Fast Facts to Raise Your Smart Manufacturing IQ

NEXT

Courtesy of UBM Advanced Manufacturing Group

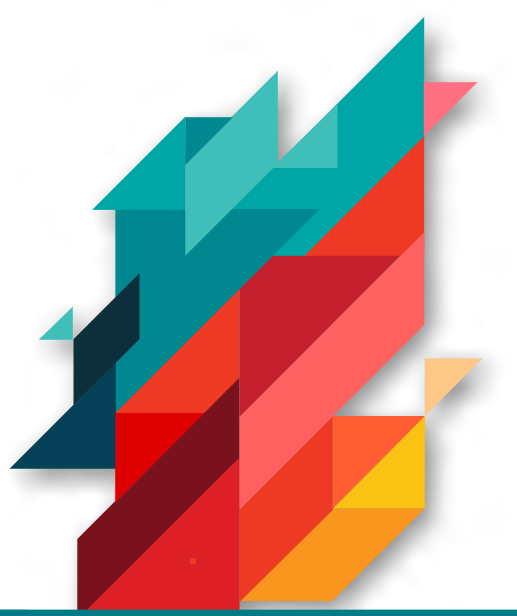
UBM

CONTENTS

The future's coming fast, and it's dazzling.

Soon, you'll work with intelligent robots to create new products. The products will tell you how they're coming together on the factory floor and how they're functioning when their buyers use them. If buyers have problems with the products, you'll know right away, and you'll change details of design and manufacturing on the fly.

This book reveals the changes that are bringing the world of smart manufacturing into reality, plus glimpses into the future. It's got facts, quotes, statistics, anecdotes, and even a game or three. All of the pieces here come from stories in the trade journals Design News, Medical Device and Diagnostic Industry, Packaging Digest, PlasticsToday, and Powder & Bulk Solids, which have been covering the rise of smart manufacturing since its first glimmerings.



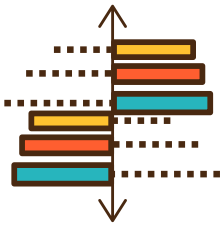
The door to smart manufacturing is open, and the welcome mat is out. Come inside and look around.

CHAPTER 1

The ABCs of Smart Manufacturing

ESSENTIAL WORDS AND IDEAS

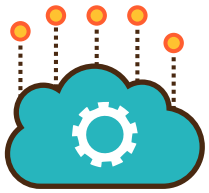
AI
Acronym for artificial intelligence.



analytics
The process of examining data to find patterns and draw conclusions. It's sometimes called data analytics. "Analytics is crucial to obtaining the true value of a digital plant," according to Jiani Zhang, director of product management at IBM Watson Internet of Things. "Analytics allows us to identify patterns in our manufacturing process, enabling us to predict failure and improve quality."

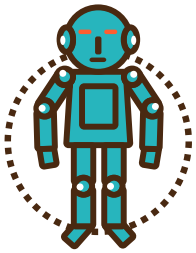
artificial intelligence
A machine's ability to simulate human thinking. Apple co-founder Steve Wozniak says, "There's sort of a fear with artificial intelligence that machines could become so intelligent and versatile that they could totally replace a person so there wouldn't be other jobs to go to, but that is so far off it's an unrealistic fear at this stage. It would take decades and decades."

big data
(1) A volume of information too large and complex for traditional methods to process. (2) New processes that can handle large, complex volumes of information. The use of big data can help to analyze and adjust production to speed the manufacturing process, reduce inefficiencies, and drive down energy consumption.



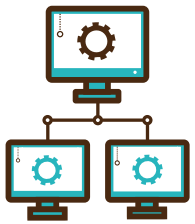
cloud, the
A network of servers and other computer resources that store and process data. The cloud evolved as manufacturers began using machines of greater and greater complexity. Storing the enormous files of data involved in running the machines grew burdensome. Keeping the data in the cloud and accessing it as needed was more convenient and less costly.

cobot
Abbreviation for collaborative robot.



collaborative robot

A robot that works with a human worker in a space that they share. Collaborative robots are good at assembling products; factories have also deployed them to move heavy objects. "There's growth in collaborative robots, but not to an extreme extent," says Michael Sullivan, an analyst for market research firm BCC. "If you look down the road, the impact will be stronger."



connectivity

The ability of a computer or other device or system to connect with other computers, devices, or systems. Connectivity is central to smart manufacturing. According to systems engineer Benjamin Kiefer of MAJiK Systems, which helps manufacturers view and track data from their equipment, "To benefit from an automated system, you have to create a connectivity strategy."

edge

A place physically close to a machine. Data at the edge travels a shorter path than data sent to the cloud, so it's more secure against hacking. Vivek Dave, director of new technology for connection company Harting, has said, "As you envision an Internet of Things with tens of billions of connected devices, you have to ask yourself, 'Is it practical to send all this data to the cloud?' "

fog, the

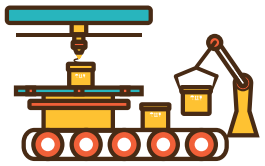
A computing infrastructure at the edge of a network. The fog is an alternative to managing data in your computer network or in the cloud. "Examples would be switches or wireless devices that have embedded computers in them," according to Thomas Nuth, global vertical manager for networking company Moxa. "Fog computing is essentially where edge meets cloud."

IIoT

Acronym for Industrial Internet of Things.

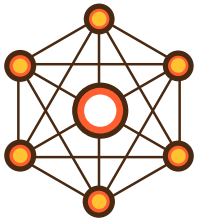
Industrial Internet of Things

An aspect of the Internet of Things associated with manufacturing. "Connected technology made possible by the Industrial Internet of Things has drastically improved visibility in manufacturing," says Jonathan Wilkins, marketing director at industrial parts supplier EU Automation. "Manufacturers now have access to real-time data to see how the assembly line is running."



Industry 4.0

The trend toward smart manufacturing. It's called "Industry 4.0" because it follows the first industrial revolution, which moved away from an economy based on muscle and farming to one that used steam engines and other machines; the second revolution, which brought in electricity and mass production; and the third, which introduced computers and automation.

