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Worldwide patent analysis and mapping of combine harvester innovation

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The patent literature contains a wealth of detailed information existing. Patent analysis contributes to marketing and business strategy. While excellent searching tools have existed for many years for identifying patents relating to specific topics, it is only recently that it has been feasible to map the complete archive of patent literature to identify important trends and competition pattern. In this project, the author experimented with several analysis and visualization techniques on combine harvester-related patent documents between 1991 and 2009, including issued and application patent. The data sets are from the Patent Cooperation Treaty and European Patent offices, plus a range of national patent collections including those of the U.S.A., Japan, the U.K., France, Germany, Switzerland and Russia. Through patent analysis, mapping and citing tree analysis, the results demonstrate potential of information-based discovery and visualization technologies to capture knowledge regarding combine harvester technology performance, leaders or rivals, hot patents or core technology, new application and new technology in the field.

Key words: Combine harvester, patent analysis, trends of development, patent map, patent distribution, competition pattern.

INTRODUCTION

The best integrated agricultural machines are combine harvesters (Čuljat et al., 1997). The combine was patented in 1835 in the USA, which marked the beginning of this machine type. The machine “combined” harvesting, threshing, and cleaning grain plants and all that at one go (Brkić et al., 2002). Combine harvesters have been developed through the years from narrowly specialized machines to today’s universal agricultural machines used for harvesting and picking some of the most important agricultural plants. The number of combines is nowadays decreasing, whereas their capacity is rising. The development of modern combine harvesters shows the tendency towards increasing the efficiency by improving the present constructions as well as by developing new ones. This refers to redesign of cutting, threshing and cleaning devices; the implementation of wide types in order to preserve the soil; making the combine an even more universal machine; and the application of electronics and telecommunication in control and steering management. The speed and scope

of development in the field have made it essential for researchers to be informed on the progress across different laboratories, companies, industries and countries.

Patents are a very useful source of technical information. 90% of human knowledge are published as patent archive and 70% spread only through patent literature, which records achievement description of worldwide latest invention. Patents are used as an ideas resource thus improving technological innovation in developing countries. Previous articles have described the importance of patents as a key source of technical and commercial intelligence (Dou et al., 2005; Huang et al., 2003). Patent analysis has much application and has been widely used (Breitzman et al., 2002). It serves as an economical approach to determine a focused marketing area, risk of new combine harvester technology development, and potential value of a technology by addressing the following questions: What are my resources of Intellectual Property (IP)? How can I best use my IP?

How does my innovation differ from that of my rivals? Who are my rivals? What are the potential markets? How crowded are these markets? Who are the innovators, leaders and laggards in these markets? Are there IP barriers to entry into this market? What is the likely direction of the market? What will it take to stay competitive in this market? Through regular use of patent analysis people will be able to bring themselves the field development, IP portfolio management, business strategy, and business development groups together, use an integrative approach to minimizing research and development spending through targeted research projects and/or partnerships. As a single group, they can collectively use patent analysis to better position the company for the future through innovation and innovative strategies (Norman, 2010). The use of patent mapping to visualize large sets of patent data and to identify trends contained within that data has also been demonstrated in some research (Seymour, 2008) and other field (Lee, 2009). The study of using patent mapping to visualize patent distribution, competition status and trends of development in combine harvester field based on large sets of patent data is very important.

Based on the method of patent mapping and citing analysis, this paper focused on the following perspective of combine harvester technology including worldwide patent embattle, trends of development, core technologies with great value ("hot" patents) and new technologies, organizations with leading technologies (leaders), inventors and their employers with leading technologies, which are just some of the groups that contribute to and influence decisions made related to intellectual property in the field. This paper is also to help people to streamline workflow processes, to improve decision making, to get useful business insight out of IP data, to extend collaboration throughout their organization and ultimately reduce the time and expense associated with IP creation and management in the field.

MATERIALS AND METHODS

The paper further develops these themes by examining the patent literature on combine harvester published between 1st January 1991 and 31st December 2009. Which patent collections are to be used to search for is the first question. Here the software package used at the Johnson Matthey Technology Centre is Aureka (a product available from Thomson Reuters, an advanced IP management and analysis platform, the world's leading source of intelligent information for businesses and professionals) which includes patent data sets from the Patent Cooperation Treaty (PCT) and European Patent offices, plus a range of national patent collections including those of the U.S.A., Japan, the U.K., France, Germany, Switzerland and Russia. They are usually called seven nations and two organizations (SNTO). These collections contain full-text patent documents, available either as PDF or HTML files. In the case of Japanese patents, a text version of the English Language title, abstract and other front page details is available, together with a PDF file of the full specification in Japanese. It must be borne in mind that using the French and German collections would require us to search in French or German respectively, and

of course the results obtained would also be in French or German.

