Visualization of knowledge maps by linking social network analysis with the analytic hierarchy process for assessing academic performance – The case of Taiwan's Intelligent Transportation Systems discipline

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Abstract: - This paper introduces empirical studies of visualizing Taiwan's Intelligent Transportation Systems (ITS) knowledge maps and assessing academic performance. Social network analysis is applied to visualize ITS knowledge maps to quantify the strength of the connections between individuals or universities. The results from the empirical study show that the development of ITS research is very promising worldwide. CiteSpace and UCINET have proven to be useful tools for demonstrating ITS knowledge maps with clusters by fields, institutions, and authors. Taiwan's ITS knowledge maps with clusters can be summarized to assess their academic performance by using AHP analysis. The ranking indicators and corresponding knowledge maps provide an overview of current performance status of ITS researchers in different ITS fields in Taiwan. This can eventually identify the most important ITS fields in local areas and contribute to highlighting hot topics of ITS researchers in the future.

Key-Words: - Intelligent Transportation Systems, Visualization of knowledge maps, Academic performance assessment

1 Introduction

In the age of digital information, the increasing amount of information being generated means that people can access the sources of knowledge from electronic publications, web pages and e-mails over the internet, rather than from traditional paper sources such as books, magazines, and newspapers. It creates a new generation to help researchers explore information and its transfer into knowledge.

In recent years, many advances have been made in the area of information visualization. However, those who proposed visualization methods neglected to link them to the background of researchers and to the knowledge management life cycle. As a result, researchers had difficulty in adapting to these new methods. Because of the need for knowledge visualization is promising, using visualization methods, from information exploration to the transfer of knowledge, is especially helpful for academic researchers.

The primary goal of knowledge visualization is to detect and monitor the evolution of a knowledge domain. More and more, researchers in recent years have focused on scientific collaboration networks such as co-citation networks or social networks of co-authorships. The growing interests in mapping and visualizing the structure and dynamics of specialties is due to the widely accessible bibliographic data sources such as Web of Science and Google Scholar (Bar-Ilan, 2008; Meho & Yang, 2007) and freely available web-based special-purpose citation analysis tools such as CiteSpace, and social network analysis (SNA) such as UCINET.

Since the 1990s, Intelligent Transportation Systems (ITS) have become a promising research trend in Taiwan. The ITS fields can be classified into ATMS (Advance Traffic Management System), ATIS (Advanced Traveler Information System), APTS (Advanced Public Transportation System), CVOS (Commercial Vehicle Operation System), ETC

(Electronic Toll Collection)/ EPS (Electronic Payment System), AVCSS (Advanced Vehicle Control Safety System), VIPS (Vulnerable Individual Protection System) and EMS (Emergency Management System). Theses, dissertations, and journal papers increased rapidly. Most of ITS academic publications are available in Web databases. Academic researchers are, therefore, interested in identifying underlying specialties in ITS fields, in terms of related universities or groups of researchers by visualization tools. These new techniques can reveal where the most researchable topics in ITS knowledge domain are and how these major topics associate. Social network analysis is chosen to produce interval/ratio measures of relations among various researchers in ITS knowledge domain to determine the strength of their ties.

In this paper, we apply the methods in quantitative studies of science by the visualization software. Our goal is to present both global ITS knowledge maps and domestic ones respectively and to provide a set of cues to facilitate a variety of common tasks in interpretations. Focusing on authors can improve our understanding of the nature of ITS current development status and research fronts.

Although knowledge maps form the big picture to analyze the data and trend, it is still difficult to assess academic performance due to various types of academic rankings. Our work contributes to quantitative indicator studies of science in two ways: (1) developing generic indicators by Analytic Hierarchy Process (AHP) to assess individual researcher's academic performance in ITS fields objectively, and (2) calculating the total scores for researchers from different universities to provide an overview of academic performance in ITS knowledge domain in Taiwan.

2 Background

White and McCain (1997) defined five models of literature: (1) bibliographic, (2) editorial, (3) bibliometric, (4) user, and (5) synthetic. With the computerized tools and techniques available today, the lines between these traditional models can become blurred. In modern visualizations, many user metadata - authors, titles, descriptive terms, dates, etc. - or bibliometric data - citation counts, term distributions, attributes by year, impact factors, etc. can be easily displayed by visualizations to enhance map interpretations.

This paper conducts the co-citation network analysis of ITS research fields based on the data downloaded from the Web of Science at Institute for Scientific Information (ISI) using high-impact international journals as data sources. It illustrates document co-citation networks of the notable authors and keyword clusters from ITS fields, and it reveals the topic changes of knowledge structure in different stages of development.

When mapping the structure of science, citation analysis always plays a prominent role. In general, the steps to visualize the knowledge domains include: (1) data extraction, (2) definition of unit of analysis, (3) selection of measures, (4) calculation of similarity between units, (5) ordination or assignment of coordinates to each unit, and (6) results in visualization for analysis and interpretation. Steps (4) and (5) are often distilled into one operation which can be described as data layout.

