A Study on the Change of Manufacturing Design Process due to the Development of A.I Design and 3D Printing

Chun Hyunjin1,*

1 School of Arts, Nanjing University of Aeronautics and Astronautics, No. 29 Jiangjung Road, Jiangning District, Nanjing 211106, Jiangsu, China

*Corresponding E-mail: tough4324@naver.com

Abstract. The fourth industrial revolution brought about changes in various fields. The speed of the fourth industrial revolution will proceed faster than the previous ones. It is a new revolution in which new technologies are integrated. So the convergence of new technologies in the fourth industrial revolution will affect many areas. In particular, new technologies such as artificial intelligence and 3D printing technology are being used in the manufacturing industry. The fourth industrial revolution will change the manufacturing design process in the future. Predicted changes are as follows: First, existing management processes are divided into planning, design and manufacturing processes. The collection and analysis of many data are important in the planning process. This planning phase enabled data collection, processing and management through cloud computing and big data technologies. Based on these plans, artificial intelligence can produce thousands of design results. Next, based on the design plan, products can be produced in 3D printing. As such, the manufacturing process has been very simplified by 3D printing. The study can offer some solutions for social changing problems by predicting the future of manufacturing. And the results of the study can be used as a research base in the manufacturing design sector using artificial intelligence and 3D printing.

1. Introduction

1.1. Research Background and Purpose

Recently, the Fourth Industrial Revolution has brought about changes in various fields. The fourth industrial revolution is a convergence of information intelligence technologies such as artificial intelligence, Internet and big data, as well as new technologies such as 3D printing and robots. So all the products are connected and the product can solve problems on its own. The speed of the Fourth Industrial Revolution will proceed faster than the First, Second and Third Industrial Revolution. Some scholars argued that the Fourth Industrial Revolution was an extension of the Third Industrial Revolution. But the term "fourth industrial revolution" was first used at the World Economic Forum in 2016. The World Economic Forum declared that the Fourth Industrial Revolution would be different from the Third Industrial Revolution. The Fourth Industrial Revolution is a new revolution in which new technologies are integrated. So the convergence of new technologies in the Fourth Industrial Revolution will affect various areas. In particular, new technologies such as artificial intelligence and 3D printing technology are being used in the manufacturing field. While this is not yet practical due to the lack of technology in manufacturing, a variety of new technologies will be used in manufacturing in the future. It is expected that this technology will bring significant changes to the manufacturing...
design process as well. The environment of the design industry such as the fashion industry is rapidly changed from the human-involved production process to the IT and AI-based automatic production process (Jung Ju Ri etc. 2019). In particular, the manufacturing sector has a lot of interest at the government level. So a variety of researchers are researching manufacturing. However, while there is a lot of research on technology and methods in manufacturing design, there is a lack of research on the changes and social implications that these technologies will bring to the design industry. So in this study, current technologies for artificial intelligence and 3D printing were analyzed. Then, based on the results of the analysis, the applicability was analyzed in the manufacturing design field. It also predicted changes in society. This study can prepare for social change by predicting the future of the manufacturing industry. And the results of this study can be used as a basis for research in the field of manufacturing design using artificial intelligence and 3D printing.

1.2. Literature Review
The Fourth Industrial Revolution is recognized by researchers as an important issue. Thus, advanced countries are conducting various researches, including artificial intelligence related to the Fourth Industrial Revolution. So this study summarized the researches that were done concerning artificial intelligence and 3D printing. Lee Jae Ik (2018) suggested the direction of the next-generation convergence design based on the important issues and alternatives in each area, by analyzing the characteristics of the 4th industrial revolution and the design convergence of the 4th industrial revolution era [1]. Jung Ju Ri etc. (2019) examined the change in the environment of fashion design resulting from the fourth industrial revolution among AI-based innovative cases, and further draw its characteristics [2]. Kim Hye Eun (2015) investigated the changes taking place in the industrial field through the development of 3D printing and its meanings, and forecasting the changes in fashion and society through its popularisation and generalization, exemplified by a case study of 3D printing in fashion [3]. Jeong Won Joon etc. (2018) proposed the role of future designers and capabilities to be developed in the age of AI [4]. Han Jung yeob (2013) tried a comprehensive study on applying domestic and foreign 3D printing case to the analysis sheet [5]. Chun Ha bong (2017) analyzed on the convergence service design for designing users’ experience, through which users make conclusive data at the stage of using smart-connected product and service in daily life, extracted a concept and structure model of convergence design, through phases of business model, combination and analysis at the stage of use, and finally researched methodical access for corporate’s strategic utilization, for the purpose of designing the business model at such stage of use [6]. In previous studies, many studies have been conducted on the technical methods and solutions for manufacturing related to the Fourth Industrial Revolution. However, there is still a lack of research on how manufacturing industries can change due to the development of new technologies. Besides, the fourth industrial revolution is to converge information technology such as big data and mobile with new technologies such as artificial intelligence and robotics. There is also a lack of research on this convergence of intelligence information technology and new technologies. So in this study, I conducted a study on the convergence of artificial intelligence and 3D printing. Also, the application of these technologies in manufacturing and design was analyzed in this study. Lastly, the changes in the manufacturing design process were analyzed through these applications. These studies may be the theoretical basis for the field of manufacturing design using new technology.

