A Bibliographic Analysis of the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS Literature

Linjing Li, Xin Li, *Member, IEEE*, Zhenjiang Li, Daniel Dajun Zeng, *Senior Member, IEEE*, and William T. Scherer, *Member, IEEE*

***Abstract*—This paper presents a bibliographic analysis of the papers published in the IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS (T-ITS). We identify the most productive and high-impact authors, institutions, and countries/regions. We find that research on intelligent transportation systems is dominated by U.S. researchers and institutions and that China and Japan are the second most productive countries. According to this analysis, M. M. Trivedi, N. P. Papanikolopoulos, and P. A. Ioannou are the three most productive and influential authors in the IEEE T-ITS, whereas the Massachusetts Institute of Technology, Cambridge, the University of California, San Diego, and the University of Minnesota, Minneapolis, are three of the most productive and influential institutions in the IEEE T-ITS.**

***Index Terms*—Bibliographic analysis, impact, intelligent transportation systems (ITS), productivity.**

I. INTRODUCTION

INTELLIGENT transportation systems (ITS) refers to utilizing synergistic technologies and system engineering methods to develop and improve transportation systems of all kinds [1]. Due to the close relationship between transportation systems and our daily life and the economy, studies on ITS have a wide range of critical applications, such as increasing transportation safety and convenience (e.g., automatic driving), improving transportation efficiency (e.g., reducing congestions), and making environmentally friendly transportation solutions (e.g., fuel consumption reduction) [2].

The IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS (T-ITS) has focused on publishing advances and innovations in the ITS field since its launch in 2000. Although it is one of the youngest journals in the IEEE publication family [3], it now has the highest impact factor (2.844 in 2008 [4], [5]) among all journals in the transportation sector of the Thomson ISI SCI database and has ambition to achieve more success [5]. The ten-year history of the IEEE T-ITS reflects the development of the ITS field. Analyzing its publications can help us assess the productive and high-impact authors, institutions, and regions in worldwide ITS research.

In this paper, we employ bibliographic analysis to assess the publication and citation patterns of IEEE T-ITS research papers. Section II explains our methodology, Section III presents the findings from the analysis, and Section IV summarizes our findings.

II. METHODOLOGY

We downloaded the metadata for all IEEE T-ITS publications from IEEE Xplore, including title, abstract, authors, author affiliations, references, and keywords. In this research, we consider only research papers, including original research papers, reviews, and letters. Editorials, therefore, were excluded from this research, except for guest editorials for Special Issues since 2006, which summarized the recent research status and indicated future research directions. To assess the impact of these papers, we downloaded citation information, during March 2010, from the Thomson ISI SCI-E database, which is one of the most comprehensive citation repositories in the world. (Note that the ISI SCI-E database does not include the 18 T-ITS papers published in 2000.)

Initially, we preprocessed the collected data for bibliographic analysis by identifying authors based on their full names and affiliations and made an effort to align authors with multiple affiliations so that their contributions would not be underestimated. Multiple affiliations were still considered separately when assessing contributions of institutions and countries/regions.

To measure the productivity of authors, institutions, and countries/regions, we employed the adjusted productivity score (APS) introduced in [6]. For a paper with n authors, the APS credits each author $1/n$ of the paper. The APS of an author is the sum of all such credits of all his/her publications. The APS

Manuscript received March 11, 2010; revised May 1, 2010; accepted May 4, 2010. Date of current version May 25, 2010. This work was supported in part by the National Natural Science Foundation of China under Grant 60621001, Grant 70890084, Grant 90924302, and Grant 90920305; by the Ministry of Science and Technology under Grant 2006CB705500 and Grant 2006AA010106; by the Chinese Academy of Sciences under Grant 2F08N03 and Grant 2F07C01; and by the City University of Hong Kong under Grant 7200170. The Associate Editor for this paper was N. N. Zheng.

