

Examination of International Collaborative Research Status and Co-Authorship Network Visualization of Korean Researchers in the Computer Field

Byung-Kyu Kim¹, Beom-Jong You², Ji-Hoon Kang^{*3}

¹Dept. of data-centric problem solving research, Korea Institute of Science and Technology, 245 Daehak-ro, Yuseong-gu, Daejeon, 34141, SOUTH KOREA

²Dept. of data-centric problem solving research, Korea Institute of Science and Technology, 245 Daehak-ro, Yuseong-gu, Daejeon, 34141, SOUTH KOREA

³Chungnam National University, Department of Computer Science and Engineering, 99 Daehak-ro, Yuseong-gu, Daejeon 34134, SOUTH KOREA
bk.kim@kisti.re.kr¹, you@kisti.re.kr², jhkang@cnu.ac.kr³

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Abstract

Background/Objectives: According to a recent WEF report, Korea's competitiveness ranking in the Information & Communication Technology (ICT) sector, which provides the foundation technology of the Fourth Industrial Revolution, ranks among the highest in the world. It is very important to analyze the research behavior in the computer field, which is a core discipline in the ICT field. In this paper, to investigate the current status of international joint research by computer researchers in Korea, this study analyzed the current status of cooperative relations between domestic and foreign author-affiliated institutions by using the papers of Korean computer researchers published in core journals.

Methods/Statistical analysis: Author's organization and country information were extracted from the collected papers by preprocessing. Based on these, the rankings by institution, country ranking, and the status of collaboration between countries and institutions were statistically analyzed. Thirdly, a network was created and visualized on a map based on the co-authorship between the author's institution and the country of each article examined in the previous step.

Findings: The findings of this study are as follows. First, popular SCI journals preferred by Korean researchers were analyzed. Second, the statistics of author's affiliated institutions (author's organization, author's country) were counted by year of publication and period of year of publication. The rankings of domestic and overseas author-affiliated institutions and the rankings of countries were calculated. In the case of the United States, which has the highest rate of deductions, the rankings were also calculated by US states. Third, international collaborative networks of Korean computer researchers were created and visualized by author-level institutions and country levels.

Improvements/Applications: The results of this study can help us to identify trends in computer researchers and research institutes in Korea. To this end, it is necessary to identify and collect key academic resources in the computer field as a whole.

Keywords: Computer Science Field; Korean Research Output; Co-

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I. Introduction

As a result of the 2018 World Economic Forum's report, Korea's national competitiveness and ICT competitiveness were very high in the world, reaching 15th and 1st place respectively[1]. In particular, it is significant that Korea's competitiveness ranks high in the ICT sector, which is the foundation of the Fourth Industrial Revolution. In addition, Korea ranks 12th in the world by the number of SCI papers published in 2016, and in 2005, leydesdorff's research found that Korea is becoming a global research center with China[2]. It is very important to analyze the research behaviors of researchers in computer science, a core field of ICT field and competitive field of Korea.

In this paper, we analyzed the co-authorship relations between Korean and foreign institutions in the sci papers of Korean computer researchers published in core journals. For this study, Korean papers in computer field, which were included in the SCI(SCI, SCIE) journal from 2001 to 2014, were selected and collected for analysis. First, the ranking of journals with many articles published were measured. Second, in these papers, the author's address information was pre-processed and used to extract the author's institution and institution's national information, and the author's institution and the country's status were statistically analyzed. Lastly, the co-authorship relations between the authors' organizations and their countries identified by individual articles were created and networked. This paper examines related studies, research materials, and methods in Chapters 2 and 3, describes the main findings in Chapter 4, and concludes in the last chapter.

II. Related Research

In a previous study conducted in 2014, bibliometric analysis was performed on all Korean SCI papers from 1968 to 2012, and the research results and behaviors of Korean

