스마트 그리드 예비 연구를 위한 계량정보분석

박종규* · 배영철**

Scientometric Analysis for Pilot Study of Smart Grid

Jong-Kyu Park* · Young-Chul Bae**

요 약

특허, 논문, 연구 주제에서 중복을 피하기 위해서 많은 연구자들은 다양한 방법을 가지고 특허와 이전의 연구 결과들을 검토한다. 이러한 노력을 줄이기 위하여 본 논문에서는 스마트 그리드에서 중복을 피하고 연구자들을 도와주기 위한 방법으로 수준지수분석, 국제협력 연구 네트워크, 소속과 저자의 핵심 분석을 통한 계량정보분석 방법을 제안한다.

ABSTRACT

In order to avoid duplication in patents, papers and research subjects, many researchers have to review previous research work and patents with various methods. To reduce the our efforts in preview of research work, in this paper, we present scientometric analysis including Analysis of Index Level, International Cooperation Research Network, Analysis of Key Organizations and their Authors to help researchers to avoid duplication problems in field of smart grid.

키워드

Scientometric analysis, Smart grid, Index level, International cooperation Research network, Analysis of key
계량정보분석, 스마트 그리드, 수준 분석, 국제협력연구네트워크, 핵심 분석

I. Introduction

The advancement of scientific technology has been conducted by researchers written as papers or patents in the area. Recently, as we know, two big companies, Samsung and Apple, filed patent suits for each other over their smart-phones. All technology that is being used or will be used in the future will likely face same problem of copyright. Many researchers in engineering or related areas have difficult time to discover unique and reasonable research themes due to the fact that more than two millions papers and themes have been published. Generally speaking, we live in age when information is overwhelming and it is not always easy to avoid duplication with any interesting research themes nowadays. Hence, to solve this problem, many researchers put an effort to monitor all information available using the database. However, such a method requires enormous amount of time and cost to acquire all necessary information from the database system. Therefore, many researchers desire

* 한국과학기술정보연구원(jkpa가@kisti.re.kr), **교신저자: 전남대학교 전기 · 전자통신 · 컴퓨터 공학부(ycbae@jnu.ac.kr)
접수일자 : 2011. 12. 20 심사(수정)일자 : 2012. 01. 05 게재확정일자 : 2012. 01. 25

to have more efficient search method.

Many researcher study to find new result in their various research area such as engineering and seience[1-10]. In order to avoid duplication in patents, papers and research subjects, many researchers have to review previous research work and patents with various methods [11-13]. Among those methods, scientometric analysis in global dimensions emerged as one of the necessary methodsto avoid duplication in science and technology areas. However there is hardly any paper applied with scientometric analysis for information retrieval.

Jong-Kyu Park and Young-Chul Bae[14] proposed similar paper for Grading Criteria as a Rubric for Research Focus in wind power generation. Because this paper focuses on making the roadmap for research, it is not sufficient enough to make scientometric analysis for research. In order to apply scienometric analysis, it is necessary to use clustering method. Clustering methods can largely be divided into three methods including co-citation method, bibliographic coupling and KISTI coupling method. Co-citation (Cij) method is a method of binding the related citations simultaneously between two similar papers A and B. Bibliographic coupling (Bij) [ ] is a method of binding simultaneous related citations that has been used in both paper A and B.0 KISTI coupling (Kij) technique is a method of combining above two methods and the result came out to with higher value compare to the coefficient of similarityyielded from both of co-citation method and bibliographic method.

In this paper, we present scientometric analysis including Analysis of Index Level, International Cooperation Research Network, Analysis of Key Organizations and their Authors to help researchers to avoid duplication problems in field of smart grid.

II. Information extraction from paper published in smart grid

To extract the information from database, we used SCOPUS which contained 98% of SCI(Scientific Citation Index) information. SCOUPS DB has a 16,000 number of journals and has collected more than 240 million academic papers including citations since 1996. In order to apply the scientometric analysis in smart grid research, we extract highlycited paper from SCOUPS(Elsevier, Netherlands) and select smart grid related group of papersusing clustering technique.

