

A Study on Forecasting System of Patent Registration Based on Bayesian Network

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Received August 30, 2012; revised October 5, 2012; accepted October 13, 2012

ABSTRACT

Recently the importance of intellectual property has been increased. There has been various ways of research on analysis of companies, forecast of technology and so on through patents and many investments of money and time. Unlike traditional method of patent analysis such as company analysis, forecasting technologies, this research is to suggest the ways to forecast registration and rejection of patents which help minimize the efforts to register patents. To do so, information such as inventors, applicants, application date, and IPC codes were extracted to be used as input variables for analyzing Bayesian network. Especially, among various forms of Bayesian network, we used Tree Augmented NBN (TAN) to forecast registration and rejection of patent. This is because, TAN was assumed to have dependence between variables. As a result of this Bayesian network, it was shown that there are nearly more than 80% of accuracy to forecast registration and rejection of patents. Therefore, we expect the minimization of time and cost of registration by forecasting registration and rejection of R&D patent through this research.

Keywords: Bayesian Network; Patent Registration; Tree Augmented NBN; Forecast

1. Introduction

In general, display technology is technology that shows various information on screen. From screen of mobile phone that we encounter everyday life, the field of application of display technology is applied to TV and PC monitors as well as the automotive industry, military, and medical care and spacecraft for battle. The market of Liquid Crystal Display (LCD) tends to grow with the development of relevant technology according to increasing demand of the LCD. In the 1990s, the market was dominated by the PDP and LCD screen for large equipment. In 2000s, however, as the market expanded to small devices, the market of LCD screen had declined and the LED industry tended to be in the limelight. Like the case above, advanced technique often replace the existing technology in the marketplace. Therefore, it is required to continuously research related technology [1]. There have been many researches on new technologies to dominate the market by introducing new products. Such keen competitions within the country and internationally has led to active development in display industry. The most typical and rapidly emerging next-generation display technology is Organic Light Emitting Diode (OLED).

OLED has faster response speed than that of LCD. Also, it has excellent viewing angle and contrast ratio as it is a self-luminous type. OLED materials market is expected to enter a phase of full-scale growth in the second half of 2012. Diffusion of smart phones equipped with OLED is expected to drive demand for OLED. Not only by strong sales of Samsung smart phones, but also because OLED are diffused to other brands, the penetration rate of OLED into smart phone is expected to rise to 30% in 2014 from 20% in present [2].

With this trend, each country or company has put a lot of efforts to obtain intellectual property rights before its rivals to dominate the market. As a part of preoccupation of intellectual property rights in the field of R&D, a number of research institutions are registered their results as patent. With an increase in the importance of the patent, the number of patents filed in the country is increasing year by year [3]. However, according to the Patent Office, despite the large number of patent applications, patent registration rate is 50% or less [4]. It generates a problem that a lot of human resources, capital, time and efforts put into register a patent could be wasted. Thus, most researchers usually survey patent information on patent DB in advance before they apply for a patent. At this time, the investigation of patent information is

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mainly done by patent agencies or corporate patent departments. Research should be based on expert and subjective judgment. This method has a fatal defect if it lacks of objectivity in evaluating the quality of the patent. In this paper, we present a patent registration prediction method that used by patent information to avoid subjective judgments.

2. Advanced Research

2.1. Related Literature

Until recently, studies on the patent have been used primarily by mining the text of the specification and bibliographic to analyze vacant technology. The data that was used on this paper is application number, filing date, publication number, publication date, IPC code and extracted keywords using the text mining. Tseng *et al.* conducted a study to create a patent map using text mining techniques to analyze the relationship between each technology [5]. Subject to US 14 patents in the field of biotechnology, using a simple regression analysis, Lin, Chen and Wu revealed that the nationality of the patent applicant, geographic location and the number of claims are a statistically significant correlation with the number of citations while there is a positive or negative correlation between examination period and the number of citations partially [6]. Jun, Park and Jang used the patent data with method of support vector machine and patent matrix to predict the vacant technology in the field of Management of Technology [7].

