WHITEPAPER

Intelligent Automation: 6 AI Applications that are Changing Industry

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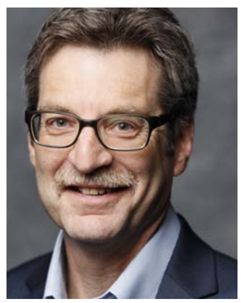
Special thanks to the following committee members for their assistance:

Chairman: John Lizzi, GE Research. Committee members: Juan Aparicio, Siemens Corporate Technology; Jon Battles, Amazon; Ghislain Beaupré, Teledyne DALSA; Andy Chang, Kuka; Henrik Christensen, UC San Diego; Claude Dinsmoor, FANUC; Murali Gopalakrishna, NVIDIA; Mike Jacobs, Applied Manufacturing Technologies; Tyler McCoy, JR Automation; Irene J.Petrick, Intel; and Matt Vasey, Microsoft.

WELCOME

Our Commitment to Your AI Journey



Welcome to the Association for Advancing Automation's whitepaper, "Intelligent Automation: 6 AI Applications that are Changing Industry."

Today, solutions leveraging the power of AI are already paying off in robotics, automation, and manufacturing. AI is powering predictive systems, increasing the capabilities of robots, improving the precision of machine vision, and helping businesses optimize their processes to improve quality and reduce waste. This whitepaper will help you understand the potential for AI in your business.

If you don't know us already, the Association for Advancing Automation (A3) is a global trade organization that represents more than 1,250 member companies in robotics, artificial intelligence, machine vision, motion control, and other advanced automation technologies. We are the umbrella association for the Robotic Industries Association (RIA), AIA – Advancing Vision + Imaging, Motion Control & Motor Association (MCMA), and A3 México.

This year, A3 is putting AI at the center of our activities. We've created a Strategic Advisory Committee on Artificial Intelligence, comprised of experts from leading AI and automation companies. We've launched a new portal on our website where you can easily access our AI content. Plus, make sure to subscribe to our new AI Insider newsletter with the latest updates on AI in automation. Our team is already working on our next AI whitepapers and collecting real-world use cases to share with our members. Our 2020 industry-leading events, such as our Autonomous Mobile Robot Conference and The Vision Show, will feature AI technology prominently. A3 is adding more staff to support these AI initiatives.

We need the involvement of our members in these efforts. If you are interested in submitting use cases or helping with our events or whitepapers, please reach out to Robert Huschka at rhuschka@a3automate.org, who is coordinating our activities.

We are committed to helping you on your AI journey.

Jeff Burnstein
President
Association for Advancing Automation

PART ONE

Introduction: A Revolution with Many Names

Magic and hype.

Two words that are frequently applied to artificial intelligence.

You can't watch a football game anymore without seeing ads claiming that AI will fix whatever ails your business, from shipping logistics and cybersecurity to manufacturing optimization and human resources. The drumbeat is relentless. Just wave an AI magic wand and all your business' problems will disappear.

Artificial intelligence is being slapped on products from toasters to lawnmowers to factory robots – often as a marketing gimmick with little-to-no actual "intelligence" backing up the claim. This marketing hype is concerning and has led some to worry that a backlash against artificial intelligence – another so-called AI winter – may be coming when the technology doesn't live up to overstated claims.

But in truth, artificial intelligence is neither *hype* nor *magic*.

Solutions leveraging the power of artificial intelligence are already paying off in automation. Artificial intelligence – in many shapes and forms – will be the stitching that weaves together this new age of industry.

This revolution goes by many names… Industry 4.0… The Factory of the Future … Smart Manufacturing… the Industrial Internet of Things. No matter the label you choose, this transformation will touch every aspect of the automation ecosystem from product design to manufacturing processes to the delivery at a customer's door.

At the same time, AI isn't some Harry Potter spell. It's not a black box you can drop in your factory and yield instant results. You need access to the data that can unlock its powers and expertise to put that data to work. And, you need the right leadership culture in your organization that will drive these efforts forward.

In this whitepaper, we will examine six application spaces where AI is already taking hold in automation and manufacturing. We will discuss how the technology is making a difference and what you should consider in your enterprise's AI journey.

