A New Method of Creating Technology/Function Matrix for Systematic Innovation without Expert

Tien-Yuan Cheng[1]

Abstract

The technology/function matrix is comprised by specific technologies and functions, and through the technology/function matrix we can known what the technologies with functions have opportunities for innovation of product or technology. However, the technology/function matrix is very difficult to create, because the patents need to be read, analyzed and categorized into the technology/function matrix always more than hundreds or thousands. In this research, I propose a method to create a technology/function matrix just need to execute patent search without reading and analyzing patents. Through the proposed method anyone can create a technology/function matrix in a short time without experts' help even if there are thousands of thousands of patents need to be read and analyzed.

Keywords: Technology/function matrix; patent map; patent search; patent classification; systematic innovation.

[1] Legal/IP Department of Delta Electronics, Inc. 4F., No.10, Huzhu St., Banqiao Dist., New Taipei City 22048, Taiwan (R.O.C.) 886-912026957
Email: iamkevincheng@gmail.com

Introduction

Patent map is to collect patent information from patent specification for a specific purpose of use, and assembled, analyzed and drew in a visual form of presentation such as a chart, graph, table or matrix (Shin-Ichiro Suzuki, 2011). Patent map helps us to select subject for research and development, pick out new ideas for innovation, and gain information of competitors' technology development for making strategy. Patent map has two major types, one is the technology map and another one is the management map. The management map is the statistic of assignee, country, application date, publication date, IPC (international patent classification), USPC (US patent classification), citation or other bibliographies of patent (Byung-Un Yoon, Chang-Byung Yoon and Yong-

Tae Park, 2002). Usually, the technology map is a matrix like assignee/IPC matrix, assignee/USPC and technology/function matrix and so on.

The management maps help managers to known trends of the target technology (Zan Huang, Hsinchun Chen, Alan Yip, Gavin Ng, Fei Guo, Zhi-Kai Chen and Mihail C. Roco, 2003). See the figure 1, it is the statistic of patent application date and draws in graph. The figure 1 shows that development of wind power technology starts from 1978 and the development have gone down a little form 1980 to 1996, but it has a sharp increase in patent application after 1996. It shows the development trend of wind power technology (WIPO, 2009).
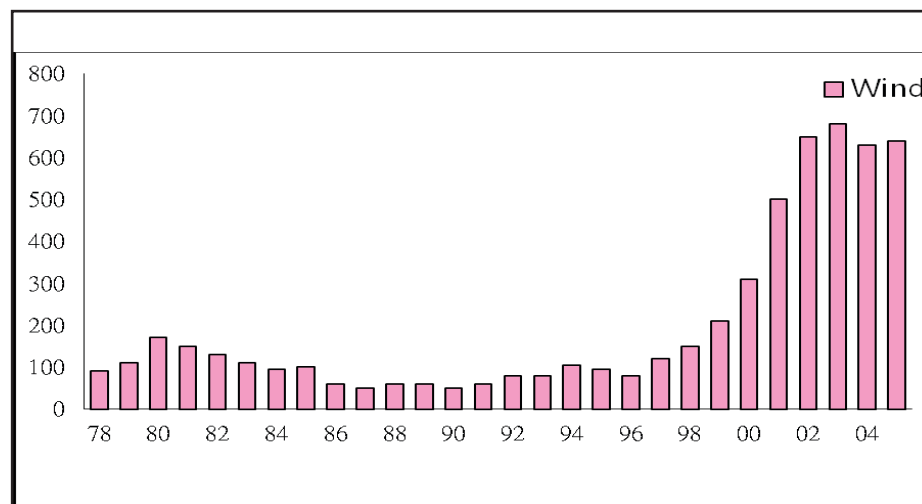

Figure 1: Applications date for wind power technology. Data from WIPO - Patent-based Technology Analysis Report (2009)

The technology maps help managers, R&D people and engineers to know the development of target technology or product (Holger Ernst, 2003). For example, the technology/function matrix shows what the development phase of technology with function, and what the technology with function have opportunities or ricks. Managers, R&D people and engineers can make decision for development of technology or product base on the technology/function matrix.

