

Analyzing the Major Issues of the 4th Industrial Revolution¹

Jeonghwan Jeon^{*}, Yongyoon Suh^{**}

Abstracts Recently, the attention to the 4th Industrial Revolution has been increasing. In the 4th Industrial Revolution era, the boundaries between physical space, digital space, and biological space are becoming blurred because of the active convergence between various fields. There are many issues about the 4th Industrial Revolution such as artificial intelligence, Internet of things, big data, and cyber physical system. To cope with the 4th Industrial Revolution, an accurate analysis and technology planning need to be undertaken from a broad point of view. However, there is little research on the analysis of the major issues about the 4th Industrial Revolution. Accordingly, this study aims to analyse these major issues. Data mining such as topic modelling method is used for this analysis. This study is expected to be helpful for the researcher and policy maker of the 4th Industrial Revolution.

Keywords 4th Industrial Revolution, convergence, major issue, data mining, topic modelling

I. Introduction

Recently, the boundary between physical space, digital space and biological space is blurring due to the 4th Industrial Revolution. Since the 1st Industrial Revolution, there were some major inventions and major technologies in each Industrial Revolution era. For example, in the 1st Industrial Revolution era, the main invention was the steam engine of James Watt. In the 2nd Industrial Revolution era, it was electric by Bell. In the 3rd Industrial Revolution era, it was computer and internet. However, in the 4th Industrial Revolution, there are various major inventions and many issues such as information and

Submitted, December 14, 2017; 1st Revised, December 22, 2017; Accepted, December 25

^{*} Department of Industrial & Systems Engineering / Engineering Research Institute; jhjeon@gnu.ac.kr

^{**} Corresponding, Department of Safety Engineering, Pukyong National University; ysuh@pknu.ac.kr

¹ Original idea presented at the Korea 4.0 Forum in May 2017, and revised one in the ASIP 2017 Hanoi Conference on September 22, 2017.

communication technology (ICT), artificial intelligence (AI), IoT, big data, energy, smart city, the cyber physical system (CPS), etc. Moreover, there are complicate relationships and many convergences among various issues across these fields. The 4th Industrial Revolution appeared in a variety of fields as a lively state.

To cope with the 4th Industrial Revolution era properly, it is important to identify the issues related to it. There are issues such as employment, shared economy, education, health, life style, etc. To cope with the 4th Industrial Revolution, an accurate analysis and technology planning need to be undertaken from a comprehensive point of view. The investigation and understanding on the 4th Industrial Revolution can link to the establishment of mid - and long-term technology planning. The process of analysing the level and trends of relevant technologies in the planning phase is critical. However, there is little research on the analysis of the major issues surrounding the 4th Industrial Revolution.

Therefore, the purpose of this study is to analyse major issues of the 4th Industrial Revolution using topic modelling to raise the understanding of the key issues. Topic modelling is a widely used method for analysing technological trends in the context of data mining technique. Topic modelling makes it possible to analyse the issues of the 4th Industrial Revolution quantitatively.

The remainder of this paper is organized as follows. We review the Industrial Revolution and topic modelling in Section 2. The research procedure is described in Section 3. The analysed results are described in Section 4. Lastly, Section 5 offers concluding remarks.

II. Literature Review

1. Brief Review of the Industrial Revolution

The Fourth Industrial Revolution is described as a range of new technologies that are fusing the physical, digital and biological worlds, and impacting all disciplines, economies, and industries (Schwab, 2016). The 4th Industrial Revolution is the fourth major industrial era since the 1st Industrial Revolution of the 18th century in the United Kingdom, which began with the steam engine of James Watt. In each Industrial Revolution, there were main inventions, main technologies, and main energies, taking place in leading countries. The brief review of the each Industrial Revolution such as period, technology, production methods, traffic, and communication is described in Table 1.