Previous studies have mainly done about bibliographic item and analyzing of correlation and progress of technology by using text mining. Recently, researchers suggested forecasting of registration and rejection of patent using text mining. Jung, Park and Jang investigated the existence patent registration in the field of Bluetooth, solar and hard disk by using the registration refusal similarity [8]. Our research is different from the previous studies. We gathered OLED patent data from KIPRIS and used as the raw data that contains novelty, rights, scope of technology, collaboration of research development, subdivision of technology, technology innovation activity and technology importance.

2.2. Intellectual Property

Intellectual property right can be divided into three rights. Industrial property right includes patent, utility model, model design and trademark. Copyrights include creation of culture and art such as music, art image and literature. There is advanced intellectual property right that is begun to be recognized as intellectual property right lately according to the changes and rapid developments in the social environment. It has economic value as well. It is

not an exaggeration to say that patent right occupies one of the most important part of intellectual property rights. Not all the inventions are registered of patents. To be registered of a patent, it must meet several criteria. The criteria of patent are divided to subjective requirements, objective requirements and procedural requirements [9]. Subjective requirements are required to applicants. It means that inventor must not imitate other inventions and the inventor must have a right to apply for registering of a patent by the law. To satisfy the objective requirements, invention should be highly creative technical idea with the law of nature. Also, it must have industrial applicability, novelty and progressivity. In order to register of a patent, applicants must apply for patent in accordance with procedure that is required by the patent law as well as the substantive requirements. In Republic of Korea, it takes 10 to 16 months for registering of a patent by these patent examination procedures. Furthermore, applicant needs more finances that are required to pay patent office, agent commission, registration fee and examination fee. Therefore, companies and the government in the keen global competition need patent forecasting systems for minimization of time and cost of patent registration.

2.3. Bayesian Network

Data mining is a process of discovering meaningful information in large data repositories [10]. A Bayesian network is one of the Data mining methods and a graphical model that encodes probabilistic relationships among variables of interests [11]. Therefore, Bayesian network is defined as Conditional Probability Table (CPT) and Directed Acyclic Graph (DAG) that can be used to represent causal relationships among a set of random variables. In this regard each node represents variable and DAG connected to nodes means relationship between variables.

Figure 1 shows the network between random variables. In this diagram, the node labeled A has three children, labeled B, C and D, and the node labeled B, C and D has one parent, labeled A. Generally, Bayesian network is a model that represents the probability distribution of a set of random variables in combination with dependent variables as Bayes' theorem can be used to calculate the

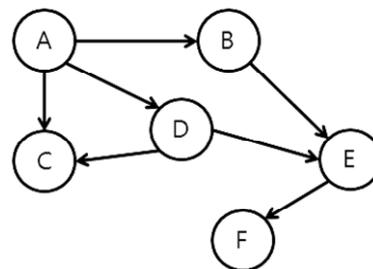


Figure 1. An example of resulting network.

posterior probability [12]. Consequently, Bayesian network can be formulated as in Equation (1) by conditional probability and Bayes' theorem.

$$P(X|Y) = \frac{P(X|Y)P(Y)}{P(X)} \tag{1}$$

Bayes' rule computes a conditional probability, based on the probability that the hypothesis holds given the observed data sample Y to judge the relative truth of the hypothesis X and the prior probability $P(Y)$ of the hypothesis X .

There are several types of Bayesian network such as Naïve BN (NBN), General BN (GBN), Tree Augmented NBN (TAN) etc. Among them, NBN is the most concise and assumes that every attribute is independent from the rest of the attributes, given the state of the class variable. However, NBNs' dependencies among these cannot be modeled in reality. Freidman *et al.* proposed the Tree Augmented NBN (TAN) in order to overcome the strong independence assumptions imposed by the NBN. The TAN is an extension of NB which allows additional edges between the attributes of the network in order to capture correlations among them [13].

3. Data and Variables Definition

This thesis is an analysis of Korea patent data of both registered and rejected patents on OLED technology between 2000 and 2011. There had been 348 cases of registered patents and 90 of rejected patents on OLED technology. Total of 438 documents had been experimented. For classification analysis, 1 was given to Registered patents and 0 was given to the rejected ones. In that, it was expected to select input variables for analyzing technology information and patent rights given by the gathered data as shown in **Table 1**.