The steps of creating a technology/function matrix are patent search, reading, analyzing and categorizing patents into all fields of technology/function matrix. It usually needs experts to help especially in reading, analyzing and categorizing patents (Young Gil Kim, Jong Hwan Suh and Sang Chan Park, 2008). The table 1 is a technology/function matrix of "nano-composite material" subject. The matrix shows the field of "Polymer" technology with "Mechanical and dimensional stability" function is developed more mature because patents in this field are more than other fields of technology with function (Hsin-Ning Su and Pei-Chun Lee, 2009).

		MATRIX MATERIAL					
		Polymer	Clay	Ceramic	Metal	Other	Total
FUNCTION	Mechanical dimensional stability	176	4	59	35	11	285
	Permeability	52	1	1	0	1	55
	Thermal stability	70	1	16	13	3	103
	Flame retardancy	19	0	0	0	1	20
	Chemical resistance	17	0	5	4	4	30
	Surface appearance	6	0	2	0	1	9
	Electric conductivity	69	0	28	30	21	148
	Optical and light emitting property	77	0	19	10	15	121
	Cement/adhesivity	7	0	1	0	0	8
	Magnetic property	10	0	7	28	0	45
	Other	56	2	20	19	23	120
	Total	503	6	138	120	57	824

Table 1: Technology/Function Matrix of "nano-composite material". Data from Hsin-Ning Su and Pei-Chun Lee (2009)

To create the management maps is easy. First, make sure the key words of subject and using the key words for patent search. Second, gathering statistics of the patent information search out by patent search. And the last step is using the statistics of patent information to draw graphs. For example, we can gather statistics of patent application date and using the statistics to draw a run chart for understanding the technology development trend.

However, creating a technology/function matrix is very difficult. The first step of traditional method of creating a technology/function matrix is deciding search terms which are the technology or function terms of the subject (Young Gil Kim, Jong Hwan Suh and Sang Chan Park, 2008). For example, if the subject is "nano-composite material" and then the search terms could be "nano" and "composite" appeared in title or abstract (Hsin-Ning Su and Pei-Chun Lee, 2009). The second step is creating the technology category and function category (Young Gil Kim, Jong Hwan Suh and Sang Chan Park, 2008). For example, for the "nano-composite material" subject, the technology category includes Polymer, Clay, Ceramic and Metal, and the function category includes "Mechanical and dimensional stability", Permeability, "Thermal stability", "Flame retardancy", "Chemical resistance", "Surface appearance" and etc (Hsin-Ning Su and Pei-Chun Lee,

2009), but the second step usually needs experts' help, because experts know what the major technologies and functions of the subject. And the last step is reading, analyzing and categorizing patents search out by patent search into the technology/function matrix by manpower (Young Gil Kim, Jong Hwan Suh and Sang Chan Park, 2008). In this step we need to read and analyze what the technologies and functions of patents, and then categorize patents into fields of the technology/function matrix. For accuracy of categorizing patents into the technology/function matrix we always need experts' help (Yuen-Hsien Tseng a, Chi-Jen Lin b and Yu-I Lin, 2007). It is a heavy workload to read, analyze and categorize patents into the technology/function matrix, especially when the patents are more than thousands. The heavy workload is the main reason of why a technology/function matrix is difficult to create.

Another problem of traditional method is that it is difficult to build the technology category and function category without experts' help, needless to say reading, analyzing and categorizing more than thousands patents into a technology/function matrix. Accordingly, without experts' help creating the technology/function matrix is being a mission impossible.

Proposed Method

In this research, I propose a new method to create a technology/function matrix without help of expert or the person having ordinary skill in the art. Through the proposed method, we don't need experts' help for creating the technology category and function category, and reading, analyzing and categorizing patents into the technology/function matrix. We just need to execute patent search for collecting patents, gathering statistics of the patents' information and then fill in fields of the technology/function matrix with the result of second patent search. It means everyone can create the technology category and function category and categorize patents into the technology/function matrix without experts' help. The steps of the proposed method are below.