Table 1 Brief review of each Industrial Revolution

Type	1 st	2 nd	3 rd	4 th
Revolution	Power revolution	Energy revolution	Digital revolution	Convergence revolution
Starting year	1784	1870	1969	Now
Main invention	Steam engine	Electricity	Computer, Internet	AI, IoT
Technology & resources	Steam engine, Machine,	Electricity, Chemistry, Combustion engine	Information, communication, New material, Biotechnology	Big data, AI, Drone
Innovation areas	Steam power	Division of Labor	Electronic devices	Convergence
Production methods	Production system	Mass production	Automation, Informatisation	CPS, Smart factory
Main energy	Coal	Coal, Oil	Renewable energy	Renewable, Eco-friendly
Traffic	Railway	Car, Aircraft	Internet, Mobile	Smart car
Communication means	Book, Newspaper	Telephone, TV	Internet, SNS	AI, IoT, etc.
Leading country	Britain	USA, Germany	USA	USA, Germany, Japan

Source: Author

2. Topic Modelling

Topic modelling is a technique used in text mining, which is an algorithm for discovering topics that are potentially present in a large set of unstructured documents (Blei, 2012). The specific words extracted by topic modelling algorithm can be used to estimate the topic embedded in a set of documents as in Figure 1. In this study, we use Latent Dirichlet Allocation (LDA), the most iconic algorithm among topic modelling techniques (Yau et al., 2014). LDA refers to a probability model for which topics are distributed in each of the observed documents (Blei et al., 2003). A brief process of LDA algorithm is described in Figure 2.

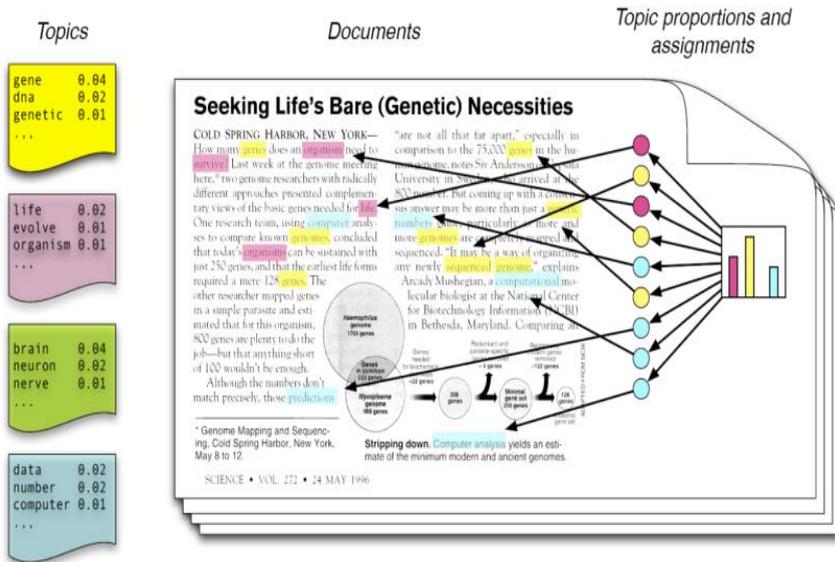


Figure 1 Example of topic modelling (Blei, 2012)

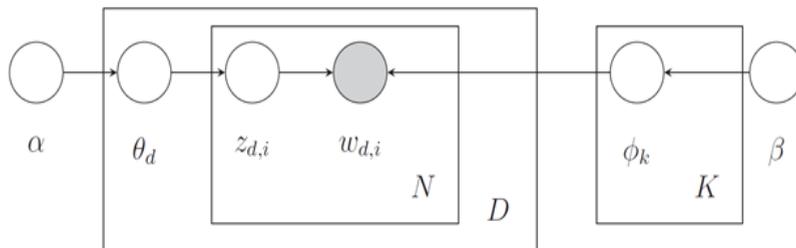


Figure 2 Process of LDA algorithm (Blei et al., 2003)

III. Research Design

Figure 3 shows the research process for analysing the major issues of the 4th Industrial Revolution. Firstly, data related to the 4th Industrial Revolution were collected. The database was EBSCO Discovery (<https://www.ebsco.com/>). EBSCO Discovery is one of the largest and reliable academic data sources. The searching word was the 4th Industrial Revolution. Then, data were pre-processed by text mining technique for extracting keywords via tokenization and remove abuse. Extracted keywords were used for identifying major issues

based on topic modelling. R program, which is open source, is utilized for topic modelling analysis.