PART TWO

Evolving Definitions: What is Artificial Intelligence?

Ask five technologists to define artificial intelligence and you may very well get five different answers. The definition of artificial intelligence has evolved over the decades and takes on different flavors when you consider subsets of AI such as machine learning and deep learning.

The English Oxford Dictionary provides this definition: "The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."

Stanford computer scientist and researcher Nils J. Nilsson defined AI this way: "Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment."

Ultimately, AI is probably more of a spectrum (with a range of capabilities and intelligence), not a line in the sand – where a system on one side has AI and on the other does not.

John Lizzi, the executive leader of robotics for General Electric and the chairman of the Strategic Advisory Committee on AI for the Association for Advancing Automation, recently offered up this simple test of whether a system possesses intelligence. Is your system *reactive*, *proactive,* and *social*? If it's reactive, it can sense and respond to its environment. If it's proactive, it can anticipate a future state and guide its actions away from or toward that projected scenario. And, if it's social, it can share information and engage with other intelligent agents – both human and machine – and direct or learn from the action of others.

Ultimately, AI is probably more of a spectrum (with a range of capabilities and intelligence), not a line in the sand – where a system on one side has AI and on the other does not.

This is an important distinction to consider when someone tells you their tool includes artificial intelligence. The applications and capabilities are far more important than a simple marketing phrase.

But when discussing AI, there are some terms you are likely to encounter. Here's a quick overview of a few:

ALGORITHM: Algorithms are the backbone of artificial intelligence, providing a formula or set of rules that allow an AI system to find answers to a question, solutions to a problem and ultimately to learn on its own.

TRAINING DATA: Training data is the information – or data sets – that are used to "teach" an AI algorithm to recognize patterns and develop a model. For example, you could teach a system to recognize cats by providing it with thousands of photos of cats.

MACHINE LEARNING: Machine learning (ML) is a field of AI that focused on teaching a system to form a specific task without using explicit instructions. ML systems build mathematical models from training data, in order to take actions, make decisions or generate predictions. Types of machine learning include reinforcement learning, supervised learning and unsupervised learning.

NEURAL NETWORK: Neural networks are a form of powerful machine learning that is inspired by biological brains. Neural networks use multiple layers of connected nodes to process data and find patterns. They are frequently used in visual recognition systems and natural language processing.

DEEP LEARNING: Deep learning is a subset of machine learning that uses neural networks to solve complex problems with large, unstructured sets of data.

COMPUTER VISION: A subset of AI that focuses on extracting high level information from digital images or videos. One example would be a system that identifies faces in images of people, or defects in images of manufactured parts. Machine learning is used in many modern computer vision systems.

Most experts doubt that we will achieve broad human-like AI anytime soon – with some wondering if it's even possible at all.

NATURAL LANGUAGE PROCESSING (NLP): Another subset of AI that focuses on building systems that can understand and analyze human generated language and speech. Examples include speech recognition systems, chat bots, and systems that automatically summarize news articles.

BLACK BOX AI: Decisions made by complex deep learning neural networks are often rendered without explanation. Since these systems are basically programming themselves, their decision-making can lack explainability. This has been called Black Box AI. Ongoing research and regulation have been aimed at building more transparency into AI's decisions.

ARTIFICIAL GENERAL INTELLIGENCE: AGI is the term used for an AI system that approximates human-level reasoning and decision making. Most experts doubt that we will achieve broad human-like AI anytime soon – with some wondering if it's even possible at all.

PART THREE

AI in Automation: 6 Leading Applications

We've identified six applications where AI already is making a substantial difference in manufacturing and automation. Some, like machine learning for vision inspections, are already widely in use. Others, like intelligent grasping for robotics, are just beginning to unlock their tremendous potential. But all six of these may help solve real-world problems facing your enterprise today.

1. Manipulation and Grasping

For a human, it seems so simple. Pick all the red triangles out of a bin full of toys. A 5-year-old could accomplish this. For robots, this has been a challenge. Not all objects are the same size or shape – or these objects may be made of materials that aren't easy to grasp. Machine learning is now being applied to help robots with material-handling tasks.