Step 1: Patent search

The first step of the proposed method is patent search, and we need to make different patent search strategy for different purpose. For the purpose of study, research or industrial analysis, the patent search strategy will be simple for collecting more enough patents. For example, one case of the research subject is nano-composite material, and then the patent search strategy will be just "nano" and "composite" appeared in title or abstract (Hsin-Ning Su and Pei-Chun Lee, 2009). Another research subject is "solar power inverter", and the patent search strategy is that interaction of inverter and the result of union of events solar, Photovoltaic and "PV" appeared in description of issued patents, and then we search out 6,393 patents (the search date is 2011/11/09 and the patent search engine is "Free Patent Online").

However, the purpose of creating a technology/function matrix is for R&D, design around or patent portfolio, the patent search strategy need to narrow down for fitting the patent search result to the subject. As the "solar power inverter" subject, the patent search strategy is that "(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2))" appeared in description of issued patents, and then we search out 1,697 patents (the searching date is 2011/11/09 and the patent search engine is "Free Patent Online").

Step 2: Creating technology category and function category

The second step is creating the technology category and function category. The traditional method needs experts to help to create the technology category and function category according to the subject, but the proposed method without help of experts, R&D people or person skilled in the art. The proposed method just needs to gather statistics of IPC and USPC of the patents searched out by the first step.

IPC is a kind of patent classification built by WIPO (World Intellectual Property Organization) and the classification of IPC is based on the different areas of technology to patent relate (WIPO, 2011), and the IPC divides technology into eight sections with more than 70,000 subdivisions, and the eight technology sections are "HUMAN NECESSITIES", "PERFORMING OPERATIONS; TRANSPORTING", "CHEMISTRY; METALLURGY", "TEXTILES; PAPER", "FIXED CONSTRUCTIONS", "MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING", "PHYSICS" and "ELECTRICITY". IPC is consisted of Section, Class, Subclass, Main Group and Subgroup, and the Sections are the highest level of hierarchy of IPC, and the Subgroups are the detail description of technology of IPC.

USPC is another patent classification built by USPTO (United States Patent and Trademark Office) and the classification of USPC is based on the function, effect, end-product, structure or use of a patent (USPTO, 2011). There are about 450 Classes of patent and about 150,000 subclasses of patent in the USPC. Classes and subclasses have titles which provide a short description of the class or subclass. Classes and subclasses also have definitions which provide a more detailed explanation.

There are at least one IPC code and USPC code distributed to every US patent. For example, the Figure 2 is part of US6657118 patent specification and it shows the bibliographic data of US6657118 patent. Form the Figure 2 we can know that US6657118 patent has H01L21/33 and H01L31/048 two IPC code, and 136/244, 136/251, 136/291, 136/293,136/258, 363/60, 323/906, 323/221, 60/641.8 nine USPC code.

(12) **United States Patent**
Toyomura et al.

(10) **Patent No.:** US 6,657,118 B2
(45) **Date of Patent:** Dec. 2, 2003

(54) **SOLAR BATTERY MODULE, METHOD OF MANUFACTURING SAME AND POWER GENERATING APPARATUS**

(75) Inventors: **Fumitaka Toyomura**, Nara (JP); **Nobuyoshi Takehara**, Kyoto (JP)

(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **U.S. Cl.** **136/244**; 136/251; 136/291; 136/293; 136/258; 363/60; 323/906; 323/221; 60/541.8
(58) **Field of Search** 136/244, 251, 136/291, 293, 258; 363/60, 147; 323/906, 221; 60/541.8

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Primary Examiner—Alan Diamond
(74) *Attorney, Agent, or Firm*—Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

If an inverter is merely attached to the back side of a solar battery module, the inverter becomes an obstacle to transport and installation, it may be broken if it strikes a building structure at the time of installation and it may malfunction owing to impact with an object. Accordingly, a weather-resistant film, a first filler, a solar battery element, a second filler and a back reinforcing material are stacked in the order mentioned and the fillers are melted using a vacuum laminator to thereby seal the solar battery element in resin between the back reinforcing material and weather-resistant film. At this time an inverter is placed on the surface of the back reinforcing material that opposes the solar battery element.

