Research and Application of Patent Map Analysis

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Abstract
Patent documents embed many important research results. But they often appear as legal documents covering the technology and business information therein. Effective intelligence tools are necessary for patent information extraction. Patent Map (PM) provides visualized expression of total patent analysis results, describing the signification of all the charts, figs, graphs and so on, helping the non-specialists understand the patent analytical results easily and effectively. It is used as the starting point to investigate technology trend, and find out new emerging technology, valuable to both technologists and organizational managers or industry watchers. This paper discussed the typical representations of PM results about their functions, usual formats. A case study, patents activity analysis of the Vehicle Navigation either global or within China, was conducted by PM analyzing. Analysis results, including the development trends, technology mature degrees, technology structural distributions, major competitors, core patents, citation relationships, R&D hotspots, co-operations between major players, attributes in Chinese domestic market, etc., were presented in suitable visual maps.

Keywords
patent map; patent information analysis; patent intelligence analysis; intelligence analysis and synthesis

Introduction
As EPO disclosed, “patents reveal solutions to technical problems, and they represent an inexhaustible source of information: more than 80% of man’s technical knowledge is described in patent literature”. The investigation of existing patent literature can avoid research duplication. However, patent documents are often lengthy and rich in legal items. Data processing and comparative intelligence tools are necessary when obtaining valuable information from patent documents. Patent Map (PM) is such an intelligence tool having evolved from a simple concept to an important new discipline in intellectual property. Basing on clustering, aggregation, and other operations, it extracts the technological value from patents and provides visualized expression of total patent analysis results, describing the signification of all the charts, figs, graphs and so on. Used as the starting point to investigate technology trends, and find out new emerging technology, PM is valuable to both technologists and organizational managers or industry watchers. The functions, procedures, typical representations of PM results are discussed in this article. A case study, patents activity analysis of the Vehicle Navigation either global or within China, is conducted by PM analyzing, and many research results visualized in suitable maps are presented.

Background
By quantitative or qualitative analysis methods or both, the Administrative, technological and rights information is extracted to produce all kinds of charts, graphs, maps, etc. In general, the typical representations of patent map results are presented as follows (Jung, 2003) (JIII, 2000).

Quantitative analysis maps
They are results of quantitative analysis method such as quantity-based analysis, time-based analysis, and ranking analysis, etc., analyzing patents through numerical statistic. Most usable data come from bibliographical information including the number of patent applications, assignees, inventors, or patent classification codes, etc. The follows are the typical quantitative maps.

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1. This work was supported by West Light Foundation of The Chinese Academy of Sciences.
1. **Portion rate map**
   Portraying composition ratios by some attributes such as applications, applicants, countries and so on, this map shows the structural difference within them. It is always represented as a pie graph, bar graph or ring graph.

2. **Ranking map**
   It portrays the sort results in a specific field, highlighting the prominent objects such as identifying possible competitors or core patents, etc. Bar graph is more popular in this type.

3. **Trend map**
   Depicting the development trend over time in a specific field, it is help for the future forecast. This kind of map is represented as broken line graph or bar graph usually.

**Qualitative analysis maps**
They are results of qualitative analysis method such as selection of core patents, citation analysis, technology development analysis, etc. They analyze the content of patents. Generally, they were performed by the inter-relationship of technology content or patent classification code, assignee, application date, etc. Typical qualitative maps are listed as following.

1. **Matrix map**
   Matrix map shows the correlation between technical elements (such as purpose and technical item, problems and solvable technologies) obtained from patent information in the form of matrix. It helps to find important problems affecting the development of a technology field. It is even more effective to indicate the strength of the solvable technologies required for solving problems and consider the technical potential of developer. It is possible to estimate the degree of difficulty of realizing a development plan.

2. **TEMPST map**
   TEMPST Map shows the technology analysis based on different points of analysis views. What the points of analysis views may include is listed as Table 1. In this map, the pertinent patents are classified by the analysis results of each point.