For example, in a factory, robots might need to move large objects onto pallets. In a pharmaceutical plant, smaller delta robots might need to manipulate small tablets with extreme dexterity. In a shipping facility, a robot may need to pick up packages of various shapes and sizes to load them onto a conveyor.

Material handling in the manufacturing process is often called a "pick and place" operation, where a machine will grasp or pick up an object and place it in another location. Increasingly, these tasks involve more than rigid, repeated motions. These processes can involve computer vision and the ability for a robot to "see" and respond to objects in its environment, to better determine how to grasp or place an object. These applications – with greater and greater accuracy – are sorting objects of different types.

"This is a key space where the application of machine vision (MV) with machine learning (ML) can provide significant advantages," says Claude Dinsmoor, General Manager of Product Development at FANUC America. "Bin-picking today is a common application typically using traditional MV with tools specifically designed for picking. To expand this space, especially in emerging applications like picking for logistics, ML is being used today to help simplify the setup and programming effort needed to make a working system."

As Dinsmoor mentions, machine vision and machine learning can help get a robotic operation off the ground easier — without needing to micromanage workflow and the inputs. This may both increase the amount of tasks that can be handled by robots while reducing the time and resources needed to begin a new automated workflow.

"ML tools are being used increasingly in large SKU applications where traditional MV/application techniques cannot deal with the variability or 'corner' cases presented by the wide differences in the items to be picked," Dinsmoor says. "ML is being used in both the identification of pick locations of items and 'learning' correct robot motion needed to grasp the objects."

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CLAUDE DINSMOOR, FANUC AMERICA

It is this iterative "learning" from many gripping experiences that opens up the promise of ML for manipulation tasks.

Traditional machine vision methods have had some success when the variability in production process is low and the orientation and type of objects are all similar in nature. Predictability is imperative in these traditional systems. That's why ML approaches are critical to modern grasping applications.

Objects placed in a bin are often not organized or stacked in a specific and convenient way for robots to handle them. Robots dealing with situations of these kinds must adapt to the chaotic and somewhat unpredictable placement of items and respond accordingly.

Machine learning software can help robots by training them in controlled situations and teaching them the best way to pick and place objects in each orientation, through repetition and feedback. This is shifting the paradigm of applications: robotic systems can now adapt to their work environments and workflows, rather than designing every aspect of the environment and processes to suit the limitations of the machines.

While there's been tremendous progress in grasping applications, much work remains to be done. Juan Aparicio, Head of Research Group Advanced Manufacturing Automation at Siemens Corporate Technology, explains how this remains an important machine learning challenge. He notes that Bill Gates recently listed robot dexterity as one of the next great technology breakthroughs that are poised to deeply impact our lives.

"Universal grasping is still considered the 'Holy Grail' of robotics. While robots have mastered repetitive tasks and material handling operations, they still struggle to grasp unpredictable objects,"Aparicio says.

On the algorithmic side, the problem of object manipulation can be broken into different stages,

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JUAN APARICIO, SIEMENS CORPORATE TECHNOLOGY

according to Aparicio. First, the object needs to be recognized. (Is that a hammer? for example.) Then, the system needs to calculate the right pose of the object with respect to the coordinate system of the robot. After that, the process becomes task-specific.

Machine learning can help to train robots to respond to the real world with greater ability and dexterity, but AI is just one piece of a wider puzzle of hardware, software, safety, materials, and experimentation.

"For bin-picking operations, it is enough to grasp the object robustly from a bin and place it into a box," Aparicio says. "For assembly, the object needs to be picked at a specific location that enables the next operation; and then placed with precision."

Recent advances of AI have enabled this set of operations with impressive results and expanded the type of sectors where robotic picking can be deployed, such as recycling operations or agriculture.

For certain objects, it is now possible to achieve close to 400 picks an hour (vs. 400-600 picks/hour for a person). But picking an object is not the only piece of the puzzle. Human are dexterous and also very versatile in new situations. Without tedious and exhaustive rule-programming, robots have a hard time to flexibly react to unforeseen situations, such as dropping an object after grasping or picking two objects instead of one," Aparicio says. The good news is that in manufacturing we can control the environment to make it easier for robots.

