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Corporate Decision Making with Self-Organizing Patent Maps Labeled by Technical Terms and AHP

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Abstract
In this paper, we propose an approach for corporate decision making with self-organizing patent maps labeled by technical terms and AHP. First, we select the patent area of interest and collect pertinent patent documents in text format. Second, we extract keywords by text mining to transform patent documents into feature vectors of the companies. Third, we input the feature matrix of technical terms and company names into self-organizing maps to create patent maps labeled by the technical terms. Then, we consider several corporate strategies utilizing the patent maps and make a decision with AHP. We apply our approach to two patent areas (information home appliance and 3D image) to show examples of corporate decision making.

Keywords
Decision Making, Corporate Strategy, Patent Maps, Self-Organizing Maps, Text Mining, and AHP.

1. Introduction
When a company starts research and development or licensing for entering into a new business in a certain technology field, the company needs to recognize the overall scope of that and other related technology fields, including pertinent patents. A patent map is the visualized expression of total patent analysis results for understanding complex patent information easily and effectively. The patent map is produced by gathering, processing, and analyzing pertinent patent information of the targeted technology field. Creating and updating such a map requires substantial human effort. Because automatic tools for assisting patent analysis are in demand, patent documents are typically analyzed by *text mining*, which is a technique for finding hidden and useful patterns in a text database (e.g., (Yoon et al. 2002), (Jun, 2011)). In addition, numerous works show that *self-organizing maps* (SOMs) (Kohonen, 1995) are effective in classifying a collection of text documents and building two-dimensional maps (e.g., (Yoon et al.

2002), (Jun, 2011), (Kohonen et al. 2000)). The SOM algorithm provides a topology-preserving mapping from high-dimensional space into map units. Although hierarchical or non-hierarchical clustering methods can be used, the utility is limited due to the lack of visual capability.
In this paper, we propose an approach for decision making of corporate strategy that uses self-organizing patent maps labeled by technical terms and the *analytic hierarchy process* (AHP) (Saaty, 1980). First, we select the patent area of interest and collect pertinent patent documents in text format. Second, we extract keywords by text mining to transform patent documents into feature vectors of the companies. Third, we input the feature matrix, in which technical terms are rows and company names are columns, into the SOM and create patent maps labeled by the technical terms. Then, we consider several corporate strategies utilizing the patent maps and make a decision with AHP. We apply our approach to two patent areas as examples of corporate decision making.

2. Creating self-organizing patent maps and considering corporate strategies

Here, we propose a way of creating self-organizing patent maps labeled by technical terms. The steps are as follows.

Step 1: Select the patent area of interest and collect pertinent patent documents in text format. We collect patent documents (in Japanese) containing a summary of the problem and the solution by using the Industrial Property Digital Library (IPDL) provided by Japan's National Center for Industrial Property Information and Training.

Step 2: Extract technical terms by word frequency analysis. We extract nouns whose frequency is five or more and whose number of letters is three or more. We ignore words which are vague, such as "computer," "data," or "system."

Step 3: Extract technical terms by dependence relation analysis. Here, we extract nouns according to four cues of Japanese words: *hon-hatumei* (this invention), *teikyou* (offer), *kadai* (problem) and *mokuteki* (purpose) (Sakai et al. 2009).

Step 4: Create feature vectors of companies by using the terms extracted in **Steps 2** and **3**.

Step 5: Input the feature matrix, in which technical terms are rows and company names are columns, into the SOM and create patent maps labeled by the technical terms.