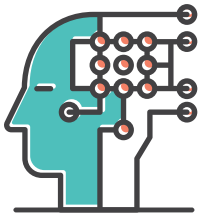


Internet of Things

A network of objects that can interact with each other via the Internet. "The IoT has the potential to transform manufacturing," according to Rick Schreiber, manufacturing lead at accounting and consulting firm BDO, "because of the additional technologies it enables — machine-to-machine communication, machine learning, robotics, virtual reality, 3D printing, and more."

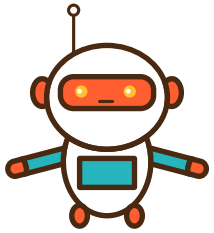
IoT

Acronym for Internet of Things.



machine learning

A type of artificial intelligence that gives a computer the ability to learn from new data and modify its activities based on the data rather than on new programming. Medical device design expert Srihari Yamanoor says that machine learning will help "to improve production quality, impacting error rates, product security, tamper proofing, and other features."



robotics

The science of designing, building, and operating robots. The advantages of robots are obvious; a report from robot maker ABB Group says, "Robots will sort all day without complaint. They can work next to hot ovens or cold freezers without needing gloves. They can even work with the lights off, saving more money."

sensor

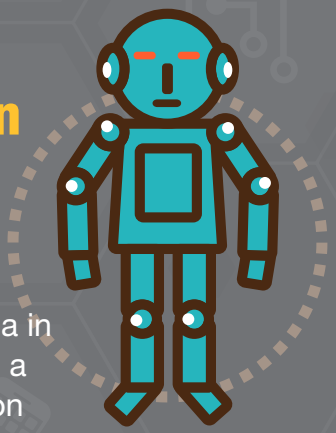
A device that detects a stimulus (such as heat, light, or motion) and responds to it, often by transmitting information about the stimulus to a control instrument such as a computer. Robots use sensors to guide their movements, moisture sensors tell food processing machines when to dry out their products, and maintenance sensors tell when a factory machine is about to fail.

Statistics to Make You Smart

Numbers that you need to know

$1 billion
The amount in grants that Apple is offering via its US Advanced Manufacturing Fund to support smart manufacturing

More than 1.5 billion
Industrial robots operating in factories worldwide



34,606
Robots ordered in North America in 2016 — up 10% from 2015 — at a value of approximately $1.9 billion

80%
Percentage of manufacturers investing in the Internet of Things

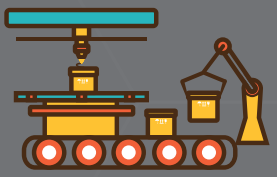
63%
Percentage of manufacturers that have implemented or plan to implement the Industrial Internet of Things

Increase in sales/orders of robots during 2016:

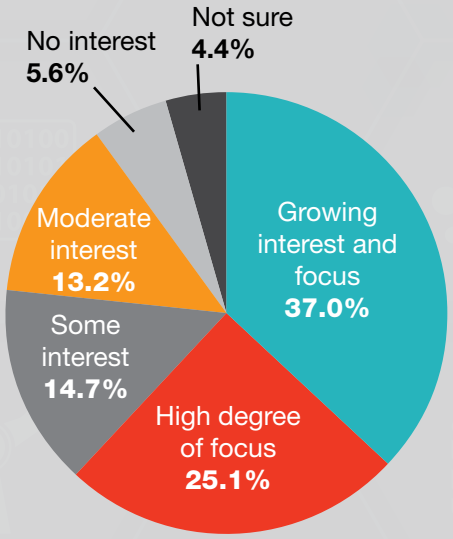
Automotive:
25%

Food and consumer goods packaging and related tasks:
32%

Product assembly:
61%



Manufacturers' focus on the IIoT



Top objectives driving manufacturers' desire to adopt the IIoT:

1. Improve product quality
2. Increase the speed of operations
3. Decrease manufacturing costs
4. Improve maintenance/uptime
5. Improve information for business analytics

#1
Cyber security's rank among the reasons why manufacturers hesitate to adopt the IIoT.

Statistics to Make You Smart

The four core sensor functions:

1. Vision
2. Touch
3. Hearing
4. Movement detection

12.6%
Rate at which the global sensors market for robotics is expanding per year

More than 40%
Percentage of the sensor market in industrial settings

Poll of Americans on artificial intelligence:

52%
would want an AI assistant to help them at work

35%
believe that workers with AI skills will replace those without

32%
believe that workers without AI assistance will be less efficient and productive

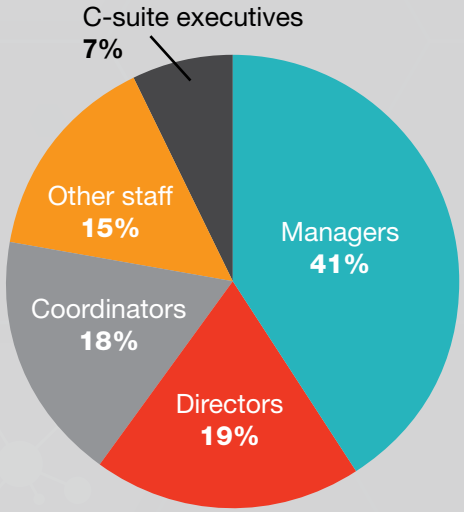
Companies report progress thanks to AI:

