



Industry 4.0: Manufacturing Informatics-driven Innovation

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Abstract

This article introduces the background, core technologies, and future challenges of Industry 4.0. Unlike previous industrial revolutions, Industry 4.0 relies on emerging technologies such as the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) to drive intelligent and sustainable development in manufacturing. Major global powers like Germany, the United States, and the United Kingdom have proposed relevant strategies aimed at accelerating the digital transformation of manufacturing industries. The article emphasizes the critical role of Manufacturing Informatics in achieving Industry 4.0, as it integrates computer science and engineering to enhance management efficiency and resource conservation in companies. Furthermore, the article explores various challenges posed by Industry 4.0, including sustainable development, high costs, and employment concerns. Despite these challenges, the advancement of Industry 4.0 remains inevitable. In the future, as Manufacturing Informatics continues to evolve, Industry 4.0 is expected to drive more efficient and intelligent production models, leading to new technological breakthroughs and the creation of more job opportunities. The article also forecasts the potential arrival of Industry 5.0, where manufacturing may increasingly focus on human value and social responsibility.

Keywords

Industry 4.0; Artificial Intelligence; Sustainable; Digitalization

1. Introduction

England from 1759 started to convert manual production to mechanized production, which we called this transition as the Industrial Revolution, also known as the First Industrial Revolution. Today, with the development of modern society and manufacturing technology, we usher in Industry 4.0 or The Fourth Industrial Revolution, an age different from the previous age and industrial revolution of using steam power, electricity, and information technology for manufacturing [1], besides, it's also an age based on the Manufacturing Informatics.

2. Definition of Industry 4.0

What is Industry 4.0? As mentioned above, Industry 4.0 is far different from the past, it is on the basis of the definitions of the first three Industrial Revolutions [2]. on the one hand, emerging technologies lets us have the possibility to create a new industrial production system, which can combine all the factor of production into one, on the other hand, the improvement of production management level leads to intelligent and efficient production, the mainly definition of Industry 4.0 is to use the emerging technologies and the improvement of production management to create a highly efficient and intelligent production mode [3]. Frankly speaking the key words of Industry 4.0 is Intelligent and Sustainable.

3. Industry 4.0 Policies of Major Countries

Over the past few years, many governments have introduced plan, such as Germany – ‘High Tech Strategy 2020’ and ‘Industry 4.0’; the United Kingdom – ‘Future of Manufacturing’ (Foresight Citation 2013); the United States – ‘Advanced Manufacturing Partnership’ (President’s Council of Advisors on Science and Technology Citation 2014). Judging from the policies of these major countries in the world, the current status of Industry 4.0 is just like the newborn sun, which is full of power to light the human history. Besides, for our Individuals, Industry 4.0 has already influenced our daily routine, such as Tik Tok, which is one of the most popular social applications, based on the technology of the Big Date, one of the most important components of the Industry 4.0. In addition, nowadays, enterprises focusing on manufacturing are facing digital transformation, so there is no doubt that they should hold the chance given by Industry 4.0, such as Bosch AG, they are one of the first companies to participate in Industry 4.0. In 2011, they proposed the idea of Industry 4.0 with the German National Academy of Sciences Leopoldina [4], and it was soon picked up by the Federal Ministry of Education and Research, this proposal made Germany become the first country that began to carry out Industry 4.0 [5].

In general, compared with the past Industrial Revolution, it’s not hard to find out the components of Industry 4.0. Here are the three important components of the Industry 4.0. First and foremost, based on the third industrial revolution and automation technology, we built the Internet of Things (IoT), which allows Information sharing between devices and systems through sensors and networks, obviously without the Internet of Things, it’s hard to achieve highly centralized production, Besides, the Big Date also play a great role in Industry 4.0, that’s because industrial workers can know the demands of the market by analyzing the date. Last but not least, Artificial Intelligence (AI), can analyze the dates faster than before, predict the future demands of the market, and help people make better decisions. Apart from those three major components of Industry 4.0, there are some other components like Embedded Systems, Cloud Computing, and Virtual Reality (VR).

4. Role of Manufacturing Informatics in Industry 4.0

For the purpose of achieving Industry 4.0, we have to use the knowledge of Manufacturing Informatics, the reasons are as follows. To begin with, Manufacturing Informatics is an interdisciplinary subject, which combines computer science, engineering, and informatics, so in order to achieve the technique I just mentioned above, practitioners have to learn this subject. Besides, as I just mentioned above, after we fully understand the main knowledge of Manufacturing Informatics, it’s not hard for us to participate in Industry 4.0, that’s because not only those companies but also our country need the people who study this subject to carry out their digital transformation, so there is a huge gap in this era, and I think it’s not only a gap but also a chance. At last, the concept of high-quality development is gradually gaining popularity, and Manufacturing Informatics can help companies to manage all aspects of the production process, which can reduce the waste of resources, thus our society can achieve sustainable development.

Manufacturing Informatics not only meaning of technology but also organizational to Industry 4.0. In some cases, technology is the cornerstone of the development of the industrial age, without those emerging technologies, it’s hard to tell what age we live in. In other cases, like the old saying goes, “With people united, Mount will move”, good organization and management is significant to production, it’s more important than technology in some condition. If an enterprise wants to develop better and achieve transformation, they have to take Manufacturing Informatics seriously. Siemens AG, a traditional company whose business includes automation and digitalization industries, proposed “Towards Industry 4.0 - Leading the process of digital enterprise” in 2015, They vigorously developed the Internet of Things and big data technologies, so they can achieve digital transformation easily than other enterprise.