2.1 Patents on "information home appliances"

We collected 190 patent documents from IPDL using the keyword "information home appliance." The number of applicants was 83 from the time period 1994 to 2009. We extracted 32 words by using the word frequency and dependence relation analysis. We considered similar words as one word to reduce the number of words because a large number of words cannot be used to cluster patents using SOM. Table 1 shows part of the feature matrix. For example, in this table, the number of "Security" terms in all patents of Company 5 is two.
Figure 1 (a) shows clusters of technical terms for "information home appliance." Figures 1 (b), (c), (d) and (e) show patent maps of Companies A, B, C and D, respectively, in which a color scale shows the number of terms. The color similarity of Companies A and B in Figures 1 (b) and (c) indicate the companies are highly competitive. They are leading companies in this field. The red node for the technical term "User" indicates the frequency of occurrence of "User" is high in the patents applied for by Companies A and B. The green and light blue nodes for technical terms "In-the-home," "TV," and "Efficient" in Companies A and Company B indicate

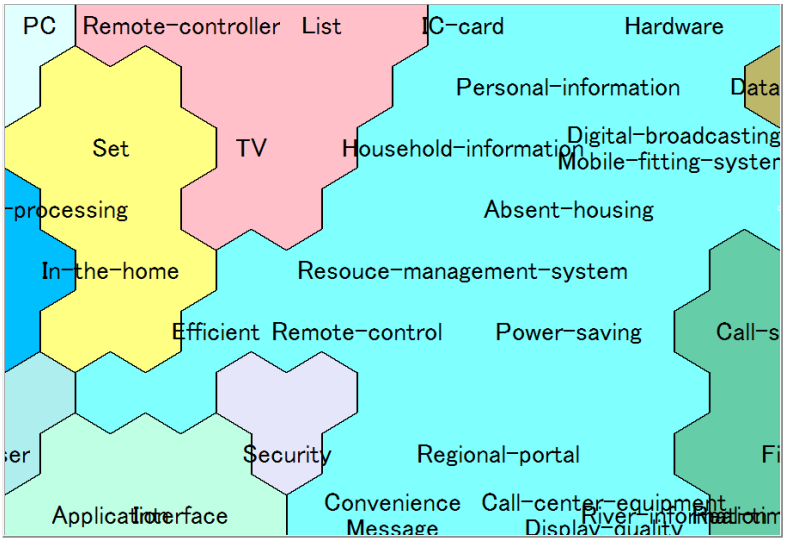
the frequency of occurrence of these terms is comparatively high. Dark blue means that corresponding terms are not present. Therefore, Companies A and B have developed technologies for users who can use information home appliances efficiently in the home.

	Company 1	Company 2	Company 3	Company 4	Company 5
Security	0	0	0	1	2
Remote controller	1	1	0	0	0
In-the-home	1	0	1	1	0
TV	1	0	0	1	0
User	2	0	1	6	0
Power saving	0	0	0	1	0

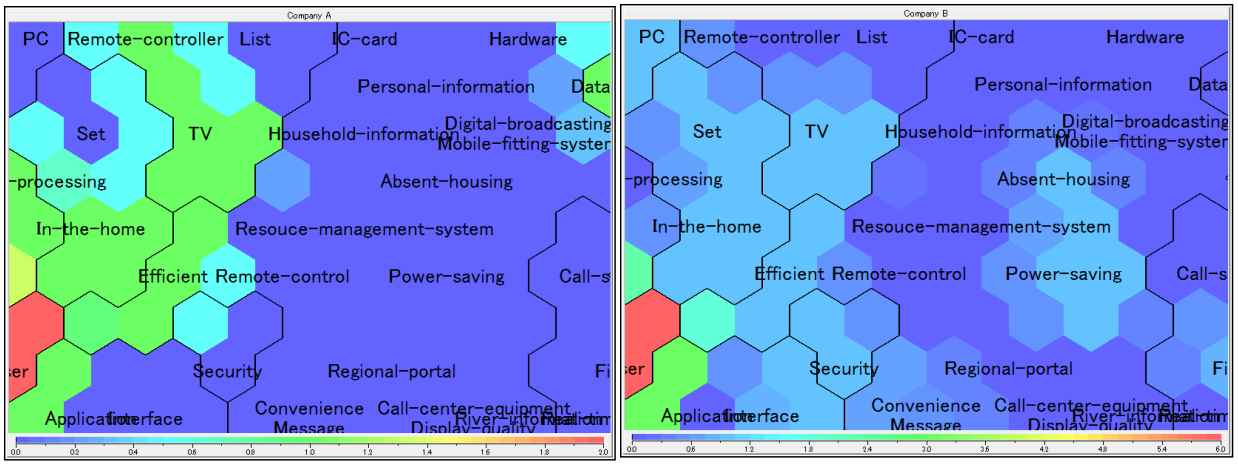
Table 1: Part of the feature matrix for "information home appliance"