   Table 1. TEMPST analysis view points
<table>
<thead>
<tr>
<th>The point of analysis view</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Treatment</td>
</tr>
<tr>
<td>E</td>
<td>Effect</td>
</tr>
<tr>
<td>M</td>
<td>Material</td>
</tr>
<tr>
<td>P1</td>
<td>Process</td>
</tr>
<tr>
<td>P2</td>
<td>Product</td>
</tr>
<tr>
<td>S</td>
<td>Structure</td>
</tr>
</tbody>
</table>

3. **Citation analysis map**
   There are backward citation map and forward citation map (3i-Analytics, 2004). Backward map features patents being cited most frequently by patents in the field. These cited patents can be expected to cover a core technology or a valuable invention that is significant to the development of the technology. Forward map features patents citing the most number of patents among the field. These citing patents would help in mapping the trends and dependencies in the field.

4. **Technology development map**
   Portraying the technological progress, this map discloses the expanse flow of technology from a basic patent. It is produced by extracting patents related to a specific field, layering and displaying them on time series. This map helps to grasp the source of the technology and ascertain the process by which technologies advanced. It can be used as an effective tool providing a hint for creating new ideas.
5. **Claim point map**
Portraying the claim points and their relationships of existing patents, claim point map is useful to identify the existing claim coverage in a specific field to investigate whether the new technology infringes (Shinmori, Okumura, Marukawa & Iwayama, 2004). It is critical in managing technical assets, planning R&D projects and avoiding the possible conflicts.

6. **Component map**
In component map, a product is portrayed while the key components are marked with the related patents respectively. About each component, the quantities of the relative patents and the key claims can be seen from this map. It is useful to regard the patent protection net about a specific product (JAPIO, 1998).

7. **Portfolio map**
This map produces multiple clusters where respective clusters contain similar technologies in terms of major attributes of interest (Ernst, 1998). It is expected that the portfolio map can detect the relationships that are not obvious in other patent classification systems. Portfolio map is used to identify technology portfolios of patentees, which provides guidance to the investment.

8. **Landscape map**
It portrays the concentration of patent documents on some themes (Yeap, Loo & Pang, 2003). In this map, each hill represents a concentration of patent documents of a related theme. The peak indicates a higher concentration while labels on the peak of each hill signify themes. Each black dot in the map represents a cluster of documents. The proximity between objects (patent documents and hills) in the landscape is directly related the strength of relationships between them.

9. **Technology Vacuum Map**
This map portrays a technology vacuum (missing area), indicating blank zones having great potential for prior occupation. It is useful in developing business strategy and making R&D projects. Technology vacuum map can be developed in two ways, dynamic and static. The static map represents a snapshot of technology vacuum at a particular point in time, while the dynamic map provides information on the changing pattern of technology vacuum over time (Yoon & Park, 2002). It is considered a starting point for discovering new emerging technologies.

**Case study - Vehicle Navigation patent activities analyzing**

**Objectives of the study**
The objectives of this study are to collect statistical data on vehicle navigation patents, estimate the development stage, discover the distributions of applications and applicants, weigh the roles that major patentees played, determine the core patents and R&D hotspots, explore the relationships between patents and corporations, and provide a better understanding of either global or domestic patent activities in this field. The analytical results are presented in suitable visual maps.

**Databases and tools selection**
Since the accuracy of a study largely depends on the quality of data sources and research tools, we first spent lengthy hours to locate the best suitable data source. After careful examination and repeated experimental searches, Derwent Innovation Index (DII) was decided to be used as the data collection for its worldwide content coverage and outstanding patent family registration, while the Derwent Analyst (DA) as the analytical tool for its powerful functions and compatibility with the DII data format. In study of Chinese patent activity, as the time lagging of DII’s coverage, the SIPO official Web-based database was employed to insure the recall ratio.

**Study process**
With the selected database and tool mentioned above, this study was conducted as the following:
1. Pre-searched repeatedly and built search strategies basing the results returned.
2. Searched the DII and 13610 published records including granted patents and unexamined applications were found till June, 2006.
3. Downloaded these 13610 records and transferred them into the DA tool.
4. Cleaned all the records and analyzed them by DA.
5. Designed some self-programming for the analytical functions unavailable in DA.
6. In accordance with analytical results, performed suitable charts, diagrams and maps. As needed, some statistical data were processed by Microsoft Excel.
7. Only the records of inventions were employed in most of this study, except the developmental stage measuring in Chinese activity where analytical data covered three kinds of Chinese patent type: Invention, Utility Model and Industrial Design.