"Grasping and material handling require the robot to interact with a physical object," Aparicio says. "It is different than other operations that are performed in free space. Contact dynamics are difficult to model and therefore difficult to control." These tasks are commonly automated today using force and torque sensors and task-based rules. Popular machine learning techniques, such as Reinforcement Learning (RL), which give the robots the ability to learn by themselves, have the potential to automate those rules and add true flexibility to assembly.

Hardware also plays a big role, from sensing to actuation. On the sensing side, new powerful RGB-D cameras have reached the market. On the actuation side, new gripper modalities such as soft materials or a combination of grasping/suction are now available.

The advances are such that Aparicio is willing to make this prediction: "Grippers that combine multiple modalities, together with advances in computer vision and robust learning, will enable commercial robots to manipulate items as reliably as humans (at least in a complementary fashion, with humans still needed for corner cases) in the next 10 years."

2. Defect Analysis/Machine Vision

Using AI and machine learning for inspections and defect analysis is one of the most common applications of AI in use in automation today. In a recent survey of Association for Advancing Automation members, 82% of companies that had implemented AI technologies said they were using vision/inspection applications in their processes.

Advancements in lidar, laser, 3D, infrared, and 2D systems – combined with analysis powered by machine learning – are leading to unprecedented gains in manufacturing quality. Such systems can be deployed in industry for applications such as inspection and monitoring and can spot defects invisible to the human eye at amazing speeds.

AI technology primarily comes in the form of machine learning and deep convolutional neural networks to help vision systems learn, distinguish between objects, and even recognize objects.

Deep learning uses thousands of layers within neural networks to distinguish anomalies, parts, and characters all while tolerating natural variations. Deep neural networks improve as they are exposed to new images, speech, and text.

Traditional computer vision systems can be set up with some tolerances. But, systems without deep learning are limited. It's the artificial intelligence that helps analyze complex surface and cosmetic defects, like scratches or dents on parts that are turned, brushed, or shiny.

AI doesn't require a lot of physical equipment. Hardware only requires a feeding system, an optical system, and a separation system. But, the software is robust. It requires advanced image analysis algorithms and heavy programming. The systems are often trained on thousands of images to detect meaningful deviations from the "standard" appearance.

In many cases, machine vision systems surpass human vision in quality and quantity measurements because of its speed, accuracy, and repeatability. These systems can find object details too small to be detected by the human eye and inspect them with greater reliability. Machine vision can view in the ultraviolet, x-ray, and infrared regions of the spectrum. On production lines, machine vision systems can inspect hundreds or thousands of components per minute. For example, in textile manufacturing, finished products need to be inspected to discern if there are any defects in the final product in terms of weaving, knitting, braiding, finishing, and printing. The software can be trained to identify what the final product should ideally look like using digital images. Then, the software inspects images of cloth to identify if there are any deviations from the ideal

"You can now look at things like shelf space and answer questions like is the product in the right place? Is there dust on the shelf? Are the marketing agreements we made with vendors being fulfilled? Three years ago, you couldn't do that – there wasn't enough compute in the world to do that a smart way."

MATT VASEY, MICROSOFT

image. Human subject matter experts annotate each of the defects identified as required to help the software learn to identify defects more accurately.

Automated inspection overcomes many of the limitations of manual inspection systems. In manufacturing, visual inspection errors take one of two forms. The first is the missing of an existing defect. The second is the incorrect identification of a defect. Misses lead to a loss in quality while incorrect identifications result in unnecessary production costs and overall waste. These errors are often traced back to the undependability of human vision alone, imprecision of eyesight, and cost of labor.

With deep learning, machines learn by example. Automated inspection systems can recognize images, distinguish trends, and make intelligent decisions. Deep learning and machine vision enable a system to perform quality checks in great detail. Inspections are accomplished by means of image acquisition, preprocessing, and classification.

"Object recognition has advanced so much in the last three years," says Matt Vasey, senior director of AI at Microsoft. "You can now look at things like shelf space and answer questions like is the product in the right place? Is there dust on the shelf? Are the marketing agreements we made with vendors being fulfilled? Three years ago, you couldn't do that – there wasn't enough compute in the world to do that a smart way."

For a machine vision system, it's pretty easy to identify a Coke can. But identifying a papaya is a fuzzier problem.