After learning the story and achievements in manufacturing informatics given by the company such as Siemens and Bosch, we can easily predict a technical blueprint for Industry 4.0. On the one hand, some old technologies have improved and become better than before. Such as IoT, emerged at Carnegie Mellon University as early as 1982, at first, it was just a new kind of Coca-Cola vending machine that could connect internet to check cola stock, but after forty years of development, IoT become much more intelligent than before, and it can be used not only just a cola machine but also all aspects of society, such as automobile industry, GM has changed an old technology called OnStar into a new one based on the Internet of Things, which connect our car and internet, and after something urgent happened, this technology can protect the safety of drivers. On the other hand, there will be many new things invented by scientists, such as ChatGPT, based on Artificial Intelligence, Big Data, and other new technologies, which not only can answer the questions given by us and do some programming missions but will also bring huge changes to

our daily life. In this blueprint of Industry 4.0, I think with the development of ChatGPT, manufacturing won't need employee work on the job like traditional documents and programming, that's because ChatGPT can deal with those kinds of work, which will cause a large number of people lose their job. certainly, every coin has two sides, even though, ChatGPT makes some people lose their job, there will still be lots of new jobs created by ChatGPT, besides, this new technology will help manufacturing to improve work efficiency by reducing those repetitive works, let people have more time to focus on what's really important in production, besides, it goes without saying that ChatGPT and other Advanced Technology will become indispensable in building smart factories.

5. Challenges Brought by Industry 4.0

Industry 4.0 still needs to face lots of barriers and challenges like sustainable development, high cost, and employee issues, and I think the most important one is sustainable development. We cannot ignore the potential problems of the environment such as waste of resources, ocean pollution, and acid rain, The United Nations Environment Programme regards Industry 4.0 as a "new economic paradigm – one in which material wealth is not delivered at the expense of growing environmental risks, ecological scarcities and social disparities" (United Nations Environment Programme, 2011) in that case, we must take sustainable development into consideration. Not only companies but also our individuals should think about how to keep sustainable development under the condition of our world having to do the digital transformation. Besides, I think employee issues are also a major challenge, for one thing, like I just said before, some emerging technologies might let some people lose their jobs, so governments have to face the problem of dealing with the unemployment problem, furthermore, emerging technologies ask practitioners to equip new knowledge and skills to get used to those emerging technologies, so here comes a challenge, whether they can overcome that? No one knows for sure. So human-centric should be taken seriously.

Even though there are some barriers and challenges in the way of Industry 4.0, Industry 4.0 is still worth pursuing. One aspect, none of us can hold back the wheel of history, we can easily see from the past few years that under the age of Industry 4.0, global manufacturing is slowly getting together, like Lithography Machine, there is no country can build it on their own, even the most powerful country in the world, that's the main reason why ASML employs top scientists from all around the world, and Air Bus, they have established production lines all over the world, every single big company knows they should take the advantage of the fact that global manufacturing is slowly getting together. Another aspect, After the COVID-19 epidemic is over, the global economy needs to recover, under this circumstance, some people think we should stop the Industry 4.0, it's absolutely wrong, we can use more emerging technologies to create some new stuff to stimulate consumption and economy recovery.

Otherwise, Industry 4.0 can promote innovation, just like the slogan proposed by the Chinese government, "Mass Innovation, Mass Entrepreneurship", so Chinese economy is growing rapidly in the past few years, and during that period of time, I can feel innovative ethos spread in society and school, so I participated in the National College Student Innovation Competition, although I didn't win any kinds of prizes, but my cognition of related fields like materials and computer programming has also been enhanced by consulting professors and learning by myself on the Internet, all in all, innovation is also a learning process. I think this sentence is not just for people but also for society.

All in all, the information generated by the integrated systems, sensors, and intelligent machines needs to be translated into useful insights and recommendations for more informed decision-making and hence the need for solid data analytics systems [6]. Besides, these challenges and barriers also suggest several avenues for future research: First, additional data sets of Industry 4.0-related use cases can be examined. Second, multiple in-depth case studies can be used to study in more detail the drivers, success factors, and challenges associated with Industry 4.0-enabled SCI. Finally, the business impact, especially improved productivity, can be analyzed to determine the actual benefits of digital SC transformation [7]. Therefore, under the conditions of Industry 4.0, new obstacles and challenges are driving the transformation of factories towards a digital future.

6. Conclusion

How should we face the challenges and seize opportunities? Firstly, Industry 4.0 is an age of diversification [5], and Manufacturing Informatics is an interdisciplinary subject, that combines computer science, engineering, and informatics, so if we only learned the knowledge of Mechanical Engineering, we wouldn't adapt to the changes brought by Industry 4.0, seriously, we might be abandoned by those big companies which are doing digital transformation, so we need learn knowledge of various subjects. In addition, as so many companies are undergoing digital

transformation, we should take full use of the chance to visit them, and learn about emerging technologies in the industry and those advanced management experience, maybe someday, we can use those emerging technologies and advanced management experience to carry out our own career, I believe it's precious wealth in our own life, especially as young people. Last but not least, with the development of modern society and history, the speed of technological upgrading is much faster than before, so we should keep learning and improving ourself, like attending some training course or take part in some seminars.

In summary, like the past industrial revolution, Industry 4.0 is part of the human's history, so we can't hold it back, it's totally worth pursuing. Besides, due to the emerging technologies invented in the past few years and the changes of people's attitude to technology, we can face the status of those companies' productivity greatly improved than before. During this process, we still need forces on the knowledge of Manufacturing Informatics, without this, we can't invent those emerging technologies. In addition, in the age of Industry 4.0, there are still lots of barriers and challenges, like sustainable development, high cost and employee issue, we can't ignore those problem, and I think we can overcome it as time goes on, maybe one day after we solve those problems, we can see the coming of Industry 5.0, let's do a simple predict, at that time, industry might don't need emerging technologies to drive the production, but value-driven, under that condition, our human will our humans will have a better future.

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