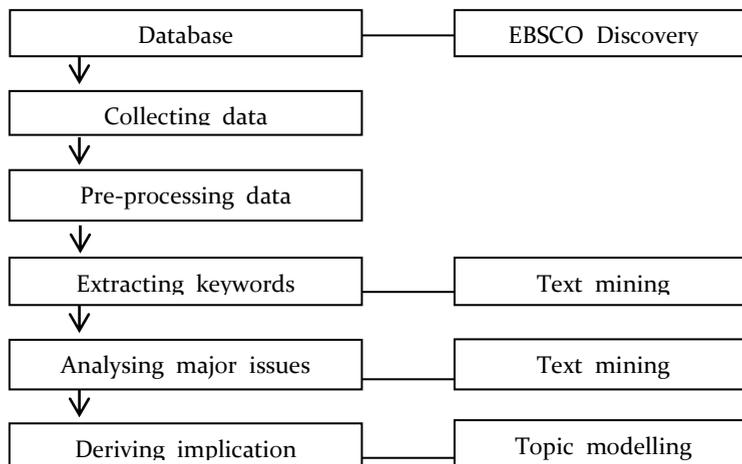


Figure 3 Research process

Data collection was conducted on June 10, 2017. A total of 399 articles were collected. Data type consisted of materials, magazines, and reports on the 4th Industrial Revolution. DBPIA was the largest data source with 221 data. Detailed data source are shown in Table 2.

Table 2 List of data source

No	Data source	Number of collected data
1	DBPIA	221
2	KISS	101
3	KyoboScholar	27
4	Academic institute	21
5	Complementary Index	18
6	KoreaScience	10
7	Business Source Complete	1
Total		399

IV. Analysis of Major Issues

For analysing major issues from text documents, data pre-processing is necessary. Text data is operated by text mining. Insignificant words such as abbreviations and symbols were removed after executing text mining. Remove methods are tokenization and remove abuse as shown in Table 3. Despite having the same meaning, if there was a possibility that the keywords may be recognized as different entries because of spacing or expressions, a linking of the words was carried out.

Table 3 Method for pre-processing data

Pre-processing method	Contents	Example
Tokenization	Separating text by word	The key point is that the Fourth Industrial Revolution is the key goal of convergence of technologies as the boundaries of digital, physical, and biological areas disappear. Key / essential / 4th Industrial Revolution / digital, / physical, / biological / area / boundary / gone / technologist / fused / thing / core / goal / will be
Remove abuse	Analysis, articles & Deleting unnecessary words	Key / essential / 4th Industrial Revolution / digital, / physical, / biological / area / boundary / gone / technologist / fused / thing / core / goal / will be 4th Industrial Revolution / digital/ physical /biological / area / boundary / gone / technologist / fused / core / goal /
Title extraction	Extracting word titles	4th Industrial Revolution / digital/ physical /biological / area / boundary / gone / technologist / fused / core /goal/ 4th Industrial Revolution / digital/ physical /biological / area / boundary / gone / technologist / fused / core /goal

After pre-processing data, various keywords were extracted. The most frequent keywords are shown in Table 4. As a matter of course, Industrial Revolution is the most frequent keyword. Then, in that order, AI, service, Internet, smart, manufacturing, data. The most frequent keywords are technological terms. This result shows that a matter of concern and academic interest are focused on the technological side. However, there are various other

issues in the era of the 4th Industrial Revolution such as employment, shared economy, education, health, life style, etc. Therefore, an analysis needs to be taken from a broad point of view. We examine the major issues of the 4th Industrial Revolution based on the extracted keywords.