"There's not usually a bar code on papaya," Vasey says. "But pilot programs are running now using self-checkout stations. Usually, you have to look up the number for papaya or avocado to checkout. But now a visual recognition system can ask a customer can make a solid guess: Is that an avocado or a peach? We can't tell, but it's either one or the other. And this will get better and better over time so eventually, you won't have to do even that."

3. Asset/Process Optimization

There's a saying that data will be the gold of the 21st Century. But data is only worth something if it's put to good use.

Some of the most well-established use cases for AI in automation involve making good use of this data: predictive and prescriptive maintenance.

The wave of advanced automation technology that has been implemented in modern factories has brought with it a multitude of sensors that are diligently collecting and cataloguing valuable information and data from the factory floor. For example, in process automation or discrete automation projects, companies might use readings from pressure sensors, temperature sensors, and vibration sensors to automate a control loop.

That said, many enterprises are not yet fully taking advantage of all the opportunities from the data that these sensors are collecting. This is where AI and machine learning can help.

Sensor readings from when a machine is functioning normally and other readings from when a machine has broken down can provide insights into when a system is approaching failure. Given enough such data, a machine learning algo-

"Can we leverage raw data to optimize the way we interact, operate, and manage our assets? The ability to couple robot data and process data can help to provide the insights around a specific work-cell like never before."

ANDY CHANG, KUKA

rithm can identify patterns in the data that are most commonly associated with breakdowns.

Manufacturing companies are installing these predictive maintenance applications into their system, and digitally connecting them to machine sensors. When the application detects a similar pattern in the future, it can automatically alert the maintenance engineers in the plant to take necessary steps toward repairing the machine before it breaks down. This can save manufacturing companies on loss from machine downtime and repair costs.

FANUC's Claude Dinsmoor says that AI can deliver these predictive capabilities at huge scale.

"For example, FANUC has over 21,000 robots connected with our predictive maintenance product, providing operational data which customers are using to plan maintenance, prevent production issues, and actively monitor the productivity on a global basis," Dinsmoor says,

With the emergence of machine learning, AI tools can be applied on large data sets, unlocking additional capabilities to gain insight into the condition of robot systems using the monitoring tools for systems and individual robot operations.

Andy Chang, director of Product Marketing Americas, KUKA, also sees huge potential.

"This is one of the main areas that we can see a tremendous impact in the near term. Robots and robot controllers have been producing and exchanging large amounts of data each and every day," Chang says. "Beyond informing the operator on production throughput, can those data be transformed

into insightful information to help streamline the maintenance and operation of those robots? Can we leverage those raw data to optimize the way we interact, operate, and manage our assets?"

Data is also being used on a smaller scale to fine-tune processes.

"Moreover, robot controllers also have access to process information," Chang says. "The ability to couple robot data and process data can help to provide the insights around a specific work-cell like never before."

And industry is looking to leverage this industrial data beyond just one robot or one cell.

"A lot of people are thinking about how to make their workstations better – a cellular level. But you should be thinking about using AI in a full end-to-end process. For example, is the routing of material between lines optimized?" asks Matt Vasey, senior director of AI at Microsoft. "Can we tailor jobs based on the parts that are currently in flight to the factory? Or can we go farther back and understand what products customers are demanding so we can make predictive choices around what we are producing?"

AI can potentially improve operations within processes, such as additive manufacturing, by taking tasks like scanning that require a lot of time to do manually and identifying the correct rate of building a part.

Paul Ardis, Senior Machine Learning Scientist at GE Research, discusses how AI is helping research into types of additive manufacturing modalities. Engineers must must determine a set of sequential motions that add material to the desired areas. These explicit instructions are provided to a team of robots. Since the outputs may have variance, the engineers might be required to stop the process after a set of actions, rescan the part that's being created, and determine how to proceed. The process is extremely time-consuming, even for simple parts or shapes.

"Advanced AI techniques, however, can enable a system to learn on the fly to determine an optimal set of actions or corrections given even partial scans or lower-cost images of the part's surface, intending that material is deposited to rapidly build up a shape and guarantee completed part properties," Ardis says.

4. Cybersecurity

What can go wrong if you aren't worried about cybersecurity? Nearly everything, it seems.