After collection selection, the search strategy is next thought about. In this case, the initial objective is to create a large set of patents relating to combine harvester technology, which will later be analyzed and refined. In the patent literature it is unlikely that the names of combine harvester would be used in other contexts. Moreover, how to overcome the problems of different expression brought by different languages such as Japanese, German and English is a vital problem in retrieval. To improve the recall and precision of retrieval for patent information, we select International Patent Classification (IPC) as retrieval strategy. The analysis was based on selected IPC codes, rather than keywords in title, abstract, claims or description as search strategy. The IPC code for combine harvester is A01D41/00 (Int. Cl.8). In addition, the detailed patent analysis methods used in this paper are statistical methods of analysis, patent mapping, text clustering, combined qualitative and quantitative analysis.

RESULTS AND DISCUSSION

The search results have then been "deduplicated" to exclude patent family members filed in different geographical regions, to leave one patent per invention.

The results list and initial analysis

All patents published by the SNTO between 1st January 1991 and 31st December 2009 were focused on. There are 2531 different innovations after been debugged in the field of combine harvester. The retrieval and analyses were carried out to show changing trends in the patent literature, leaders, hot patents, new technologies, top 10 patent assignees, inventors and their employers with leading technologies (Tables 1 to 5).

Table 1 demonstrates combine harvester technology patent application trends in the past ten years. The number of innovations decreased slightly from 2001 to 2005 year and from then on increased annually to 2009 year. Generally speaking, the development of combine harvester technology is in a state of stability.

Table 2 shows top 9 patent assignees or rivals in combine harvester technology field. Iseki Agricult Mach is ahead with near 500 patents, followed by Kubota KK with 419 innovations. Yanmar Agricult Equip is in third place with 310 patents while Deere and Co ranks fourth with 211 innovations. Other leaders in the field are Mitsubishi Agricult Mach, Claas Selbstfahr Erntemasch, Seirei Ind, Yanmar co Ltd and CLAAS OHG.

Table 3 illustrates top 10 inventors in combine harvester field. Satoji Hisayuki has more than 50 percent innovations and is way ahead of Hayashi Shigeki which is in the second place. Kawase Muneyuki is in the third place, with less 9 innovations than Hayashi Shigeki. In addition, other leading inventors in the field are Nakagawa Wataru, Naka Tamaki, Kirihata Toshinori, Hidaka Shigemi, Ohara Kazushi, Yoshimura Fumio, and Mizukura Taiji.

Hot patents are generally older patents that have a large number of citations by patents that expand a variety

Table 1. Search results in SNT0 patent collections, published between 1st January 1991 and 31st December 2009 results, count by publication year.

Year published	Doc count	Percentage (%)
2009	210	7.7
2008	212	7.8
2007	202	7.4
2006	170	6.3
2005	129	4.8
2004	145	5.3
2003	133	4.9
2002	159	5.9
2001	163	6.05

Table 2. Top assignees for the set of search results in SNT0 patent collections, published between 1st January 1991 and 31st December 2009 results.

Rank	Assignee	Doc count	Percentage (%)
1	Iseki Agricult Mach	487	16.9
2	Kubota KK	419	14.5
3	Yanmar Agricult Equip	310	10.8
4	Deere and Company	211	7.3
5	Mitsubishi Agricult Mach	184	6.4
6	CLAAS Selbstfahr Erntemasch	152	5.3
7	Seirei Ind	107	3.7
8	Yanmar Co Ltd	103	3.6
9	CLAAS Ohg	66	2.3

Table 3. Top inventors for the set of search results in SNT0 patent collections, published between 1st January 1991 and 31st December 2009 results.