Table 4 Frequent keywords

Keyword	Frequency
Industrial Revolution	722
AI	268
Service	194
Internet	188
Smart	157
Manufacturing	118
Data	108
System	105
Digital	103
Car	95

The analysis of the major issues of the 4th Industrial Revolution is as follows. Based on topic modelling, ten groups of keywords were classified. The number of group was determined by conducting topic modelling by trial and error with various numbers such as 5, 6, 7, 8, 9, 10, 11, and 12. Most issues were covered among these groups and each group was mutually exclusive.

Issue 1, represented by ICT and IoT, reflects the issue of the manufacturing paradigm. Actually, the initial attention of the 4th Industrial Revolution was the manufacturing paradigm. For example, Germany initiated Industry 4.0 as their manufacturing policy. Smart factory, CPS, and robotization were discussed as the future of manufacturing. Accordingly, many countries focused on the development and change of their manufacturing environment.

Issue 2, represented by FinTech and block chain, reflects the issue of the sharing economy. Professor Laurence Lessig of the Harvard Business School, who may be the first researcher to use the term, defined the sharing economy as a "consumer culture and economics" that maximizes the use of resources. Sharing economy has emerged as new business structures. Sharing economy is characterized by the following keywords (FinTech, block chain, security, etc.) compared to traditional economic methods, based on the sharing of IT technology and social network society.

Issue 3, represented by traffic sector and traffic safety, reflects the issue of transportation. Not only Tesla, but also global ICT companies such as Google

and Apple have focused on the development of autonomous driving car. Uber is the world largest taxi company without owning taxis. There may be a mass paradigm shift in the transportation field.

Issue 4, represented by labour, workforce and job, reflects the issue of employment and labour. Klaus Schwab forecast that 7 million jobs may disappear and 2 million jobs may be created in the future (Schwab, 2016). In particular, there are many concerns that the future of the workplace will disappear due to AI.

Issue 5, represented by Airbnb, connectivity, tourism, and health, reflects the issue of quality of life. Airbnb is one of the largest lodging company in the world. More and more people want to enjoy their leisure time and healthy life.

Issue 6, represented by platform, open data, and information gathering, reflects the issue of big data. Big data refers to large amounts of data, such as data generated in digital environments that contain character and image. With the expansion of digital economies, there is a big data universe where the vast amounts of data are produced around us. Big data is regarded as the coal during the 1st Industrial Revolution. Big data is an important source of enhancing competitiveness and increasing productivity.

Issue 7, represented by advanced technology and technology revolution, reflects the issue of future orientation. There are various future orienting words such as the degree of change, future industry, and Davos Forum. The World Economic Forum (WEF), which is held in Davos, Switzerland, is a non-profit foundation. Its mission is cited as "committed to improving the state of the world by engaging business, political, academic, and other leaders of society to shape global, regional, and industry agendas" for responding to future changes (Wikipedia).

Issue 8, represented by privacy and individual, reflects the privacy issue. Under the development of ICT technology and the spread of SNS, privacy protection issue such as leaking personal information is emerging with the advent of the 4th Industrial Revolution.

Issue 9, represented by smart city, future city, and energy building, reflects the issue of smart city. Smart City is a smart platform that operates efficiently urban assets and provides safe and secure lives for citizens base on recent ICT technology such as IoT, cyber physics, and big data. Urbanism is the important index of human development (Morris, 2010).

Issue 10, represented by communication and service business, reflects the issue of business. In the era of the 4th Industrial Revolution, business model from technology to market is expected to change following the changes in technology and market.

Table 5 10 major issues of the 4th Industrial Revolution

Issue 1	I2	I3	I4
Manufacturing paradigm	Sharing economy	Transportation	Employment & labour
ICT IoT Digital Communication Robot engineering Intelligent Cyber IoT Mechanization	FinTech Privacy protection Block chain Shared economy Security Information communication Fragility	New product Traffic sector Traffic safety Road policy Navigation Autono. driving Aging Uber	Labor law Workshop Education method S&T policy Working condit'ns Profnl workforce Job creation

