The Internet Information and Technology Research Directions based on the Fourth Industrial Revolution

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Abstract

The fourth industrial revolution is currently proceeding and is expected to significantly affect the way individuals live and in result change the society in various aspects. The ICT-based convergence industries of the fourth industrial revolution contain various fields such as driverless cars, lighter and tougher materials, robotics, 3D printing and even biotechnology. This paper examines the researches done in fourth industrial revolution field based on the articles submitted to APIC-IST 2015. The topics from articles related to the fourth industrial revolution were categorized based on the keyword frequency of main issues. Results suggested that IoT and Wireless sensor network related researches were among the fields that the most researches were done in it and topics like nanotechnology, biotechnology, driverless cars, sharing economy and 3D printing were not mentioned at all. This paper also suggests necessary contents in the fourth industrial revolution to be focused on for further research in this field.

Keywords: APIC-IST 2015, Internet Information & Technology, Technology Trend, Industry 4.0, The Fourth Industrial Revolution

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1. Introduction

Recently, the world's major institutions such as Deloitte, Gartner, IBM, IDC, IEEE and Red Hat introduced IoT, Big data, Cloud, 3D Printing, Healthcare, Mobile Devices, Smart Machines, 3rd Platform, Block Chain and Security technologies as the future of core technology trends. Especially wireless sensor networks (WSNs) that is regarded as the basic components of internet of things (IoT) and the main mean for communications between machines and the future internet was highlighted the most in this field[1][2][3][4][5][6]. On the other hand, as almost all of the large industries are heading toward smart systems, a new era of information and communications technology (ICT) is becoming more visible during the past few years[7].

These changes are expected to result in the Fourth industrial revolution by the year 2020[7]. Industry 4.0 is referred to a number of automated systems with automatic data exchange and manufacturing technology capabilities. All systems in Industry 4.0 communicate with each other and with humans and all the data are accessible and shared on internet for operators as well as users. Through the Fourth industrial revolution, utilization of Industry 4.0 that is based on cyber-physical system has become possible and various biological, physical and digital systems are combined together to achieve the same goal[7][8]. Although some believe that the fourth industrial revolution will result in a greater level of inequality, it is not possible to stop it from happening. Therefore, it is important for individuals to be aware of the changes that will happen in near future through the fourth industrial revolution and be prepared for it. As the fourth industrial revolution is an opportunity to improve and shape current technologies to improve people's lives, we have focused on ongoing researches and topics discussed the most in this field.

The objective of this study is to investigate on Industry 4.0, the Fourth industrial revolution, and their effects on society through a series of surveys performed on expected technological shifts that are expected to occur in future. In this paper, we categorized and classified the frequency of keywords mentioned in the articles submitted to APIC-IST 2015 and suggest future direction and topics for research in this field.

2. The Fourth Industrial Revolution

2.1 Industry 4.0

The term Industry 4.0 was first introduced in 2011 by Fraunhofer-Gesellschaft institute and the German federal government as a collective term that draws together various information exchange, automation and manufacturing technologies[8]. In other words, the Industry 4.0 is combination of Internet of Things, Cyber-physical Systems(CPS) and Internet of Services cooperating with each other and with human within a system[8][9][10][11].

Industry 4.0 is mainly based on highly automated smart factories as well as smart products and services. Development toward Industry 4.0 creates various opportunities in sustainable industrial manufacturing[12]. Ability to produce customized and small-scale products is among the consumer needs that can be covered through Industry 4.0.

To get the most out of industry 4.0, it is essential to utilize the integration of inter-corporation value network and engineering value chain[13]. Additionally, Suhel Dhanani mentioned of essential system considerations required for realizing industry 4.0 and

categorized them into six sections as (1) Distributed Computing and Control, (2) Pervasive Sensors, (3) Authenticated Security, (4) Distributed, Local Control: the Rise of the Micro PLC, (5) Successful Analog Integration and (6) Heat Dissipation and Efficient Power Conversion[14]. **Fig.1** shows an overview of all four industrial revolutions since 1784 up to 2011[15]. Although the complete transformation of current systems into Industry 4.0 is not a simple process and it may take a while to happen, the signs of Industry 4.0 revolution have been already observed since 2014 in sensing, big data, networking, software and various other systems[15][16][17].