In Figures 1 (d) and (e), the colors of the patent maps of Companies C and D are also similar. The red node corresponding to the technical term "Security" means that the frequency of occurrence of "Security" in the patents applied for by Companies C and D is high. Consequently, the figures show that Companies C and D have developed security technologies. By observing Figures 1 (b), (c), (d) and (e), we consider the following corporate strategies of Company A required to overcome its competitor, Company B.

Strategy A1: Company A makes plans for business expansion using database technology (the green node in the upper right part of Figure 1 (b)), patents for which Company B has not yet applied.
Strategy A2: Company A promotes R&D of security technology or enters into licensing agreements with Company C or D, both of whom have already applied for a security patent.
Strategy A3: Company A emphasizes R&D of digital broadcasting technology, patents for which neither Company A nor Company B has yet applied.



(a) Clusters of technical terms for "information home appliance"



(b) Company A (c) Company B

(d) Company C (e) Company D

Figure 1: Self-organizing patent maps labeled by tech. terms for "information home appliance"

2.2 Patents on "3D image"

We collected 668 patent documents from IPDL using the word "3D image." The number of applicants was 228 for the time period 2001 to 2010. Using the word frequency and dependence relation analysis, we extracted 49 words.

Figure 2 (a) shows clusters of technical terms for "3D image." Figures 2 (b), (c), (d) and (e) show patent maps of Companies E, F, G and H, respectively. In Figures 2 (b) and (c), the similar colors of the patent maps of Companies E and F indicate they are highly competitive. They are leading companies in this field. The red node for "For-right/left-eye" indicates the high frequency of occurrence of this term in the patents applied for by Companies E and F. The green and light blue nodes for the technical terms "3D-display," "Image-information," "Camera" and "Depth" in Companies E and F indicate their comparatively high frequency of occurrence.

In Figures 2 (d) and (e), the colors of the patent maps of Companies G and H are similar. The red node for the technical term "Display" indicates a high frequency of occurrence of this term in the patents applied for by Companies G and H. The orange, yellow, green, and light blue nodes for the technical terms "Image-information," "3D-display," "High-resolution," "Camera" and

"Lens" in Companies G and H indicate a comparatively high frequency of occurrence of these terms. By observing Figures 2 (b), (c), (d), (e), we consider the following corporate strategies of Company E required to overcome its competitor, Company F.

Strategy E1: Company E makes plans for business expansion by using low-cost technology (the light blue node in the middle part of Figure 2 (b) corresponds to low cost), patents for which Company F has not yet applied.

Strategy E2: Company E promotes R&D of high-resolution technology or enters into licensing agreements with Company G or H, both of whom have already applied for high-resolution patents.

Strategy E3: Company E emphasizes R&D of optical disk technology (the dark blue node in the upper right part of Figure 2 (b) corresponds to optical disk), patents for which neither Company E nor Company F has yet applied.

3. Corporate decision making with AHP

AHP has been widely used for economic, political, social and corporate decision making (e.g., (Saaty & Vargas 1994), (Saaty, 2001)). An example of the AHP model created for the task of corporate decision making by Company A is as follows:

First level (task): Decision making on the corporate strategy by Company A.
Second level (criteria): R&D funds, human resources, required time, income.
Third level (alternatives): Strategy A1, Strategy A2, Strategy A3.