Research findings
At the end of series of database searches, data analysis, comparisons and PM drawings, some research results about vehicle navigation patent activities are summarized and presented in visual maps as follows.

Statistical information
As of Jun 2006, 13610 applications were published. The very first patent was a French application filed in 1957, followed by a gradual growth until 1993 with only 781 applications published as the 5.7% of the total. Only during the recent 10-year period time appeared a very substantial increase, indicating the rapidly growing in R&D activities. Fig. 1 shows the increasing trend of applications according to the earliest prior year. For the primary examination system, most applications filed in 2004 and 2005 have not been published yet, so the data about 2004 and 2005 is not of adequate statistical significance.

![Figure 1. Vehicle Navigation Patent Applications Change Trend](image)

Technological Life Cycle (TLC) analysis
TLC map is a plot of the number of patent applications versus the number of applicants over time (Liu, 2005). It portrays the maturity degree of a specific field. The cycle is divided into 5 periods (Fig. 2): emergence, development, mature, declining and recovery. Whether entering the recovery period is depended on whether the innovation elements appear. TLC map is useful in observing the stage of technological development, judging whether to go into the business of the technology field or not.

The TLC analysis results about global vehicle navigation technology are illustrated in Fig. 3. The mid of 1990s was the beginning of the development period, as the number of patent applications and applicants began to increase dramatically. After 1999 even more players entered. But from 2002 the applicants began to decrease while the applications kept increasing. It seemed some major players conducted this field and a beginning of gradual transmission from development to mature period appeared.
Country (regional) distributions analysis
The top 6 countries of patent applications in this field are Japan, US, Germany, Korea, France and English. 13144 applications filed by them, as 97% of the total (Fig. 4). Japanese applications advanced remotely as 75% of the total, suggesting their domination in the industry.

Technology structure analysis
Employing the IPC system, the technological structure was investigated (Meyer, 2003). Top 5 IPC classes of applications are listed in Table 2. The majority applications are concentrated in 4 classes: G01C-021/00, G08G-001/0969, G09B-029/10 and G09B-029/00, indicating the main patent activities in this field focus on the technologies about navigation instruments, transmission control systems, locations, and map data storage.

Table 2. Top 5 IPC Classes about Vehicle Navigation Patents

<table>
<thead>
<tr>
<th>Rank</th>
<th>IPC classes</th>
<th>No. of appl.</th>
<th>Class titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G01C-021/00</td>
<td>8907</td>
<td>Navigation; Navigational instruments not provided for in groups G01C 1/00- G01C 19/00</td>
</tr>
<tr>
<td>2</td>
<td>G08G-001/0969</td>
<td>6711</td>
<td>Traffic control systems for road vehicles, having a display in the form of a map involving transmission of navigation instructions to the vehicle, giving variable traffic instructions, having an indicator mounted inside the vehicle, e.g. giving voice messages</td>
</tr>
<tr>
<td>3</td>
<td>G09B-029/10</td>
<td>4853</td>
<td>Map spot or co-ordinate position indicators; Map-reading aids</td>
</tr>
<tr>
<td>4</td>
<td>G09B-029/00</td>
<td>4602</td>
<td>Maps; Plans; Charts; Diagrams, e.g. route diagram</td>
</tr>
<tr>
<td>5</td>
<td>G08G-001/09</td>
<td>1419</td>
<td>Traffic control systems for road vehicles, arrangement for giving variable traffic instructions</td>
</tr>
</tbody>
</table>
Similar analyses could be done at both the macro and micro levels. For instance, an IPC structural comparison between major applicants helps to investigate these corporations’ predominance in any unique field.

**Major competitors analysis**

Relative R&D ability (RRDA) was introduced to assess the levels, qualities and influences of the patent activities to determine the competitors of this field. The value of RRDA is achieved by $\text{RRDA} = \text{NOP} \times W_1 + \text{SCI} \times W_2 + \text{OCI} \times W_3$, wherein NOP means the number of patents, OCI means other-cited times, and SCI means self-cited times. In this study, $W_1$, $W_2$ and $W_3$ were evaluated as 1, 1.2 and 1.4 respectively (Wu, 2003).

Regarding the maximal as 100%, the Top 10 are ranked (Table 3). 9 of them are from Japan except BOSCH GMBH ROBER from Germany, indicating Japan’s absolute domination in this business. As for BOSCH, his RRDA ranks 6 although his application counts only ranks 11. This suggests his high innovation ability.