The approach in this paper aims at using ITS research literature from the ISI database to describe how to use CiteSpace software to demonstrate knowledge maps. Chinese academic publishing is not collected by English databases. The shortage of web-based citation databases is not available in Taiwan. An alternative approach to using UCINET is to analyse a variety of local Chinese academic publishing.

3 Problem Solution

3.1 Measures and similarity calculation

Citations may be counted and used as a threshold (e.g., only keep the documents that have been cited more than 5 times) in a mapping exercise. Journal impact factors calculated from citation counts are published by ISI, and can be used to enhance visualizations as can the raw citation counts themselves. Basically, the similarity between units is based on citation linkages or co-occurrence similarities. Citation linkage similarities are naturally constrained to use with data derived from citation databases, and the most common co-occurrence similarities include co-term, co-classification, author co-citation, and paper co-citation.

The Vector Space Model (VSM) developed by Gerald Salton (Salton, Yang, & Wong, 1975) is a powerful tool for storing, analyzing, and structuring documents. Originally developed for information retrieval, the VSM is a widely used method for indexing documents based on term frequencies. Its three stages are document indexing, term weighting, and computation of similarity coefficients.

The discriminative power of a term is determined by the well-known *tf·idf* model, in which *tf* denotes the term frequency and *idf* represents the inverse document frequency. Each document can be represented by an array of terms ***T*** and each term is associated with a weight determined by the *tf·idf* model. In general, the weight of term T_k in document D_i, is estimated as follows:

$$w_{ik} = \frac{tf_{ik} \times \log(\frac{N}{n_k})}{\sqrt{\sum_{j=1}^{T}(tf_{ij})^2 \times \log(\frac{N}{n_j})^2}} \quad (1)$$

where,

tf_{ik}: the number of occurrences of term T_k in D_i,
N: the number of documents in a given collection,
n_k: the number of documents containing term T_k,

The document similarity is computed as follows based on corresponding vectors $Di = (w_{i1}, w_{i2}, ..., w_{iT})$ and $D_j = (w_{j1}, w_{j2}, ..., w_{jT})$:

$$sim_{ij}^{content} = \sum_{k=1}^{T} w_{ik} \times w_{jk} \quad (2)$$

Social Network Analysis (SNA) is a strategy for investigating social structures for the situation that there is no adequate citation database in Taiwan. According to E. Otte & R. Rousseau (2002), SNA is the mapping and measuring of relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities. Within SNA, there is a variety of strategies used to collect measurements on the relations among the set of actors. The central players are pointed out as are the underlying collaborative relationships between authors. Our SNA using UCINET is performed to describe relationships between scientific authors.

Freeman (1979) defined degree, closeness, and betweeness. Degree is the number of ties or neighbors of a node, closeness is the inverse of the sum of all shortest paths to others or the smallest number of links to go through to reach all others individually, and betweeness is the number of shortest paths that a node is on.

Degree Centrality:

$$C_D(n_i) = \sum\nolimits_j (x_{ij}) = \sum\nolimits_j (x_{ji})$$

$$C'_D(n_i) = \frac{C_D(n_i)}{g-1} \quad (3)$$

where,

x_{ij}: the actor *i* and actor *j* co-occurring in the same literature,
g: the number that actor on the network,

Closeness Centrality:

$$C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1} \quad (4)$$

where,
d: the shortest path between the two actor,

Betweenness Centrality:

$$C_B(n_i) = \sum_{j<k} \frac{g_{jk}(n_i)}{g_{jk}} \quad (5)$$

where,
g_{jk}: the number of geodesics connecting *jk*,
$g_{jk}(n_i)$: the number that actor *i* is on,

4 Empirical studies

4.1 Visualization by Citespace and Ucinet

This paper demonstrates the visualization of knowledge maps by Citespace with case studies of Advanced Traffic Management System (ATMS) knowledge domain in Taiwan. We concentrate on topics in land transport and screen out irrelevant publications manually. First, we identify keywords in the ATMS field for literature searching based on definitions of Taiwan's Ministry of Transportation and Communication (MOTC). Although we can collect reference material from ISI databases, a manual process is still necessary to identify whether the reference material is correct or not. The case study in the ATMS field is then provided to illustrate the proposed research design. However, the process of other ITS fields can be done in the same way.

In the beginning, we searched the citation results with keywords in the ATMS field, such as traffic control or traffic management from ISI database. There were 1,274 journal papers between 1990 and 2010 in transportation science & technology discipline. The statistical information shows that those articles were cited by 10,034 times, and the average citations were 7.88. This means global ATMS knowledge domains increase rapidly. We downloaded all available ATMS publications including title, year, author's information, abstract, and reference and used CiteSpace software to illustrate all literature data. CiteSpace can visualize a merged network based on several networks corresponding to snapshots of consecutive years. The merged network characterizes the development of the field over time, showing the most significant footprints of the related research activities.