Tech company Siemens: improved turbines' emission performance by 20%

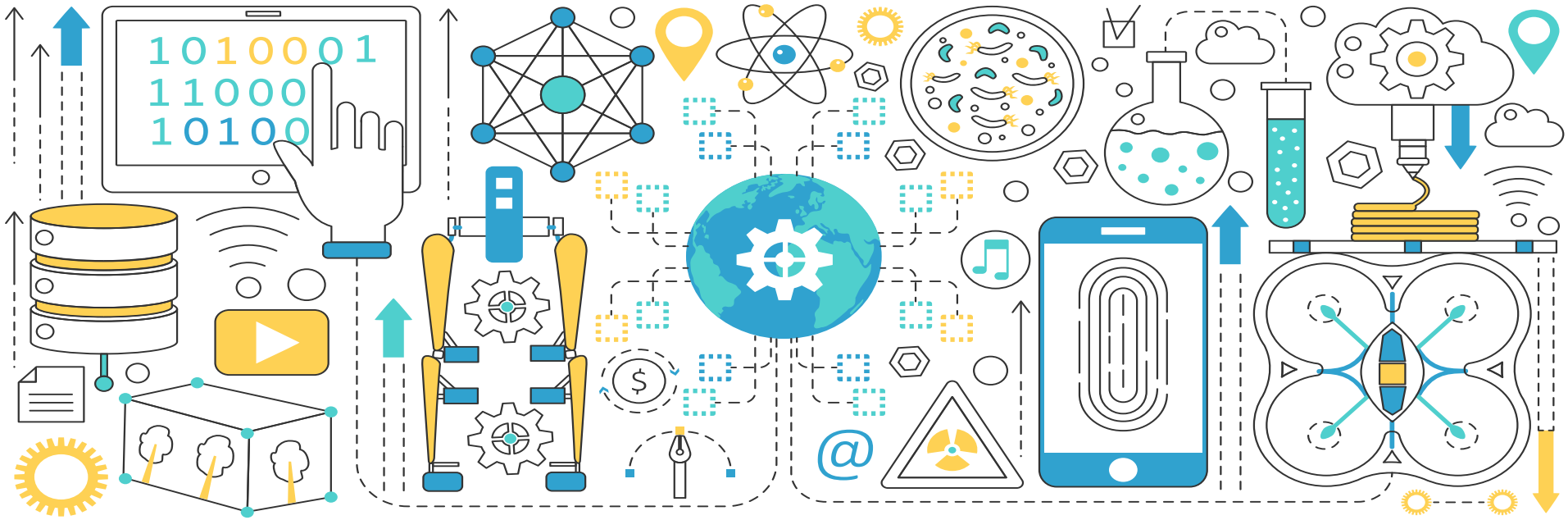
Dutch airline KLM: rise in customer service by 35%

Harley Davidson: increase in sales leads by 2,930%

New jobs created by AI



83%
Amount of respondents in a poll of large companies using AI who say that AI has created new jobs



What's Happening Today

Big trends and fresh developments

Big trend #1:
Industry 4.0 on the rise – three viewpoints

"Industry 4.0 is the next step in the evolution from steam engines to motors to digital electronics to cyber-physical systems. It's an evolution that involves merging the networks with manufacturing, resulting in smart automation."

Robert Trask, senior systems architect at Beckhoff Automation

"The Internet of Things, the cloud, remote monitoring, embedded software, simulation, big data analytics: All of these have a role to play in Industry 4.0. But they are just enablers. The creation of better, more useful stuff in less time and at lower cost is the promise that spurs Industry 4.0 investment."

Peter Thorne, director of analyst firm Cambashi

"With Industry 4.0, industry is coming back stronger. There are more jobs in an industry with connectivity."

Klaus Heimrich, member of the managing board of Siemens

Big trend #2:
Baby boomers are triggering smart manufacturing

Engineers of the baby boom generation, the old experts who can detect problems just by hearing a machine's whirs and thrums, are retiring and taking their knowledge with them. "When baby boomers retire, there will be a skills gap," says Matt Fitzgerald, vice president of product experience at collaborative robot maker Rethink Robotics.

"Technology is the best bet for replacing that expertise," says Saar Yoskovitz, CEO of predictive machine diagnostics company Augury. Atul Mahamuni, vice president of IoT at Oracle, explains: "We're going to replace the knowledge of the aging workforce with data. The machine needs to get smarter. We don't have the mental capacity of looking at billions of data points to see what's relevant, but the software does."

Musical mechanism

A robot called YuMi conducted the Lucca Philharmonic Orchestra at the Teatro Verdi in Pisa, Italy, as part of the gala of the First International Festival of Robotics. The team at robotics manufacturer ABB Group set out to show that YuMi, a cobot made to assemble consumer electronics and other products, could learn precise movements — even the movements of an orchestra conductor.

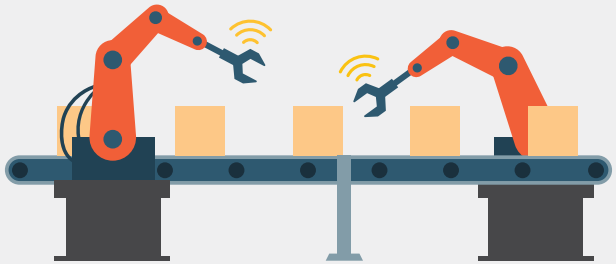
Automatic Otto

Technicians at GE Healthcare's Repair Operations Center handle more than 2,000 medical devices every week. To pick up the devices needing repair and drop off repaired devices, the workers used rolling carts — until GE added Otto, a self-driving vehicle that collects and delivers on its own. Rolling out Otto at the 280,000-square-foot facility has resulted in a 66% increase in productive floor space.

Big trend #3:
Reviving old equipment

"The average age of a plant in North America is 40 years old," says Greg Newman, vice president of marketing at manufacturing software firm Parsec. How should an old factory bring in new technology?

"The best approach," says Steve Mustard, the Automation Federation trade group's cybersecurity chair, "is to identify the business need and design an end-to-end architecture that works, rather than trying to bolt on [new tech] to a legacy environment." Other experts recommend taking one move at a time; Marc Ostertag, North America president of B&R Automation, suggests starting with smart sensors. Either way, says John Carrier, senior lecturer of system dynamics at the MIT Sloan School of Management, "You'll start measuring what's going wrong … [and] start to run well."