- Novelty

Patent is a monopoly obtained by introducing new invention. The invention should be something innovative. This characteristic helps to prevent duplicated research or investment for companies, individuals or the government. Application date in patent technology document shows the period of invention and enables to find out patents' new. On this thesis, application date was converted to number 0 - 1 as application date index by the Method (2) below [8].

$$ADI = \frac{\text{Application date} - \text{Min}(\text{Application date})}{\text{Max}(\text{Application date}) - \text{Min}(\text{Application date})} \tag{2}$$

- Rights Scope of Technology

Claims on patent document are content of invention that was written thoroughly in order to protect patent rights. The number of request index enables the number

of inventions of companies or the government in fixed quantity. Also, it can be used to measure the patent's range of invention and extent of rights. This can be considered to an index which measure the result of innovation of companies or the government and this possibility is based on logical reasoning that claims provide the right information on activities of innovative technology rather than the number of patents as substantial patented inventions has been written on the claims [14].

- Collaboration of Research Development

The patent is not only submitted from the applicator but also it is submitted by a group of people. This suggests that by the number of collaborated application, it can be an index showing collaboration with other companies or independent development. By patent information, using number of patent with co-applications, with co-inventors is the most basic way to understand the relationship of collaboration to research development [14]. On this thesis, the number of applicators or inventors was regarded as information for collaboration of research development and analyzed.

- Subdivision of Technology

IPC (International Patent Classification) is used worldwide and is a treaty to search and classify patent documents and further to exchange technology between countries. IPC divides total technology into eight sections which are from section A to H and each section is divided into Class, Subclass, Group, and Subgroup.

Table 2 shows that detailed OLED technology was divided or replaced as five sections of B, C, F, G, H and used for analysis.

- Technology Innovation Activity

Activity Index (AI) is the major index to analyze the present condition of specialization of technology, this provides the information about which technology is concentrated to the technology innovation activity by comparing other company with certain company that is interested [14]. This shows the area of technology that is centered by certain companies or the government, it is not analyzing by the size of the number of patents. The Method (3) shows the Activity Index.

$$AI = \frac{\frac{\text{The number of applicants' specific technical area}}{\text{Total number of specific technical areas}}}{\frac{\text{Total number of applicants}}{\text{Total number of patents}}} \tag{3}$$

Activity Index is ranged from 0 to infinity and it gains meanings by the number. With 1 as a standard number, Activity Index is relatively less concentrated to the area of technology when the certain company is smaller than 1 and vice versa [9].

On this research, it was assumed that if AI is lower than 0.5, the concentration is also low, if it is between 0.5 - 1.5, the concentration is middle and the higher number

Table 1. Independent variables.

	Independent variables	Character	Type
1	Application date index	Novelty	Set
2	The number of claims	Rights scope of technology	Range
3	The number of applicants	Collaboration of research development	Range
4	The number of Inventors	Collaboration of research development	Range
5	IPC	Subdivision of technology	Set
6	AI	Technology innovation activity	Set
7	Of PCT	Importance of technology	Set

Table 2. OLED technology section and IPC code.

IPC	Section	Technology	Description
B60R	B	Optical clock device	Installation in a car
C03C	C	Glass composition	Glass composition without silica
...
H05B	H	Electric luminous material	Device for production of electric luminous material

of 1.5 in order to divide them into three groups.

- Importance of Technology

In patent document, international application and related information enable to quantitatively evaluate the technology [15]. Generally budgets such as public commission, translation fee, legal fee are required to apply the patent and keep the registration abroad and this leads to less number of international application. Because the time, costs and efforts spent indirectly show level of patent technology, international application can be connected to the technological importance and opportunity in market places. This thesis checked status of international application and gave number 1 when there had been international application and number 0 when there had been no international application.

4. Experiments and Results

From these input variables, Bayesian Network was selected among many other datamining techniques that are provided by SPSS Clementine. The type of Bayesian Network used in this thesis is TAN. In order to set the model, 90% of raw data is categorized as training set and that of 10% as testing set.