Figure 1 shows benchmarking countries of journal papers relating to ATMS worldwide. As shown in Table 1, USA's academic performance in ATMS field is remarkably rich. The number of citations is higher than other countries, reaching 522 times. Other countries include England, Canada, China, South Korea, Taiwan, the Netherlands, Greece, and Italy respectively.

It is worth noting that England has the highest burstness value, 5.36, in ATMS field, and the centrality value is 0.11. It reveals that England has a vital position to connect other countries and lots of academic cooperations as well. The linkages of nodes show relationships to published papers, and the cooperative relationships to publish papers in Europe are closer than other countries. It can also been found that China and South Korea have fairly good cited times to show their academic performance.

Table 1: The cited times of author's country in Global ATMS fields (Cited times > 30times)

Country	Cited times	Burstness	Centrality
USA	522	-	0
ENGLAND	92	5.36	0.11
CANADA	75	-	0
CHINA	74	-	0
SOUTH KOREA	59	-	0
TAIWAN	43	-	0
NETHERLANDS	43	3.97	0.04
GREECE	36	-	0.05
ITALY	35	4.31	0.02

Table 2 shows automatically chosen cluster labels of 3 largest ACA clusters along with their size. Top-ranked title terms by *tf·idf* are selected as cluster labels. Urban traffic control system is the largest cluster and has 27 members with weight value 10.62. Other candidate clusters include energy saving and transportation management, which have the same weight value 8.57, confirming that transportation management and energy saving are closely connected to urban traffic control system. The second largest cluster with 11 members is labeled as area traffic control & assignment with weight value 5.72. The third largest cluster is dynamic network flow approach with 10 members.

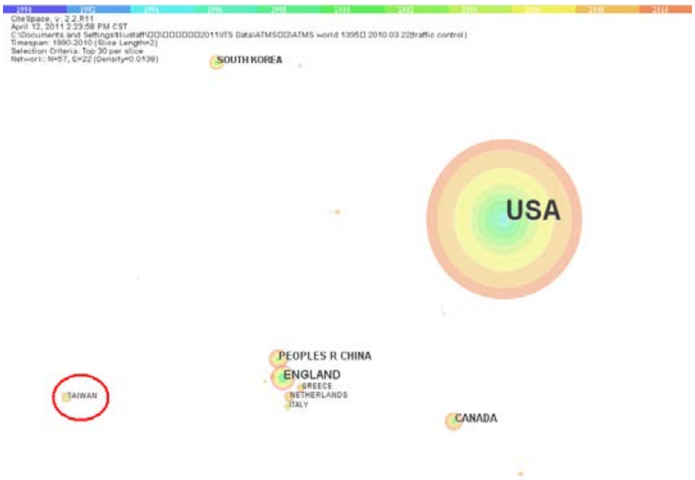

Fig. 1: The knowledge map of author's country in Global ATMS fields

Table 2: The four largest ACA clusters of a 270-author network (1990-2010) (CiteSpace parameters: Nodes=270, Edges=345, top N=30, time slice length=2, clusters=58)

N	Keywords label	Title terms by *tf·idf*
27	urban traffic control system energy saving transportation management	10.62 8.57 8.57
11	area traffic control & assignment signal control traffic control	5.72 4.83 2.70
10	dynamic network flow approach rerouting problem traffic flow management	15.58 15.58 13.4

The DCA network shown in Figure 2 is also generated by CiteSpace. The largest component shown above evidently contains relevant topics such as traffic control system, networks, performance, assignment, traffic accident, driver behavior, and simulation. The results show that traffic flow and risk analysis become hot topics in ATMS field.

On the whole, the integration of ACA and DCA techniques in a unifying framework will enable analysts, researchers, and students to investigate and understand the dynamic interrelationship between an academic field and an inspired research front. Using visualization tools can simplify and reduce operational costs and search time.

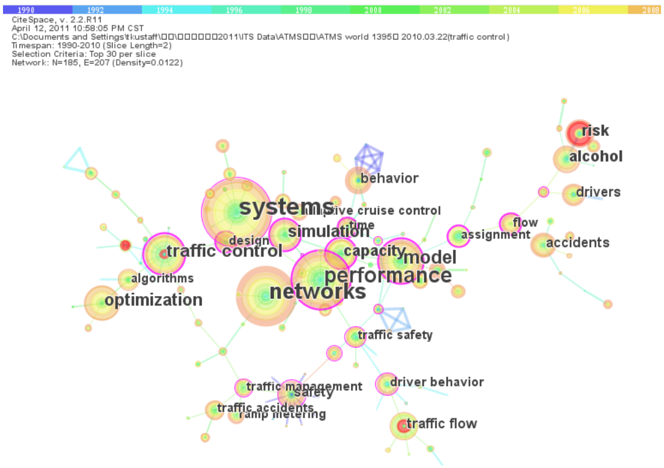

Fig. 2: DCA clusters (1990-2010) network of co-occurring phrases in ATMS field

Since 1990, ten universities have participated ITS research in Taiwan. The ITS database in our study was defined in terms of academic publications from 10 universities. All possible theses, dissertations and journal papers concerning ITS were searched from Taiwan's National Digital Library. Irrelevant publications were then screened out manually to identify their uniqueness of ITS research. According to topic search on key technologies in the database, it is apparently clear that the number of ITS research in Taiwan is growing. There were 690 theses and dissertations after screening. Figure 3 shows a steady growth in the number of academic papers published in Taiwan over a period of 22 years. Obviously, the number of papers increased steadily from 1991 to 2000, ranging 7 to 16.