In this paper, we perform clustering method by using one of three methods explained above to test which method provide the best coefficient of similarity. Moreover, we expressed cosine coefficient (Sij = Cij / SQRT(Ci * Cj) as a degree of similarity and as crowding method which is the single linkage that links the shortest distance between neighboring two points as a hierarchal clustering method. We also perform clustering method that have the maximum and minimum size clusters that is 50 and 5, respectively and choosethe optimal value of threshold between 0.1-0.3.

In this paper, we search a paper of smart grid using equation as the following (1). We exclude Ultra High Voltage Direct Current in this equation to avoid consider a number of searches.

Topic="(smart-grid)"OR (Topic=(smart) AND Topic=(grid)) (1)

We also restrict search year between 2001-2011 in an search equation and got 418 of numbers of papers.

In order to compute an average annual increase of smart grid papers, we use equation (2) as follows:

$$g_{gap} = (\prod_{i=1}^{n}(g_i+1)^{n-1} - 1_{\times 100[\%]} \quad (2)$$

Where, g_i is $g_i = (P_{i+1} - P_i)/P_i^*$

From the equation (2), we get 38.34% as an

average annual rate increase and 52.83% as an increase in accumulated rate of smart grid papers. In Figure 1, it shows the trend of number of published papers in the world and Korean author. The bar graph and polygonal line display the number of total papers published in the world and the number of papers published by Korean author, respectively.

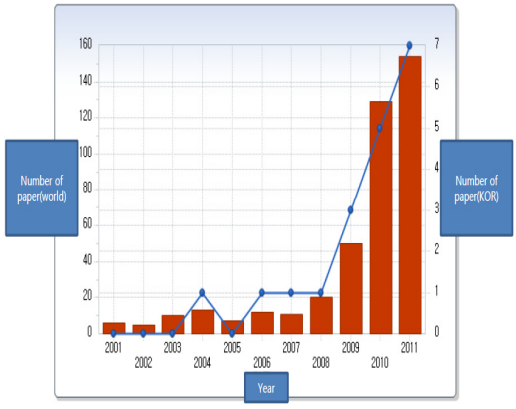

Fig. 1 Trend of number of published papers in the world and Korean author in smart grid

III. Scientometric analysis for Smart Grid

3.1 Analysis of index level

In order to analyze the index level of scientometric analysis for smart grid using published papers, we have to define the index level. In this paper, we used three index levels including countries, organizations, and authors. Generally, index levels can be defined by equation (3) for countries, organizations, and authors.

$$Q_{c,o,a} = \frac{N_{c,o,a}}{M} \tag{3}$$

Where, Q means index level and infix c,o,a is country (c), organization (o) and author (a) respectively. M is the number of average citations for the total papers published in certain technical area, smart grid in this paper; N_c, N_o, N_a are the number of average cited published papers of certain country (c), organization (o) and author (a), respectively.

Equation (3) meansqualitative level evaluation index based on the number of citrated papers. For example, if we calculate the index level of countries, organizations and authors by using equation (3), we can describe the equation (3) as a Q_c, Q_o, Q_a, respectively. If index level Q_c, Q_o, Q_a is equal to 1.0, it means that number of average cited papers in certain countries, organizations and authors is equal to number of average total cited papers published in related subject area. If the index level is over 1.0, it means that the numbers of average cited paper in certain countries, organizations and authors are higher than the number of average cited paper published in the certain area. Figure 2, Figure 3, and Figure 4 represent index level of papers published by countries, organizations and authors, respectively.

We get theresult of analysis of index levels for each country, organization and authors of total papers published in smart grid between year 2001-2010 using equation (3). In index level of countries, France gets the highest value of 2.367.