In June 2017, a crippling Russian cyberattack on the Ukraine spread worldwide, costing nearly $10 billion in total damages. One company, a global shipping giant, was paralyzed after a vulnerability on just a single computer opened a door to malware that shut down ports, froze them out of their manifests and software – and even sealed doors and turned off their phones. In June 2019, a Belgium aircraft parts manufacturer shut down operations worldwide in response to a major "cybersecurity event." Later that year, hackers broke in and stole data from a nuclear power plant in India. Cyberattacks on manufacturing and infrastructure are only expected to grow in number and ferocity.

The good news is AI cybersecurity measures are emerging to protect systems such as those that control factory automation or industrial robots from hacking and cyberattacks.

For example, industrial networks might also be vulnerable to attack from malware such as the

AI systems can use anomaly detection approaches to continually monitor network communication traffic to identify any behavior that is significantly out of the ordinary. In manufacturing, similar technology can be used to secure industrial networks from intrusions.

recent WannaCry attack that locked down several computers for ransom.

Two distinct types of cyber threats can be especially harmful for collaborative robots. Cyberattacks on robots could possibly cause damage or harm robots from a particular manufacturer by targeting a specific new vulnerability in the robot's software system. Other attacks might use AI technologies to conduct automated intrusions against industrial automation networks. These attacks can potentially even shut down entire plants, causing significant losses in terms of downtimes and system recovery which are time-consuming and costly.

Traditionally, cybersecurity systems require human officers to review suspicious network behavior. AI systems can use anomaly detection approaches to continually monitor network communication traffic to identify any behavior that is significantly out of the ordinary. In manufacturing, similar technology can be used to secure industrial networks from intrusions.

"AI tools are being used today at a high level within an IT environment to detect unusual or suspicious activity on a network or running application-level within enterprise-level computing environments," says Claude Dinsmoor of FANUC America. "These similar tools can be applied to running industrial networks including robots today. The actual application of these tools at the robot device levels is possible but may make more sense practically at the enterprise level."

5. Autonomous Mobile Systems

Autonomous mobile robots are already a mainstay in the e-commerce warehouse. They zip around vast stacks of products, ferrying the latest purchases to awaiting parcels for shipment across the world. Mobile robots have been replacing forklifts, pulling 1,000-kg payloads around a factory. Robots are stitching together production processes by moving products from one conveyer belt to another. They'll even clean the floors.

Today, autonomous mobile robots (AMRs) are changing the landscape across many environments – from factories to grocery stores to farms. Businesses are drawn to the increasing flexibility and diversifying of their applications. And, the easy programming and implementation of mobile robots make them attractive to end-users. Also, the tight job market is pushing companies to look to automation to solve worker shortages.

Companies, such as MiR, Fetch Robotics, Vecna, Locus, Omron, Otto, and others have been continually expanding the capabilities and the potential use cases for autonomous mobile robots. Interest in the technology has been off-the-charts. The sale of professional service robots – which includes AMRs – grew 32% in 2018. Logistics systems made up 41% of those sales.

Last year, Walmart announced that it's putting Bossa Nova robots in 350 of its stores. The robots will scan shelves for inventory and check to see that the items are correctly priced. They also note if products are located in the wrong spot. The retail giant, with the help of Brain Corp., is also rolling out aisle-cleaning robots. Other robots are used to detect spills or trip hazards in stores.

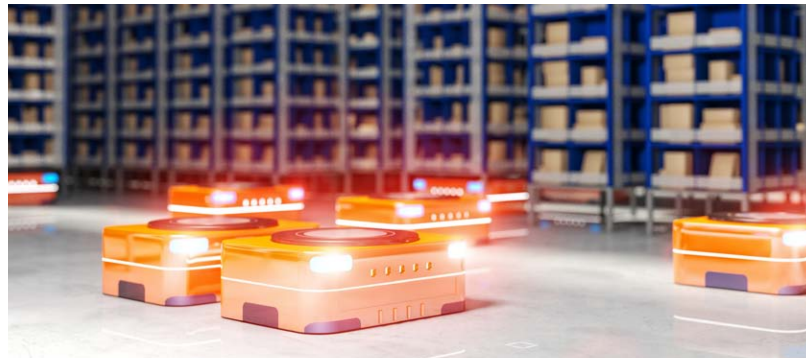
In 2019, the Association for Advancing Automation sold out our first-ever Autonomous Mobile Robot Conference – with more than 400 attendees – in Louisville. We are planning two more AMR Conferences in 2020 – the first of which will be in Boston on June 10.

