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# THE ESSENCE OF INDUSTRY 4.0

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***ABSTRACT:*** *Industry 4.0 refers to the current trend of automation and deployment of Internet technologies in manufacturing. This includes using machine-to-machine and Internet of Things (IoT) deployments to help manufacturers implement increased automation, improved communication and process monitoring. This trend of Industry 4.0 (sometimes referred to as the 4th Industrial Revolution) affects most processes and people throughout society. This paper provides a brief introduction to Industry 4.0.*

***KEY WORDS:*** *Industry 4.0, fourth industrial revolution, intelligent manufacturing, smart factory*

## I. INTRODUCTION

The first industrial revolution witnessed the transition from manual agricultural and material production using small tools and very basic machines to large-scale mechanized factories in the 19th Century. The second revolution spanned the period from the 1850s to World War I and saw the age of steam and fossil fuel-based power and the electrification of factories. The third industrial revolution took place from late 1950s to late 1970s and saw the age of electronics and computerization, with an eventual change from analog to digital technology. Finally, the fourth industrial revolution is upon us and promises a move towards full digitization and automation of manufacturing processes [1]. The four revolutions have resulted in radical changes in the manufacturing process and disruption of the workforce. These changes are illustrated in Figure 1 [2]. The fourth industrial revolution is commonly referred to as Industry 4.0.

The prevalence of the Internet of things in manufacturing and the consequent technology-driven changes have triggered a new industrial revolution which is known as Industry 4.0. It is a convergence of two worlds: Information Technology (IT) and Operational Technology (OT). The term "Industry 4.0" emerged from the German term "Industrie 4.0," which was first used in 2011 in a project sponsored by the German government that was focused on promoting computerization of manufacturing [3]. To meet the challenges of traditional manufacturing, Germany introduced the concept of "Industry 4.0," the Chinese government put forward the concept of "China Made 2025.", while the United States proposed the concept of "Industrial Internet" [4].

## II. FUNDAMENTAL CONCEPTS

Industry 4.0 collectively refers to a wide range of current concepts, processes, and technologies [5]:

- **Required Technologies:** As shown in Figure 2 [6], the required technologies for Industry 4.0 transformation include cloud computing technologies, Internet of things (IoT) technologies or Industrial Internet of things (IIoT), cyber physical systems (CPS), advanced materials, additive manufacturing, cloud manufacturing, artificial intelligence, machine learning, cybersecurity, big data analytics, cognitive computing, autonomous robots, and mobile services. These are the technologies that are transforming industrial production.

- **Smart Factory:** This is where the Internet, wireless sensors, and other advanced technologies work together to optimize the production process, reduce manufacturing variability, and improve customer satisfaction. Industry 4.0 is an emerging network approach where components, processes, and machines are becoming smart. Factories will gradually become highly automated and self-monitoring as the machines are given the ability to communicate with each other and their human co-workers. The smart factory has overcome vendor-specific, stand-alone solutions and creates a solid base for cross-vendor solutions within the manufacturing environment. Manufacturing will be equipped with sensors, actuators, and autonomous systems and will be decentralized.

## III. DESIGN PRINCIPLES

As shown in Figure 3, there are four design principles [7] in Industry 4.0.

- Interconnection: The ability of machines, devices, and humans to connect and communicate with each other via the Internet of Things (IoT). This requires collaboration, security, and standards.
- Information transparency: The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with vast amounts of sensor data augmented by data analysis and provision for retention, analysis, and association of that information with relevant simulation models and operating protocols to handle normal operations as well as exception events.
- Technical assistance: This refers to the ability of CPS to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers. This requires visual and physical assistance.
- Decentralized decisions: The ability of CPS to make decisions on their own and to perform their tasks as autonomously as possible. Their tasks are delegated to a higher level only when there is interference, conflicting goals, or an exception event.

## IV. APPLICATIONS

One of the original objectives of Industry 4.0 was serving small and medium enterprises (SME) first. The major applications of Industry 4.0 are smart factory, smart manufacturing, smart product, and smart city [8]. Industry 4.0 has also been applied in semiconductor industry, furniture industry, aluminum industry, food industry, automotive industry, and mining industry. Those who promote Industry 4.0 claim that it will affect many areas such as services and business models, productivity, machine safety, product lifecycles, and industry value chain.

## V. BENEFITS AND CHALLENGES

Industry 4.0 will increase productivity, cause macroeconomic shifts, foster industrial growth, increase production speed, and boost employment and productivity. It benefits the factory, business, products, and customers [9]. It has potential to positively affect meeting individual customer requirements, production flexibility, data-driven decision-making, better customer proximity, efficiency, value creation opportunities through new services, and a competitive economy. Businesses everywhere can benefit from embracing Industry 4.0. This will create wealth and plenty of job opportunities. Industry 4.0 may benefit emerging economies such as India

However, companies face formidable challenges in the adoption of Industry 4.0 because it is hard to achieve. The challenges in the implementation of Industry 4.0 include [10]:

- Unclear legal and data security issues
- Threat of redundancy of the corporate IT department
- Disruption of current employment patterns through loss of many jobs to automated processes
- Reliability and stability needed for critical machine-to-machine communication
- Need to maintain the integrity of production processes
- Lack of adequate skill-sets to expedite the march towards fourth industrial revolution
- General reluctance to change by stakeholders
- Unclear economic benefits/ excessive investment
- Lack of regulation, standards, and forms of certifications
- Heterogeneity of the systems involved and integrating data from various sources
- Increasing age of employees and globalization of markets
- A new generation of machines may be required to participate in Industry 4.0

All contributing parties will need to collaborate well to overcome the challenges mentioned above.