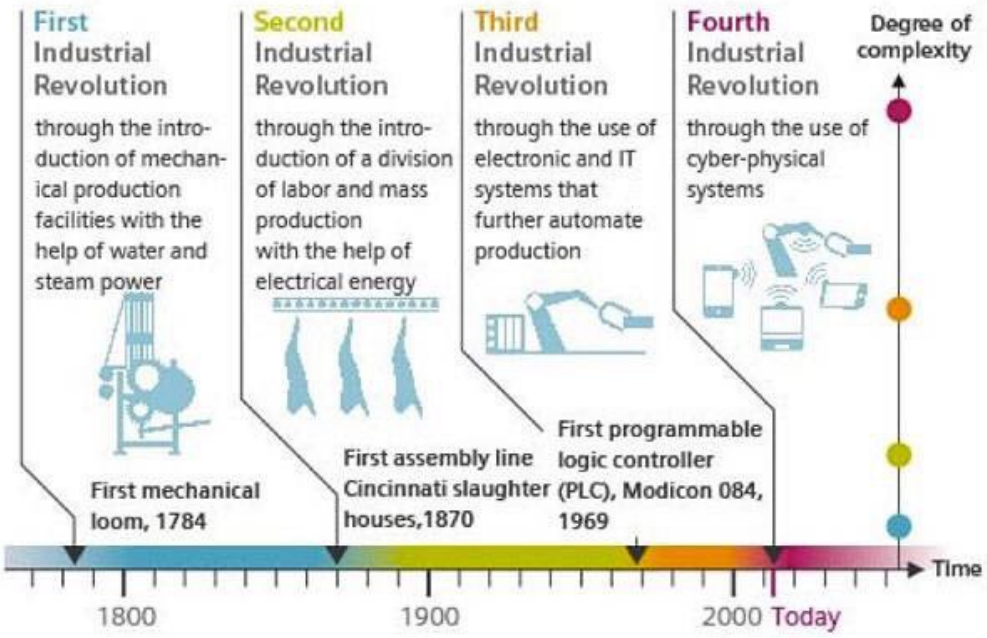

Fig. 1. From Industry 1.0 to Industry 4.0. Source: DFKI (2011)[15]

2.2 The Fourth Industrial Revolution

Previous industrial revolutions mainly focused on digital systems and various mass production technologies with the goal of liberating humankind from animal power. The first Industrial Revolution was to mechanize production through utilizing steam and waterpower. The electric power was then used in the Second Industrial Revolution for mass production. The Third Industrial Revolution covered automation of production by using information technology and electronics. Finally, the Forth Industrial Revolution is a fusion of all current technologies to create a cyber-physical system[18].

In January 2016, during the 46th World Economic Forum with subject of ‘Mastering the Fourth industrial revolution’, the founder and executive chairman of World Economic Forum (WEF), professor Klaus Schwab has published ‘The Fourth industrial revolution’ as a “technological revolution that will fundamentally alter the way we live, work and relate to one another”.

Professor Klaus Schwab described the fourth industrial revolution as a range of new technologies that combine biological, physical and digital worlds and affect all disciplines to an extend that ideology of human being is challenged. He believes that the Fourth industrial

revolution as a convergence of ICT will fundamentally change the way people relate to each other which changes the way we live. The Fourth industrial revolution will highly affect businesses through transforming the current economy and society using artificial intelligence (AI), robotics, IoT, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing[19][20]. It has the potential to increase the quality of life among people through different means such as increasing the global income levels.

Professor Klaus Schwab in 'The Fourth industrial revolution' clearly distinguished the Fourth industrial revolution as a separate and novel Industrial Revolution from the third one. He described the Fourth industrial revolution as a deeply interconnected world of technologies evolving at an exponential rather than previously known liner pace. He continued by mentioning the paradigm shifts that will be caused in individual lives as well as society upon Fourth industrial revolution and pointed out the fact that "It is not only changing the "what" and the "how" of doing things but also "who" we are". In the end, Professor Klaus Schwab mentioned of another aspect of Fourth industrial revolution as a transformation that covers the whole system of countries and industries as a whole that was not accounted in previous revolutions[20][21].

