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Industry 4.0 on Keyword Network Analysis

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Abstract: This research to analyze research trend on industry 4.0 through keyword network analysis and text mining techniques. Industry 4.0 articles were collected and an analysis was carried out using R, Rstudio, Tagxedo in this research. In order to analyze collected data, NLP package was used. After cleaning data, the number of frequency for important words was calculated. For key word network analysis, UCINET 6.0 was used in this research. Research on industry 4.0 is still in its initial stage but in this research documents were collected from Scopus an open access DB. These documents were used to grasp the trend of industry 4.0 by implementing text mining and network analysis which are big data techniques. Technologies, process and new turned out to be pretty high in in-degree in comparison to other key words. High in-degree indicates that it has strong power to absorb other key words. In contrast, industry, systems, production turned out to be relatively low in in-degree. Also when out-degree is examined, words such as industry, systems turned out to be high whereas words such as technologies, process turned out to below. This study is a study on the trend of industry 4.0. It provides a cornerstone for research on research support for industry 4.0.

Key words: Industry 4.0, big data, text mining, network analysis, scopus, Process

INTRODUCTION

Innovation is the engine of economic growth. Innovation contributes to competitive growth of a nation and is a must in reinforcing competitiveness of businesses (Park *et al*., 2015; Cheon *et al*., 2015). Even when Korean economy was stagnating due to global financial crisis, ICT industry played a very important role as the driving force of Korean economy. However, despite the recovery of economy in advanced countries such as the US and Japan, slowdown of Chinese economy, stagnating world trade and interest hike in the US are fueling uncertainty of future world economy. Under this kind of environment, Korea's ICT is faced with a new challenge. ICT paradigms are changing and the industry is being transformed to ICT convergence market. Especially, the advent of the so called 4th industrial revolution is transforming not only ICT industry but the entire industrial field as well.

The 4th industry has started in 2011 with Germany's industry 4.0. Initially, industry 4.0 has emphasized smart factory oriented innovation of the manufacturing field based on Cyber Physical Systems (CPS). But recently, it encompasses the entire environmental change including service industry and diverse business developments.

The 4th industrial revolution was selected as the main topic of Dabos Forum in January, 2016. In Korea, it began to attract increasing attention from the industry and Government after the Go contest between Alpha Go and Lee Sedol.

The 4th industrial revolution is diversely defined in each country such as digital single market of EU, advanced manufacturing program of the U. S., Germany's industry 4.0, made in china 2025 and Korea's Manufacturing Innovation 3.0 (Yang, 2017).

Currently, efforts are being made in Korea to introduce smart factories. Also, there is a good likelihood that global economic stagnation is going to last for quite some time and countries are showing an interest to find a new growth engine for employment and investment expansion. Along with this change in environment, digitalization of economy is making a meteoric rise as an alternative.

For establishment of a policy that can best respond to this changing environment, the time has come to analyze

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data on research trend of industry 4.0. Accordingly an attempt was made in this research to analyze research trend on industry 4.0 through key word network analysis and text mining techniques.

Theoretical background

Industrial 4.0: The 1st industrial revolution started with a change in production method caused by the invention of a steam engine during the 18th century which transformed domestic handicraft industry to factory handicraft manufacturing. The 2nd industrial revolution resulted from division of labor and automated manufacturing through the use of conveyor belt which became possible with the introduction of electric power that replaced steam engine of the 19th century.

Industrial 3.0 denotes automated mass production systems that became available by the development of ICT, computer and robot, since 1970's. Industrial 4.0 started with the arrival of a flexible production system that utilized various forms of internet, inter-connecting humans and machine as well as things and thing. This can be defined as the evolution of production paradigms that enabled mass production of mixed products (Lasi *et al*, 2014).

Industrial 4.0 signifies when defined broadly an automated production system wherein information exchange is possible between production equipment and products through cyber physical systems and internet of things (Lee, 2016). When narrowly defined, it signifies a national-level manufacturing development strategy that was first conceived in Germany in order to enhance production competitiveness and reinforce its position as a manufacturing power-horse through convergence of ICT and manufacturing (Lee, 2016).

The essential element in Industrial 4.0 is none other than smart factory. As sensors (IoT) are installed in facilities and machines within a factory, data are collected and analyzed in real time, so that, all situations are visible at a glance (observability).

The factory so analyzed as intended (controllability) is called smart factory. Major elements of smart factory include cyber physical system, internet of things, cloud computing, big data and mobile. At present, Korea smart factory foundation (www.smart-factory.kr) is established in Korea as part of an effort to disseminate smart factory.