**Table 3. RRDA Details of Major Competitors about Vehicle Navigation**

<table>
<thead>
<tr>
<th>RRDA Rank</th>
<th>Appl. Rank</th>
<th>Patentees</th>
<th>RRDA</th>
<th>Inventions</th>
<th>Cited Ratio</th>
<th>Tech. Independence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>MATSUSHITA DENKI SANGYO KK (MATU)</td>
<td>100.0%</td>
<td>310</td>
<td>0.660</td>
<td>0.121</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>AISIN AW CO LTD (AISW)</td>
<td>82.8%</td>
<td>176</td>
<td>1.382</td>
<td>0.112</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>NIPPONDENSO CO LTD (NPDE)</td>
<td>80.3%</td>
<td>297</td>
<td>0.442</td>
<td>0.064</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>ALPINE KK (ALPN)</td>
<td>66.3%</td>
<td>166</td>
<td>0.386</td>
<td>0.100</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>MITSUBISHI DENKI KK (MITQ)</td>
<td>66.1%</td>
<td>236</td>
<td>1.893</td>
<td>0.062</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>BOSCH GMBH ROBERT (BOSC)</td>
<td>59.7%</td>
<td>348</td>
<td>1.892</td>
<td>0.164</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>NISSAN MOTOR CO LTD (NSMO)</td>
<td>58.2%</td>
<td>156</td>
<td>1.394</td>
<td>0.056</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>PIONEER ELECTRONIC CORP (PIOE)</td>
<td>54.7%</td>
<td>253</td>
<td>1.501</td>
<td>0.173</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>TOYOTA JIDOSHA KK (TOYT)</td>
<td>54.1%</td>
<td>170</td>
<td>1.136</td>
<td>0.059</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>HONDA GIKEN KOGYO KK (HOND)</td>
<td>46.2%</td>
<td>91</td>
<td>2.222</td>
<td>0.069</td>
</tr>
</tbody>
</table>

To investigate the R&D abilities in details, more indicators were employed in this section. For example, BOSCH had the most inventors so he held the largest R&D group of them; their cited ratios are closely to each other; the gaps of technological independences of them are not apparent.

The co-operation between the competitors was examined to investigate the penetration and interaction between major players of this field. As illustrated in Fig. 5: each node represents one assignee; the size of the node reflects the number of records associated with the assignee; these nodes are all the same because the assignees have a similar number of records (when compared to the total number of records in the dataset); the lines reflect the joint applications between the assignees; the strength of the lines is related to the number of joint applications.

From this map, Japanese corporations connected closely to each other. The co-operations between US, JP and EU are few. It seems that the European, American and Asian-Pacific R&D markets are kept under a system of its own without any connection on each other.
Figure 5. Co-operation Analysis of Major Competitors in Vehicle Navigation Field²

Core patents analysis
Although the earlier the patent is published the more possibly it is cited, the citation frequency is regarded as a key indicator to evaluate the patents' qualities, being used to identify the core patents of a specific field usually (Ernst, 2003).

In this study, the given patents were ranked on their citation frequencies. The top 10 are regarded as the core patents of vehicle navigation technology field (Table 4). They are all US patent documents while 4 filed by American corporations and 6 by Japanese corporations. Because of the important R&D position and high-tech market of America, Many developers regard America as the preferred country when seeking patent protection for their key innovations. On the other hand, 60% of the core patents are owned by Japanese players. It suggests Japanese corporations' core status in this field instead of the periphery in other fields usually.

Citations analysis
To investigate the technology advancement, the core patents were kept as sources and their citation process over time were explored. In this citation advancement map (Fig. 6), 5 bigger nodes are the core patents. The other smaller ones are citing patents. Arrows represent the citation relationships pointing to the cited patents. As there are too many following citing patents to show in one map completely, some main citing ones are showed in this illustration.