3. Technological tipping points expected to occur by 2025

A survey report conducted in 2015 at WEF to capture the shifts that will occur in society, and encouraged people to prepare for the possible changes in the society. The Global Agenda Council conducted the Technological Tipping Points survey in March 2015 on the Future of Software and Society. Views of 800 experts from information and communication technology sector on 21 tipping point moments of specific technological shift were collected. The tipping point range was divided into various sections such as "it has already happened" up to "20+ years" and "never" [22]. The results of this survey were also included in the appendix section of 'The Fourth Industrial Revolution' by Professor Klaus Schwab. **Table 1** summarizes the tipping points expected to occur by 2025 based on the survey.

Table 1. Shifts Expected to Occur by 2025[22]

Shift	Description	%
Implantable Technologies	The first implantable mobile phone available commercially	81.7
Vision as the New Interface	10% of reading glasses connected to the internet	85.5
Wearable Internet	10% of people wearing clothes connected to the internet	91.2
The Internet of and for Things	1 trillion sensors connected to the internet	89.2
The Connected Home	Over 50% of internet traffic to homes for appliances and devices	69.9
Our Digital Presence	80% of people with a digital presence on the internet	84.4
Ubiquitous Computing	90% of the population with regular access to the internet	78.8
A Supercomputer in Your Pocket	90% of the population using smartphones	80.7

Storage for All	90% of people having unlimited and free (advertising-supported) storage	91.0
Smart Cities	The first city with more than 50,000 people and no traffic lights	63.7
Big Data for Decisions	The first government to replace its census with big-data sources	82.9
Driverless Cars	Driverless cars equalling 10% of all cars on US roads	78.2
Artificial Intelligence and Decision-Making	The first AI machine on a corporate board of directors	45.2
AI and White-Collar Jobs	30% of corporate audits performed by AI	75.4
Robotics and Services	The first robotic pharmacist in the US	86.5
Bitcoin and the Blockchain	10% of global gross domestic product stored on blockchain technology	57.9
Governments and the Blockchain	Tax collected for the first time by a government via a blockchain	73.1
3D Printing and Manufacturing	The first 3D-printed car in production	84.1
3D Printing and Human Health	The first transplant of a 3D-printed liver	76.4
3D Printing and Consumer Products	5% of consumer products printed in 3D	81.1
The Sharing Economy	Globally more trips/journeys via car sharing than in private cars	67.2

As seen in the results of survey conducted by WEF, the Internet, IoT (including wearable systems), Big Data, AI, Block chain, 3D Printing, Sharing Economy and biotechnology were among the main fields that will significantly affect the our lives upon Fourth industrial revolution. Therefore, it is important to prepare for the changes that will soon or later occur in the society.

4. Research Contributions

The Asia Pacific International Conference on Information Science and Technology (APIC-IST 2015) was hosted in Da Nang, Vietnam on July 13-15, 2015. The APIC-IST 2015 developed emerging Internet-related issues and invited prospective authors to submit research papers in the following tracks organized by the issues. Among 64 submitted papers, 12 papers were selected as outstanding researches and presented at APIC-IST 2015.

- Track 1: Smart Phone Applications and Service / Mobile Internet Computing
- Track 2: Wireless and Sensor Network / Security & Privacy in Internet
- Track 3: IoT / Machine to Machine
- Track 4: Green(Energy-efficient) Computing & Smart Grid
- Track 5: Multimedia / Image Processing / HCI(Human Computer Interaction) / Intelligent Systems
- Track 6: Database / Data Mining / Big Data / Mobile Object Database
- Track 7: Software Engineering & Architecture / Cloud Computing

- Track 8: Smart Learning / e-Learning / Learning Contents Management Systems
- Track 9: Internet Business related Policy, Communication and Services
- Track 10: Management of Internet Application / E-Business / E-Commerce
- Track 11: SNS & Communications / Digital media use & effects
- Track 12: Content based R&D Project Management and Testing(Special Session)

Main keywords of Fourth industrial revolution were among the actively researched topics in the ICT research field. Therefore, we analyzed the keywords of above mentioned 64 manuscripts submitted to APIC-IST 2015 and based on that we encourage readers to be prepared for significant changes in individuals and society. Additionally, the purpose of this study was to investigate on the topics that must be researched in future.