scientific journals were outlined [3]. In addition, in a previous study conducted in 2013, Using the KSCD (Korea Science Citation Database), which KISTI produces based on articles and references of academic journals published in Korea, the researcher's research results, citation behavior, and citation relations among domestic author institutions are analyzed. Prior to this, in 2012, a study was conducted for the system to analyze affiliation of domestic Paper Author using KSCD to analyze the cooperative relations of domestic researchers[5]. In 2018, as a follow-up of previous studies, an evaluation study of SCI journals using KSCD was also carried out [6,7]. These previous studies were conducted separately, and there were limitations in the analysis of author-affiliated institutions in domestic and international cooperative relations of domestic SCI academic papers. Separately, in Korea, quantitative analysis is conducted and published as a report based on SCI papers of major research institutes and universities[8-9]. However, these reports are focused on quantitative analysis, and results of author-affiliated institutional analysis and co-relationship network visualization based on co-relationship are insufficient. Based on the collaborative relationship of academic papers, many collaborative relationship analysis studies have been conducted in foreign countries and in Korea. In Korea, a collaborative relationship analysis was conducted for key researchers in China based on academic paper information from the Chinese Advanced S & T Information Service (CAIS) operated by KISTI[10]. In addition, co-relationship analysis research was conducted on the journals of Library and Information Science, Computer Science, and Statistics, and co-author analysis of MIS Quarterly, an international journal in the information system field[10-14]. A similar study to this research is the knowledge structure network research of international joint research in the field of

Psychiatry. However, this study also differs in the scope of research and subjects in the field of research[15].

III. Materials and Methods

For the purpose of this study, Korean computer papers from SCI journals from 2001 to 2014 were selected and collected for analysis. This paper focuses on Korean academic publications in the SCI (E) database of the Web of Science (WoS) and computer papers among them, and includes all document types for analysis. The relevant data is collected and selected in the following way.

- (1) EndNote version 6, a bibliographic management tool from Clarivate Analytics, was used and the bibliographic data download function was used.
- (2) The bibliographic data search was restricted to “Web of Science, Science Citation Index Expanded (SCI-EXPANDED)” and the keyword “South Korea” was entered in the Author address field.
- (3) The data from 2001 to 2012 were retrieved and collected in the same way in May 2013, and the data from 2013 to 2015 were retrieved and collected in November 2016.
- (4) The final research data of 17,223 research papers were selected for the computer field (COMPUTER SCIENCE_SOFTWARE ENGINEERING, COMPUTER SCIENCE_ARTIFICIAL INTELLIGENCE, COMPUTER SCIENCE_INFORMATION SYSTEMS, COMPUTER SCIENCE_THEORY & METHODS, COMPUTER SCIENCE_HARDWARE & ARCHITECTURE). To this end, the Subject Category used by WoS to classify journal topics is used.

In order to map the WoS subject areas to SCI journals, the authority data of the journals

established in previous studies was used [7]. Table 1 below shows the current state of thesis data collection from 2001 to 2014. Main items (Record Number / Year / Journal Title / Volume / Issue / Pages / Article Title / Keyword / Author / Author Address) that make up the collected article records. Among these items, the "Author Address" item is used to extract the author's affiliate and the author's country. Since the focus of the analysis is not the individual author, but the author's own country and the author's country, the author's institution extracted from the "Auhor Address" and the country of the institution to which the author belongs are de-duplicated for each article. For analytical research, first, the ranking of journals was examined based on the number of articles published in individual journals. Second, the author's organization and country information was extracted from the collected papers by preprocessing. Based on these, the rankings by institution, country ranking, and the status of collaboration between countries and institutions were statistically analyzed. Thirdly, a network was created and visualized on a map based on the co-authorship between the author's institution and the country of each article examined in the previous step. For data preprocessing and statistical analysis, we used Microsoft's 2019 version of Excel, and for the creation of co-operation network, we used Python-based program developed by ourselves, and vosviewer software, a specialized analysis tool for map and visualization of the network[16].

Table 1: The number of SCI papers by Korean in Computer Field per year (2001-2014)

Years Published	# of Articles	# of Journals
2001	473	114
2002	704	113
2003	1329	130
2004	2063	135
2005	2580	137
2006	2507	147
2007	660	153
2008	793	166
2009	843	183

2010	915	192
2011	908	186
2012	1005	183
2013	1163	201
2014	1280	207
Total	17223	341

IV. Results

In this study, a total of 17,223 SCI papers were collected from WoS in Korea. The rankings were calculated by dividing the total 14 years

based on the year of issue and the last 5 years (2001 ~ 2015). Between 2001 and 2006, the journal abbreviations "Lect Notes ComputSc" and "Lect Notes ArtifInt", which Korean researchers published relatively many articles, were dropped from SCI. The trends in the number of authors and the number of authors in SCI papers in the Korean computer field are shown in Table 2 below.