Rank	Inventor	Doc count	Percentage (%)
1	Satoji Hisayuki	110	1.7
2	Hayashi Shigeki	71	1.1
3	Kawase Muneyuki	62	0.9
4	Nakagawa Wataru	53	0.8
5	Naka Tamaki	49	0.7
6	Kirihata Toshinori	47	0.7
7	Hidaka Shigemi	45	0.7
8	Ohara Kazushi	43	0.7
9	Yoshimura Fumio	43	0.7
10	Mizukura Taiji	41	0.6

of technologies. They tend to be patents that lead to industry standards, disruptive technologies, and/or made a substantial impact across various industries. Table 4 shows that top 10 hot patents in the field are U.S. patent US5282389 of Dawn Equipment Company, Schroeder Michael J.,s U.S. patent US5092819, Myers Allen"s U.S. patent US5343761, CLAAS KGaA"s patents US5712782 and EP843959, Case Corporation"s patents US5318475, US5455769 and US5560246 of CLAAS Ohg Beschrant

Haftende Offene Handelsgesellschaft, US5488817 of Ford New Holland, Inc. Table 5 shows top 10 new technologies in the field. The new technologies and their holders and inventors are the U.S. patent 6418805 titled "Constituent sensing system" of Textron Systems Corporation, which was invented by Arney, Kevin J. and Brown, John S.; the U.S. patent 6966506 titled "Method and apparatus for harvesting crop" of McLeod Harvest Inc., which was invented by McLeod, Robert H. and

Table 4. Search results by top ten forward citation frequency for most cited documents for patents in SNTO patent collections, published between 1st January 1991 and 31st December 2009 results.

Rank	Document ID	Assignee	Cited by	Percentage (%)
1	US5282389	Dawn Equipment Company	55	1.7
2	US5092819	Schroeder Michael J	46	1.4
3	US5343761	Myers Allen	41	1.2
4	US5712782	CLAAS KGaA	37	1.1
5	US5318475	Case Corporation	36	1.1
6	US5560246	CLAAS Ohg Beschränkt Haftende Offene Handelsgesellschaft	35	1.1
7	US5455769	Case Corporation	34	1.0
8	US5488817	Ford New Holland, INC.	34	1.0
9	US5797793	Case Corporation	33	1.0
10	EP843959	CLAAS KGaA	32	1.0

Table 5. Search Results by Top Ten Top Backward Citation Frequencies for Patents in the U.S. Patent Collection, Published between 1st January 1991 and 31st December 2009.

Rank	Document ID	Assignee	Cites	Percentage (%)
1	US6418805	Textron Systems Corporation	83	1.0
2	US6966506	Mcleod harvest Inc.	49	0.6
3	US7593798	Deere and Company	46	0.5
4	US5394678	The Toro Company	45	0.5
5	US730809	CLAAS Selbstfahrende Erntemaschinen GmbH	43	0.5
6	US7073314	Deere and Company	41	0.5
7	US6582298	Case Corporation	40	0.5
8	US6435966	CLAAS Selbstfahrende Erntemaschinen GmbH	38	0.4
9	US7401455	Cnh Americallc	38	0.4
10	US6073427	Nichols; Stephen W.	37	0.4

Oswald, Wilfried; the U.S. patent 7593798 titled "Vehicular guidance system having compensation for variations in ground elevation" of deere and company which was invented by Han, Shufeng. Additionally, other new technologies in the field are US7073314 of Deere And Company, US730809 and US6435966 of CLAAS Selbstfahrende Erntemaschinen GMBH, US5394678 of the Toro Compan, US6582298 of Case Corporation, US7401455 of Cnh Americallc, and US6073427 of Nichols and Stephen W.

Patent mapping

The Aureka ThemeScape™ tool was used to create a

visualization of the document list described above. The results are shown in Figures 1 to 2. The resulting map looks like a mountainous island surrounded by sea. The visualization is helpful because ThemeScape groups together similar documents and labels these groups according to frequently used key terms found within those groups. The more documents contained within each group, the higher the „mountain“ appears. The automatic labeling sometimes produces meaningful headings, but sometimes these are less obviously meaningful. Where necessary these can be edited following an inspection of documents contained within the groups. The dots with different color represent patent documents published in different years or periods. Clicking on specific dots will display the original document. The contour lines



Figure 1. Patent map with decadal time slices covering granted patents or patent applications in SNT0 published between 1st January 1991 and 31st December, 2009.