Next, the figures for papers fluctuate between 2004 and 2013. The number of papers increased significantly from 16 in 2001 to 43 in 2013. It can be concluded that papers in ITS fields became more popular after 2000, and Figure 3 shows that Taiwan's government has contributed significantly to ITS deployments since 2000.

The degree centrality and betweenness centrality from different universities in Taiwan can be shown in Table 3. In general, betweenness centrality represents the importance of linking a range of nodes, and degree centrality represents the importance of the position of nodes. The thickness of lines represents the number of theses.

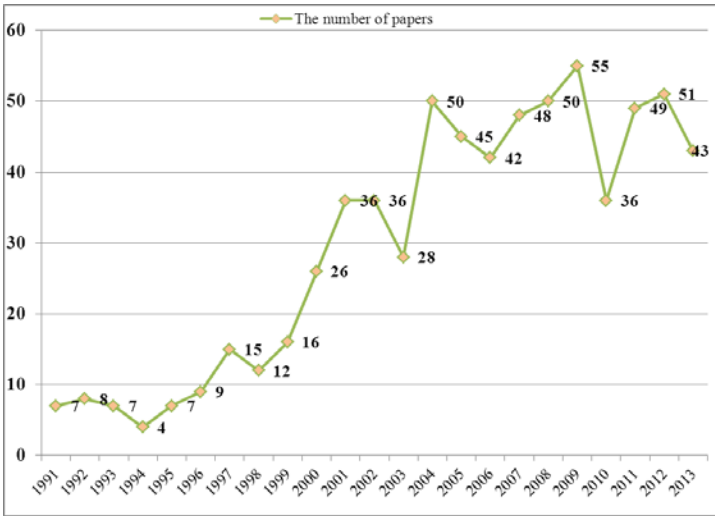

Fig. 3: The number of ITS academic papers in Taiwan from 1991-2013

In order to understand the current research status in ITS knowledge domain in Taiwan, UCINET software is used to classify ITS technology types by fishbone diagrams and to illustrate Taiwan's ITS knowledge maps. These results are validated by experts, professors, and researchers in government.

All fishbone diagrams in Taiwan's ITS fields with the help of expert interviews and literature reviews are depicted according to key ITS technologies. Due to limitation of space, the ATMS field is taken as an example to demonstrate the process of visualizing knowledge maps.

There are several hot topics in ATMS field according to four core technologies which can be divided into hardware and software area. The fishbone diagram shown in Figure 4 indicates signals automatic control, traffic management/traffic control, dynamic traffic flow prediction and accident management concerning hardware module are more common than other topics.

In the communication module area, the communication protocol is found to be the main hot topic. Automatic vehicle location, automatic vehicle identification, and automatic vehicle classification concerning traffic information collection system are three hot topics.