Figure 2: The bibliographic data of US6657118

According to the definitions of IPC and USPC, we know that the classification of IPC is base on technologies of patents, and the classification of USPC is base on functions of patents. This is the reason for why the proposed method use IPC as the technology category and USPC as the function category. For the purpose to decide what the IPCs and USPCs to be the technology category and function category, we need to gather statistics of IPC and USPC, and then we choose the IPC and USPC which the counts in TOP 10 or TOP 20, or counts add up to 80% or 90% to be the technology category and function category. But the IPCs or USPCs chose by the way may not match our subject. For example, the top 10 IPC of the "solar power inverter" subject are H02J, H02M, H01L, G05F, H01M, E21B, G06F, H02P, H02H and B60L, but E21B (EARTH OR ROCK DRILLING; OBTAINING OIL, GAS, WATER, SOLUBLE OR MELTABLE MATERIALS OR A SLURRY OF MINERALS FROM WELLS) or B60L (PROPULSION OF ELECTRICALLY-PROPELLED VEHICLES) don't match our subject. For the purpose of matching subject we need to exclude the IPCs and USPCs which we don't interest.

As shown in table 2 and table 3, the IPC and USPC chose for technology category and function category. For reason of understanding the technology category and function category we need to give descriptions to IPC n and USPC n with short words, because the IPC and USPC classifications just codes can't be understood.

Technology code	IPC Class	IPC Description	Technology Term
T1	H02J	CIRCUIT ARRANGEMENTS OR SYSTEMS FOR SUPPLYING OR DISTRIBUTING ELECTRIC POWER; SYSTEMS FOR STORING ELECTRIC ENERGY	Power Supply System
T2	H02M	APPARATUS FOR CONVERSION BETWEEN AC AND AC, BETWEEN AC AND DC, OR BETWEEN DC AND DC, AND FOR USE WITH MAINS OR SIMILAR POWER SUPPLY SYSTEMS; CONVERSION OF DC OR AC INPUT POWER INTO SURGE OUTPUT POWER; CONTROL OR REGULATION THEREOF	Converter
T3	H01L	SEMICONDUCTOR DEVICES; ELECTRIC SOLID STATE DEVICES NOT OTHERWISE PROVIDED FOR	Semiconductor Device
T4	H01M	PROCESSES OR MEANS, e.g. BATTERIES, FOR THE DIRECT CONVERSION OF CHEMICAL ENERGY INTO ELECTRICAL ENERGY	Conversion Mean
T5	H02P	CONTROL OR REGULATION OF ELECTRIC MOTORS, GENERATORS, OR DYNAMO-ELECTRIC CONVERTERS; CONTROLLING TRANSFORMERS, REACTORS OR CHOKE COILS	Motor Control
T6	H02H	EMERGENCY PROTECTIVE CIRCUIT ARRANGEMENTS	Emergency Protective
T7	H05B	ELECTRIC HEATING; ELECTRIC LIGHTING NOT OTHERWISE PROVIDED FOR	Electric Heating
T8	H04B	TRANSMISSION	Transmission
T9	H04N	PICTORIAL COMMUNICATION	Pictorial Communication
T10	H01J	ELECTRIC DISCHARGE TUBES OR DISCHARGE LAMPS	Discharge Device

Table 2: Technology Category (IPC)

Function Code	USPC Class	Description	Function term
F1	363	Electric power conversion systems	Power Conversion
F2	307	Electrical transmission or interconnection systems	Electrical Transmission
F3	320	Electricity: battery or capacitor charging or discharging	Charge
F4	323	Electricity: power supply or regulation systems	Power Regulation
F5	136	Batteries: thermoelectric and photoelectric	Batteries of Photoelectric
F6	340	Communications: electrical	Electrical Communications
F7	361	Electricity: electrical systems and devices (SAFETY, PROTECTION, CONTROL CIRCUITS)	Control System
F8	315	Electric lamp and discharge devices: systems	Discharge
F9	700	Data processing: generic control systems or specific applications	Data processing
F10	438	Semiconductor device manufacturing: process	Semiconductor Device Manufacturing