I5	I6	I7
Quality of life	Big data	Future orientation
Airbnb Informatization Connectivity Tourism contents Health Community life Public transport Area informatization	Platform Open Data Information gathering Algorithm Modularity Google Shared government	Advanced technology Technology revolution Structuring Degree of change Future oriented Future industry Davos forum

I8	I9	I10
Privacy	Smart city	Business
Privacy Individual Communication ind. Device Social network Visual data Android Terminal	Smart city Construction policy Construction site Workplace High precision Urban spatial structure Future city Energy building	Communication Service business Idea Area destruction Commercialization Optimization Demand management

Weight and rank of 10 issues are shown in table 6. Among 10 issues on the 4th industrial revolution, manufacturing paradigm (I1) is the highest rank. The issue of manufacturing paradigm has received the most attention. It means that technological development about manufacturing is very active. Big data (I6) is the second highest rank. Big data is one of the important motivations of the technological paradigm shift. Technological development such as A.I. or AlphaGo has been conducted. Future oriented (I7) is the third highest rank. I7 is also about the technological revolution. To sum up, top 3 issues are about the technological development. On the other hand, the issues with the lowest rank are sharing economy (I2), transportation (I3), and quality of life (I5). Given their relatively low rank, it appears that they are still being discussed relatively small in academic terms.

Table 6 Weight and rank of 10 issues

Issue	Weight	Rank
[I1] Manufacturing paradigm	18.81%	1
[I6] Big data	15.93%	2
[I7] Future orientation	13.77%	3
[I10] Business	11.29%	4
[I4] Employment & labor	8.11%	5
[I8] Privacy	8.00%	6
[I9] Smart city	7.54%	7
[I5] Quality of life	6.34%	8
[I3] Transportation	5.12%	9
[I2] Sharing economy	5.10%	10

V. Conclusions

In this study, major issues of the 4th Industrial Revolution are analysed. Data source is extracted from EBSCO Discovery. 399 articles on the 4th Industrial Revolution are extracted by applying a text mining approach. Topic modelling, one of the data mining techniques, is applied to identify major issues of the 4th

Industrial Revolution. Ten major issues emerge which are then analysed in depth and implications derived: (1) manufacturing paradigm, (2) sharing economy, (3) transportation, (4) employment and labour, (5) quality of life, (6) big data, (7) future orientation, (8) privacy, (9) smart city, and (10) business. These results are expected to be possible guidelines in understanding contemporary paradigm shifts from 3rd Industrial Revolution to 4th Industrial Revolution and policy making for promoting the 4th Industrial Revolution. Weight and rank of 10 issues are analysed.

Nevertheless, this research suffers from limitations. Firstly, the data source is limited to academic documents such as paper and reports. Other data source such as newspaper and patents would cover more issues related the 4th Industrial Revolution and result in a more substantial analysis. Secondly, the number of issues is decided by numerous trial and errors. The systematic process for selecting the number of issues and the validation process is needed.

Acknowledgements

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2017R1D1A3B03034060).

References

- Blei, D.M. (2012) Probabilistic topic models, *Communications of the ACM*, 55(4), 77-84.
- Blei, D.M., Ng, A.Y. and Jordan, M.I. (2003) Latent dirichlet allocation, *The Journal of Machine Learning Research*, 3, 993-1022.
- Lessig, L. (2008) *Remix: Making Art and Commerce Thrive in the Hybrid Economy*, Penguin Press.
- Morris, I. (2010) *Why the West Rules for Now: the Patterns of History and What They Reveal about the Future*. New York: Picador.
- Schwab, K. (2016) *The Fourth Industrial Revolution*, World Economic Forum.
- Schwab, K. (2016) *The Fourth Industrial Revolution*, New York: Crown Publishing Group.
- Seol, S.S. and Moon, Y.H. (2017) An evaluation of the theories of the 4th Industrial Revolution, presented at the ASIP 2017 Hanoi Conference, Asian Society for Innovation and Policy, September 21-23.
- Yau, C.K., Porter, A., Newman, N. and Suominen, A. (2014) Clustering scientific documents with topic modeling, *Sciencemetrics*, 100(3), 767-786.