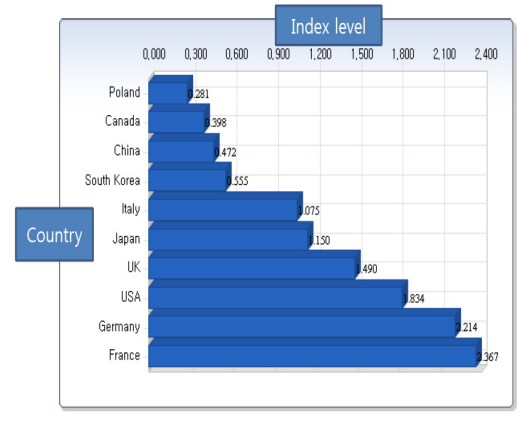

Fig. 2 Index levels of countries for paper published in smart grid

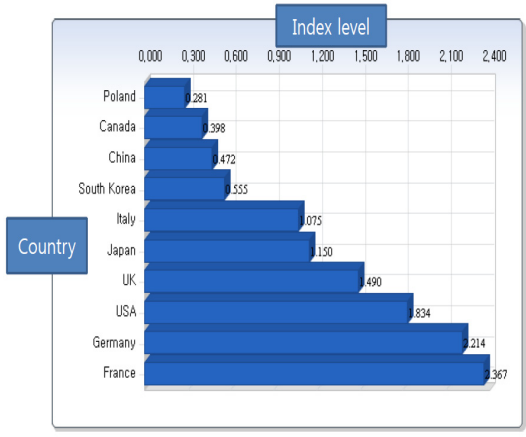

Fig. 3 Index levels of organizations for paper published in smart grid

It means the level of qualities of papers is the top compared with other countries. Several countries including France (2.367), Germany (2.214), USA (1.834), UK (1.49), Japan (1.15), Italy (1.075) displays index level above average. The index level of Republic of Korea records 0.555 which is below average.

In the index level of organizations, Georgia Institute Technology gets the highest value of 16.444 meaning that this organization shows the highest qualities of papers.

Fig. 4 Index levels of authors for paper published in smart grid

The organizations with index level above average are Georgia Institute Technology (16.444), University Illinois (4.722), Duke University (3.12), University Wisconsin (2.319), University California Berkeley (1.687), and University New South Wales (1.16). Finally in index level of authors, Wang, KM scores 4.919, Lorente, S 3.9, Bejan, A 3.9.

Figure 2, Figure 3 and Figure 4 shows us relationship between index level versus number of papers published for each country, organization, and author, respectively. Figure 5, Figure 6 and Figure 7 shows index level versus number of papers of each country, organization, and author, respectively.

3.2 International cooperation research network

In order to study International Cooperation Research Relationship, we try to investigate International Cooperation Research Network between countries and Relationship index of international cooperation(S) and Intensity of International Cooperation (L) in organizations and authors.

