Cognishen Focus

Industry 4.0 and Smart Factory

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Our February 2023 newsletter described forefront technologies, an Industry 4.0 component and the root component of smart factories. To recall, a smart factory may be visualized as one equipped to collect data, analyze the collected data, and use the data to make intelligent operations decisions. We will continue to discuss the components of Industry 4.0 in simple terms in this newsletter.

Forefront technologies such as system integration, cloud computing, and cyber security help smart factories to gainfully use the basic necessities in order to be competitive. The forefront technologies fend off cyber invaders, use a firm resources wisely, and deploy well-integrated systems to achieve the strategic goals of an organization. But that is not enough! Smart factories must use the "state-of-the-art" **smart systems** to be adept and agile. The forefront technologies in place can be used in deploying the smart systems. The components of smart systems include Internet of Things (IoT), additive manufacturing, and simulation. Let us take a look at the Figure 1 below. The forefront technologies are used by the smart systems, which in turn drive the intelligent automation that is required of smart factories.

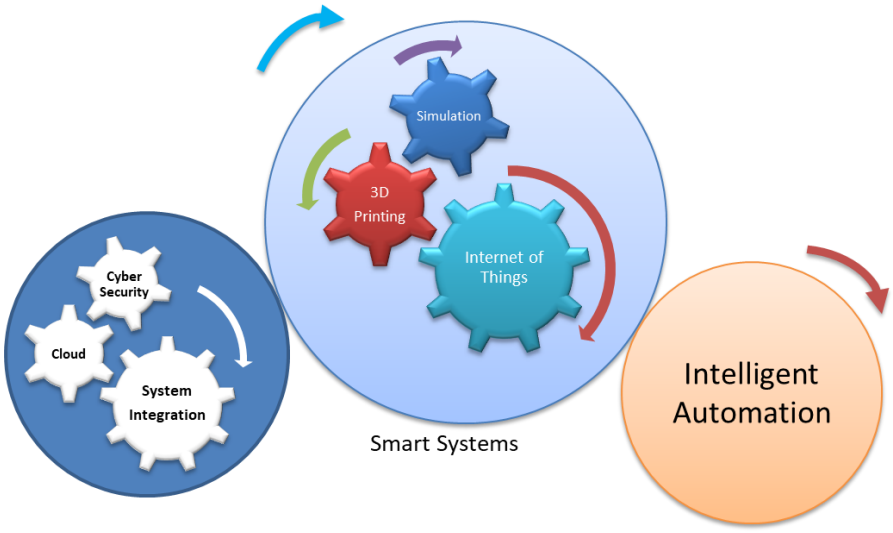

Figure 1 Digital Transformation Components of Industry 4.0

Internet of Things (IoT)

It is common nowadays for humans to monitor their glucose level, animals to be watched using radio frequency identification (RFID) tags, and automobiles controlled using sensors through Internet. The devices are assigned an internet protocol (IP) address so that they can transfer and share the data over the network. The Internet of things (IoT) is a term used for machines or other physical objects equipped with sensors and software. A sensor is a device that senses a physical phenomenon. For example, a thermometer is a device that senses the physical phenomenon—the temperature of a human body. Devises and machines can process the sensor output using software that is built in the device and transfer the sensed information to a computer. Sensors can connect and exchange data with each other and other devices and systems over the Internet.

Our body is a classic example of sensor fusion. Humans sense by their vision, hearing, smell, taste, and touch. This sensory information travels to the brain for processing though our nervous system. For example, you go to a store and find a desk that you like. Your eyes sense the grey-colored desktop, your fingers sense the smoothness, your nose and ears sense the environment around the desk.

Research Insight

"Concerning all the technologies of Industry 4.0, it is necessary that engineers need to improve their professional, social, methodical and personal competences. The ***manufacturing engineers need an interdisciplinary understanding of systems, production processes, automation technology, information technology, ergonomic principles and of business processes****. In addition, the skills for cooperation and communication in interdisciplinary groups are of crucial importance.* ***The modern engineer in Industry 4.0 must have a holistic perspective on complex production systems.*** *"*

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"Additive manufacturing (AM) does not necessarily imply building parts, as it also refers to innovation in materials and novel combination of properties between systems and materials. The most exciting features of AM are related to the development of radically new systems and materials that can be used in advanced products with the aim of reducing costs, manufacturing difficulties, weight, waste and energy consumption.