Autonomous mobile robots are known for their unique ability to navigate in an uncontrolled environment with a higher level of understanding via sensors, blueprints, artificial intelligence, 3D or 2D vision, and more. AMRs are highly innovative compared to a traditional automatic guided vehicle (AGV), which is also mobile but uses wires or magnets to navigate a narrowly-defined area, along a predetermined path.

"We now have SLAM (simultaneous localization and mapping) and other advanced techniques that help these autonomous mobile systems navigate. They can synthesize a point cloud into a 3D map – clearly an AI workload – and that allows you to navigate around effectively," says Matt Vasey of Microsoft. "They can identify obstacles in real-time. These systems can identify a human or a piece of luggage and understand how to navigate around it. They can spot a spill on the floor and notify a worker."

Mobile vehicles without AI capabilities might react in the same way to every situation, avoiding obstacles by simply moving backward or turning in a predetermined way. AI-enabled robots can make better decisions on routing by using all the data available to them, optimizing the path efficiency, leading to much more accurate and faster navigation.

Today, multiple companies are working on robotic solutions that harness the mobility of an AMR with the reach and precision of a collaborative arm. These robots could be used to restock grocery store shelves, select products for e-commerce shipments, or even unload tractor-trailers filled with boxes.



Mobile robots are rolling into the great outdoors. Traditional robots can have some difficulties when facing off with Mother Nature. Outdoor robots will have to deal with hot and cold temperatures and humid conditions while navigating more complex environments.

AMRs are currently being tested (by FedEx, Amazon and others) to solve "last-mile" delivery challenges. Starship Technologies, Kiwi and others have begun testing small robots that roll along sidewalks on a college campus to deliver food purchases to students. These robots can navigate around people and even understand stoplights.

Farming operations are looking to robots to inspect crops, seed fields, and battle weeds and other pests. Robot makers are working on picking and harvesting applications. For example, UK-based Fieldwork Robots has created a robot and says it will be able to pick 25,000 raspberries a day – 10,000 more than the typical human worker.

Data from IDC's 2018 Commercial Service Robotics Survey shows there is no slowing down of the deployment of AMR technology. More than 90% of companies surveyed indicated some plans for commercial service robots in their organizations. The industries with the most active robot deployment are retail and wholesale/distribution. More than 70% of users noted double-digit KPI improvements from increased capacity, productivity, efficiency, operational speed, customer service, inventory turnover, and reduced operating costs.

6. Safety Technologies

Worker safety has long been one of the most important facets of the automation industry. For more than 30 years, our association has been central in the development of standards for industrial robot safety.

Safety technologies need to be highly-deterministic – where any safety system in place needs to be predictable to workers around machines and robots.

However, most AI methodologies and approaches are, in fact, non-deterministic. It is challenging to get a consistently predictable outcome in all situations. Thus applying AI in machine safety technologies is still highly-challenging and in its nascency. However, there are AI use-cases that are transferable from commercial and corporate products that might be applicable to industry.

"A vision system will be able to check if a worker entering through a door is wearing the correct protective equipment: Do they have a hard hat on? Are you carrying equipment into an area that won't be safe for use here? Or are you leaving an area with unauthorized equipment?"

MATT VASEY, MICROSOFT

AI-based machine vision systems might be used to determine if workers in an environment are appropriately dressed or if objects in the workplace are in unintended positions. For example, the SmartTag software by Smartvid.io is an industrial photo and video management platform. The software reportedly uses AI to look at photos and videos of industrial job sites to tag individual objects and people in the images. The company's software uses speech recognition, image recognition, and other machine learning techniques so that the AI agent gets better at tagging photos and videos over time.

Microsoft's Matt Vasey sees a variety of use cases in which AI might be applicable for safety in the industry.