L. Li and Z. Li are with the Key Laboratory of Complex Systems and Intelligence Science, Institute of Automation, Chinese Academy of Sciences, Beijing 100190, China (e-mail: linjing.li.cas@gmail.com; lzjwhb@gmail.com).

X. Li is with the Department of Information Systems, City University of Hong Kong, Kowloon, Hong Kong (e-mail: Xin.Li@cityu.edu.hk).

D. D. Zeng is with the Key Laboratory of Complex Systems and Intelligence Science, Institute of Automation, Chinese Academy of Sciences, Beijing 100190, China, and also with the Department of Management Information Systems, University of Arizona, Tucson, AZ 85721 USA (e-mail: zeng@email.arizona.edu).

W. T. Scherer is with the Department of Systems and Information Engineering, University of Virginia, Charlottesville, VA 22904 USA (e-mail: wts@virginia.edu).

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TITS.2010.2049890

TABLE I
STATISTICS OF T-ITS PUBLICATIONS IN THE DATA SET

	Papers	Authors	Institutions	Countries
Original research	392	985	449	36
Review	4	14	8	5
Letter	1	1	1	1
Guest editorial	8	17	16	9
Total	405	1001	457	36

TABLE II
MOST PRODUCTIVE AUTHORS IN THE IEEE T-ITS

Rank	Name	Affiliation	Counts	APS
1	Mohan M.Trivedi	UC, San Diego	9	3.75
2	Petros A. Ioannou	U of S California	7	3.00
3	Shigang Li	Tottori U; Iwate U	2	2.00
4	Han-Shue Tan	UC, Berkeley	4	1.83
5	N.Papanikolopoulos	U of Minnesota	6	1.70
6	Tarak Gandhi	UC, San Diego	4	1.67
7	Sergiu Nedevschi	Tech. U of Cluj-Napoca	4	1.58
8	Fei-Yue Wang	CASIA; U of Arizona	4	1.50
8	Tsu-Tian Lee	Nat. Taipei U of Tech.	4	1.50
10	M. A. Abdel-Aty	U of Central Florida	3	1.50

UC: University of California; U: University; S: Southern; Nat.: National; Tech.: Technology; CASIA: Institute of Automation, Chinese Academy of Sciences.

has widely been adopted in previous bibliographic analysis studies, such as [7]–[10]. For comparison purposes, we still report the total count of papers for which an author was involved. The difference between the two measures reflects whether an author extensively collaborates with other researchers. These two measures were also applied to institutions and for a country/region-level-productivity analysis.

To measure the impact of individual authors, institutions, and countries/regions, we employed two measures. The adjusted citation score (ACS) follows a similar methodology as APS and credits each author $1/n$ of the paper's citations. The number of citations credits every author with all citations his/her paper received [11], [12].

III. RESULTS

From 2000 to the end of 2009, IEEE T-ITS published, in total, 421 papers and articles. In our data set, there are 392 original research papers, four reviews, one letter, and eight guest editorials. In these papers, we identified 1001 authors from 457 institutions in 36 countries/regions (see Table I). For the research papers, on average, each author is involved with 1.21 papers, each institution publishes 1.64 papers, and each country/region is related to 13.44 papers.

A. Productivity Analysis

Table II reports the most productive authors in the IEEE T-ITS. In the past decade, M. M. Trivedi (University of California (UC), San Diego) published the largest number of papers in the IEEE T-ITS (according to both APS and paper counts), followed by P. A. Ioannou (University of Southern California, Los Angeles) and S. Li (Tottori University, Tottori, Japan, and Iwate University, Morioka, Japan). In general, most of the top authors work in a collaborative manner. Most top authors have been involved in more than three papers with an adjusted score of more than 1.5. Furthermore, we notice that six of these top authors are in the U.S., often in California.