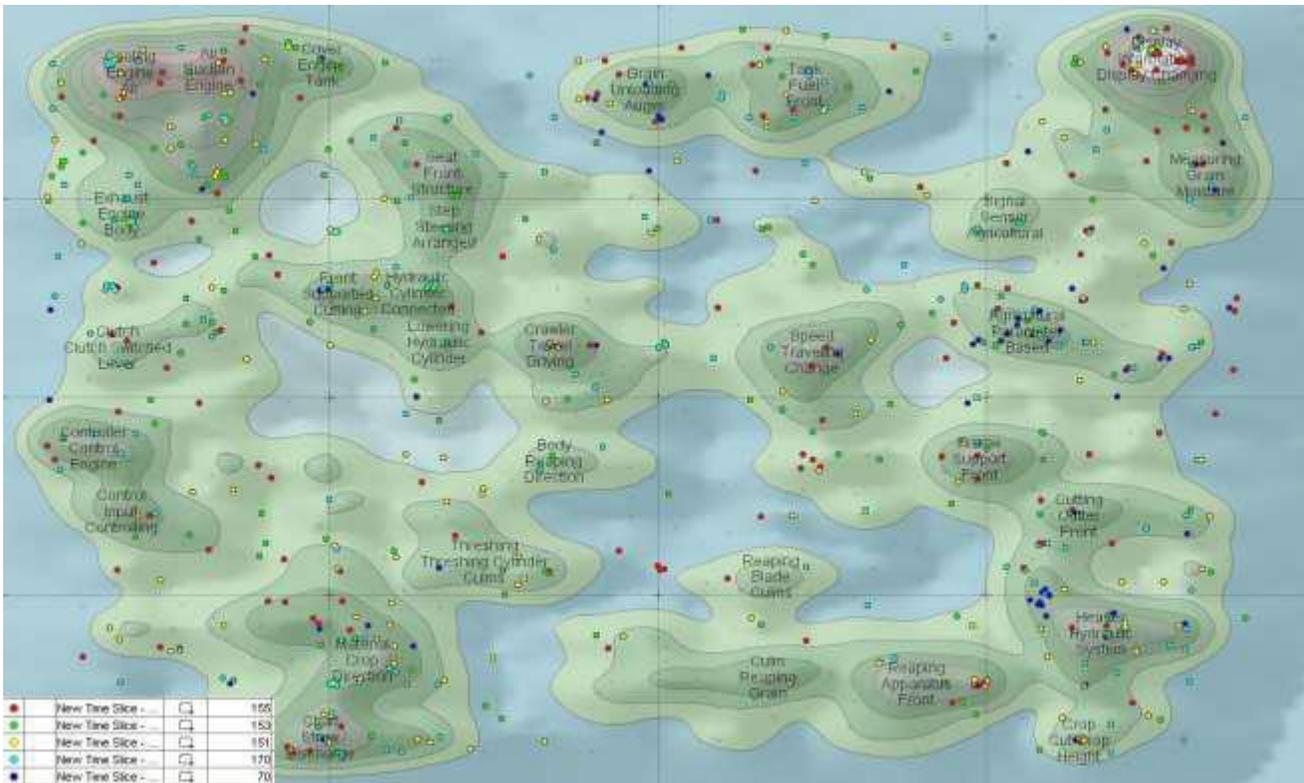


Figure 2. Patent map with annual time slices covering granted patents or patent applications in SNT0 published between 1st January 2006 and 31st December, 2009.



Figure 3. Clustering topics of Combine harvester innovations covering granted patents or patent applications in SNTD published between 1st January 2005 and 31st December, 2009.

enclosing particular areas can be used to select groups of documents for inspection or further analysis.

From Figure 1, the map shows that the worldwide patents situation in combine harvester field mainly concentrated in topics of “Display information control”, “Grain culm reaps”, “Detecting sensor”, “Control information”, “Measuring sensor”, “Front cutter”, “Crop processing apparatus” and so on. The improvement in combine harvester was steadily in the last two decade and technologies are in autumn.

In Figure 2, we have further processed the basic map shown in Figure 1 to create an annual time slice covering documents published only in the period January 2005 to December 2009 with different color dots for different year as shown in the picture. The results of this exercise show that changing trends in recent years is not obvious.

Moreover, we gave a quantitative analysis by topic clustering. Figure 3 quantificationally shows the innovations on different topics of combine harvester patents between 2005 and 2009 years.