2. Research Method
The research method in this study analyzed the characteristics and processes of manufacturing design through literature research related to artificial intelligence and 3D printing. In the literature study, the technology of artificial intelligence and 3D printing was analyzed through related papers, reports, and online data. It also analyzed the current situation of the manufacturing industry and predicted the future manufacturing design process due to the Fourth Industrial Revolution. In this study, I compared the existing manufacturing design process with the future manufacturing design method. The main research scope of this study is the design area. Through these changes in the design area, the future of
the manufacturing industry was analyzed.

3. A Theoretical Study on A.I Design

3.1. Artificial Intelligence
Artificial intelligence is a technology that a computer performs on its own, such as human learning, awareness, and understanding. In particular, the artificial intelligence field has developed as the development of the Internet has led to the collection of a lot of data. This is how computers collect data and learn on their own. A machine is a way to analyze certain patterns based on these data, predict future outcomes, and make appropriate decisions. This principle is based on the theory of neural net. A network is formed by connecting synapses to a machine as if it had nerves in humans. The machine can solve problems by changing the connection of these synapses. Artificial intelligence technology will enhance human life quality. And these artificial intelligence technologies will be utilized in various fields [4].

3.2. Artificial Intelligence Design
As artificial intelligence technology developing, it is being used in various fields. In particular, artificial intelligence is being used in the field of design that is in desperate need of creativity. Currently, a generative design technology based on artificial intelligence has been developed. Generative designs are provided with numerous design results when designers put into materials, manufacturing methods and prices. These technologies are based on artificial intelligence’s algorithms and cloud computing technology [4], which can produce hundreds of design results within a very short time. The process of creative design is as follows (figure 1). [7].

![Figure 1 Process of generative design](image)

Artificial intelligence technology will shift the design realm where creativity is required and necessary through ‘clouding computing’ technology that solves computation and ‘dip running’ that accumulates knowledge on its own. The generative design presents a reasonable design considering structural engineering, economics, and aesthetics when the designer enters the price and material into the computer after performing basic sketches. At the University of California, Berkeley, artificial intelligence’s Philip Isola research team is mainly conducting creative design research. By sketching an approximate product and typing it into a computer, the team can create thousands of designs through artificial intelligence [7-8]. These results can replace major tasks of designers by artificial intelligence. The results produced by the Philip Isola research team are as shown in Figure 2 [8]. These studies will be used in architectural design that is more complex than product design. So far, artificial intelligence has not produced creative results compared to designers. However, in the future, AI will create creative designs through digital platforms.
4. A Theoretical Study on 3D Printing

4.1. 3D Printing

3D printing is a method that completes product form by stacking digital files one layer at a time with the Additive Manufacturing method. 3D printing can complete a model using a three-dimensional modeling file using a rigid material. It has no special processes, allowing producers to make products at lower prices while bearing the advantage of being able to create necessary objects without limitations of time and space. 3D printing, as it were, is expected to revolutionize manufacturing. With the launch of the "Maker Movement" worldwide, 3D printing technology is becoming popular.

4.2. Application of 3D Printing

As 3D printing technology emerging, businesses that utilize 3D printing are becoming more popular around the world. For example, a private operator uses 3D printing to produce and sell small products. Hospitals also adopt 3D printing technology to make artificial organs. Furthermore, a company has developed a technology to make food through 3D printing, by which various types of food can be made using 3D printing. Because of these 3D printing technologies, drawing models for 3D printing is also becoming important. Many businesses use drawings for 3D printing. Producers who are not familiar with design may purchase 3D printed drawings created by designers. A site called ‘Thingiverse’, for example, offers a service to share drawings for 3D printing. The service is a way to make money by selling 3D printed drawings made by designers. This development of 3D printing has democratized the manufacturing industries. Capital led manufacturing after the Second Industrial Revolution. However, the development of 3D printing has special and practical meaning that even the general public can do manufacturing.