Table 3: Function category (USPC)

Step 3: Creating technology/function matrix

AS shown in table 4, we put the technology category (IPC) in the first column and function category (USPC) in the first row, and then we have a matrix with n × n fields. The fields of second column like T1N, T2N,…, TnN,…T10N are the amounts of technology code T1(Power Supply System), T2(Converter) ,…Tn,…, T10(Discharge Device) and

The fields of second row like F1N, F2N, …, FnN,…F10N are the amounts of function code F1(Power Conversion), F2(Electrical Transmission) ,…,Fn,…, F10(Semiconductor device manufacturing). The field in the n rows of n columns like Tn & Fn is the amount of interaction of technology Tn and function Fn.

	Function	Power Conversion (F1)	Electrical Transmission (F2)	Charge (F3)	É (Fn)	Semiconductor device manufacturing (F10)
Technology	Amount of code	F1N	F2N	F3N	*FnN*	F10N
Power Supply System (T1)	T1N	100	195	137	*T1 & Fn*	0
Converter (T2)	T2N	232	71	23	*T2 & Fn*	0
Semiconductor device (T3)	T3N	21	18	16	*T3 & Fn*	40
É (Tn)	*TnN*	*Tn & F1*	*Tn & F2*	*Tn & F3*	*Tn & Fn*	*Tn & F10*
Discharge Device (T10)	T10N	1	4	0	*T10 & Fn*	6

Table 4: Technology/Function matrix

In the proposed method, the TnN, FnN and Tn & Fn can be obtained by patent search, the patent search strategy of "TnN", "FnN" and "Tn & Fn" fields for the "solar power inverter" subject are below:

(A) The patent search strategy of TnN
In the patent pool, the amount of the patents has technology Tn is TnN, the figure 3 shows the logic relationship between patent pool and Tn.
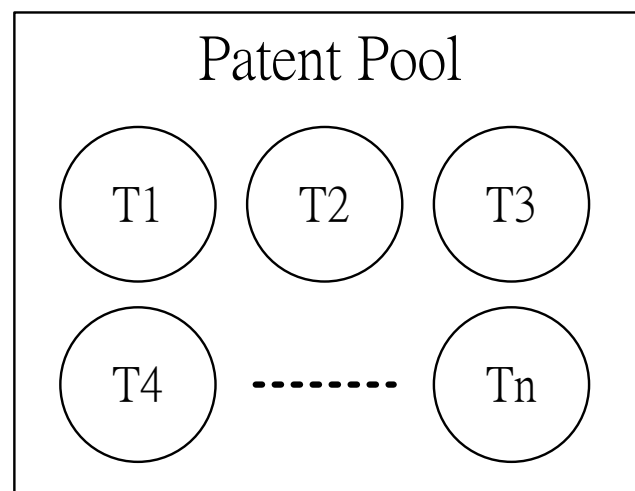

Figure 3: Logic diagram of patent pool and Tn

We know TnN is the interaction of patent pool and Tn form figure 3, and the patent pool of the "solar power inverter" subject is searched out by the strategy that SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)), so the patent search strategy of TnN is that:

SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and ICL/Tn.

For example, we know that T1 means IPC code H02J, and then we can make the patent search strategy "SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and ICL/H02J" for "T1N" field.

(B)   The patent search strategy of FnN fields
In the patent pool, the amount of the patents has function Fn is FnN, the figure 4 shows the logic relationship between patent pool and Fn.
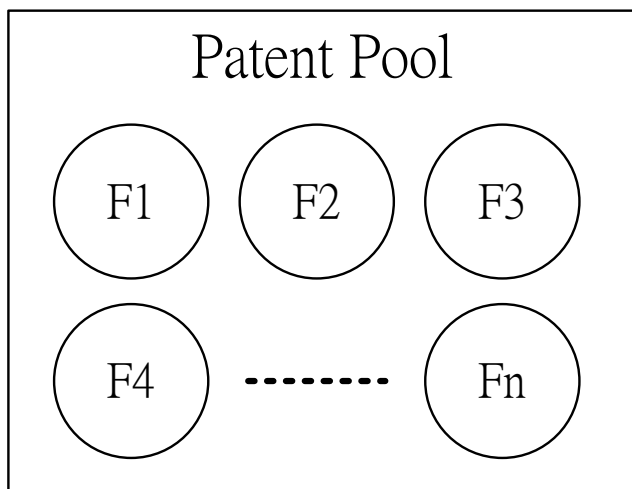