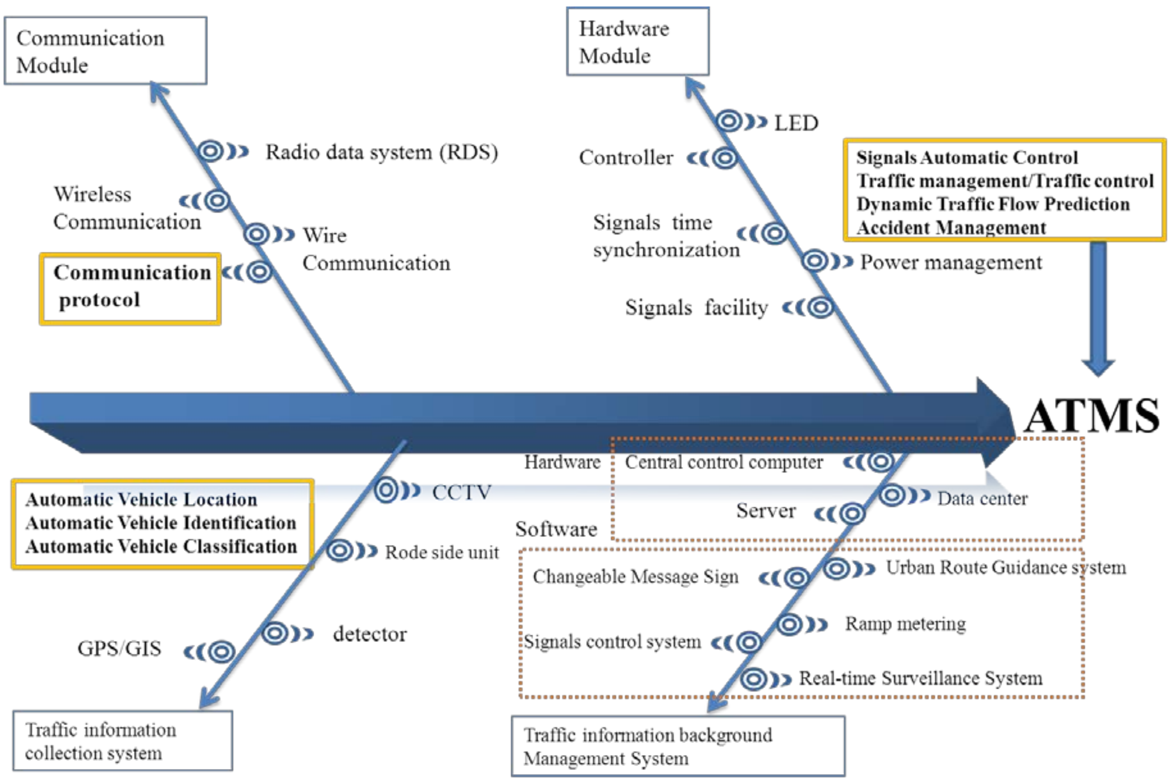

Fig. 4: The fishbone diagrams of topics in ATMS field by technologies category

Table 3: The degree centrality and betweenness centrality of universities in Taiwan (1990-2013)

University	Degree Centrality	Betweenness Centrality
National Chiao Tung University	0.474	0.015
Tamkang University	0.474	0.015
Feng Chia University	0.474	0.015
National Cheng Kung University	0.421	0.010
National Taiwan University	0.421	0.010
Chung Hua University	0.368	0.007
National Central Police University	0.316	0.006
National Kaohsiung First University	0.316	0.006
National Chiayi University	0.316	0.004
Kainan University	0.105	0.000

Degree centrality and betweenness centrality on Tamkang University, National Chiao Tung University and Feng Chia University are 0.474 and 0.015 respectively, means these universities are more important in ITS research in Taiwan. National Cheng Kung University and National Taiwan University get 0.421 and 0.01 are slightly lower than the first group. Other Universities are less than the universities with higher centrality. Chung Hua University, National Central Police University, National Kaohsiung First University, National Chiayi University get 0.4 and 0.01 with degree centrality and betweenness respectively.

Figure 5 shows that ATMS, APTS, and ATIS are three main ITS fields in Taiwan according to the thickness of lines among those three fields and universities. The figures on lines represent the number of papers published by universities. We can see that the size of square nodes represent CVOS and ETC/EPS are bigger than other fields, and almost all universities in Taiwan published papers in these two fields. And every university focused on different ITS fields respectively. For example, Tamkang University obviously focused on ATMS, ATIS and APTS research topics.

It is impossible within the space here to trace the intricate details of ITS research for each university. Therefore, we take Tamkang University as an example to demonstrate how to illustrate the academic performance in a specific field from an organizational perspective shown in Table 4 and Figure 6.

