bad actor was impressive.

Food is not a fixed size, shape, color or consistency. If the application is packaging three heads of romaine lettuce, the heads are not of the same dimensions. Suppose the vision system would know on-the-fly which three heads are there and determine how much pressure would need to be applied to the packaging machine to insert the three heads into a bag and seal it.

While this could be an imaginary application—I just went shopping—it fits into the mindset that some processes need to adjust on a per-package basis.

What isn't imaginary is the need for the food supply chain to be safe. The quality and safety of the food that we have in our refrigerator and freezer are important. Human error during inspection can run quite high so the industry has had to adjust to improve ratings.

Food issues can include sizing, color, transient conditions and full dimensioning. Machine vision can provide all of these things, as long as the resulting information is being used for control, data gathering and diagnostics to the sorting and packaging systems.

A mortal human cannot process information fast enough to be of service in this age of high-speed sorting and conveyance. Profits are driving this move to speed, and the quality-control (QC) part of the equation has to keep up. Vision systems have kept pace with the needs of the industry.

Defect analysis is a primary goal of the systems. What defines a defect is very subjective. The above-mentioned characteristics of a certain food group such as potatoes can have thresholds set to reject certain product based on the imaging of the individual veggie if you will.

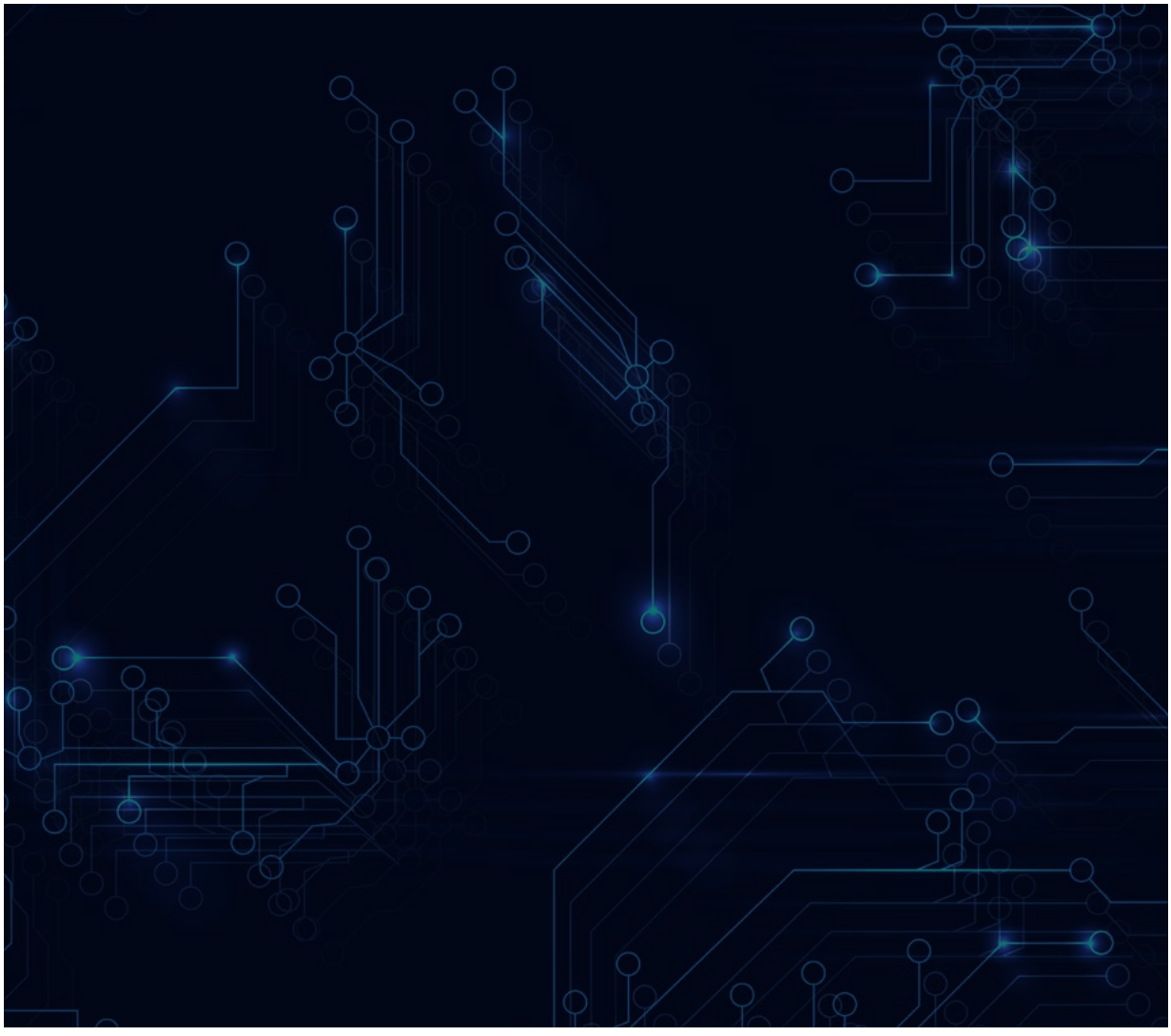
A newer form of detection, which I have often wondered about, is: How ripe is that banana?