## VI. CONCLUSION

Industry 4.0 is the current gradual industrial transformation with automation, cloud computing, cyber-physical systems, robots, and industrial IoT to realize smart industry and manufacturing. It is the new manufacturing objectives and with the aim of achieving nearly zero-defects production in the manufacturing industry. Today, the fourth industrial revolution is transforming economies, jobs, and society itself. Like any revolution, Industry 4.0 is disruptive and is rapidly changing the industrial landscape. More information about Industry 4.0 can be found in [11].

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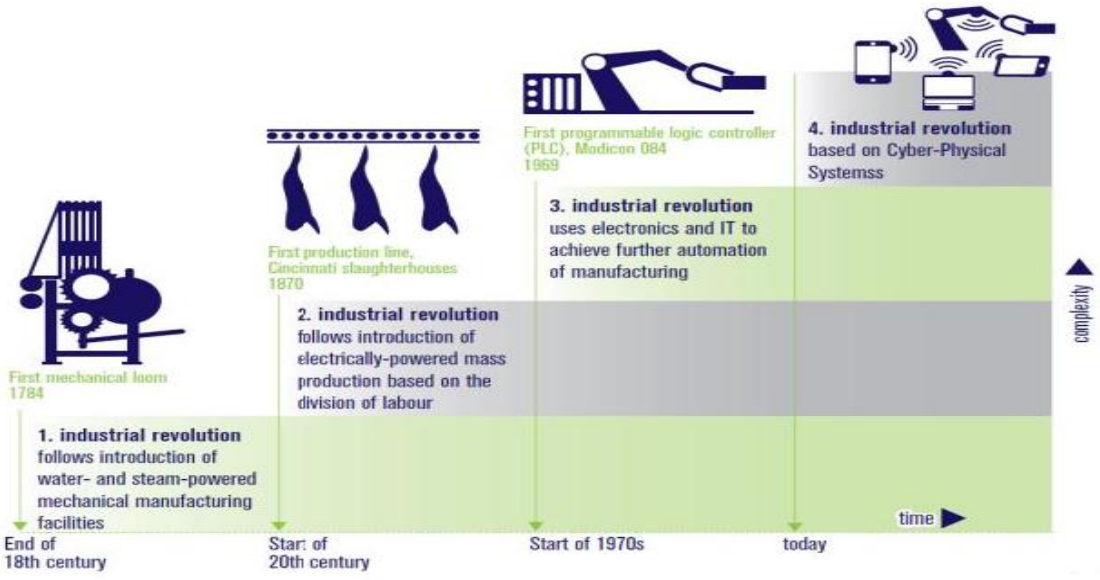


Figure 1. Four stages of industrial revolution [2].


Figure 2. Key technologies for Industry 4.0 [6].

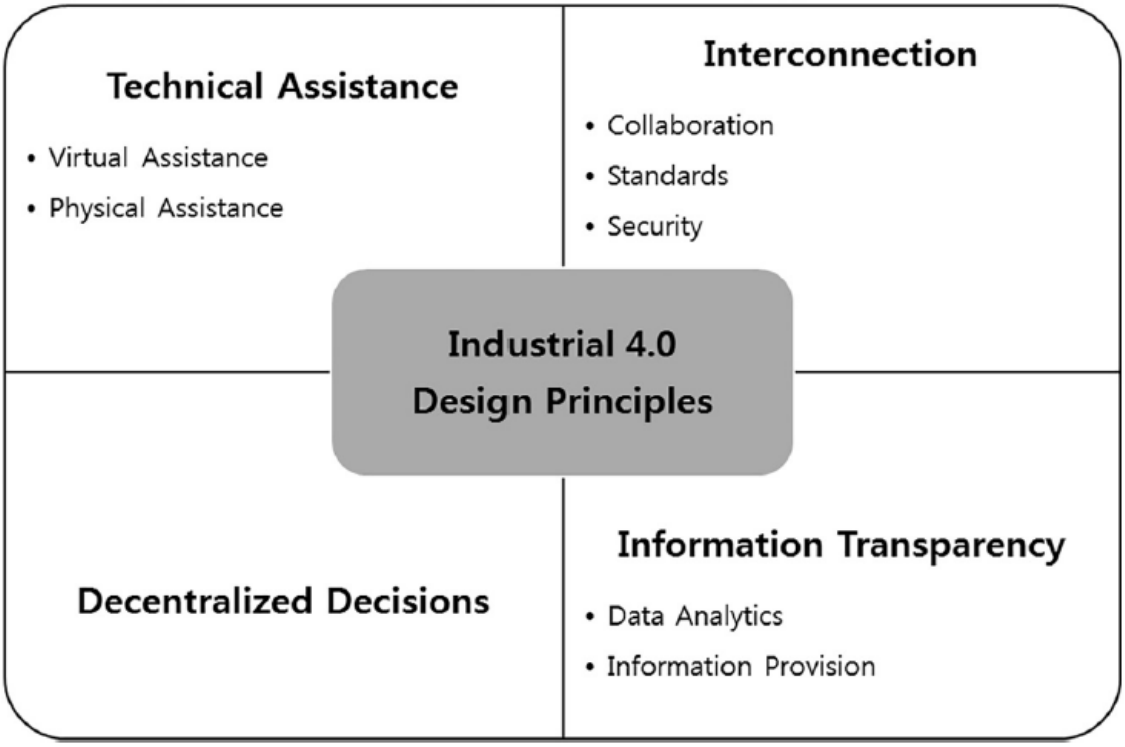


Figure 3. Four design principles in Industry 4.0 [7].