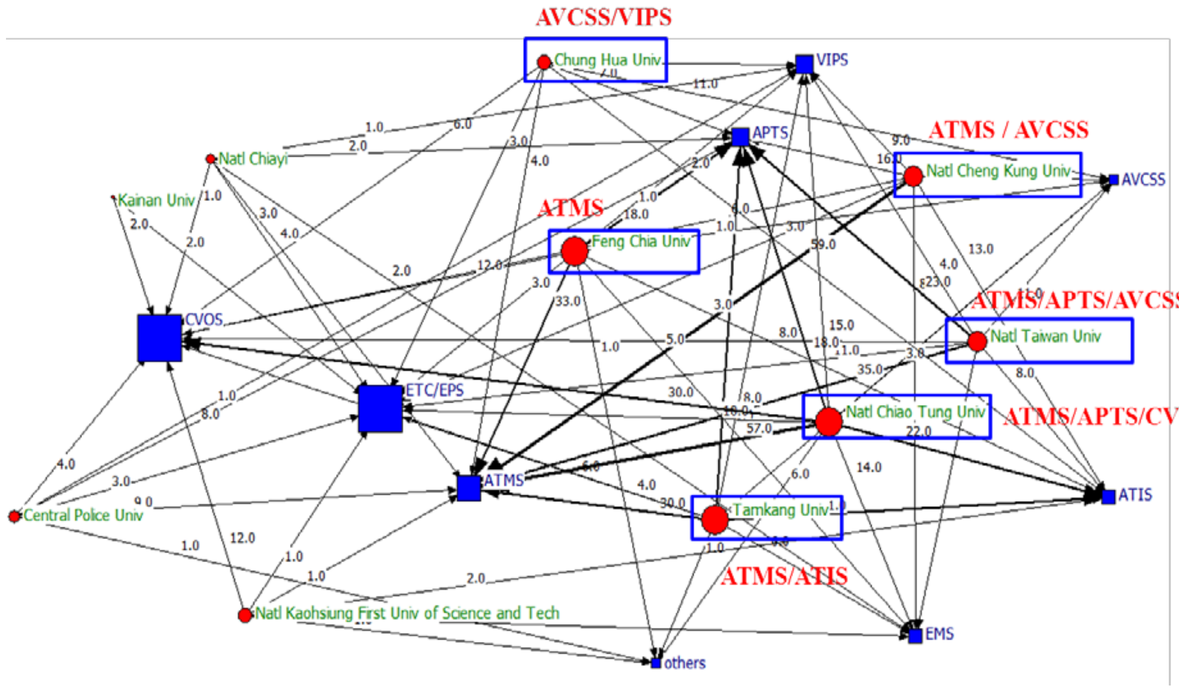

Figure 5: The visualization knowledge map of Taiwan ITS fields by universities

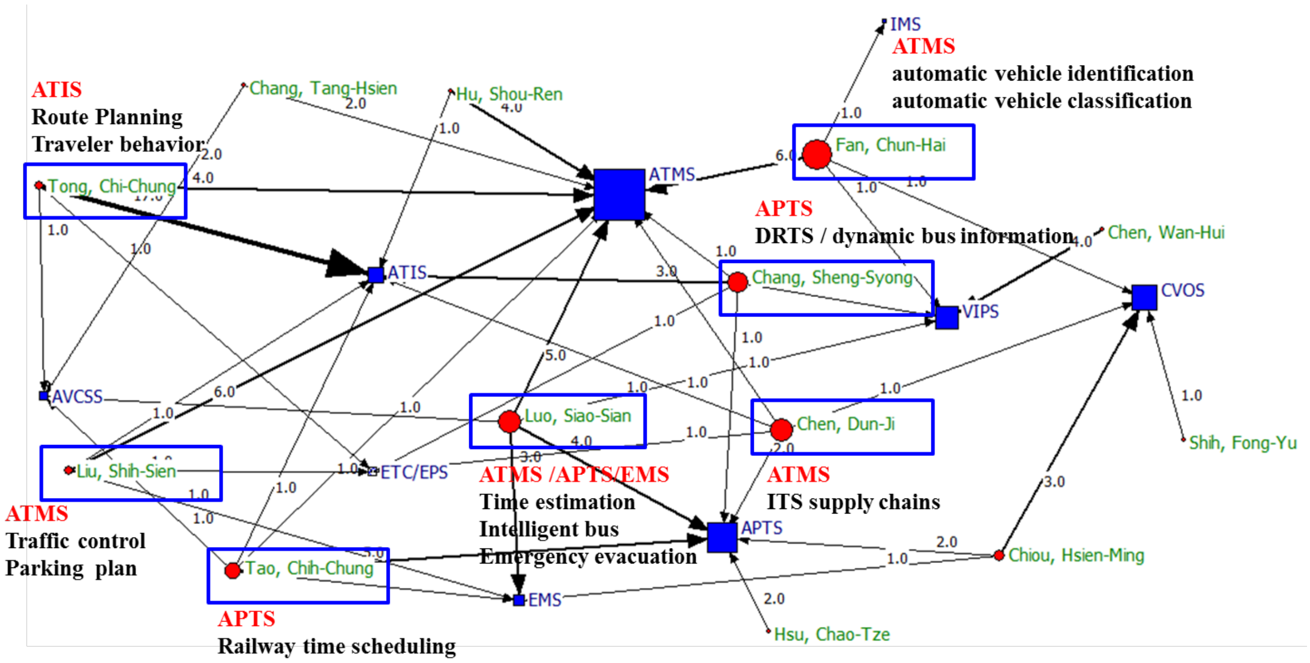

Fig. 6: The visualization knowledge map of ITS fields at Tamkang University

Table 4: ITS research fields and topics from theses at Tamkang University (1990-2013)

Field	Research topics	number of theses
ATMS	Traffic management/ Traffic control	21
	Automatic Signal Control	2
	Automatic Vehicle Classification	3
	Automatic Vehicle Identification	1
	Incident management	3
ATIS	Traveler Information	4
	Path Planning/Driver information	17
APTS	Dynamic Bus Information System	7
	Intelligent Rail Transportation	3
	Public Transportation Operation Management	2
	Intelligent Bus system	2
	Bus Priority Signal	1
	Demand Responsive Bus	2
	Car-pool Services	1
ETC/ EPS	Electronic Toll Collection	3
	IC Smart Card	1
CVOS	Fleet management system	4
	Taxi management	2
AVCSS	Driver Simulation	1
	Intelligent Driver Assistance System	3
	Advanced Intelligent Vehicles	1
VIPS	The Elderly Travel Demand	8
EMS	Emergency Notification	1
	Emergency Vehicle Operations	1
	Dispatching for disaster rescue	2
	Disaster for Traffic Control	3

The ITS fields can be classified into Table 4 presents the number of theses classified by eight ITS fields from 1990 to 2013 and illustrates that ATMS, ATIS and APTS are main research fields at Tamkang University.