Patent citation analysis

An additional use of patent citation analysis is to create categories of „hots” and „next generation” patents. The “next generation” of patents cites two or more of these „hot” patents. The “next generation” patents should represent patents that are improving and innovating upon an industry standard, suggesting that market adoption

should be quicker with these technologies as opposed to the actual disruptive technology. Secondly, this analysis provides insight into potential market direction and who the innovators are for a particular technology group. Figure 4 is citation tree of core patent US5282389 from Dawn Equipment Company, which was cited by most innovation. The different colors represent different IPC technology field. The figure shows that the technology was mainly cited by Case Corporation and other companies and show that the technology was mostly applied not only in itself field but also in other fields covering Electric Digital Data Processing (IPC code is G06F), measuring volume, volume flow, mass flow, or liquid level; metering by volume (IPC code is G01F), soil working in agriculture or forestry; parts, details, OR accessories of agricultural machines or implements, in general (IPC code is A01B), measuring distances, levels, or bearings, surveying, navigation, gyroscopic instruments, photogrammetry (IPC code is G01C) and so on.

Conclusions

After worldwide patent analysis and mapping in the field of combine harvester during the last twenty years, the conclusions are made as follows:

The combine harvester technology is now in autumn. Top leaders or rivals in the field are Iseki Agricult Mach, Kubota KK, Yanmar Agricult Equip and Deere and Co,

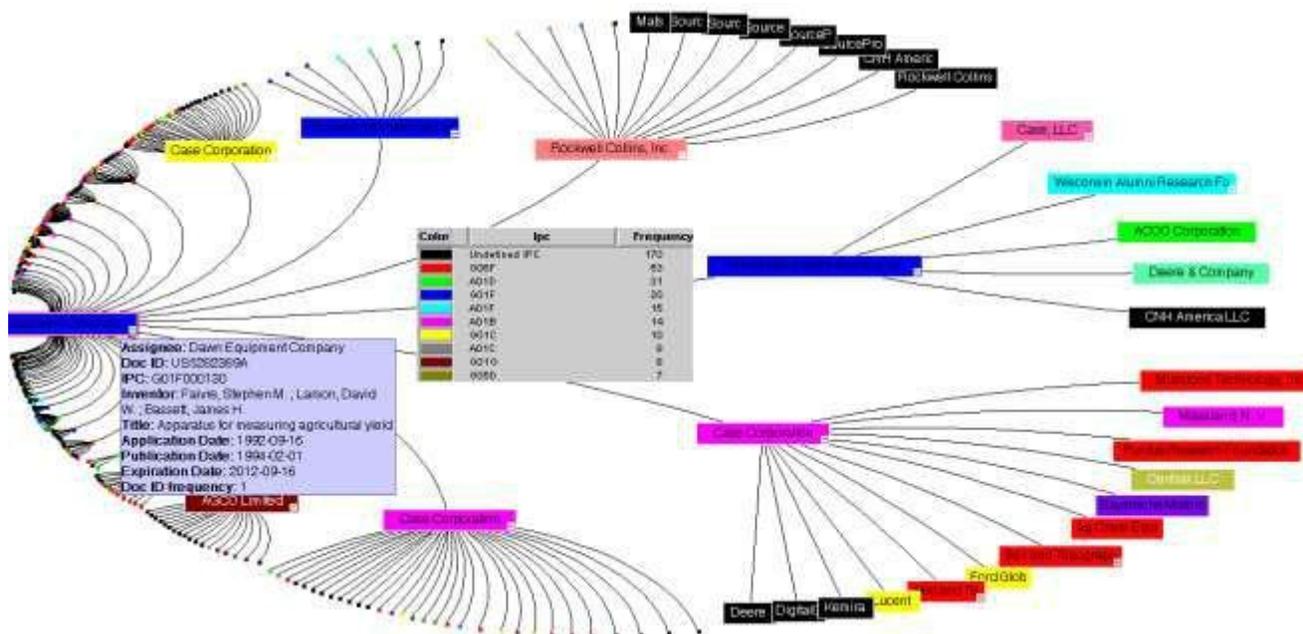


Figure 4. Citing tree of U.S. patent 5282389.

Mitsubishi Agricult Mach, CLAAS Selbstfahr Erntemasch, Seirei Ind, Yanmar Co Ltd and CLAAS Ohg. The hot patents are US5282389, US5092819, US5343761, US5712782, EP843959, US5318475, US5455769, US5560246, and US5488817. Brainpower consists of Satoji Hisayuki, Hayashi Shigeki, and Kawase Muneyuki and so on. Besides itself, the new application fields cover IPC codes including G06F, G01F, A01B and G01C. The top new patent technologies are these titled “Constituent sensing system”, “Method and apparatus for harvesting crop”, “Vehicular guidance system having compensation for variations in ground elevation” and so on.

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