Table 2: SCI journals with a large number of papers by Koreans (Top 15)

Journal Title	Subject Category	# of Articles	Journal Title	Subject Category	# of Articles
Human Society and the Internet, Proceedings	COMPUTER SCIENCE, THEORY & METHODS	5770	IEICE TRANSACTIONS ON INFORMATION AND SYSTEMS	COMPUTER SCIENCE, INFORMATION SYSTEMS	364
IEICE TRANSACTIONS ON INFORMATION AND SYSTEMS	COMPUTER SCIENCE, INFORMATION SYSTEMS	923	IEICE TRANSACTIONS ON FUNDAMENTALS OF ELECTRONICS COMMUNICATIONS AND COMPUTER SCIENCES	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	257
Machine Learning and Data Mining in Pattern Recognition	COMPUTER SCIENCE, THEORY & METHODS	861	MULTIMEDIA TOOLS AND APPLICATIONS	COMPUTER SCIENCE, THEORY & METHODS	193
IEICE TRANSACTIONS ON FUNDAMENTALS OF ELECTRONICS COMMUNICATIONS AND COMPUTER SCIENCES	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	802	INFORMATION SCIENCES	COMPUTER SCIENCE, INFORMATION SYSTEMS	158
INFORMATION SCIENCES	COMPUTER SCIENCE, INFORMATION SYSTEMS	309	JOURNAL OF SUPERCOMPUTING	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	147
JOURNAL OF COMMUNICATIONS AND NETWORKS	COMPUTER SCIENCE, INFORMATION SYSTEMS	269	JOURNAL OF COMMUNICATIONS AND NETWORKS	COMPUTER SCIENCE, INFORMATION SYSTEMS	145
MULTIMEDIA TOOLS AND APPLICATIONS	COMPUTER SCIENCE, THEORY & METHODS	229	IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	103
COMPUTER COMMUNICATIONS	COMPUTER SCIENCE, INFORMATION SYSTEMS	223	COMPUTER NETWORKS	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	92
COMPUTER-AIDED DESIGN	COMPUTER SCIENCE, SOFTWARE ENGINEERING	204	JOURNAL OF INFORMATION SCIENCE AND ENGINEERING	COMPUTER SCIENCE, INFORMATION SYSTEMS	86

JOURNAL OF SUPERCOMPUTING	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	191	IEEE TRANSACTIONS ON INFORMATION THEORY	COMPUTER SCIENCE, INFORMATION SYSTEMS	85
PATTERN RECOGNITION LETTERS	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	189	NEUROCOMPUTING	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	78
IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	165	PERSONAL AND UBIQUITOUS COMPUTING	COMPUTER SCIENCE, INFORMATION SYSTEMS	76
JOURNAL OF INFORMATION SCIENCE AND ENGINEERING	COMPUTER SCIENCE, INFORMATION SYSTEMS	162	IEEE TRANSACTIONS ON COMPUTERS	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	74
COMPUTER NETWORKS	COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	161	SCIENTOMETRICS	COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS	72
JOURNAL OF SYSTEMS AND SOFTWARE	COMPUTER SCIENCE, THEORY & METHODS	155	PATTERN RECOGNITION LETTERS	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	70

The number of authors, author institutions, and number of author countries increased from 2.88, 1.23, and 1.16 in 2001 to 3.35, 1.29, and 2.06, respectively, in 2014. On average, 3.15, 1.47 and 1.81 were found. The cooperative relations between Korea and other countries are shown in Table 3 below. 13,160 papers were written by authors belonging to Korean institutions without cooperation with foreign countries, accounting for 76.43% of the total. 4,063 papers, or 23.6%, were written in a cooperative relationship between Korea and other foreign countries.

Table 3: Number of articles by number of countries with co-authorship relationship

# of Co-authorship Country	% of total	# of Articles
One Country (Only "South Korea")	76.43%	13,160
Two Countries including "South Korea"	19.29%	3,323
Three Countries including "South Korea"	3.50%	602
Four Countries including "South Korea"	0.53%	91
Five or more Countries including "South Korea"	0.25%	47
Total # of Articles	100%	17,223

When analyzing collaborative papers with foreign countries, the highest percentage of co-authored papers between Korea and one other country was 19.29%. Analysis of the author's country is shown in the map chart in Figure 1 below.