"In an industrial setting, a machine could instantly know if you are properly trained to work with it," Vasey says. "A vision system will be able to check if a worker entering through a door is wearing the correct protective equipment: Do they have a hard hat on? Are you carrying equipment into an area that won't be safe for use here? Or are you leaving an area with unauthorized equipment?"

Cameras or sensors can watch certain processes and identify when workers may move into dangerous areas. "We can understand the behavior of workers. And we can train the workers – and the machines – to reduce interactions that cause adverse events," Vasey says.

There's a lot of potential for AI-powered mixed reality in safety. For instance, a worker wearing AR goggles could see the path-planning of a robot arm, so they stay out of the way. Or a worker could see how all of the machines are going to interact with each other and where you are in respect to those machines.

PART FOUR

Beginning an AI Journey: The Ambition-Execution Gap

Many CEOs already understand they are in a race. According to a recent study by The Boston Consulting Group and MIT Sloan School of Management, 85% of executives believe AI solutions will give their business a competitive advantage. However, just 39% of companies have started down the road. This has been called the Ambition-Execution Gap.

Companies know they need to implement AI strategies but are frequently at a loss on where to begin. Or they get stuck in a pilot purgatory where AI initiatives never reach a scale where they can help the overall enterprise. Even when on the right track, there's not the talent in the pipeline to support their efforts.

In a recent study of manufacturing by Intel, in collaboration with the Association for Advancing Automation, researchers Faith McCreary and Irene Petrick identified some of the key challenges that could derail the companies' Industry 4.0 efforts.

Here's a sampling of concerns from the survey's participants:

- 36% said technical skill gaps could prevent them from benefiting from our investment.
- 27% cited data sensitivity from increasing concerns over data and IP privacy, ownership, and management.
- 23% were worried about a lack of interoperability between protocols, components, products, and systems.
- 22% cited security threats, both in terms of current and emerging vulnerabilities in the factory.
- 18% said handling data growth in both the amount and velocity as well the ability to interpret the data.
- 18% worried about scalability roadblocks to accommodating growth without any business or performance loss.

Some basic questions to ask as you begin your AI journey:

What is your business need? The worst thing to do is to charge out of your office and demand that your company adds AI to your business. What is the actual problem you are trying to solve? Will one of the application spaces outlined in this paper help? Is artificial intelligence or even automation the right solution?

Is your "data house" in order? It's still not that usual for key information in manufacturing to be kept in paper form. How is your information being captured, cataloged and captioned? Are you already gleaning some insights from it? Can you easily increase the frequency of the data? Can you identify optimal situations vs. suboptimal conditions? Even if you aren't ready to implement an AI solution, start asking questions now about your data.

Do you understand the challenges of bias and explainability? Data is not always perfect. It can have hidden bias that can lead to inaccurate or unfair results. This bias can result from historical decisions, human imprecision or social inequality. It's important that your team tracks decisions made by AI for evidence of these biases. Also, your team must be made aware of the limitations of some "black box" AI, where the explainability of decisions is challenging or even impossible.

Are you and your leaders committed? Automation challenges aren't always technical. Is your team ready to accept change? Often AI solutions require cross-function teams to work in concert. One Industry 4.0 expert once joked: "We need your OT and IT teams living in the same house, but they aren't even in the same city." Your leadership and your employees will need to overcome the inertia against change. Often by starting small, by solving one problem, your enterprise can see the benefits of AI implementation.

Do you have the skills you need? As mentioned, the skills gap is often cited as a roadblock to AI implementation. The competition for qualified computer and data scientists is obviously fierce. Look for trusted partners or system integrators to help guide you.

Understanding the challenges ahead, the Association for Advancing Automation has launched major initiatives to help companies navigate this journey. Microsoft, Intel, GE, Amazon, Siemens, Google and others are assisting the Association in an effort to help business leaders understand the evolving AI opportunities and discover valuable use cases that will drive their industries forward. For the latest details, visit www.a3automate.org.

The companies who navigate these uncharted waters by leveraging their data, who invest in the necessary workforce, and who are brave and nimble enough to evolve, will gain unprecedented advantages. These companies will blend human know-how with AI insights and precision.

The future is arriving fast – and it will be powered by AI and automation.

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