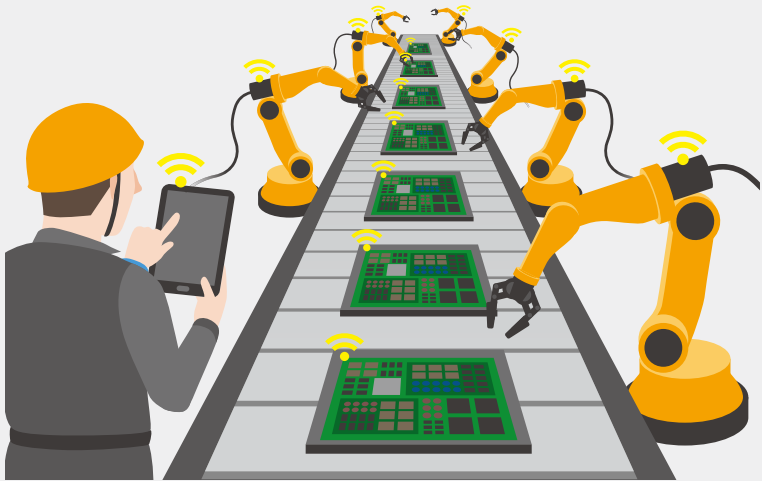
Who's most connected via the IIoT?

Germany and Japan are the "furthest along" in companies connecting their operations through the Industrial Internet of things, according to the Global Industry 4.0 Survey by PricewaterhouseCoopers (PwC). But North American countries should be catching up. PwC expects high growth in North America's IIoT over the next several years.

How to defend connected factories from cyber threats

Business consultancy Deloitte & Touche has recommended three ways a company can protect products connected to the Internet of Things from hackers:

- Organize cybersecurity activities to check safety and respond quickly to incidents.
- Conduct security risk assessments both annually and when the business undergoes shifts such as acquisitions, divestitures, or supplier changes.
- Take a forensic approach to incident response. Establish the incident timeline, detect anomalous behavior, and figure out which data was accessed.



AI immediately

Artificial intelligence usually needs time to process data. But Microsoft says that it's found a way for AI to do the job immediately: field programmable gate arrays (FPGAs). Microsoft says that FGPAs allow it to deliver a cloud-based deep learning platform that is more powerful and more easily scalable than other solutions. The company has codenamed its new platform Project Brainwave.

A brain on the factory floor

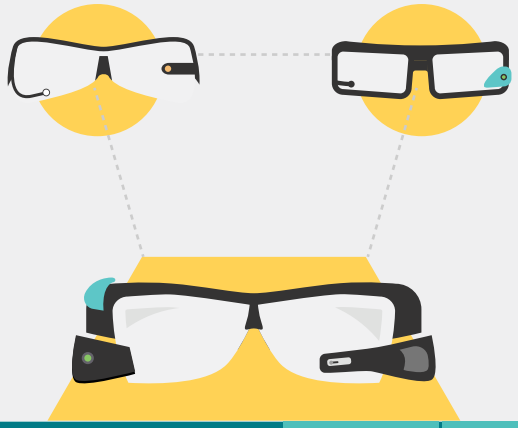
IBM has launched Cognitive Visual Inspection, a system that provides manufacturers with a "cognitive assistant" on the factory floor to minimize defects and improve product quality. In early testing, according to IBM, the system reduced manufacturing defects by 7% to 10% while reducing inspection time by 80%.

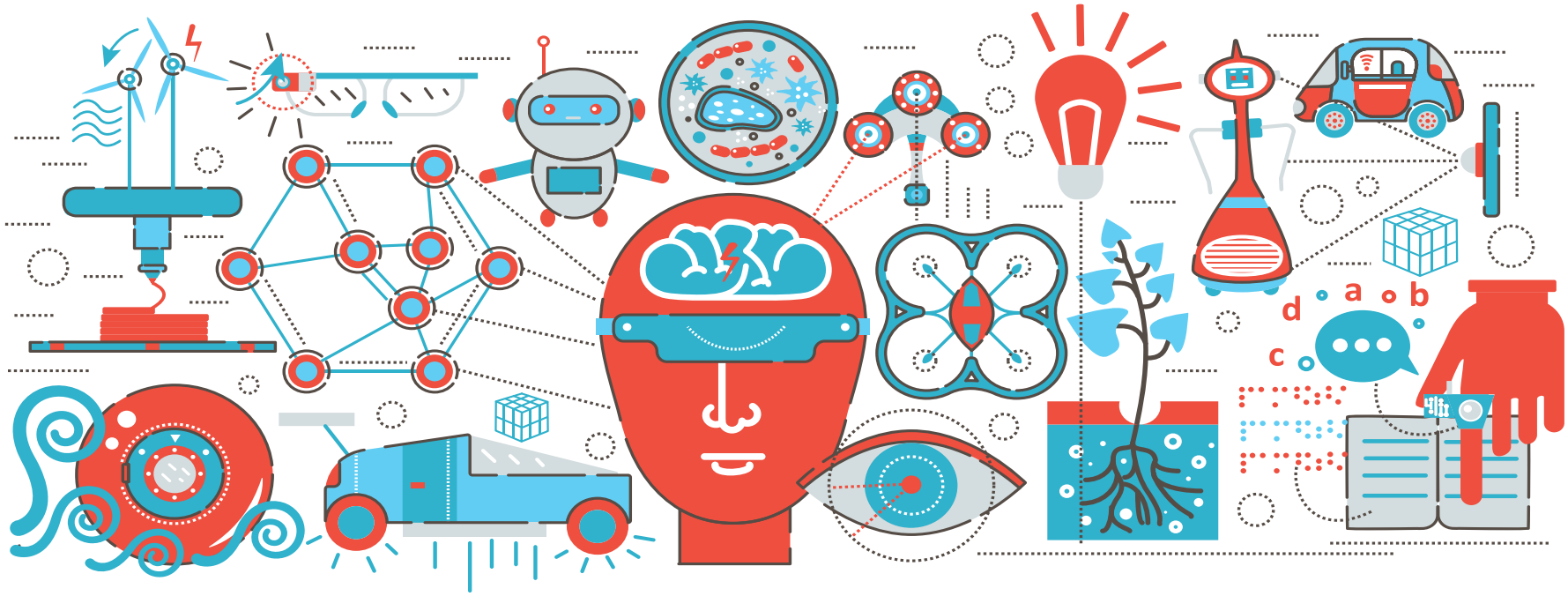
Smart glasses cut downtime

Service technicians from food packager Tetra Pak cut downtime on 17 packaging lines by up to 48 hours over six months for each line. Tetra Pak accomplished the feat by using Microsoft's Azure software and HoloLens augmented-reality smart glasses. The glasses helped workers do fast diagnostics, while Azure used data mining and analysis to predict when machines needed maintenance.