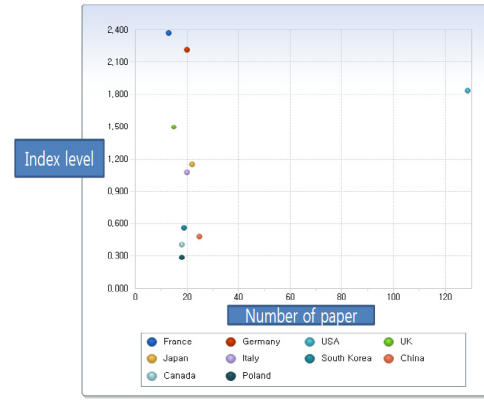

Fig. 5 Index level versus number of papers of each country in smart grid

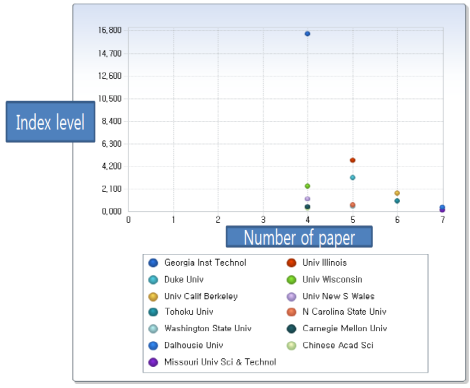

Fig. 6 Index level versus number of papers of each organizations in smart grid

International Cooperation Research Network displays relationship between nations to cooperate research in field of smart grid. As a result of the analysis, the U.S.A was placed at top ranking with most number of countries cooperating in research. It had cooperated with 20 countries excluding the U.S.A this means that USA is most active in establishing international network for research in smart grid.

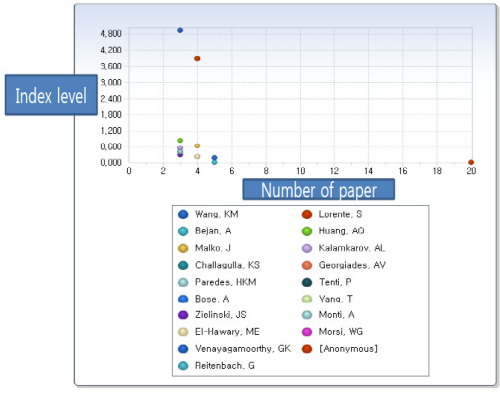

Fig. 7 Index level versus number of paper of each authors in smart grid

On the side note, Republic of Korea only cooperated with two nations Japan and Australia during last10 years.

International Cooperation Research Network displays relationship between nations to cooperate research in field of smart grid. As a result of the analysis, the U.S.A was placed at top ranking with most number of countries cooperating in research. It had cooperated with 20 countries excluding the U.S.A this means that USA is most active in establishing international network for research in smart grid. On the side note, Republic of Korea only cooperated with two nations Japan and Australia during last10 years.

In order to calculate international cooperation research relationship between organizations and between authors, we introduce the concept of the Relation Index of International Cooperation(S) and Intensity of International Cooperation (L).

We define Relation Index of International Cooperation using following equation (4).

$$S_{o,a} = \frac{T_F}{T_P} \tag{4}$$

Where, T_F is the total number of organizations of located overseas, T_P is the total number of organizations involved in certain research. Subscripts o and s are organization and author, respectively

From equation (4), we can see that S getting larger means that research relationship between international cooperation becomes more active establishment of strong international network.

The Intensity of International Cooperation (L) can be defined by equation (5).

$$L_{O,S} = \frac{S_{o,a}}{A_{o,a}} \tag{5}$$

Where, $S_{o,a}$ is Relation Index of International Cooperation, and $A_{o,a}$ is average of Relation Index of International Cooperation of the subject for certain research execution. Equation (5) can acquire average by normalizations.

From equation (5), if value of L is 1, it means that

average for the Intensity of International Cooperation Research of related researcher. Value greater than 1.0 means above average, and value less than 1.0 means below average.

From equation (4) and (5), we get the Relation Index of International Cooperation(S) and Intensity of International Cooperation (L) for organizations and authors and are shown in Table 1 and 2, respectively.

As a result of analysis of Intensity of International Cooperation (L) for organizations from Table 1, University New South Wales appear to have the highest point of 5.278 which is the top among the organization for smart grid research. The organizations have above average as follows: Univ New S Wales(5.278), Carnegie Mellon Univ(5.278), Univ Calif Berkeley(4.397), Duke Univ(4.223), Univ Wisconsin(3.959), Dalhousie Univ(2.264), Washington State Univ(2.111), Georgia Inst Technol(1.32), Univ Illinois(1.056), Tohoku Univ(1.056).