² Mapped by Derwent Analyst
<table>
<thead>
<tr>
<th>Rank</th>
<th>Pat. Num.</th>
<th>Title</th>
<th>Cited Times</th>
<th>Other Cited</th>
<th>Assignee</th>
<th>Appl. Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>US 5177685</td>
<td>Automobile navigation system using real time spoken driving instructions</td>
<td>90</td>
<td>89</td>
<td>MASSACHUSETTS INST TECHNOLOGY (MASI), US</td>
<td>1990.8.9</td>
</tr>
<tr>
<td>2</td>
<td>US 4796191</td>
<td>Vehicle navigational system and method</td>
<td>64</td>
<td>61</td>
<td>ETAK INC (ETAK-Non-standard), US</td>
<td>1984.6.7</td>
</tr>
<tr>
<td>4</td>
<td>US 5272638</td>
<td>Systems and methods for planning the scheduling travel routes</td>
<td>62</td>
<td>62</td>
<td>TEXAS INSTR INC (TEXI), US</td>
<td>1991.5.31</td>
</tr>
<tr>
<td>6</td>
<td>US 5031104</td>
<td>Adaptive in-vehicle route guidance system</td>
<td>51</td>
<td>47</td>
<td>SUMITOMO ELECTRIC IND CO (SUME), JP</td>
<td>1989.11.29</td>
</tr>
<tr>
<td>7</td>
<td>US 4608656</td>
<td>Road map display system with indication of a vehicle position</td>
<td>50</td>
<td>47</td>
<td>NISSAN MOTOR CO LTD (NSMO), JP</td>
<td>1982.4.2</td>
</tr>
<tr>
<td>8</td>
<td>US 4782447</td>
<td>System and method for navigating a vehicle</td>
<td>49</td>
<td>45</td>
<td>NISSAN MOTOR CO LTD (NSMO); NILES PARTS CO LTD (NILE-Non-standard), JP</td>
<td>1986.3.28</td>
</tr>
<tr>
<td>10</td>
<td>US 5243528</td>
<td>Land vehicle navigation apparatus with visual display</td>
<td>48</td>
<td>45</td>
<td>MOTOROLA INC (MOTI), US</td>
<td>1990.9.12</td>
</tr>
</tbody>
</table>

**Figure 6. Citation Process Map of 5 Core Patents (Partly)**

Basing the core patents, great technological families have developed by the citations. The members could be grouped on their similar subjects. The aggregations and dependences of them are plain to see in the technological family tree map (Fig. 7). Each node represents one patent. Arrows represent the citation relationship pointing to the citing patents. Some main citing ones are showed in this illustration.
Figure 7. Technological Family Tree Map of US4796191 by Citation (Partly)

R&D Hotspots analysis
To find out the R&D hotspots, the average growth rates of IPC classes in recent 5 years were measured in this study. The top 5 are listed in Table 5, reflecting the hot technologies in this field recently.

Table 5. Average Growth Rates of IPC Classes in Vehicle Navigation Patents

<table>
<thead>
<tr>
<th>Rank</th>
<th>IPC Classes</th>
<th>Aver. Growth Rate</th>
<th>Class Titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G06T-011/60</td>
<td>520%</td>
<td>Two dimensional (2D) image generation by Editing figures and text or Combining figures or text</td>
</tr>
<tr>
<td>2</td>
<td>H04M-001/72</td>
<td>240%</td>
<td>Substation extension arrangements; Cordless telephones, i.e. devices for establishing wireless links to base stations without route selecting</td>
</tr>
<tr>
<td>3</td>
<td>G06T-003/00</td>
<td>220%</td>
<td>Geometric image transformation in the plane of the image, e.g. from bit-mapped to bit-mapped creating a different image</td>
</tr>
<tr>
<td>4</td>
<td>H04N-005/44</td>
<td>170%</td>
<td>Receiver circuitry of television systems</td>
</tr>
<tr>
<td>5</td>
<td>G06F-009/44</td>
<td>160%</td>
<td>Arrangements for executing specific programmes, using stored programme for programme control</td>
</tr>
</tbody>
</table>

G06T-011/60 ranks first by a growth rate of 520% per year while G06T-003/00 ranks third by 220%. Both are about image technology. It indicates that pictorial communication technology would be the hotspot in this field recently, wherein the patent activity should be further studied. Besides, major players' activities were focused to trace the new innovation directions in this study.

Claim points analysis
As the claims are the most important in patent specifications, claim points and their relationships of the key patents were examined. From the claim points map of US7126579-B2 (Fig. 8), the claims can be seen to categorize into 6 groups by their protected objects. The keywords and the relationships are illustrated.