The return of Google Glass

GE Aviation and DHL are having workers use Google Glass to provide hands-free guidance and instructions to workers. Glass has increased GE's worker compliance and job satisfaction, and has resulted in an 8%-12% increase in mechanic efficiency. DHL estimates that its workers wearing Google Glass have increased supply chain efficiency by 15%.





What's Coming Tomorrow

Future tech that's on its way

Robots that hear, understand, and obey

MIT researchers have developed a system to let robots understand verbal commands much as the iPhone's Siri does. The researchers placed objects like a box of snacks on a table and tell the robot, "This is my box." When the researchers said, "Pick up my box," the robot could find the right object and pick it up. The system may help manufacturers communicate more easily with industrial robots.

The Matrix for robots

Robots usually learn slowly, by trial and error. But non-profit company OpenAI has developed a faster way: virtual reality simulations that quickly teach a robot to recognize "thousands of object locations, light settings, and surface textures," says OpenAI researcher Josh Tobin. Meanwhile, tech firm Nvidia has built its own virtual simulator, named Isaac. "The virtual brain gets trained [in Isaac], then transferred into a real robot, and the robot does its last bit of adaptation in the physical world," says Nvidia CEO Jensen Huang.

Robots forming their own teams

A new style of robotics may be coming. Maria Gini, University of Minnesota professor of computer science and engineering, has been exploring distributed robotics — bots that work in teams rather than obey a centralized control hub. She explains, "If I have a central system, then if one robot breaks, maybe the system doesn't know, and if it does know, it has to reallocate everything." But in a distributed system, "if one robot breaks, other robots can still do the work."

Robots with skin

Researchers at UCLA and the University of Washington have developed a flexible sensor "skin" that transmits information about shear forces and vibration, allowing its robot wearer to "feel" objects. Meanwhile, researchers at Harbin University in China have developed a sensor using tiny wires to mimic the function of hairs, which increase human skin's sensitivity. The sensor wires can distinguish among rubber, plastic, ceramic, and glass.

Powering sensors without wires

A new, coin-sized battery called the Stereax P180 — believed to be the first wireless, solid-state battery for the Industrial Internet of Things — could help engineers create long-life, wireless sensor packages for hostile industrial environments where running cables is difficult or impossible. Graeme Purdy, CEO of materials tech firm Ilika Technologies, which made the battery, has explained that it "allows engineers to come up with untethered designs."

A digital double

Companies such as GE and Siemens have been exploring the digital twin, a collection of information about each physical product. The twin can include design data, simulation results, the bill of materials (from supplier to costs), the manufacturing configuration, production data, sales records, information on how consumers use the product, and maintenance and defect records. This information can help manufacturers refine and improve products swiftly.

Microscopic, cybernetic medics

Inspired by the natural processes of self-healing in the human body, researchers at the University of California San Diego have developed nanomotors that can act as a self-healing system for electronics. The motors can work within a computer, a robot, or any other system as an automatic immune response, searching for damage and performing repairs without human intervention.

Connecting the IoT dots

Industry 4.0 depends on devices talking with each other, but differences in software and operating systems block them. So the FDT Group and the OPC Foundation, two global groups of automation and industrial firms devoted to helping machines work together, are themselves working together on systems, structures, and standards that lower the barriers between devices. Their initiatives may make it easier for manufacturers to bring in technologies ranging from mobile apps to augmented reality.

CHAPTER 5

Opinions and Predictions

The experts speak out on smart manufacturing

The origins of Industry 4.0

"The driving force behind industry 4.0 is the German government. The real reason behind it is that a scientist said, 'You have negative population growth, and the German economy is built on manufacturing. That means people. With a negative population, we're in trouble unless we do something now. Unless manufacturing systems have the intelligence to do things on their own, Germany won't have enough people [to] do the work.' "

— *Robert Trask, senior systems architect at Beckhoff Automation, on the early development of Industry 4.0.*

The U.S. will lead in disrupting manufacturing

"The United States plays a pivotal role in industrial digitation. In the U.S., you have leading companies with leading expertise. Digitalization is improving the quality of life, and now visualization is knocking on the door. This is a chance for companies in the U.S. to be even more competitive than they are today."

— *Klaus Heimrich, member of the German tech company Siemens' managing board, on the United States' status in Industry 4.0.*

Goodbye, product engineering; hello, systems design

"The focus on mechanical or machine design is gone. The successful engineer is now a systems designer."

— *Gian Paolo Bassi, CEO of the design software company SolidWorks, predicting that smarter computers will take over engineering tasks such as designing objects and configuring the objects' manufacturing process.*

Do robots mean layoffs?

"In our 20 years of robot installations, no one has been laid off by a robot."

— *Mark Noschang, chief robotics engineer of Omron Industrial Automation, a maker of sensors, switches, relays, and other components, on job security for manufacturing workers*

Where machines outdo humans, part I

"Moving to robotic production improves consistency of production and the cleanliness of manufacturing space. People bring contaminants into the food and beverage manufacturing space. People have contaminants on their hands and head. Robots can be sterile."

— *Tatjana Milenovic, global marketing and portfolio manager of ABB's Food and Beverage Program, on why food processors are switching to robotic production.*

Start IIoT slowly

"Don't go gangbusters. Start on a small scale. You have to take a conservative approach because millions of dollars can be at stake."

— *Sandhiprakash Bhide, former director of innovation for Intel's Internet of Things Group, recommending that engineers begin with a proof-of-concept IoT application in a small area before spreading it broadly across a factory.*

Don't be a dinosaur

"IIoT is an opportunity for fast-moving engineers and a threat to dinosaurs. We started in the '90s with [communications protocol] Modbus to allow machines and PLCs [programmable logic controllers] to talk with each other and talk with control and IT. Now new skills are needed. A lot more time needs to be spent on software design."

— *Mark Duncan, segment manager of material handling & packaging machinery at Schneider Electric, on engineers and the Industrial Internet of Things.*

Sensors that save millions of dollars

"We will see a slow but steady stream of progress wherein sensor innovation — better, faster, and cheaper sensors — feed data into analytics systems that will provide more accurate feedback and monitoring. Slow and steady progress should not be discouraging, because that progress can lead to huge savings — like the offshore oil rig operator that uses GE's connected solutions and was able to save $7.5 million in lost production by replacing a part proactively."