Table 1. Relation Index of International Cooperation(S) and Intensity of International Cooperation (L) for organization

O*	N*	S*	L*
Univ New S Wales	4	1	5.278
Carnegie Mellon Univ	4	1	5.278
Univ Calif Berkeley	6	0.833	4.397
Duke Univ	5	0.8	4.223
Univ Wisconsin	4	0.75	3.959
Dalhousie Univ	7	0.429	2.264
Washington State Univ	5	0.4	2.111
Georgia Inst Technol	4	0.25	1.32
Univ Illinois	5	0.2	1.056
Tohoku Univ	5	0.2	1.056
N Carolina State Univ	5	0	0
Chinese Acad Sci	4	0	0
Missouri Univ Sci & Technol	7	0	0

O*: Organization, N*: Number of paper, S*: Relation index of international cooperation(S), L*: Strength of international cooperation(L)

From the result of analysis of authors for International Cooperation (L) from Table 2, Tenti, P appears to have the highest point, 7.036, among the authors for smart grid research. The authors has a more than average as follows: Tenti, P(7.036), Paredes, HKM(7.036), Kalamkarov, AL(5.278), Lorente, S(5.278), Bejan, A(5.278), Wang, KM(5.278), Challagulla, KS(5.278), Georgiades, AV(5.278), Bose, A(3.521), Yang, T(3.521), Monti, A(1.758).

3.3 Analysis of key organizations and authors

Selection of key organizations and authors are accomplished using the result of analysis of Index Level of Authors (Q) and Intensity of International Cooperation (L). Index level of authors (Q) and Intensity of International Cooperation (L) can be classified in four areas (I-IV) as reference Q=L=1. Table 3 and Table 4 show Q-L distribution to select key organizations and authors in the smart grid, respectively.

Table 2. Relation index of international cooperation(S) and strength of international cooperation (L) for authors

A*	N*	S*	L*
Tenti, P	3	1.333	7.036
Paredes, HKM	3	1.333	7.036
Kalamkarov, ALKalamkarov, AL	3	1	5.278
Lorente, S	4	1	5.278
Bejan, A	4	1	5.278
Wang, KM	3	1	5.278
Challagulla, KS	3	1	5.278
Georgiades, AV	3	1	5.278
Bose, A	3	9,667	3.521
Yang, T	3	0.667	3.521
Monti, A	3	0.333	1.758
El-Hawary, ME	4	0	0
Huang, AQ	3	0	0

Anonymous	20	0	0
Zielinski, JS	3	0	0
Reitenbach, G	5	0	0
Morsi, WG	4	0	0
Venayagamoorthy, GK	5	0	0
Malko, J	4	0	0

A*: Organization, N*: Number of paper, S*: Relation index of international cooperation(S), L*: Strength of international cooperation(L)

Table 3. Q-L distributions to select key organization in smart grid

O*	N*	CPP*	Q*	S*	L*
Dalhousie Univ	7	0.857	0.361	0.429	2.264
Missouri Univ Sci & Technol	7	0.286	0.121	0	0
Univ Calif Berkeley	6	4	1.687	0.833	4.397
Tohoku Univ	6	2.333	0.984	0	0
N Carolina State Univ	5	1.4	0.59	0.2	1.056
Univ Illinois	5	11.2	4.722	0.2	1.056
Duke Univ	5	7.4	3.12	0.4	2.111
Washington State Univ	5	1.2	0.506	0.8	4.223
Georgia Inst Technol	4	39	16.444	0	0
Chinese Acad Sci	4	0.75	0.316	1	5.278
Univ New S Wales	4	2.75	1.16	1	5.278
Univ Wisconsin	4	5.5	2.319	0.75	3.959
Carnegie Mellon Univ	4	1	0.422	0.25	1.32

* N: Number of paper, CPP*: Citation per Paper, S*: Relation index of international cooperation(S), L*: Strength of international cooperation(L)