TABLE III
MOST PRODUCTIVE INSTITUTIONS IN THE IEEE T-ITS (BY COUNTS)

Rank	Institution	Counts
1	Massachusetts Institute of Technology	14
1	University of California, Berkeley	14
3	University of Arizona	12
4	University of Michigan, Ann Arbor	11
5	University of California, San Diego	10
6	National Chiao Tung University	9
6	University of Southern California	9
8	Delft University of Technology	8
8	University of Minnesota	8
10	Institute of Automation, CAS	7

TABLE IV
MOST PRODUCTIVE INSTITUTIONS IN THE IEEE T-ITS (BY APS)

Rank	Institution	APS
1	University of California, Berkeley	9.12
2	Massachusetts Institute of Technology	8.20
3	University of California, San Diego	7.83
4	University of Michigan, Ann Arbor	6.33
5	University of Arizona	6.17
6	University of Minnesota	6.00
7	University of Hong Kong	5.75
8	University of Southern California	5.67
9	Tsinghua University	5.50
10	Delft University of Technology	5.08

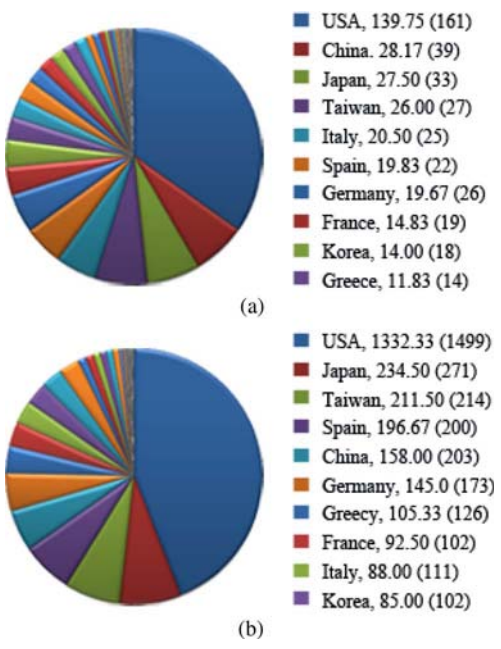

Fig. 1. Productivity and impact per country/region. (a) APS and paper counts. (b) ACS and citation counts.

TABLE V
MOST CITED PAPERS IN THE IEEE T-ITS

Rank	Title	Authors	Year	Ctry/Reg	Cites
1	Detection and classification of vehicles	S. Gupte, O. Masoud, R. Martin, N. P. Papanikolopoulos	2002	USA	107
2	Automatic license plate recognition	S. Chang, L. Chen, Y. Chung, S. Chen	2004	Taiwan	97
3	Challenges of intervehicle ad hoc networks	J. J. Blum, A. Eskandarian, L. J. Hoffman	2004	USA	63
4	Video-based lane estimation and tracking for driver assistance: survey, system, and evaluation	J. C. McCall, M. M. Trivedi	2006	USA	55
5	Freeway ramp metering: an overview	M. Papageorgiou, A. Kotsialos	2002	Greece	51
5	Research advances in intelligent collision avoidance and adaptive cruise control	A. Vahidi, A. Eskandarian	2003	USA	51
7	Vehicle control algorithms for cooperative driving with automated vehicles and intervehicle communications	S. Kato, S. Tsugawa	2002	Japan	50
8	Travel-time prediction with support vector regression	C. Wu, J. Ho, D. T. Lee	2004	Taiwan	46
9	Determining driver visual attention with one camera	P. Smith, M. Shah, N. Lobo	2003	USA	45
9	Pedestrian detection and tracking with night vision	F. Xu, X. Liu, K. Fujimura	2005	USA	45

This clearly shows the role of the U.S. (and the UC system) in ITS research. Other productive authors are in Japan, Taiwan, Romania, and China.