— *Maryanna Saenko, analyst at Lux Research, on the importance of sensor advances.*

Where machines outdo humans, part II

"[AI] devices are better at identifying anomalies than people are because they can see things and nuances that humans would miss because of the minute detail. AI is good at seeing the detail. These things that AI sees in industrial settings may be an early indicator, and it may be missed by any human who monitors the system. The computer can look at partial hits that represent a pattern. Sometimes humans miss it or don't see it as having bigger significance."

— *John Crupi, VP and engineering system architect at Greenwave Systems, on how to use artificial intelligence.*

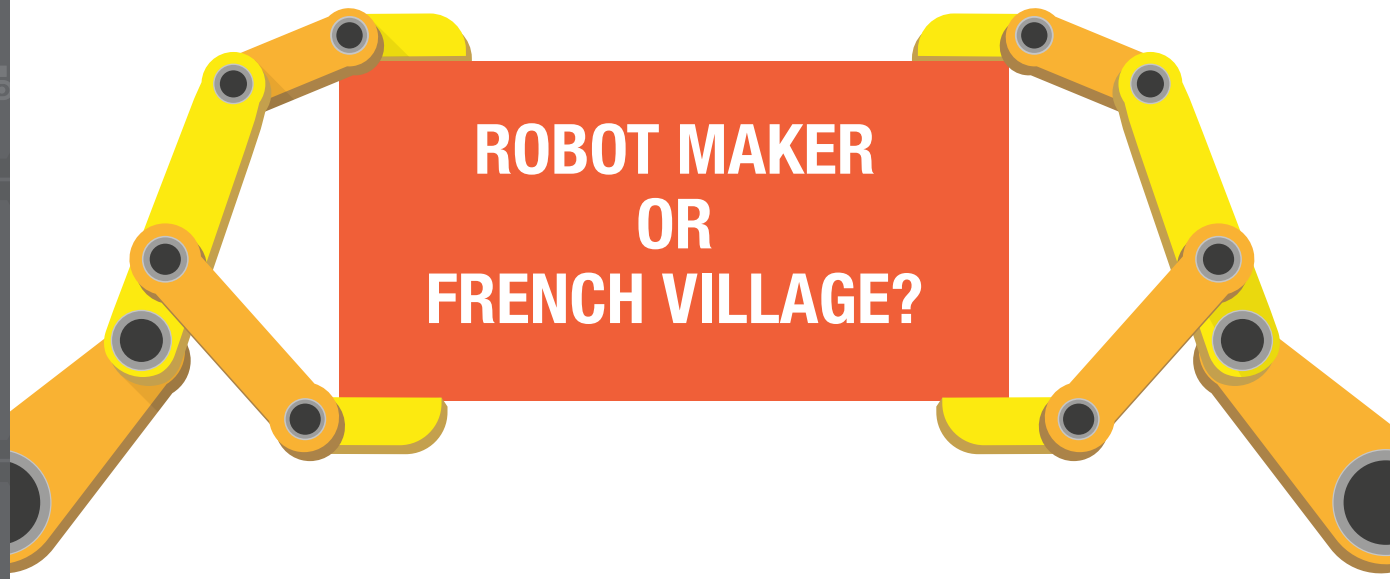
Big data and the unasked questions

"Big data performance analytics allows companies to ask the questions they didn't know they should ask, by analyzing billions of data combinations and creating insights in seconds. This discovery capability enables users to not only see what happened but also see why it happened, by revealing the combinations creating data outliers for further analysis."

— *Bill Boswell, senior director of cloud services marketing and business strategy for Siemens PLM Software, on how to use big data.*

Industrial Strength Fun

Games and quizzes to test your smart manufacturing smarts



ROBOT MAKER OR FRENCH VILLAGE?

For some reason, a number of robot makers have names that sound like French villages. Camon, for instance, is both a small company that makes a robotic videographer and a village between the city of Toulouse and the Spanish border.

Which of the names below belongs to a robot maker, and which is a French village?

Click on "Robot" or "Village," then check your answers on the next page!

Fanuc	ROBOT	VILLAGE
Festo	ROBOT	VILLAGE
Locronan	ROBOT	VILLAGE
Locus	ROBOT	VILLAGE
Omron	ROBOT	VILLAGE
Piana	ROBOT	VILLAGE
Riquewihr	ROBOT	VILLAGE
Rodemack	ROBOT	VILLAGE
Salers	ROBOT	VILLAGE
Vecna	ROBOT	VILLAGE

Fanuc: a robot maker

Fanuc makes cobots such as the CR-35iA, which can lift 35 kilograms (more than 75 pounds) and is covered in soft foam to prevent it from hurting its human co-workers.

Festo: a robot maker

Based in Germany, Festo makes robots based on examples from nature. Its BionicMotionRobot, for instance, is inspired by an elephant's trunk and an octopus's tentacles.

Locronan: a French village

Located in the Brittany region, Locronan is one of France's loveliest villages, so picturesque that it's appeared as a location in a number of movies.

Locus: a robot maker

Locus Robotics focuses on making robots for use in warehouses as well as a navigation system for coordinating multiple robots in a factory environment.

Omron: a robot maker

Like Locus, Omron makes bots such as the Lynx, which can move 130 kilograms (about 287 pounds) and find its way around busy warehouses and factories.

Piana: a French village

Standing on the island of Corsica, Piana is known for its beautiful creeks and striking rock formations.

Riquewihr: a French village

A wine-country village in northeastern France, Riquewihr looks like a town straight out of the 16th century.

Rodemack: a French village

Sitting close to the border with Germany in eastern France, Rodemack is so old-fashioned that it stages re-enactments of medieval events for tourists.

Salers: a French village

Located in south-central France, Salers is famous for its cheeses. The town has been called a black pearl or black diamond due to the dark grey stone used in many of its buildings.

Vecna: a robot maker

Vecna makes robotic lifters and conveyors that use technology behind autonomous cars to navigate their workspace.

