Fourth Industrial Revolution

This article is part of the Digitalization Applications 101 Technology Training Course, which provides a comprehensive understanding on the basic concepts of digitalization terminologies, technologies and its applications in the steel industry. The course was developed by the Digitalization Applications Technology Committee as an introductory course to educate industry personnel in digitalization.

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The Fourth Industrial Revolution (Industry 4.0) is the ongoing transformation of traditional manufacturing and industrial practices combined with the latest smart technology.[1] Digitalization, smart manufacturing, as well as a few other terms all relate to Industry 4.0. At its core, Industry 4.0 makes use of digital technologies to improve business. This means business and manufacturing information (data) that is natively digital or digitized can come together and be used to solve complex business challenges.

Industry 4.0 includes many subcomponents such as big data, artificial intelligence and additive manufacturing. When each subcomponent is examined individually, it is apparent that data collection and analysis is a key feature of Industry 4.0 operations. This article will discuss a few key segments of technologies within Industry 4.0 such as Internet of Things (IoT), autonomous robotics, data collection, big data and cloud computing.

Additive Manufacturing

Additive manufacturing, also known as 3D printing, references the process of creating physical objects through the layering of melted or semi-melted substrate. Common substrates are polymers, composites, metals, ceramics and edible materials. Computer-aided design (CAD) software is utilized to design three-dimensional objects that can then be manufactured. Advancements in additive manufacturing have created many advantages within industrial market segments, including the rapid design and prototyping of equipment and maintenance-related parts.

Artificial Intelligence/Machine Learning

Artificial intelligence is a subset of computer science that focuses on the development of systems that can mimic certain human behaviors, such as learning and problem-solving. The advancement of computing systems in the 21st century has enabled the development of systems that can handle much more complex algorithms in much less time. Utilizing machine-learning algorithms, a corporation can now perform tasks that were once unfathomable. A corporation can now easily predict when a bearing will fail on a piece of equipment, identify which customers will potentially leave within the next quarter and hire employees based on their likelihood to succeed within the organization.

Augmented Reality

Augmented reality is an interactive experience between the real world and overlaid computer-generated sensory information. This information could be in the form of visual aids, audible queues or even haptic, somatosensory and olfactory forms. Through the implementation of an augmented reality headset, a production worker would not only be able to see and perform their job as usual, but also see additional information about the equipment or process displayed over the task.

Autonomous Robotics

Autonomous robots, also known as autorobots or autobots, perform tasks without external influences. The key components and criteria for a robot to be considered autonomous include self-maintenance, sensing the environment, task performance and autonomous navigation. With the implementation of autonomous robotics, corporations can remove process variability while decreasing the need for human interaction related to dangerous tasks.

Data Collection

Implementing data collection across the manufacturing space creates the need for robust data storage solutions. Three common local/on-premises data storage architectures include server-attached storage, network-attached storage and storage area networks.[4] There also exist many off-premises options for storing data in the cloud. Choosing the right data storage architecture is directly influenced by the needs and resources of the organization and required reliability and performance needs. Additionally, organizations must find a solution that balances optimal performance with budgetary restraints.

Big Data/Big Data Analysis

Big data is data that contains greater variety arriving in increasing volumes and with ever-higher velocity. This is known as the three Vs.[10] With recent developments in data storage solutions, corporations can now store much more data at a substantially lower cost. The availability of substantially more data allows for richer data analysis and the ability to confirm data veracity. By leveraging the ability to analyze big data, corporations can confidently gain operational insights and implement change.

Cloud Computing

Cloud computing is the on-demand online availability of computer resources such as data storage, computational processing and software. Cloud services rely on shared resources and economies of scale to provide a pay-as-you-go service for corporations. Through the utilization of cloud computing, corporations can access data, computational resources and software at an advanced rate while keeping setup and maintenance costs minimal.

Figure 1

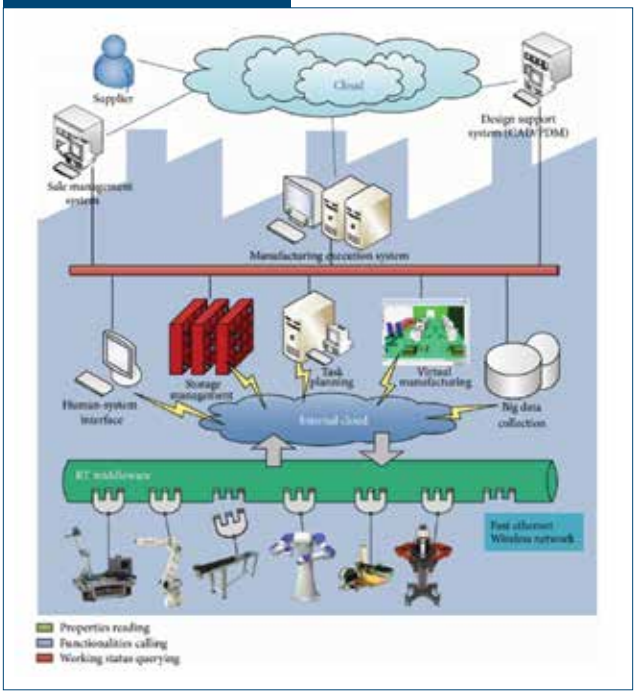

Illustration of connectivity and data collection at a digitalized manufacturing facility.[7]

Cybersecurity

Cybersecurity is the practice of defending computers, servers, mobile devices, electronic systems, networks and data from malicious attacks.[11] A few key components of cybersecurity include network security, application security, information security, operation security, disaster recovery and end-user education.

Edge Computing

Gartner defines edge computing as "part of a distributed computing topology where information processing is located close to the edge, where things and people produce or consume that information."[12] In layman's terms, edge computing is the practice of relocating processing centers near the data source to greatly reduce latency issues. Additionally, there is potential monetary savings associated with performing data processing and computations on-site rather than in a remote centralized location or in the cloud.

Internet of Things

The Internet of Things is a network of physical devices and other items embedded with electronics, software,

sensors, and connectivity that connect and exchange data. This network allows the transfer of data from physical devices such as manufacturing equipment to a data storage solution without the need for human interaction. When industrial applications and IoT are combined, it is often referred to as IIoT or the Industrial Internet of Things. Combined with operational technology (OT) monitoring devices such as smart sensors, IIoT can help regulate and monitor industrial systems to increase efficiencies, reduce downtime via predictive maintenance, and analyze real-time and historical data patterns.

Simulation

Simulation is the process of producing an approximate replication of a real physical process.[13] The three key types of models currently utilized today are active models, interactive models and computer simulations. Through the utilization of simulations, corporations can fine-tune safety protocols, work on process efficiencies, optimize operations and even replicate dangerous environments for safety training.

System Integration

There are many things to consider, plan and implement on the journey into Industry 4.0. Implementing the steps toward digitalization will require commitment from executives and senior management. The business will need to consider what resources and personnel will be required for each part of the implementation plan. IT resources, electrical engineers, automation engineers, data engineers, data analysts and machine learning engineers will all potentially have some role in this plan. Each of these roles could be filled by current employees, new employees or outside contractors. Additionally, appropriate connectivity protocols between the systems and the "outside world" must be implemented prior to beginning data collection efforts. In addition to the cost of initial equipment purchases and installation, organizations must budget for increased operations and maintenance costs associated with the added infrastructure of Industry 4.0 systems.

Summary

Each of these technologies are tools in a digitalization toolbox that can be used individually or combined to address business or manufacturing challenges whereby digital information becomes the foundation of the business.

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