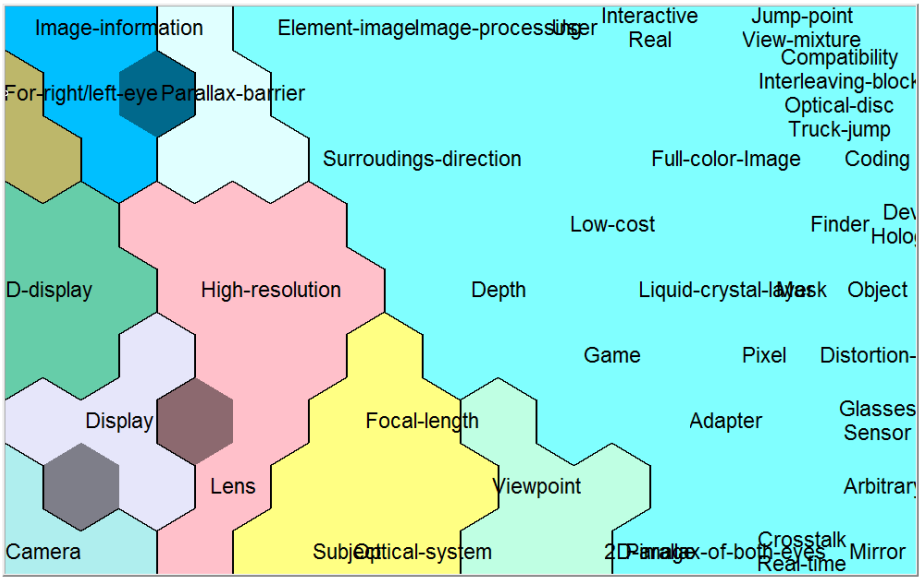
We assumed the pair comparison matrix for Company A. The weight vectors are as follows:

(1) Criteria: required time (0.565), income (0.262), human resources (0.117), R&D funds (0.055).
(2) Required time: A1 (0.637), A2 (0.258), A3 (0.105).
(3) Income: A1 (0.258), A2 (0.637), A3 (0.105).
(4) Human resources: A1 (0.637), A2 (0.105), A3 (0.258).
(5) R&D funds: A1 (0.637), A2 (0.258), A3 (0.105).

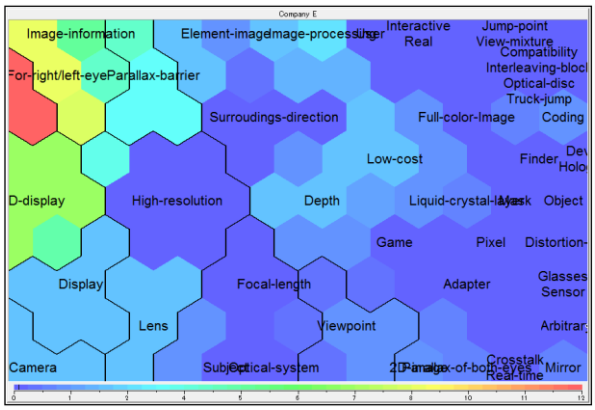
The AHP result shows that A1 is the most important: A1 (0.537), A2 (0.339), A3 (0.123).