Figure 1: Number of articles in co-authorship countries

If you look at the percentage of countries that appeared in Korean papers, that is, countries with co-authorship relations (based on the number of papers in that country), ranked "USA (12.9%)> Peoples R China (2.8%)> Japan (1.6)". %> Canada (1.6%)> Australia

(0.8%)> Germany (0.8%)> England (0.8%)> Taiwan (0.7%)> Singapore (0.6%)> Poland (0.5%). The number of co-authorship papers published by these countries with Korea is shown in Figure 2 below.

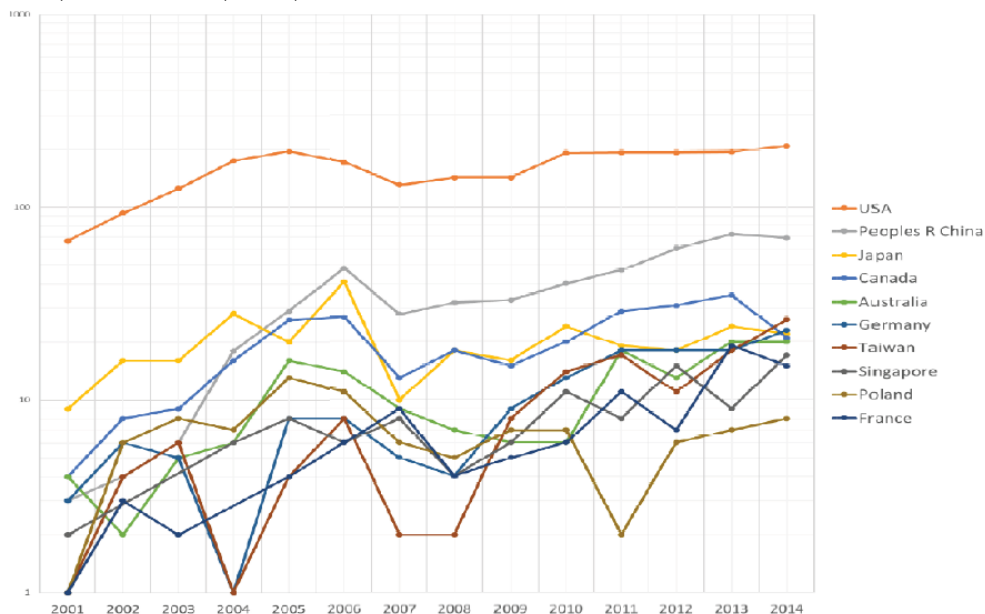


Figure 2: Number of papers by year in countries with co-authorship relationships (Top 10)

In the case of China, since 2005, it has surpassed Japan, showing a very high co-operation ratio and increasing every year. The United States was found to be very influential, accounting for 50% of the total number of co-authorship papers from all foreign countries. Therefore, in the case of the United States, the 50 states were further analyzed. The results are shown in the map chart in Figure 3 below. The

percentage of US states that have a co-authorship relationship with Korea is as follows: "California> New York> Pennsylvania> Texas> Massachusetts> Illinois> Michigan> Georgia> Indiana> North Carolina. California's co-authorship ratio was high, accounting for 20% of all US co-authorship papers.