Therefore, we classified the Fourth industrial revolution related topics introduced in APIC-ICT 2015 which are expected to have a high impact on changing of the society in the future. The keywords from submitted manuscripts to APIC-IST 2015 were then analyzed based on their frequency and categorized in **Table 2**.

Table 2. The keyword frequency of main issues in APIC-IST 2015

No.	Main Issue	Related Track No.	Keyword Frequency
1	IoT / Wireless sensor network	2, 3	15
2	Multimedia Processing	5	13
3	Distributed Computing and Control / Authenticated Security	2	12
4	SNS & Communications	11	9
5	Big Data	6	5
6	HCI / U-Healthcare	5	4
7	Energy Storage	4	3
8	Cloud Computing	7, 8	2
9	Smart Phone & Mobile Internet Computing	1	2
10	E-Business & E-Commerce (including Blockchain)	9, 10	-
11	AI (Artificial Intelligence)	5	-
12	3D Printing	-	-
13	Sharing Economy	-	-
14	Driverless Cars	-	-
15	Nanotechnology / Biotechnology	-	-

As result, we found that IoT and Wireless sensor network related researches were among the most researched fields in APIC-IST 2015. However, there were not any topics related to Block chain related E-Business, E-Commerce or AI. Additionally there were not any researches done in the fields of 3D Printing, Sharing Economy, Driverless Cars, Nanotechnology and Biotechnology as well. Therefore, due to importance of the mentioned fields and lack of publications on 3D Printing, Sharing Economy, Driverless Cars, Nanotechnology and Biotechnology topics in APIC-IST 2015, we recommend APIC-IST to encourage researchers to focus on these fields as well for future works.

As can be seen in **Table 3**, 6 out of 12 outstanding research articles were related to IoT, Wireless sensor network and Multimedia processing.

Table 3. Selected Outstanding Researches of APIC-IST 2015

Main Issue No.	Article No.	Article title
1	1	Fault Tolerance Technique using Multi-Agent System
	2	A Black Hole Detection Protocol(BHDP)
	3	Analysis of Cognitive Radio Channel Access for Individual Nodes with Distributed Control
2	4	An Efficient Facial Expression Recognition System Using LBP, GDA, and HMM from Depth Video
	5	Design of Dynamic Bitrate Optimization based on the Adaptive Stream Buffering of HLS
	6	Target Model Update of Mean-shift Tracking based on Back-projection Weight
3	7	Relevance Analysis System Design based on Content of Software Research and Development Document Artifacts
4	8	Performance Analysis of an Estimated Closeness Centrality Ranking Algorithm in Large-Scale Workflow-supported Social Network
	9	Exploring Gender Differences in Motivations for using Sina Weibo
5	10	A Process-Centered Knowledge Model for Analysis of Technology Innovation Procedures
7, 8	11	A Management Framework Towards Energy-Efficient and Performance-Aware Data Centers for Cloud-Based Wind Turbine CMS
-	12	Sustainable Strategy for Social Contents Providers: An Empirical Analysis of Korean SNS Market

The overall contents of the representative articles from each main issue are as below:

Main Issue No. 1 - IoT / Wireless sensor network (Article No. 1): HwaMin Lee et al. wrote about requirement of Wireless sensor networks with goal of reducing energy consumption. The authors used a multi agent and mobile agent configuration system to improve Wireless sensor networks to be capable of providing energy efficient services. HwaMin Lee et al. mentioned that based on mobile agent architecture, reliability, extensibility and scalability of traditional wireless sensor networks can be significantly improved[23].