An intelligent directed energy deposition (DED) technology, capable of handling the science and operational aspects of the advanced AM applications has been identified. The novel robotic AM system is designed for processing metals and alloys such as aluminum alloys, high-strength steels, stainless steels, titanium alloys, magnesium alloys, nickel-based superalloys and other metallic alloys for various applications."

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These senses are sent to your brain. The brain fuses all the sensory inputs to result in what you see—a smooth grey-colored desktop in its store environment. In the world of smart factories, sensor fusion plays a similar role. By integrating inputs from multiple sensors, the sensor fusion produces prominent levels of recognition that results in accurate and reliable information than individual sensor data. The basic purpose of IoT is to let devices self-report sensed data in real-time and use sensor fusion to provide accurate information. From machines in a factory to refrigerators in a house, IoT can extract data and provide that data to maintain devices or for further analysis to use those devices effectively and efficiently.

Additive Manufacturing or 3D Printing

Additive manufacturing or 3D printing creates a three-dimensional object from a digital 3D computer model. Traditional manufacturing includes subtractive, net shape, batch, and continuous processes. In the more common processes like subtractive process, objects are made by the removal of material until the final product is complete. Additive manufacturing is the process of adding layer on layer of material to make a finished product. The process uses data from computer-aided design (CAD) software or 3D object scanners to direct robots to deposit, join, or solidify material and make objects, typically layer by layer over a base layer of material.

One of the main advantages is that there is not much wastage of material in this process. It is economical to produce a smaller number of parts. Since the amount of material removed is less, the process results in a lower cost and more efficient use of the material than is possible in most traditional manufacturing techniques.

To create an object using additive manufacturing, a design of the final product is completed first using the CAD software. The CAD software then translates the design into a layer-by-layer framework for the additive manufacturing machine. The framework is sent to the 3D printer, which creates the object. Additive manufacturing uses many materials, from polymers, metals, and ceramics to foams, gels, and even biomaterials.

There are several additive manufacturing techniques including material extrusion, photopolymerisation, , material jetting, binder jetting, powder bed fusion, directed energy deposition, and sheet lamination.

Simulation

Many large companies have been using simulation models for a long time in the research and development of their products. Software such as Simulink have been in existence from the early 1990s. Simulation is a computer model whereby firms mimic an operation of an existing or proposed system. By using a simulation model, a company can test various scenarios of the existing or proposed system. The results from a simulation model can provide important information to make decisions. Firms use simulation to understand, enhance, and optimize manufacturing and service systems. Over the years, simulation has evolved and smart factories can use the new simulation techniques to enhance manufacturing technologies. For example, simulation can be used to investigate various workload and delivery scenarios to estimate the time required for delivery of products. Simulations of production processes provides the knowledge of machine downtimes and helps engineers to shorten downtimes and changes so that they can reduce the possibility of production failures. Simulation has been used extensively to reduce supply chain risks and find solutions to transportation problems.

Practical Insight

"L'Oréal, the French personal care company, has been using additive manufacturing for a long time to make packaging prototypes, prototype injection molds, quality control tools, and spare parts. Out of its 40 factories worldwide, 23 of them are equipped with additive manufacturing capabilities. Using a technology called laser powder bed fusion, L'Oréal uses additive manufacturing to make the La Maison Jasmins Marzipane Lancôme collection. Additive manufacturing has shortened the lifecycle for the company."

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"Sensor fusion is essential when firms use Automatic Guided Vehicles (AGV) on factory and distribution center floors. Sensors act as the "eyes and ears" of AGV. Sensors are used for functions such as navigation, guidance, safety, material handling, and obstacle avoidance of AVS. Different sensors are used for different functions. For example, safety bumper contact sensors are used to stop the AVS in case of contact with any object such as a person, pallet, or machine. Safety Laser Scanners—sensing devices designed to protect personnel from injury—scan an area, and, if a person or object is detected, a signal is sent to stop the nearby machine or hazard to prevent injury."

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