As shown in Figure 6, it is evident that Tamkang University contributes significantly to academic performance in ATMS field which can be displayed with the biggest square node on the map. In addition, the strength of the connections among professors to show their contributions to certain professional ITS fields at Tamkang University is also visualized in Figure 6. Professors who have degree centrality more than 0.182 shown in Table 5 can be highlighted clearly on the knowledge map. For instance, Professor Chee-Chung Tong has made a considerable effort in ATIS field, especially route planning and traveler information and behavior research.

Table 5: The degree centrality and betweenness centrality at Tamkang University (1990-2013)

Researcher	Degree Centrality	Betweenness Centrality
Fan, Chun-Hai	0.182	0.038
Tao, Chi-Chung	0.227	0.017
Tong, Chee-Chung	0.182	0.008
Chiu, Hsien-Ming	0.136	0.010
Chang, Sheng-Syong	0.227	0.024
Luo, Siao-Sian	0.227	0.027
Hsu, Chao-Tze	0.045	0.000
Chen, Dun-Ji	0.227	0.029
Liu, Shih-Sien	0.182	0.008
Hu, Shou-Ren	0.091	0.001
Shih, Fong-Yu	0.045	0.000
Chang, Tang-Hsien	0.091	0.002
Chen, Wan-Hui	0.045	0.000

4.2 Visualization by Citespace and Ucinet

In addition ITS knowledge maps, the aim of this paper is to propose an effective way to assess academic performance for researchers in Taiwan. Currently, the assessment of academic performance is generally to use indicators such as the average number of papers, the number of cited times, and the number of journal papers published in SCI, SSCI or EI.

We conducted a questionnaire survey with the AHP method to develop and establish the assessment indicators weightings for calculating Taiwan's ITS researcher's academic performance objectively.

The first step in AHP process is to construct a tree hierarchy to show the goal at the top, criteria in the second level, principle in the next level, and then alternatives at the lowest level. In this study, a 1–9 ratio scale is used to compare three alternatives for indicating the strength of their relative preference. The questionnaires were answered by 30 experts from industry, university and government. The final results are shown in Table 7.

Table 7: The indicators priority for Taiwan's ITS researcher academic performance (shown in appendix)

Priority	code	Weight
1	A	0.319
2	B	0.101
3	C	0.092
4	D	0.076
5	E	0.041
6	F	0.037
7	G	0.035
8	H	0.033
9	I	0.032
10	J	0.026
11	K	0.025
12	L	0.023
13	M	0.023
14	N	0.023
15	O	0.016
16	P	0.014
17	Q	0.013
18	R	0.011
19	S	0.009
20	T	0.008
21	U	0.006
22	V	0.005
23	W	0.004
24	X	0.003
25	Y	0.002

The top five codes of indicators priority more than 0.41 are A (to receive international academic award), B (to receive national academic award), C (the cited times of published papers from international journal with SCI, SSCI, EI), D (the number of published papers from international journal with SCI, SSCI, EI), and E (to receive international academic conference award) respectively. In Taiwan, the most common way to assess researcher academic performance is to calculate the times to receive academic award and the number of cited times on international journals with SCI, SSCI. However, it would be beneficial for each researcher to choose composite indicators with adjusted weights to evaluate academic performance according to one's professional knowledge in a specific field.

In order to prove all indicators can be calculate on assessing real academic performance, we finished calculations of total score of academic performance for all ITS researchers In Taiwan. Due to total scores involve personal privacy, we obtained the consent of all professors at Tamkang University and listed their total scores of ITS academic performance up to 2013. The results reflected in Table 8 and indicated that Professor Chee-Chung Tong has the best academic performance in ITS field at Tamkang University up to 2013.

Table 8: The total score of ITS academic performance for professors at Tamkang University up to 2013

Indicators / Researchers	A	B	C	D	···	Total Score
Tong, Chee-Chung	0	0	3.5	1	···	2.00
Tao, Chi-Chung	0	0	0	1	···	1.23
Chen, Wan-Hui	0	0	5.75	0	···	1.02
Chen, Dun-Ji	0	0	0	0	···	0.64
Liu, Shi-Hsien	0	0	2	0	···	0.58
Luo, Shiaw-Shyan	0	0	0	0	···	0.55
Chang, Sheng-Syong	0	0	0	0	···	0.44
Fan, Chun-Hai	0	0	0	0	···	0.44
Chiu, Hsien-Ming	0	0	0	0	···	0.31
Hsu, Chao-Tze	0	0	1.25	0	···	0.21
Wen,Yu-Hung	0	0	0	0	···	0.127

Eventually, we illustrate the most active ITS fields in Taiwan, 232 papers from 1990 to 2013 in ATMS field by calculating academic performance indicators shown in Table 7 to present a variety of clusters in ATMS field.

As shown in Figure 7, there are 24 researchers from different universities focusing on 9 topics, such as signal control, travel time estimation, dynamic traffic assignment, vehicle classification, communication systems, incident management, ramp metering control, vehicle detection, and dynamic origin-destination matrices. It can be found that signal control, communication systems, and travel time estimation are vital and hot research topics in the ATMS field in Taiwan.