4. Conclusion

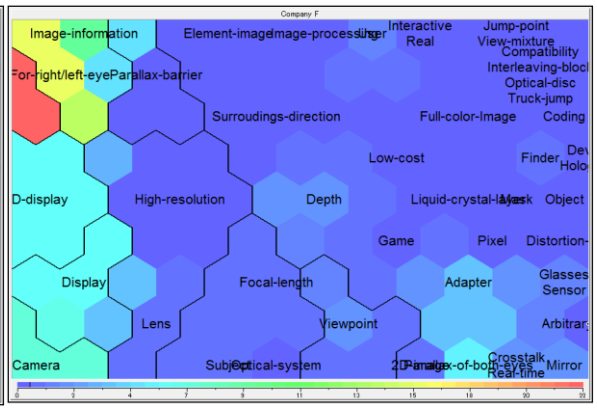
In this study, we proposed an approach for decision making on corporate strategy with self-organizing patent maps labeled by technical terms, followed by AHP. In our proposed process, we first select the patent area of interest and collect pertinent patent documents in text format. Next, we extract technical terms according to the word frequency and dependence relation analysis. Third, we create feature vectors of companies and input them into SOM to create patent maps labeled by the technical terms. Then, we consider several corporate strategies by utilizing the patent maps and make decisions with AHP. We applied our approach to two patent areas and showed examples of corporate decision making. We are sorry that we don't explain details because of limited words and figures/tables for research-in-progress submissions. In our future work, we will apply our proposed approach to other patent areas and documents.



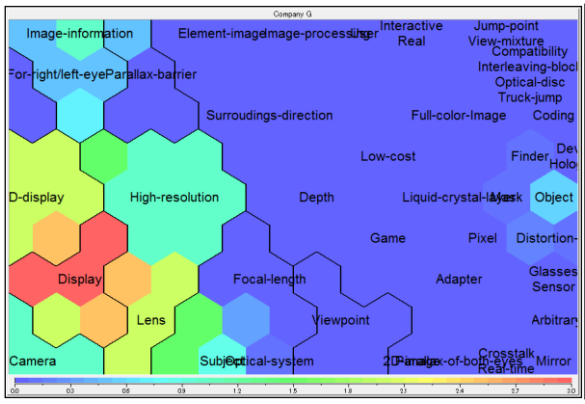
(a) Clusters of technical terms for "3D image"



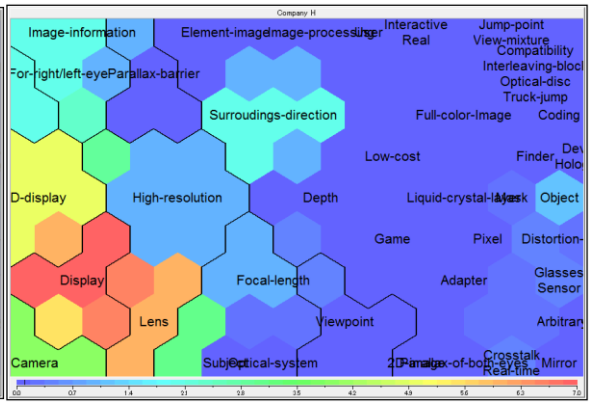
(b) Company E



(c) Company F



(d) Company G



(e) Company H

Figure 2: Self-organizing patent maps labeled by technical terms for "3D image"

References

Jun, S. (2011) "Technology marketing using PCA, SOM, and STP strategy modeling", *IJCSI International Journal of Computer Science Issues*, (8)1, pp.87-92

Kohonen, T. (1995) *Self-Organizing Maps*, New York: Springer

Kohonen, T., S. Kaski, K. Lagus, J. Salojrvi, J. Honkela, V. Paatero and A. Saarela (2000) "Self-organization of a massive document collection", *IEEE Transactions on Neural Networks*, (11)3, pp.574-585.

Saaty, T. (1980) *The Analytic Hierarchy Process*, New York: McGraw-Hill

Saaty, T. and L. G. Vargas (1994) *Decision Making in Economic, Political, Social and Technological Environments with the Analytic Hierarchy Process*, Pittsburgh: RWS Publications

Saaty, T. (2001) *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*, Pittsburgh: RWS Publications

Sakai, H., H. Nonaka and S. Masuyama (2009) "Extraction of information on the purpose and the technical effect from a patent document", *The 23rd Annual Conference of the Japanese Society for Artificial Intelligence*. (in Japanese)

Yoon, B., C. Yoon and Y. Park (2002) "On the development and application of a self-organizing feature map-based patent map", *R&D Management*, (32)4, pp.291-300