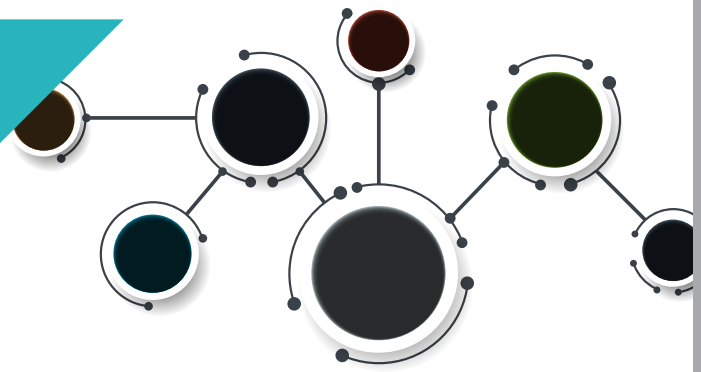
How many right answers did you get?

8-10
Crème de la crème! All of your systems and functions read green.

5-7
Comme ci, comme ça. Not bad, but your circuits could use maintenance.

1-4
C'est la vie. Take yourself in for exhaustive repairs.

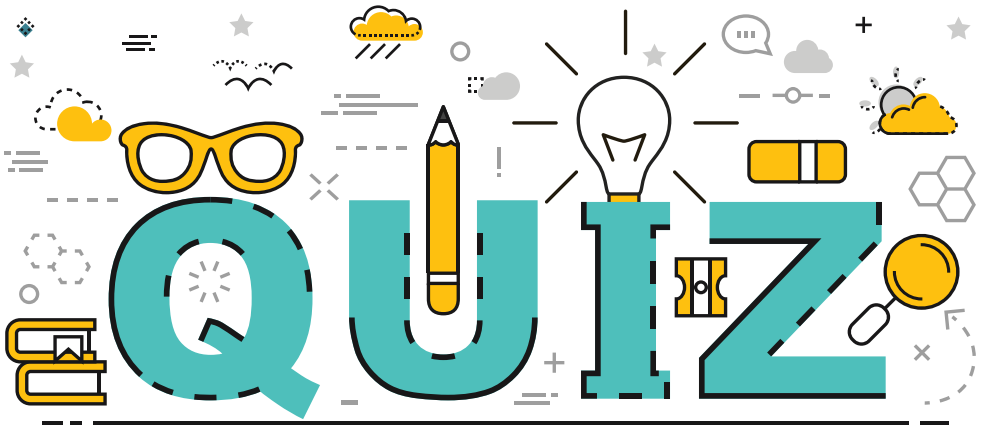
CONNECTIVITY ISN'T JUST FOR COMPUTERS



Connect each word on the left to a word on the right to create phrases often used in smart manufacturing.

Augmented	**4.0**
Big	**analytics**
Collaborative	**architecture**
Cyber	**computing**
Data	**data**
Digital	**learning**
Fog	**maintenance**
Industry	**of Things**
Internet	**reality**
Machine	**robots**
Predictive	**security**
Pressure	**sensor**
System	**twin**

CLICK HERE TO REVEAL THE ANSWERS



BRAIN CHALLENGE: CAN YOU GUESS (OR DEDUCE) THE TRUTH?

1. Saar Yoskovitz, CEO of predictive maintenance company Augury, predicts that industry will soon see:

- A. A hybrid of fog and cloud computing
- B. Greater awareness of cyber security and risk
- C. Smarter decisions by facilities managers
- D. A & B
- E. All of the above

2. Gunnar Newquist, founder and CEO of AI software firm Brain2Bot, says that engineers creating smarter machines should understand:

- A. Animal biology
- B. Freudian psychology
- C. Cybernetic neurology
- D. Human anthropology
- E. Early childhood development and morphology

3. Google has created a form of artificial intelligence that can learn without any human supervision. Google's researchers tested and improved its abilities by making it play:

- A. Chess
- B. Three-dimensional chess
- C. Checkers
- D. Go
- E. Fantasy football

4. Microsoft developed its Azure IoT software suite with input from companies including:

- A. Rolls-Royce
- B. Hershey
- C. U.S. Robots
- D. A and B
- E. None of the above

5. Before the Internet of Things let products tell the manufacturer how consumers use them, "you talked with customers to get feedback," says Steve Chalgren, chief technology officer at cloud software company Arena Solutions. "But that's like _____."

- A. A parent arguing with a teacher about how well a child behaves
- B. A crime scene where everything is remembered inaccurately
- C. A liberal news show reporting about a conservative politician
- D. The fog of war
- E. Talking with a barking dog

6. Collaborative robots were invented:

- A. At the Defense Advanced Research Projects Agency (DARPA) in 1971
- B. As a joint project of IBM and General Electric in the early 1980s
- C. At Northwestern University in the mid-1990s
- D. At Toyota in 2004
- E. By inventor Stephanie Kwolek in 2005

7. Masayoshi Son, CEO of tech investor SoftBank, has predicted that in 2021, the world will have:

- A. One hundred million robots
- B. Eliminated cloud computing
- C. Moved from Industry 4.0 to 4.5
- D. A trillion Internet of Things devices
- E. All of the above

ANSWERS

1. Saar Yoskovitz, CEO of predictive maintenance company Augury, predicts that industry will soon see:

E. All of the above

Yoskovitz sees a big future in fog computing as floods of data choke storage and processing in the cloud. He also sees growth in the awareness of security and risk: "Facilities that implement devices connected to the IoT need to think about communication and the security protocols between devices." Finally, he expects facility managers to make smarter decisions as they process more and clearer data from their machines.

2. Gunnar Newquist, founder and CEO of AI software firm Brain2Bot, says that engineers creating smarter machines should understand:

A. Animal biology

"Having an appreciation of [animal] biology for engineers is important because this is really where all the inspiration for this comes from," Newquist says. "There isn't anything that humans do that isn't in a simpler form in much simpler animals. If we take it step by step, even if we don't get to human intelligence, we're going to get to some useful features along the way, and [AI] will be way better than it is today."