Table III shows the top ten institutions according to the paper counts. In this list, five universities have published more than ten articles in the IEEE T-ITS, including the University of California, Berkeley (UCB); the Massachusetts Institute of Technology (MIT), Cambridge; the University of Arizona, Tucson; the University of Michigan, Ann Arbor; and the University of California, San Diego (UCSD), La Jolla. Table IV shows the top ten institutions in the IEEE T-ITS according to the APS. The top three institutions are the UCB; MIT; and UCSD. Among the top ten institutions, seven are in the U.S. (see Tables III and IV), which indicates the dominance of the U.S. in ITS research.

In our data set, some papers are authored by the research laboratories of private commercial companies, such as Toyota, Honda, and Daimler-Chrysler. Such laboratories may have multiple locations around the world. If we aggregate all the papers of a company in different locations together, Daimler-Chrysler is the fourth most productive institution with an adjusted score of 6.7 and a paper count of 11.

Papers published in the IEEE T-ITS represent 36 countries/regions. Fig. 1(a) shows the distribution of the research papers by country/region. Over the past ten years, the U.S. has published the most (34.8%) IEEE T-ITS papers. The number of U.S. papers published is more than the sum of next five top country/regions, including China, Japan, Taiwan, Italy, and Spain.

We examined the evolution of these top country/regions' annual publications in the IEEE T-ITS. Over the past ten years, the U.S. continued to be the most productive region in the IEEE T-ITS. However, the percentage of U.S. publications has gradually decreased from 60% to about 30%, indicating an increasing body of research conducted outside of the U.S. Similar to the U.S., publications from Japan in the IEEE T-ITS also experienced a decrease from about 30% to about 4%, and they maintained this proportion during the past five years. Taiwan publications, however, experienced a steady increase from 0% to more than 10% in recent years. We also notice that most papers from the U.S. and China are written by researchers at universities. However, papers from Japan, Italy, and Germany are dominated by laboratories or research institutes of automobile manufactories, which is likely indicative of these countries' automobile industry's research investments.

TABLE VI
MOST CITED AUTHORS (TOP TEN)

Rank	Name	Institution	Cites	ACS
1	N. Papanikolopoulos	U of Minnesota	195	52.83
1	O. Masoud	U of Minnesota	195	52.83
3	M. M. Trivedi	UC, San Diego	114	51.92
4	A. Eskandarian	G Washington U	121	50.00
5	J. C. McCall	UC, San Diego	81	35.41
6	P. A. Ioannou	U of S California	79	33.67
7	M. Papageorgiou	Tech. U of Crete	77	30.75
8	A. Kotsialos	Tech. U of Crete	76	30.50
9	R. F. K. Martin	U of Minnesota	107	26.75
9	S. Gupte	U of Minnesota	107	26.75

B. Impact Analysis

Among the 405 papers in our data set, there are 289 papers cited 3026 times by 2237 papers (including 994 citations from 200 IEEE T-ITS papers). On average, each paper is cited 10.47 times in the SCI-E database (through March 2010). The most frequent citing journals and conferences include the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, *Transportation Research Record*, *Expert Systems With Applications*, the *Proceedings of the IEEE Intelligent Vehicles Symposium*, and the *Proceedings of the IEEE Conference on Intelligent Transportation Systems*.

Table V shows the top ten most cited papers in T-ITS. Through March 2010, one article was cited more than 100 times, and six articles were cited more than 50 times. Six of the high-impact papers are from the U.S., whereas the others are from Taiwan, Japan, and Greece. Many of these papers involve employing machine learning, pattern recognition, and video-processing technologies to address problems in ITS

TABLE VII
MOST CITED INSTITUTIONS (TOP TEN)

Rank	Title	Ctry/Reg	Cites	ACS
1	U of Minnesota	USA	213	150.50
2	George Washington U	USA	121	121.00
3	UC, San Diego	USA	118	105.00
4	MIT	USA	164	99.30
5	Nat. Taiwan Normal U	Taiwan	97	97.00
6	UC, Berkeley	USA	103	69.75
7	Tech. U of Crete	Greece	82	64.80
8	U of S California	USA	90	59.50
9	Sun Microsystems	USA	107	53.50
10	Inst. de Automatica Industrial	Spain	55	52.50

applications, such as automatic lane identification, and vehicle, pedestrian, and obstacle classification [13]–[16].