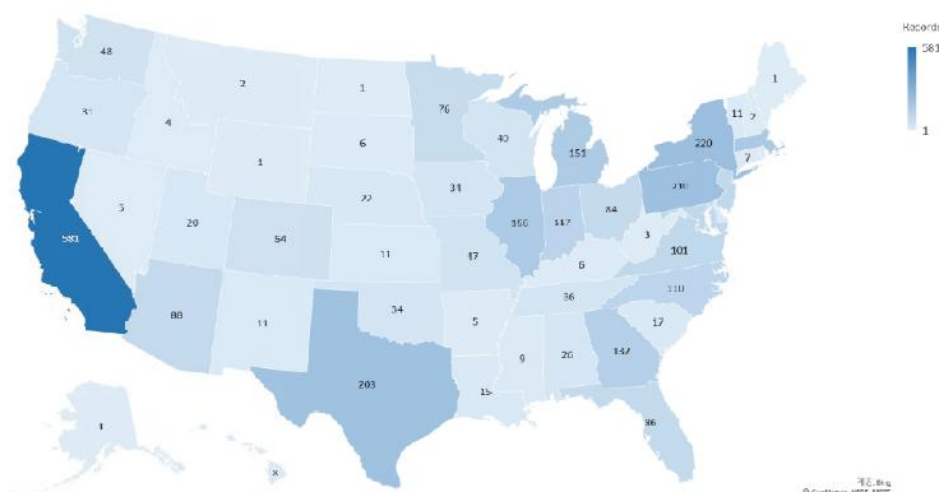


Figure 3: Number of articles in the USA with co-authorship status by 50 States

In the author's analysis, the total number of institutions appearing in the study papers was 3,388, and it increased from 258 in 2001 to 774 in 2014. 2,224 institutions appeared only once, and only 54 institutions appeared in all the publication periods. This is because the institutional information was used as the original data collected from the WoS in this

study, and this problem is a limitation of this study and a future task that requires the author's institutional authority work. Table 4 below is a list of the top 20 international author-affiliated institutions with the highest frequency of appearance among the co-authorship of Korea and foreign countries.

Table 4: Author Organizations with co-authorship Relationships (Top 20)

Author's Organizations	Country	States	# of Articles
Univ Illinois	USA	Illinois (Urbana)	90
Univ Calif Irvine	USA	California (Irvine)	75
Univ Alberta	Canada	Edmonton	74
Univ So Calif	USA	California (Los Angeles)	66
Georgia Inst Technol	USA	Georgia (Atlanta)	66
Polish Acad Sci	Poland	Warsaw	64
Purdue Univ	USA	Indiana (W Lafayette)	63
Carnegie Mellon Univ	USA	Pennsylvania (Pittsburgh)	63
Univ Minnesota	USA	Minnesota (St Paul)	47
Arizona State Univ	USA	Arizona (Tempe)	46
Univ Tokyo	Japan	Tokyo	44
Univ Michigan	USA	Michigan (Ann Arbor)	44
Michigan State Univ	USA	Michigan (E Lansing)	43
Penn State Univ	USA	Pennsylvania (University Pk)	42
Univ Texas Austin	USA	Texas (Austin)	41
Univ N Carolina	USA	North Carolina (Chapel Hill)	41
MIT	USA	Massachusetts (Cambridge)	41
Natl Univ Singapore	Singapore	Singapore	38
Univ Arizona	USA	Arizona (Tucson)	35
Univ Missouri	USA	Missouri (Kansas City)	34

The keywords of the co-authored papers of "Univ Illinois" and "UnivCalif Irvine", which had the highest co-authorship ratio, were written in word cloud. It can be seen that the frequency of the keyword is very different from the popular keyword, and further research is needed for detailed analysis. Lastly, if we create and map the network between countries at home and abroad, which have co-authorship relations, it is as follows. Figure 4 shows a network map between countries, and Figure 5

shows a network map between author institutions. In particular, Figure 6 shows and maps only the networks with cooperative relationships between Korean authors and foreign authors. Among the cooperative relations of three or more countries, the pairs with the highest proportions are "Peoples R China; South Korea; USA", "Canada; Poland; South Korea", "Canada; South Korea; USA", "South Korea; Taiwan ; USA "and" Japan; South Korea; USA ".