Figure 4: Logic diagram of patent pool and Fn

SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and CCL/Fn

For example, we know that F1 means USPC code 363, and then we can make the patent search strategy "SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and CCL/363" for "F1N" field.

(C)   The patent search strategy of Tn&Fn fields
In the patent pool, the amount of the patents has technology Tn and function Fn is Tn&Fn, the figure 5 shows the logic relationship between patent pool, Tn and Fn.
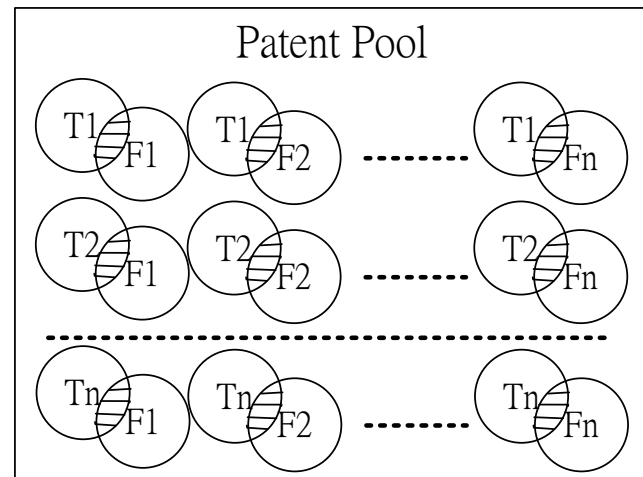

Figure 5: Logic diagram of patent pool, Tn and Fn

We know Tn&Fn is the interaction of patent pool, Tn and Fn form figure 5, and then the patent search strategy of Tn&Fn is that:

SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and ICL/Tn and CCL/Fn

For example, we know that T1 means IPC code H02J and F1 means USPC code 363, and then we can make the patent search strategy "SPEC/(("solar inverter"~3 or "Photovoltaic inverter"~3 and "PV inverter"~3) or ((solar or Photovoltaic) and "DC DC"~2)) and ICL/H02J and CCL/363" for "T1 & F1" field.

We search out 100 patents according to the patent search strategy of "T1 & F1", and the number "100" is meaning there are 100 patents have the technology "Power Supply System" and the function "Power Conversion" of the "solar power inverter" subject.

Conclusion and Limitation

The technology/function matrix of patent map is a powerful and useful tool for innovation and patent portfolio. But most people or company don't want to create it, because creating a technology/function matrix by traditional method is time-consuming, labor-intensive, high cost and it always needs experts' help.

We can make patent search strategy for every field easily, and complete the technology/function matrix by filling all fields of the technology/function matrix with patent search results. Accordingly, the first advantage of the proposed method is that we can dispose patents into technology/function matrix by patent search without help of experts or person has ordinary skill in the art to analyze patents. The second advantage of the proposed method is laborsaving, because we can dispose patents into technology/function matrix by patent search, and patent search just need one or few people to execute.

The best advantages of the proposed method are timesaving and low cost. Traditional method needs much manpower and experts to analyze patents, and the more patents the longer more of traditional method, actually it always takes several months. But the proposed method just needs short time to create technology/function matrix even if the patent pool has thousands of thousands of patents.

Although the proposed method has several advantages, it still has a main limitation. The main limitation of the proposed method is that, as it is based on the patent classification of IPC and USPC, and the USPC only US patents have, so the proposed method just can use to create the technology/function matrix for US patents. But WIPO, EPO, China, Japan or Korea has very abundant patents worthy to create technology/function matrix to analyze for innovation. For the purpose to obtain information of innovation from different patent database, future research can develop methods which can create technology/function matrix without the limitation of different patent database.

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