Table 4. Q-L distributions to select key authors in smart grid

A*	N*	CPP*	Q*	S*	L*
[Anonymous]	20	0	0	0	0
Reitenbach, G	5	0	0	0	0
Venayagamoorthy, GK	5	0.4	0.169	0	0
Morsi, WG	4	0.5	0.211	0	0
El-Hawary, ME	4	0.5	0.211	0	0
Bejan, A	4	9.25	3.9	0	0
Lorente, S	4	9.25	3.9	1	5.278
Malko, J	4	1.5	0.632	1	5.278
Zielinski, JS	3	0.667	0.281	0	0
Monti, A	3	0.667	0.281	0	0
Wang, KM	3	11.667	4.919	1.333	7.036
Yang, T	3	1	0.422	1	5.278
Challagulla, KS	3	1.333	0.562	1	5.278
Kalamkarov, AL	3	1.333	0.562	1.333	7.036
Huang, AQ	3	2	0.843	1	5.278
Georgiades, AV	3	1.333	0.562	0.667	3.521
Bose, A	3	1	0.422	0.333	1.758
Tenti, P	3	1	0.422	1	5.278
Paredes, HKM	3	1	0.422	0.667	3.521

* N: Number of paper, CPP*: Citation per Paper, S*: Relation index of international cooperation(S), L*: Strength of international cooperation(L)

By using Table 3 and Table 4, we can draw the Q-L distributions to select key organizations and authors in smart grid and represent its Q-L distribution in Figure 7 and Figure 8, respectively.

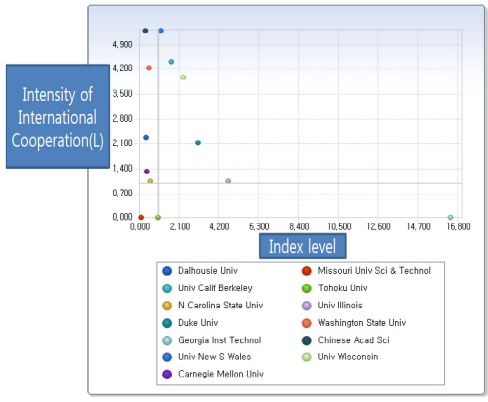

Fig. 7 Q-L distributions to select key organization in smart grid from Table 3

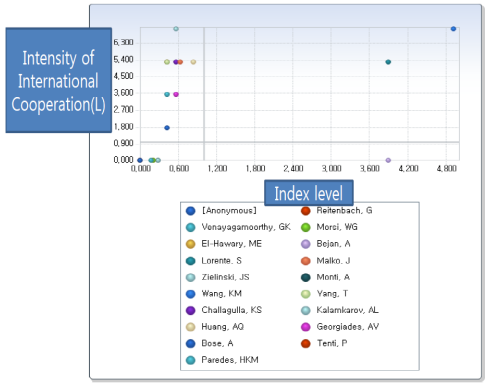

Fig. 8 Q-L distributions to select key authors in smart grid from Table 4

Ⅳ. Conclusion

In this paper, we presented scientometric analysis including Analysis of Index Level, International Cooperation Research Network, Analysis of Key Organizations and Authors. Through this presented method, we can review certain research areas previously done to avoid possible duplication problem in papers and patents. Using this method, we need to review the impact of citation, international cooperation relation in organizations and authors.

By using proposed method, it is possible to avoid any potential for duplicating published papers or patients and find new research area. In the future, more research is necessary to improve the results about scientometric analysis to properly apply them to real research environment.

REFERENCE

[1] Na-yeon Park, Cheol-su Son, Won-jung Kim,"The Efficient Computation of Node Position on Mobile Sensor Network", The Journal of The Korea Institute of Electronic Communication Science, Vol. 5, No. 4, pp. 391-398, 2010.

[2] Hee-hoon Kang, Young-jong Lee, Won-ok Han,"Energy-Efficient Hierarchical Cluster-Based Routing for Ubiquitous Sensor Networks", The Journal of The Korea Institute of Electronic Communication Science, Vol. 4, No. 3, pp. 243-246, 2009.