Text mining: Most data that are created in our everyday life such as internet data, e-Mail, study in various fields, study in a newspaper or a magazine, survey report of public opinion, etc., take the form of a text. Text mining denotes a technique that is used to discover hidden meaning in big data like unstructured text data that consist of a human language using natural language processing method such as extracting information from large-scale documents, grasping connectivity, categorizing, clustering and summarizing. Text mining process undergoes preparatory phase, pre-processing phase and knowledge extraction phase (Park *et al*., 2016).

Keyword network: Network denotes a certain relationship to connect a multitude of persons and things. Persons and things that constitute a network are called actors. Network arrangement and composition among these actors is a network structure, analyzing this kind of structure technically is a network analysis (Li *et al*., 2017).

Keyword network analysis includes the process of constructing a network using key words and the relationship among them from the stage of collection and of analyzing its structure technically. Typically, a network is defined as more than one set of nodes and links (Park *et al*., 2016).

MATERIALS AND METHODS

In this study, overall research procedure will be explained. Data was collected in this research by searching industry 4.0. from Scopus site (Fig. 1).

Defining problem: Search words are restricted in this research to industry 4.0. Search was implemented by limiting it to abstracts.

Information necessary to the problem: The stage of problem definition is where problems to be resolved are recognized. Attempts were made in this research to grasp the research trend of industry 4.0.

Necessary data for deducting information: For the purpose, related data was collected first. From the study data provided in Scopus homepage, one of the representative article sites, data was collected using the keyword industry 4.0.

Analysis technique for deducting information: Industry 4.0 articles were collected and an analysis was carried out using R, UNICET in this research.

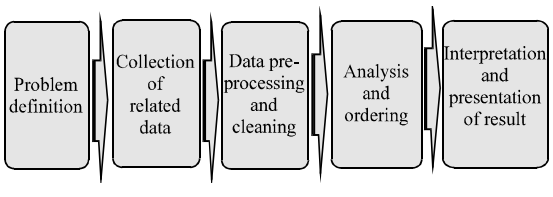

Fig. 1: Research method and procedures

RESULTS AND DISCUSSION

Data collection and analysis: In order to calculate the number of frequency for words from collected study abstracts, NLP (Natural Language Processing) was utilized. In order to analyze collected data, NLP package was used. After cleaning data, the number of frequency for important words was calculated. Then, words that are not related to this research were deleted in a lump (Fig. 2).

As of March 25, 2017, a total of 367 documents were searched. As for the process of deriving 367 key words, search was carried out with indusrty 4.0.

When document type is examined, it is possible to know that research related to indusrty 4.0 is being carried out in the order of conference study (204) and Article (132) Table 1.

When keywords are examined such words as industry 4.0, manufacture, embedded systems, cyber physical systems, IoT, automation and big data appear in descending order and they are all involved in researches related to industry 4.0 Table 2. The next step is carried out with the Tagxedo (Fig. 3 and 4).

Keyword network analysis: For key word network analysis, UCINET 6.0 was used in this research. In network analysis in-degree can be interpreted as a scale that can measure popularity whereas out-degree can be interpreted as a scale that can measure scalability as shown in Table 3.

Technologies, process and new turned out to be pretty high in in-degree in comparison to other key words. High in-degree indicates that it has strong power to absorb other key words. In contrast, industry, systems, production turned out to be relatively low in in-degree as shown in Fig. 5.

Also when out-degree is examined, words such as industry, systems turned out to be high whereas words such as technologies, process turned out to below. High out-degree indicates that it's relationship with other key words is high as shown in Fig. 6. In-degree and out degree turned out to have sizes from 0-9.

Key words such as technologies, process and new turned out to have high values in comparison to other key words. This seems to reflect that these words play a central role in industry 4.0. Keywords such as data, industry, systems also turned out to be high. This indicates that these key words have high scalability in industry 4.0. For activation of industry 4.0 research, service development seems to be needed that takes

Table 1: Industry 4.0 paper in type and keyword

Document types	Data	Key words	Counts
Conference paper	204	Industry 4.0	325
Article	132	Manufacture	101
Review	12	Embedded systems	92
Article in press	11	Cyber Physical Systems (CPSs)	72
Book Chapter	6	Internet of things	59
Editorial	1	Automation	42
Note	1	Big data	40
		Industrial revolutions	38
		Cyber-physical systems	33
		Internet	27

Table 2: Deriving 10 nouns (industry 4.0)

Nouns	Counts
Industry	517
Systems	508
Production	357
Manufacturing	298
Paper	262
Industrial	254
Data	205
New	197
Process	175
Technologies	147