Tables VI and VII show the top ten most cited authors and institutions in IEEE T-ITS. We notice that M. M. Trivedi, N. P. Papanikolopoulos, and P. A. Ioannou appear in both Tables II and VI, which means that they are both productive and highly influential in the ITS field. MIT; UCSD; and the University of Minnesota, Minneapolis (UOM) are three of the most productive and influential institutions. George Washington University, Washington, DC, is not in the top ten of the productive institution list (both Tables III and IV); however, it moves to second in the rank of high-impact institutions as a result of the high citation rate of individual papers.

Fig. 1(b) shows the high-impact countries in the IEEE T-ITS. To date, the U.S. is the most cited country, followed by Japan and Taiwan. China, which is the second most productive country, ranks only fifth according to the citations it received, which is about one fifth of U.S. citations.

IV. CONCLUSION

This paper has assessed the state of ITS research based on the publications in the IEEE T-ITS during the past decade. We have found that ITS research is dominated by U.S. researchers and institutions. Following the U.S., China and Japan have also published a significant number of papers. Chinese papers, however, have a relative lower citation rate, compared with U.S. and Japanese papers. M. M. Trivedi, N. P. Papanikolopoulos, and P. A. Ioannou are three most productive and highly influential authors, whereas MIT, UCSD and UOM are three of the most productive and highly influential institutions.

In the future work, we will conduct social networks analysis on the coauthor networks of the IEEE T-ITS to reveal the collaboration patterns in this field. We will also study active research topics in T-ITS publications.

ACKNOWLEDGMENT

The authors would like to thank Prof. F.-Y. Wang for encouraging them to conduct the reported bibliographic analysis and Y. Wang, H. Liu, W. Chen, and H. Zhou for their help with data collection.

REFERENCES

[1] ITSS, *The ITSS Website*. [Online]. Available: http://www.ewh.ieee.org/tc/its/index.html
[2] S. Ezell, "Explaining international IT application leadership: Intelligent transportation systems," The Information Technology & Innovation Foundation, Jan. 2010.
[3] F.-Y. Wang, A. Broggi, and C. C. White, "Road to transactions on intelligent transportation systems: A decade's success," *IEEE Trans. Intell. Transp. Syst.*, vol. 10, no. 4, pp. 553–556, Dec. 2009.
[4] ISI, 2008 Journal Citation Reports Science Edition. [Online]. Available: http://admin-apps.isiknowledge.com/JCR/JCR?RQ=LIST_SUMMARY_JOURNAL
[5] F.-Y. Wang, "Ahead of traffic: Where to next?" *IEEE Trans. Intell. Transp. Syst.*, vol. 10, no. 3, pp. 373–374, Sep. 2009.
[6] D. Lindsey, "Production and citation measures in the sociology of science: The problem of multiple authorship," *Soc. Stud. Sci.*, vol. 10, no. 2, pp. 145–162, May 1980.
[7] K. S. Im, K. Y. Kim, and J. S. Kim, "An assessment of individual and institutional research productivity in MIS," *Decis. Line*, vol. 29, no. 1, pp. 8–12, Dec./Jan. 1998.
[8] S. Athey and J. Plotnicki, "An evaluation of research productivity in academic IT," *Commun. Assoc. Inf. Syst.*, vol. 3, no. 2, p. 3, Apr. 2000.
[9] H.-H. Huang and J. S.-C. Hsu, "An evaluation of publication productivity in information systems: 1999 to 2003," *Commun. Assoc. Inf. Syst.*, vol. 15, pp. 555–564, 2005.
[10] J. S. Smith, K. R. Karwan, and R. E. Markland, "A note on the growth of research in service operations management," *Prod. Oper. Manage.*, vol. 16, no. 6, pp. 780–790, 2007.
[11] E. Garfield, *Citation Indexing—Its Theory and Application in Science, Technology and Humanities*. Philadelphia, PA: ISI, 1983.
[12] R. E. Rubin, *Foundations of Library and Information Science,* 2nd ed. New York: Neal-Schuman, 2004.
[13] S. Gupte, O. Masoud, R. F. K. Martinand, and N. P. Papanikolopoulos, "Detection and classification of vehicles," *IEEE Trans. Intell. Transp. Syst.*, vol. 3, no. 1, pp. 37–47, Mar. 2002.
[14] A. Vahidi and A. Eskandarian, "Research advances in intelligent collision avoidance and adaptive cruise control," *IEEE Trans. Intell. Transp. Syst.*, vol. 4, no. 3, pp. 143–153, Sep. 2003.
[15] F. Xu, X. Liu, and K. Fujimura, "Pedestrian detection and tracking with night vision," *IEEE Trans. Intell. Transp. Syst.*, vol. 6, no. 1, pp. 63–71, Mar. 2005.
[16] J. C. McCall and M. M. Trivedi, "Video-based lane estimation and tracking for driver assistance: Survey, system, and evaluation," *IEEE Trans. Intell. Transp. Syst.*, vol. 7, no. 1, pp. 20–37, Mar. 2006.