Main Issue No. 2 - Multimedia Processing (Article No. 4): Md. Zia Uddin and Jaehyoun Kim introduced a novel and efficient approach for facial expression recognition systems. This approach is based on Local Binary Pattern (LBP) and is capable of recognizing facial expressions through time sequential depth videos. The authors could successfully create and apply depth based facial expression recognition system based on Hidden Markov Models (HMMs) by which different facial expressions were trained into the system[24].

Main Issue No. 3 - Distributed Computing and Control / Authenticated Security (Article No. 7): Dusan Baek et al. wrote an article regarding software configuration management (SCM) that can be used for various software artifacts generated to guarantee the

quality of a software. The SCM introduced by the authors contains a content-based configuration management system which is based on relevance link generation phase and content based testing phase which helps the management system to manage and trace the changes[25].

Main Issue No. 4 - SNS & Communications (Article No. 8): Jawon Kim in this article introduced an estimated ranking algorithm of closeness targeting large-scale social networks. The authors applied this algorithm into weighted workflow-supported social networks and confirmed that their algorithm is 50% more time efficient than previously introduced approaches[26].

Main Issue No. 5 - Big Data (Article No. 10): Seungsu Chun wrote about knowledge model of the economic networks and the requirement for social structural changes based on technology innovations. The author defined a process centered knowledge model that can be used to analyze policy-making procedures on technology innovations. Based on the knowledge model which is based on keyword mining from natural language of a document, the keywords were automatically generated into topic networks[27].

Main Issue No. 7, 8 - Energy Storage, Cloud Computing (Article No. 11): Frank Elijorde et al. described an energy efficient performance aware cloud system which is based on a dynamic switching approach. Authors provided a platform for development of wind farm condition monitoring system with ubiquitous access. Through this system, a reliable and efficient operation system which can be controlled by multiple simultaneous users, was introduced[28].

Extra issue (Article No. 12): Kyu Tae Kwak et al. described information and communications technology (ICT) contents as an industry of high added values. Authors investigated the internationalization and industrial characteristics of ICT contents firms based on a survey analysis of 212 key decision makers of Korean ICT content firms. Based on their data, they found that the current interdependence and resource environment requires consideration in different aspects[29].

5. Conclusion

The fourth industrial revolution is a concept which had fundamental effects on economy of developed countries. The four stages of industrial revolution started by mechanical production which was powered by water and steam. Later in 20th century, the mass production powered by electricity was introduced as the 2nd industrial revolution. More recently in 70s, the 3rd industrial revolution covered IT automatic production lines and electronics. Finally the 4th industrial revolution as combination of previous industrial revolutions combined physical systems and cyber systems and introduced cyber-physical system as an intelligent network system. The fourth industrial revolution and the future of core technology trend are expected to result in an all-new era of automated industries. Furthermore, the internet devices significantly improve the quality of lives and in result will have a large impact on society. Therefore, it is necessary to be prepared for the changes that will happen in the fourth industrial revolution.

In this study, the contents of all 64 articles published in APIC-ICT 2015 were analyzed and classified based on the keywords of the fourth industrial revolution. Results of this study suggested that most researchers focused on IoT and Wireless sensor networks in their research and there were not enough researches done in 3D Printing, Sharing Economy, Driverless Cars, Nanotechnology and Biotechnology fields. As The fourth industrial revolution requires

detailed investigations from all aspects in related fields, we recommended researchers to also focus on the fields that were less examined in the past.