Patent activities in China

1. Technology developmental stage estimating
In this section, the vehicle navigation technology developmental stage in China was estimated by employing 4 metric parameters of growth rate (V), maturity coefficient (α), aging coefficient (β) and innovation coefficient (N) (Du, 2005).
Table 6. Technology Developmental Stage Metric Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Formulae</th>
<th>Statistic Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>growth rate (V)</td>
<td>V=a/A</td>
<td>an increasing V in several successive years indicates an emergence or growth in a specific field</td>
</tr>
<tr>
<td>maturity coefficient (α)</td>
<td>α=a/(a+b)</td>
<td>a decreasing α in several successive years indicates a gradual maturity in a specific field</td>
</tr>
<tr>
<td>aging coefficient (β)</td>
<td>β=(a+b)/(a+b+c)</td>
<td>a decreasing β in several successive years indicates a gradual aging in a specific field</td>
</tr>
<tr>
<td>innovation coefficient (N)</td>
<td>N=sqrt(V²+α²)</td>
<td>The higher value of N indicates the more innovative in a specific field</td>
</tr>
</tbody>
</table>

Note: a: number of Invention applications (published) in a specific field in current year
b: number of Utility Model applications (published) in a specific field in current year
c: number of Industrial Design applications (published) in a specific field in current year
A: accumulation of Invention applications (published) in retrospective 5 years in a specific field

Figure 8. Claim Points Relationship Map of US7126579-B2
The measure results are illustrated in Fig. 9.
- The value of V increased from 2000 to 2001, followed by a decrease until 2003 when appeared another increase.
- The value of α kept rising except for a slight fluctuate in 2003, achieving a historic summit in 2004.
- Slight fluctuates appeared in the value of β.
- The value changes about N were similar to the V and α, keeping rising except 2003.

Above all, the vehicle navigation technology is still a new field in China, appearing a growing characteristic without any mature or aging evidence. It would continue to grow in both the short and long term. There would be more developing and marketing chances in the following years.

2. Applicants share analysis
Looking into the applicants of Chinese patents, the share of the foreign applications was around 85%. 4 Japanese corporations and 1 Korean corporation occupied the top 5 applicants, Mitsubishi Denki KK, Aisin Aw Co Ltd, Matsushita Denki Sangyo KK, Pioneer Electronic Corp., PLOE and Samsung Electronics Co Ltd. It seems that Chinese vehicle navigation technological market is dominated by the oversea companies.

To examine the original and independent innovation activities of domestic developers, the applicants were investigated (Fig. 10). The applications of mainland corporations seem to advance that of Taiwan and Hong Kong appreciably. The Universities and Academies' applications are few. A shortage of R&D in Chinese domestic developers appeared from this share. And the Industry, University and Academy should invest more in this field in future.

Figure 9. Value Changes of V, α, β, N over time

Figure 10. Share of Applications by Applicants in Chinese Patents
Conclusion and the Road Ahead
The PM and its applications were discussed in our research. A case study on Vehicle Navigation patent activities was conducted, with research results presented in suitable patent maps. Although outside the scope of our research project, it should be pointed out that this research could also form the starting point for further studies.

Existing PM, mostly relying on manual work or simple statistical tools, are limited in terms of explanatory capacity and operational efficiency since patent information encompasses numerous variables and the relationship between variables is so complex. Some improved patent analysis software should be developed to create maps that can satisfy human experts. Currently, there are some tools (Uchida, Mano & Yukawa, 2004) (Boyack, et al., 2000) (Tripple, 2003) (Eldridge, 2006) such as the DA provided by Thomson, the PM-Manager by WIPS, the PLAS by KIPO, the Patent-Lab by Delphion, and so on, making user approach to patent information easily and obtain optimized information. However, more sophisticated analysis and high-level descriptions should be incorporated into the automatic patent map generation as human-generated patent maps. A lot of research effort is required for the automatic generation system to be practically useful.

In addition, patent mapping is a true interdisciplinary skill requiring many skills, involving understanding the science, familiar to the bibliometric theory, being able to see business opportunities, a good understanding of patent law. Virtually it is difficult for one person to have all of these skills, so a "patent mapper team" appears important, which is the guarantee for the PM analysis results.

References