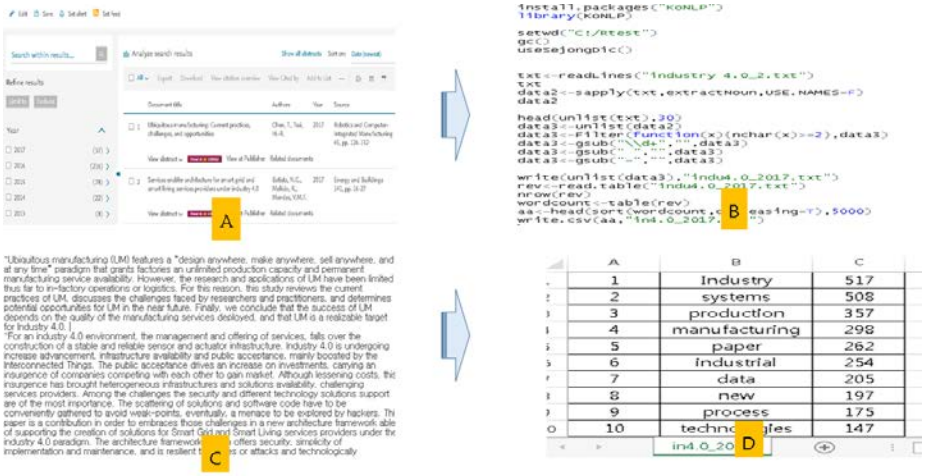

Fig. 2: Analysis procedures

Table 3: Result of Compound noun

Documents types	Industry	Systems	Production	Manufacturing	Paper	Industrial	Data	New	Process	Technologies
Industry	111	95	54	56	68	45	27	49	51	40
systems	-	156	77	66	100	73	45	60	72	60
production	-	-	164	68	101	75	52	62	101	55
manufacturing	-	-	-	143	95	61	46	52	72	55
paper	-	-	-	-	217	98	61	80	105	105
industrial	-	-	-	-	-	160	56	63	80	53
data	-	-	-	-	-	-	101	31	60	29
new	-	-	-	-	-	-	-	131	65	54
process	-	-	-	-	-	-	-	-	175	55
technologies	-	-	-	-	-	-	-	-	-	109

Fig. 3: Abstract noun derivation

Fig. 4: Key word noun derivation

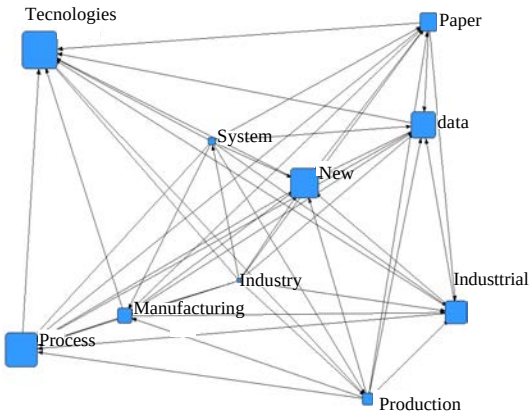

Fig. 5: Key word network (Indegree)

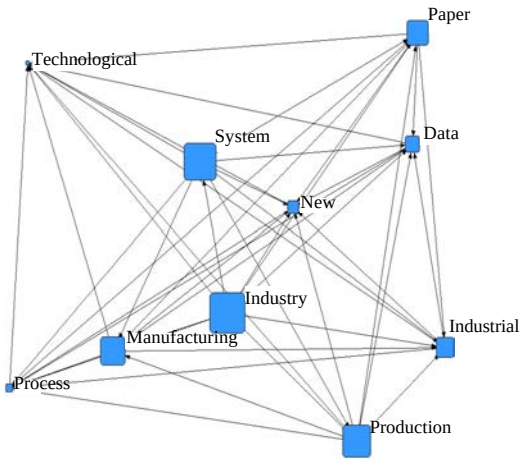

Fig. 6: Key word network (Outdegree)

industry and system into consideration and technologies and process oriented development policy and related institutional device seem to be necessary.

CONCLUSION

In the present research, researches related to industry 4.0 in article web DB were searched. Searched data are downloaded in the form of abstract and key word and analyzed using a keyword network technique. First as a result of key word analysis in industry 4.0, all turned out to be related to active industry 4.0 research but as the research is still in initial stage, it seems that research related to industry 4.0 will be increased continuously.

Second as a result of analysis of 10 major key words in industry 4.0, important key words turned out to be industry, systems, production and manufacturing in descending order. This can be interpreted that foundation of the research that has been carried out, so far is highly related to industry.

IMPLICATIONS

Implications of this research can be summarized as follows. Research on industry 4.0 is still in its initial stage

but in this research documents were collected from Scopus an open access DB. These documents were used to grasp the trend of industry 4.0 by implementing text mining and network analysis which are big data techniques.

LIMITATIONS

Despite these implications this research has limitations in that it did not take diverse Web DB's into consideration. So, it seems that in future research there is a need to expand to include diverse Web DB's and electronic journals. Also, it might be necessary to derive compound nouns that are comprised of derived key word matrix and future key words.

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