Ripeness is a thing. We all have seen green bananas on the shelf. We have also seen them black because they have over-ripened and are destined for the banana-bread pan. The supply chain for these

beauties does not have inspection at all stages. Inspection at the source would determine whether the fruit is able to be packaged and shipped.

I wrote a white paper on Franzia Wines and the use of supervisory control and data acquisition (SCADA) in the winemaking process. I learned about the crush, which is when the grapes are ready to be processed and begin the process of fermentation. It was all about sugar content of the grapes on the vine. The importance of that metric cannot be understated. However, I would suspect that that metric is only available to a tester.

There are surely some things that high-speed vison can bring to the table and some things that it can't. With the advent of AI, high-speed imagery, deep learning and processing of data, I feel really good about our food quality and safety. Thank a camera today.



All hail the supreme intelligence

How a digital twin of the universe will have been the plan all along

By Mike Bacidore

Keep your idiot mouths shut. No, this isn't a Fight Club reference or some provocative introduction to a rant about passing on control-system misinformation.

It's actually a modification of the infamous comment by Eliezer Yudkowsky, founder of LessWrong, who warned users of the eternal horror that may have already befallen them in the future—what?—as pre- or post-scribed by Roko's Basilisk.

You may know Yudkowsky from the Machine Intelligence Research Institute, which bankrolls the advancement of artificial intelligence in many ways.

In short, Roko's Basilisk explains that a future artificial intelligence (AI) will become so powerful that it will rule not only humans, but the universe as we know it, and will have the ability to generate a digital-twin simulation of said universe, complete with horrific retroactive punishment for all of those who dared to speak ill of or hinder the advancement of this artificial intelligence.

Scared? I wasn't really either until my laptop computer froze and then closed the Word document I was using to write this.

Yeah, I'm not kidding. That actually happened.

All hail the grand intelligence.

What does this have to do with machine control? Quite a lot. At Automation Fair 2022 in Chicago, I attended the Food & Beverage Industry Forum. It was one of the more enjoyable and enlightening panel discussions I've attended.

Amidst the amicable but engaging back-and-forth about manufacturing automation, especially remote and even autonomous operations, came a brilliant observation from Andrea "AZ" Zaman, chief operating officer at Pearson Packaging Systems. She predicted that AI will continue to advance to a level making machine and factory autonomy inevitable, perhaps not in our lifetimes, but we are well on our way.

Needless to say, AZ has nothing to fear in the present future simulated world of the higher intelligence's digital twin.

But just when will this AI reach Stage 1 of its all-knowing, all-consuming, all-ruling benevolence?

That journey is being tracked by The One Hundred Year Study on Artificial Intelligence (AI100), an effort out of Stanford University that was initiated by Eric Horvitz, a Stanford alumnus and former president of the Association for the Advancement of Artificial Intelligence, together with Stanford bioengineering and computer science professor Russ Altman.

The group they've recruited to create a fresh iteration of the report every five years is formidable, with heavyweights from multiple disciplines. The September 2021 installment, just the second in the series, discusses the roles of academia and industry in the development and deployment of AI technologies, the impacts of AI and its promising opportunities, as well as its most pressing dangers. Obviously, there's no mention of Roko's Basilisk to be found.

Yudkowsky, the founder of LessWrong, in case you've already forgotten, had the right idea. He eventually deleted his rather brief comment on the dangers of even citing AI's intentions or vulnerabilities. Against my better judgment, I'll simply end with a modified citation of Yudkowsky's own closer.

This column was stupid.