Linjing Li received the B.Eng. degree in electrical engineering and automation and the M.Eng. degree in control theory and control engineering from Harbin Institute of Technology, Harbin, China, in 2005 and 2007, respectively. He is currently working toward the Ph.D. degree with the Key Laboratory of Complex Systems and Intelligence Science, Institute of Automation, Chinese Academy of Sciences, Beijing, China.

His research interests include game theory, mechanism design, auction theory, and machine learning.

Xin Li (S'07–M'10) received the B.Eng. and M.Eng. degrees in control theory and control engineering from Tsinghua University, Beijing, China, and the Ph.D. degree in management information systems from the University of Arizona, Tucson.

He is currently an Assistant Professor with the Department of Information Systems, City University of Hong Kong, Kowloon, Hong Kong. His research interests include business intelligence, social network analysis, data mining, and text mining.

Dr. Li is a member of the Association for Computing Machinery and Association for Information Systems.

Zhenjiang Li received the B.Eng. degree in electrical engineering and automation from Beijing Jiaotong University, Beijing, China, in 2002 and the Ph.D. degree in control theory and control engineering from the Institute of Automation, Chinese Academy of Sciences, Beijing, in 2007.

He is currently an Assistant Professor with the Key Laboratory of Complex Systems and Intelligence Science, Institute of Automation, Chinese Academy of Sciences. His research interests include agent-based control, parallel control, and management for transportation.

Daniel Dajun Zeng (S'99–M'04–SM'07) received the M.S. and Ph.D. degrees in industrial administration from Carnegie Mellon University, Pittsburgh, PA.

He is currently an Associate Professor and a Honeywell Fellow with the Department of Management Information Systems, University of Arizona, Tucson, and a Research Professor with the Key Laboratory of Complex Systems and Intelligence Science, Institute of Automation, Chinese Academy of Sciences, Beijing, China. His research interests include software agents and their applications, security informatics, social computing, computational game theory, recommender systems, and spatiotemporal data analysis.

Dr. Zeng is the Vice President for the Technical Activities of the IEEE Intelligent Transportation Systems Society.

William T. Scherer (M'87) received the Ph.D. degree in systems engineering from the University of Virginia, Charlottesville, in 1986.

He is currently a Professor with the Department of Systems and Information Engineering, University of Virginia. His research interests include scheduling systems, decision analysis, intelligent systems, combinatorial optimization, Markov decision processes, and intelligent transportation systems.

Dr. Scherer has served as the President of the IEEE Intelligent Transportation Systems Society.