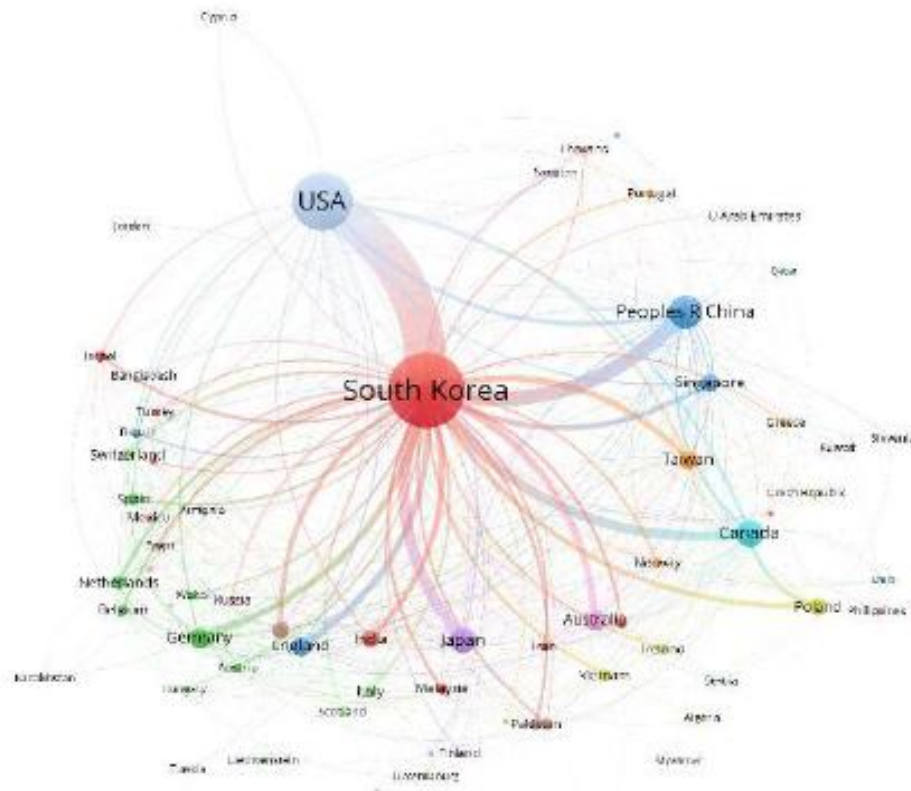


Figure 4: Co-authorship relationship network map between countries

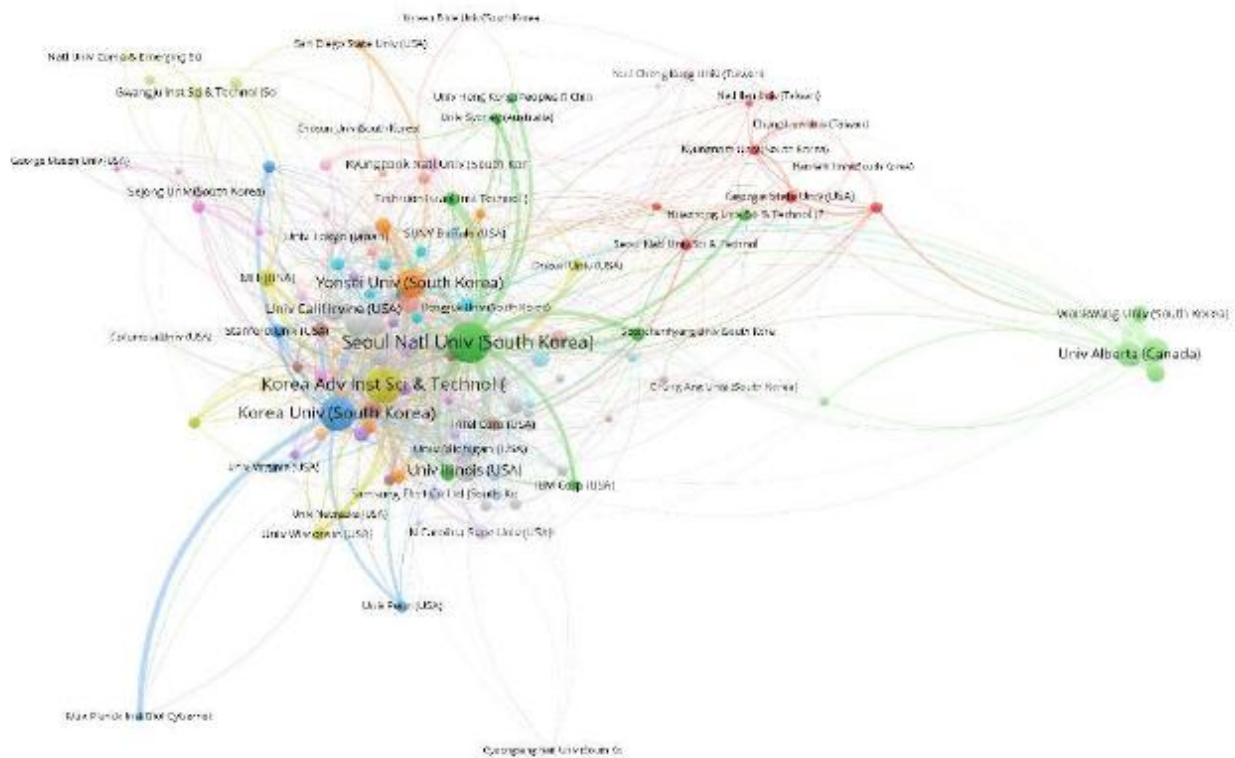


Figure 5:Map of co-authorship relationships between authors' organizations

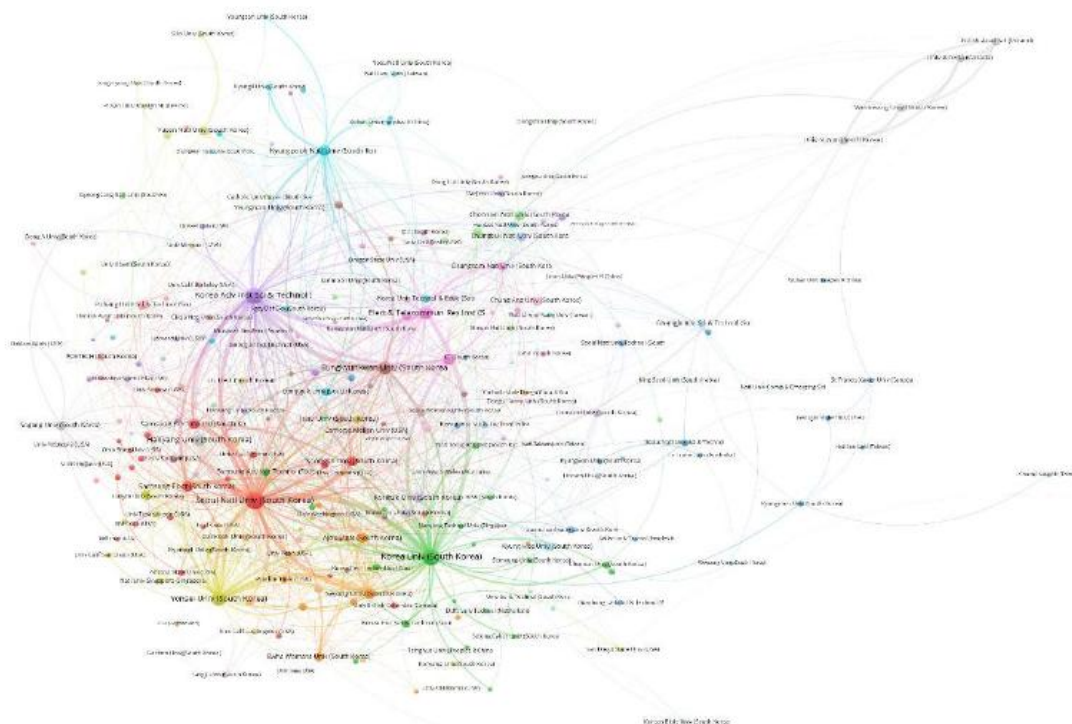


Figure 6:Map of co-authorship relations between authors' organizations (excluding inter-Korean relations)

V. Conclusion

It is very important to analyze the research

behaviors of researchers in computer science, a core field of ICT field and competitive field of Korea. In this paper, in order to grasp the

current status of joint research by computer researchers in Korea, this study analyzed the current status of cooperative relations between domestic and foreign authors' organizations. The findings of this study are as follows through the visualization of the international collaboration status and collaborative network of Korean computer researchers. First, popular SCI journals preferred by Korean researchers were analyzed. Second, the statistics of author's affiliated institutions (author's organization, author's country) were counted by year of publication and period of year of publication. The rankings of domestic and overseas author-affiliated institutions and the rankings of countries were calculated. In the case of the United States, which has the highest rate of deductions, the rankings were also calculated by US states. Third, international collaborative networks of Korean computer researchers were created and visualized by author-level institutions and country levels. As a limitation of this study, there was a limitation in unified organizational identification using the original institutional information collected by the WoS. In the future, it is necessary to build authority data on institutional information through other refining operations. The results of this study can help us to identify trends in computer researchers and research institutes in Korea. To this end, it is necessary to comprehensively identify and collect core academic resources in the computer field.

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