3. Google has created a form of artificial intelligence that can learn without human supervision. Google's researchers tested and improved its abilities by making it play:

D. Go

Google's researchers fed its AlphaGo Zero neural network the rules of Go and let it learn by playing against itself, without any human supervision. With each victory and loss, AlphaGo Zero learned more about how to play the game. In less than five days, AlphaGo Zero was better at Go than the best human players.

4. Microsoft developed its latest version of the Azure IoT software suite with input from companies including:

D. A and B

Rolls Royce and Hershey — yes, the candy-bar company — had used a previous version of Azure. They helped Microsoft simplify the process by which customers could customize the software suite to their needs. (U.S. Robots, by the way, isn't a real company; it's a creation of science-fiction writer Isaac Asimov.)

5. Before the Internet of Things could tell manufacturers how consumers use products, "you talked with customers to get feedback," says Steve Chalgren, chief technology officer at cloud software company Arena Solutions, "But that's like _____."

B. A crime scene where everything is remembered inaccurately

Chalgren said, "Now you can see whether people are actually using a particular feature. It becomes this virtuous cycle of product information."

6. Collaborative robots were invented:

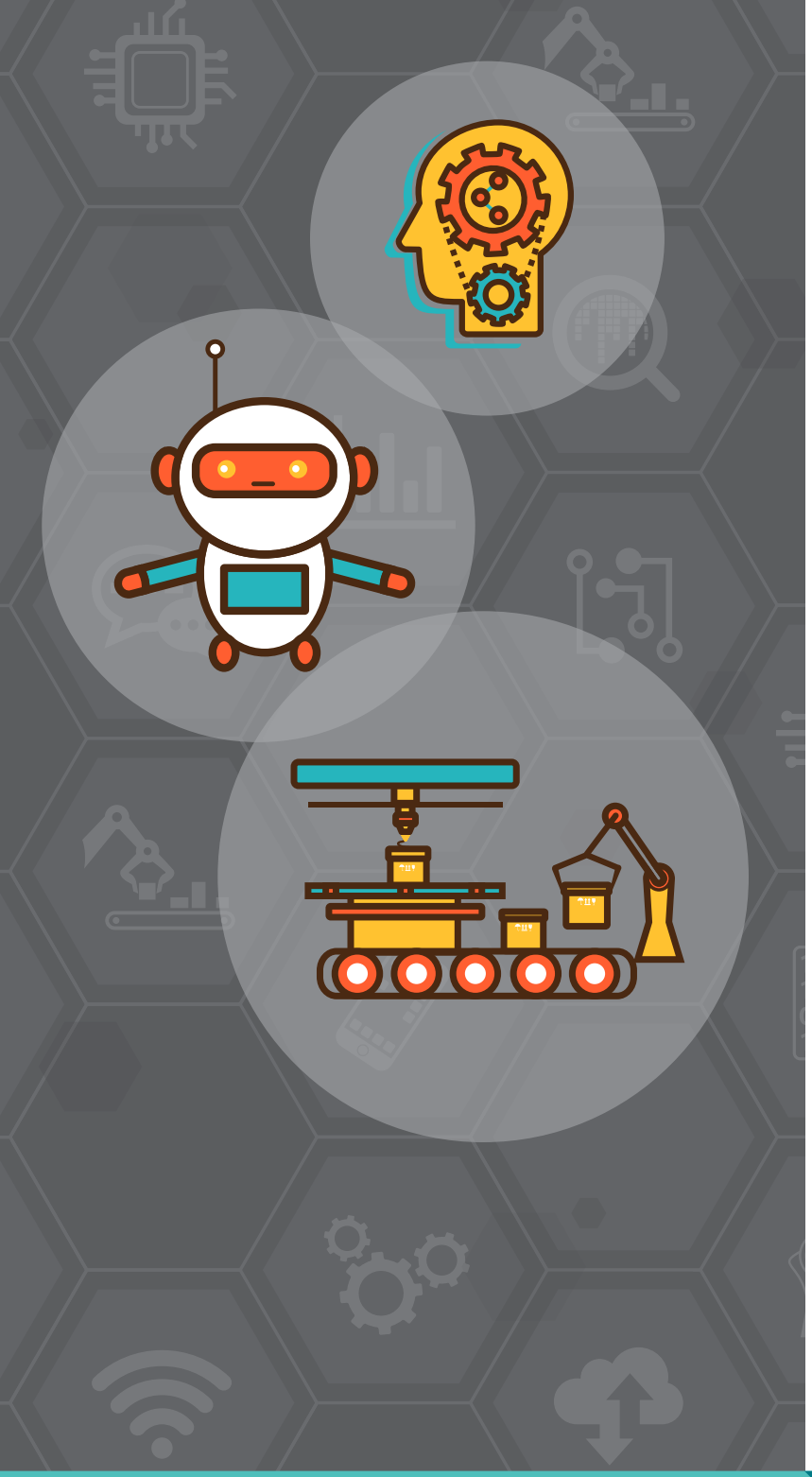
C. At Northwestern University in the 1990s

Northwestern professors J. Edward Colgate and Michael Peshkin invented these friendly bots in 1996. Their 1997 U.S. patent filing describes a cobot as "an apparatus and method for direct physical interaction between a person and a general-purpose manipulator controlled by a computer." (Stephanie Kwolek, by the way, invented Kevlar.)

7. Masayoshi Son, CEO of tech investor SoftBank, has predicted that in 2021, the world will have:

D. A trillion Internet of Things devices

Son announced in late 2016 that he expected a trillion connected devices within five years. His crystal ball also predicted that 2021 would have 1.8 billion PCs and 8.6 billion mobile devices.



Smart manufacturing is turning the old-fashioned factory into a living body. The connected systems of a manufacturing plant will pulse with news about its activities, just as your eyes, feet, and other organs constantly feed you news about what they're doing and how well they're managing. Robots, constantly improving their skills and alert to stimuli thanks to their swift and subtle sensors, will be as responsive as your own hands.

That's the dream, at least. Reality runs a little messier, as we all know. But even if smart manufacturing runs into bumps and barriers, it offers a better way to create tomorrow's products.

Welcome to the industrial future.

Courtesy of UBM Advanced Manufacturing Group

UBM