5. Change of Manufacturing Design Process

5.1. Current Process of Manufacture

The current manufacturing process is generally divided into three main categories. These three categories are planning, design and manufacturing. And the planning stage is further divided into research, design requirements, feasibility assessment, and establishing design requirements. The design stage includes concept design, primary design, and specified design. And finally, it consists of the manufacturing stage. At the planning stage, it is to analyze the market's needs and problems. Also, this step analyzes the validity of the product and the requirements of the design, which determines whether a product can be made or not. These investigations are conducted by experienced engineers. In the design stage, ideas are generated and implemented based on the data analyzed in the planning stage. In particular, the primary design is the stage in which the whole system is created. Therefore, the primary design is a step that connects the concept of design with a specific design. And the specific design is to create a complete design through modeling and drawing. At this stage, designers
can design efficiently using the Computer-Aided Design program. The manufacturing stage plans and determines how products are produced. The engineer then selects the production process and performs mass production. At this time, prototype tests are conducted to determine if they are suitable for mass production.

5.2. Future Prediction Analysis of Manufacturing Design Process
The future manufacturing design process will be changed by the Fourth Industrial Revolution. Predicting these changes are as follows (figure 3): First, the existing management process is divided into the Planning, Design and Manufacturing stage. In the planning process, the collection and analysis of many data are important. These parts can be solved a lot through artificial intelligence. In particular, the planning stage has enabled data collection, processing and management through cloud computing and big data technologies. This allows designers to process large amounts of information quickly [4]. Based on these plans, the approximate design direction is determined, and designers can input elements of design, such as goals, prices, and materials, into the algorithms of the computer, and artificial intelligence can produce thousands of design results. So far, designers have completed one design through the final analysis, but in the future, artificial intelligence can complete thousands of designs through analysis [4]. And the completion of this design allows consumers to easily change color or shape through computer programs. Next, after AI completes the design, it can manufacture it through 3D printing. So far, manufacturing has been mass-producing by lowering prices. But the development of 3D printing will change the way it is produced. 3D printing is being able to produce small amounts and individual products. So there will appear many small companies in the manufacturing sector. As a result, consumers will be more satisfied with their products. There will also be a major shift in manufacturing as individuals' 3D printing becomes common [2]. As such, the manufacturing process has been very simplified by 3D printing [2].

![Figure 3 Future Manufacturing Design Process](image)

6. Change in the Manufacturing Industry
The invention of artificial intelligence and 3D printing will make a big difference in the manufacturing industry. Especially when artificial intelligence technology develops, computers will replace many of the designers' work. And it takes the collection and analysis of a large number of data for manufacturers to design and produce products. These parts will be logically analyzed by artificial intelligence through big data. So in the future, artificial intelligence will provide the most appropriate alternative for design through the analysis of data. For this reason, much in the field of product planning and design will be replaced by machines. But innovation originates from human imagination and it is difficult to replace with technology. Even if artificial intelligence develops, it is not easy to
replace human creativity. So creativity is the most important value for designers in the future [4]. Therefore, designers who do not have well creative abilities are doomed to lose jobs. Given this, in product design education, improve creativity is especially crucial. And 3D printing will revolutionize manufacturing based on diversity and efficiency. Manufacturing will change from mass production to small production. So products will be made according to consumers' tastes. Besides, consumers will be directly involved in the production. As a result, the Fourth Industrial Revolution will democratize manufacturing. However, many problems arise with these changes in the times. For example, the gap between rich and poor will widen with technology holdings. And problems such as quality control will arise as a single-person manufacturer appears. So the government must come up with institutional devices to solve these problems.

7. Conclusion
The recent Fourth Industrial Revolution will bring about transformation in manufacturing. The Fourth Industrial Revolution is a new revolution in which several technologies are integrated. So the convergence of new technologies in the fourth industrial revolution will affect many areas. New technologies such as artificial intelligence and 3D printing technology are being employed in the manufacturing industry. It is anticipated that new technologies will bring significant changes to the manufacturing design process. As a result, the fourth industrial revolution will produce the democratization of manufacturing. Nevertheless, many social problems arise from these changes in the times. For example, the gap between rich and poor will widen to technology holdings. And with the emergence of a single-person manufacturer, problems such as quality control will spring up. The government must come up with an institutional mechanism to address these problems. In general, the study analyzed the technologies of artificial intelligence and 3D printing about manufacturing and predicted changes in society. It can provide, to some extent, with countermeasures for changes in society by predicting the future of manufacturing. The results of the study can be regarded as the basis for research in the manufacturing design field from the perspective of artificial intelligence and 3D printing.

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