[3] Young-woo Shon, Youngchul Bae "Chua's Circuit for Chaosotic Attractors creation by Hardware Implementation", The Journal of The Korea Institute of Electronic Communication Science, Vol. 5, No. 2, pp. 158-163, 2010.

[4] Gyeong-Hyu Seok, Bu-Yeon Park, "A Study on the Facal motion and for Detection of area Using Kalman Fillter algorithm", The Journal of The Korea Institute of Electronic Communication Science, Vol. 6, No. 6, pp. 973-980 .2011

[5] Un-Sook Choi,Sung-Jin Cho, "Design of Binary Sequences with Optimal Cross-correlation Values", The Journal of The Korea Institute of Electronic Communication Science, Vol. 6, No. 4. pp. 540-544, 2011.

[6] Sung-woo Noh, Nak-yong Ko, Tae-gyun Kim, "Implementing Autonomous Navigation of a Mobile Robot Integrating Localization, Obstacle Avoidance and Path Planning", The Journal of The Korea Institute of Electronic Communication Science, Vol. 6, No. 1. pp. 148-156, 2011.

[7] Dong-Hyun Kim, Yang-Kwon Jeong, Jae-Ho Choi, "A Simulation program for verify and reappearance of motor vehicle accident", The

Journal of The Korea Institute of Electronic Communication Science, Vol. 5, No. 1. pp. 1-9, 2010.

[8] Woo-seok Seo, Moon-seog Jun, " A Direction of Convergence and Security of Smart Grid and Information Communication Network", The Journal of The Korea Institute of Electronic Communication Science, Vol. 5, No. 5. pp. 477-486, 2010.

[9] Won-geun Oh, Sung-keun Lee, " MAC protocol for Energy-Efficiency and Delay in Ubiquitous Sensor Networks", The Journal of The Korea Institute of Electronic Communication Science, Vol. 4, No. 1. pp. 19-23, 2009.

[10] Yun-Seok Ko, " The Development of Collection Solution of the Three-Phase Power Data based on the Personal Computer for Supporting the Smart Grid", The Journal of The Korea Institute of Electronic Communication Science, Vol. 6, No. 4. pp. 553-558, 2011.

[11] The methodology of patent analysis to write the technical roadmap, MCIE(Ministry of Commerce, Industry and Energy) and KOTEF, 2006.

[12] H. Ernst, "Evaluation of Dynamical Technological Developments by means of Patent
data", Springer, New York, 1999.

[13] H. Ernst, " Patent portfolios for strategics R&D planning", Journal of Engineering and Technology Management, Vol. 15, pp. 279-308, 1998.

[14] Jong-Kyu Park,.Young-Chul Bae, " Development of a Technical Road Map for Future Research in Wind Power Generation using Grading Criteria as a Rubric for Research Focus", The Journal of The Korea Institute of Electronic Communication Science, Vol. 6, No. 3, pp. 417-423. 2011.

저자 소개

박종규(Jong-Kyu Park)

1984년 2월 중앙대학교 전자공학과 (공학사)
1990년 2월 중앙대학교 전자공학과 (공학석사)
1991년~현재 : 한국과학기술정보연구원 선임연구원
※ 관심분야 : 로봇 제어, 모터 제어, 산업통신망

배영철(Young-Chul Bae)

1984년 광운대학교 전기공학과(공학사)
1986년 광운대학교대학원 전기공학과(공학석사)
1997년 광운대학교대학원 전기공학과(공학박사)
1986년~1991년 한국전력공사
1991년~1997년 산업기술정보원 책임연구원
1997년~2006년 여수대학교 전자통신전기공학부 부교수
2002년~2002년 Brigham Young University 방문교수
2006년~현재 전남대학교 전기·전자통신·컴퓨터 공학부 교수
2011년~2011년 University of Utah 방문교수
※ 관심분야 : Chaos Control and Chaos Robot, Robot control etc.