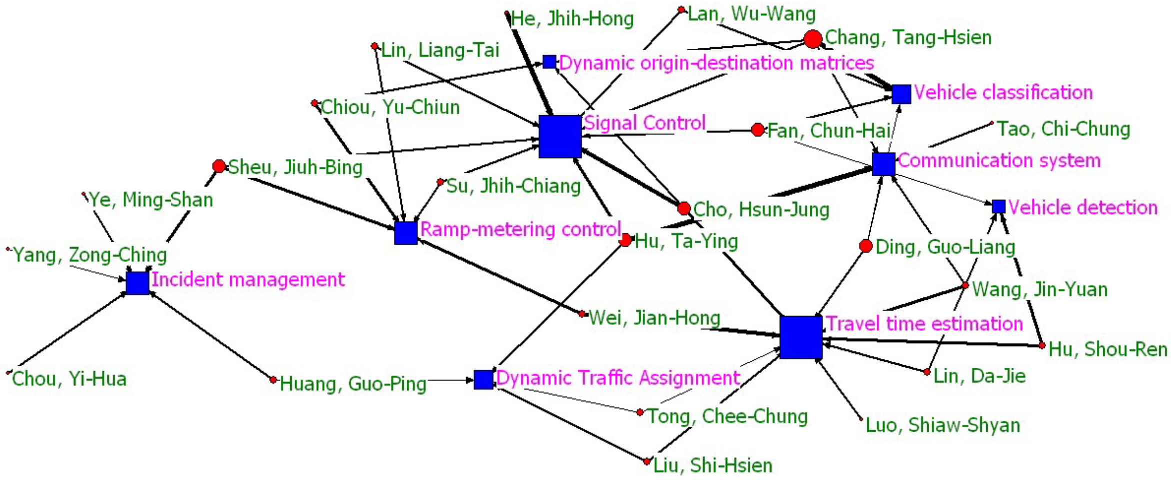

Fig. 7: The visualization knowledge map of the academic performance of Taiwan's researchers in the field of ATMS

5 Conclusion

ITS has been developing for over 20 years in Taiwan. This paper aims at focusing on Taiwan's academic performance in ITS research fields from 1990 -2013 with the help of visualizing knowledge maps supported by CiteSpace and UCIENT. The results are particularly encouraging because the presence of knowledge maps and the method using AHP to assess academic performance are useful and can be applied to other science disciplines.

Due to the limitation of databases and time for manual data screening, some significant findings are summarized as follows:

1. Based on citation analysis and theory of knowledge visualizing, CiteSpace can illustrate co-citation maps in a period of time. Clusters of ITS research can be shown by colors of nodes as cooperation relationship, cluster of author, cluster of keywords, etc. The results of the paper published on international ITS journals is not significant. The times cited by journals and amount of cooperative research are also rare. Furthermore, it is difficult to illustrate knowledge maps from Taiwan's researchers because of language weakness in English. Taiwan's researchers are still encouraged to publish related papers in international journals.

2. Due to lack of useful citation databases for ITS knowledge domain in Taiwan, screening publications manually and validating ITS literature by experts are needed. Using UCIENT software, the academic performance in term of ITS publications by universities includes National Taiwan University, National Chiao Tung University, National Cheng Kung University, Tamkang University, Feng Chia University, and Chung Hua University. Most of the papers are published in the field of ATMS.

3. The assessment of academic performance focusing on journal papers is criticized. By calculating real figures with indicators for assessing academic achievement, the proposed method in this study is validated, and can be used to successfully deploy visualization knowledge maps of the academic achievement of Taiwan's researchers in the field of ATMS as well. Developing AHP weighting on indicators will enhance the typical way to assess academic performance. It is expected that other knowledge maps in combination with methods like AHP can be applied to different science disciplines with a similar process in this paper.

4. To examine in detail domestic and overseas literature on ITS fields, visualization of knowledge maps and social network analysis methods have an important significance for the core technology research and development to guide industry or academic institutions. Nowadays, there is more and more related research using information visualization methods, especially for academic fields, technology industry or patents.

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Appendix

Indicator code
A:To receive international academic award
B:To receive national academic award
C:The cited times of published papers from international journal (SCI、SSCI、EI)
D:The number of published papers from international journal (SCI、SSCI、EI)
E:To receive international academic conference award
F:To receive national academic conference award
G:The cited times of published papers from TSSCI
H:The number of published papers from TSSCI
I:The number of research creativity award from the national science council in Taiwan
J:The number of government research
K:The number of doctoral dissertation
L:The number of technology transfer
M:International industry-university cooperative research project
N:The number of published papers from international journal (not include in SCI、SSCI、EI)
O:The number of English published books
P:The number of published papers from international academic conference
Q:The number of master's dissertation from graduate student
R:The average cited times from doctoral dissertation or master's dissertation
S:National industry-university cooperative research project (with government)
T:The number of published papers from national journal
U:The average cited times from government research
V:National patent
W:National industry-university cooperative research project
X:The number of Chinese published books
Y:The number of published papers from academic conference