References

[1] Deloitte, *Tech Trends 2015: The fusion of business and IT*, 2015.
[2] Gartner, *Top 10 Strategic Technology Trend for 2015*, 2015.
[3] IBM, *The 2015 HorizonWatch Technology Trends to Watch*, 2015.
[4] IDC, *Top 10 technology predictions for 2015*, 2014.
[5] IEEE Computer Society, *Top Technology Trends for 2015*, 2015.
[6] Red Hat, *Gazing into the crystal ball: Red Hatters offer tech predictions for 2015*, 2014.
[7] NIA, IT & Future Strategy Report, *Industry 4.0 and manufacturing creative economy strategy*, National Information Society Agency, 2014.
[8] Kagermann, H., W. Wahlster and J. Helbig, eds., Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group, 2013.
[9] Acatech: *Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0* – Abschlussbericht des Arbeitskreises Industrie 4.0. acatech, 2013.
[10] Hermann, Pentek, Otto, *Design Principles for Industrie 4.0 Scenarios, 2015*. 2015.
[11] Lee, Jay, Behrad Bagheri, and Hung-An Kao. "A cyber-physical systems architecture for industry 4.0-based manufacturing systems." Manufacturing Letters 3, pp. 18-23, 2015. Article (CrossRef Link)
[12] Stock, T., and G. Seliger. "Opportunities of Sustainable Manufacturing in Industry 4.0." *Procedia CIRP* 40, pp. 536-541, 2016. Article (CrossRef Link)
[13] Shiyong Wang, Jiafu Wan, Di Li, and Chunhua Zhang, "Implementing smart factory of industrie 4.0: an outlook," *International Journal of Distributed Sensor Networks*, Vol.2016, 2016. Article (CrossRef Link)
[14] Suhel Dhanani, *Realizing Industry 4.0: Essential System Considerations*, Maxim, APPLICATION NOTE 5991, 2015.
[15] Carolyn Mathas, *Industry 4.0 is closer than you think*, EDN's Hot Technologies, 2013.
[16] Lee, Jay, Hung-An Kao, and Shanhu Yang. "Service innovation and smart analytics for industry 4.0 and big data environment," *Procedia CIRP* 16, pp. 3-8, 2014. Article (CrossRef Link)
[17] Lukac, Dusko. "The fourth ICT-based industrial revolution" Industry 4.0"??? HMI and the case of CAE/CAD innovation with EPLAN P8," *Telecommunications Forum Telfor (TELFOR), 2015 23rd*. IEEE, 2015. Article (CrossRef Link)
[18] Pil-Sung Jang, "2016 Davos Forum: Our strategy for the upcoming fourth industrial revolution," *SCIENCE & TECHNOLOGY POLICY*, Vol.26. Iss. 2, pp. 12-15. 2016. Article (CrossRef Link)
[19] Kyoung Jun Lee, *KISA Report - 2016 world economic forum's fourth industrial revolution: focused on its impact on the economy and business*, Korea Internet & Security Agency, 2016.
[20] Schwab Klaus, *The Fourth Industrial Revolution*, Kindle Edition, 2016.
[21] Schwab Klaus, *The Fourth Industrial Revolution: what it means, how to respond*, World Economic Forum, 2016.
[22] WEF Survey Report, *Deep Shift Technology Tipping Points and Societal Impact*, World Economic Forum, 2015.
[23] HwaMin Lee, Se Dong Min, Min-Hyung Choi and DaeWon Lee, "Fault Tolerance Technique using Multi-Agent System," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 17-18, July 13-15, 2015.
[24] Md. Zia Uddin and Jaehyoun Kim, "An Efficient Facial Expression Recognition System Using LBP, GDA, and HMM from Depth Video," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 237-238, July 13-15, 2015.
[25] Dusan Baek, Byungjeong Lee and Jung-Won Lee, "Relevance Analysis System Design based on Content of Software Research and Development Document Artifacts," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 125-126, July 13-15, 2015.

[26] Jawon Kim, "Performance Analysis of an Estimated Closeness Centrality Ranking Algorithm in Large-Scale Workflow-supported Social Network," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 81-85, July 13-15, 2015.
[27] Seungsu Chun, "A Process-Centered Knowledge Model for Analysis of Technology Innovation Procedures," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 237-238, July 149-153, 2015.
[28] Frank Elijorde, Sungho Kim, and Jaewan Lee, "A Management Framework Towards Energy and Performance-Aware Data Centers for Cloud-Based Wind Farm CMS," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 129-132, July 13-15, 2015.
[29] Kyu Tae Kwak, Youngjoon Cheon and Bong Gyou Lee, "Sustainable Strategy for Social Contents Providers: An Empirical Analysis of Korean SNS Market," in *Proc. of the 10th Asia Pacific International Conference on Information Science and Technology*, pp. 91-97, July 13-15, 2015.

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