Figure 2 is the result of TAN in Bayesian Network

which was trained. It shows that the total of 9 nodes and 13 arcs were produced. Also, it leads to the fact that there is a tree relationship among input variables, which are child nodes, while every input variable is depending on whether class node is registered or not. Furthermore, it is shown that every variable can impact on status of Registration and there are causal relationships among input variables by application date index—AI, application date index—PCT, application date index—the number of assignees, application date index—the number of inventors, PCT—the number of claims. **Tables 3-8** show each variable and conditional probability number of status of registration.

Tables 3-8 show the number of conditional probability between each variable and the status of registration. **Table 3** explains the conditional probability application date index—in the case of rejection, the probability is 0.068 when the index of applicant index is less than 0.2 and that of 9.017 when application date index is less than 0.2. In **Table 4**, variables of the number of claims have subordination only to status of registration and that of PCT. Therefore, each column of the table of conditional probability has the numbers which variable of the number of claims can have. It draws the formula below.

$$\begin{aligned}
 P(\text{The number of claims} \leq 20.8 | \text{Of registration} = 0, \text{PCT} = 0) &= 0.917 \\
 P(20.8 \leq \text{The number of claims} < 41.6 | \text{Of registration} = 0, \text{PCT} = 0) &= 0.077 \\
 P(41.6 \leq \text{The number of claims} \leq 62.4 | \text{Of registration} = 0, \text{PCT} = 0) &= 0.001 \\
 P(62.4 \leq \text{The number of claims} \leq 83.2 | \text{Of registration} = 0, \text{PCT} = 0) &= 0.001 \\
 P(83.2 \leq \text{The number of claims} | \text{Of registration} = 0, \text{PCT} = 0) &= 0.001
 \end{aligned} \tag{4}$$

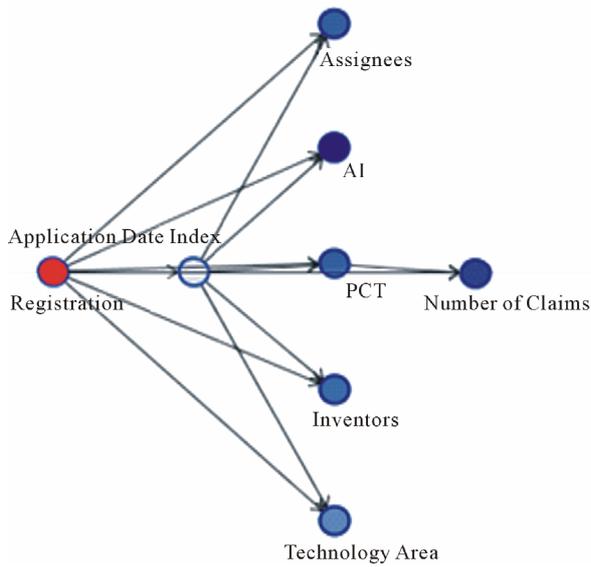


Figure 2. Bayesian network for patent registration.

Following Table 9 shows the result of experiments of total 431 OLED patents data.

In reality, 17 rejected patents were actually expected to be rejected. On the other hand, 332 patents were expected to be patented. This shows 80.97% of accuracy.

5. Conclusions

Recently, there has been keen competition between companies and the government to protect their intellectual properties resulted from R & D activity. This research is to forecast the registration of patents and that of rejection or acceptance in order to provide a model to minimize expense and time of registration. In that, this research used Bayesian network algorithm to forecast the registration and rejection of Korea patents in the area of OLED technology. From national patent data patent data of OLED technology, the date of application, the claim, the information of applicator and inventor, IPC code, AI, Interna-

Table 3. Conditional probabilities of application date index.

Parents		Probability				
Of Registration		≤0.2	0.2 - 0.4	0.4 - 0.6	0.6 - 0.8	>0.8
0		0.068	0.410	0.357	0.081	0.081
1		0.017	0.322	0.376	0.156	0.126

Table 4. Conditional probabilities of the number of claims.

Parents			Probability				
Of Registration	Of PCT		≤20.8	20.8 - 41.6	41.6 - 62.4	62.4 - 83.2	>83.2
0	0		0.917	0.077	0.001	0.001	0.001
0	1		0.676	0.2	0.104	0.009	0.009
1	0		0.866	0.121	0.011		
1	1		0.702	0.144	0.004	0.097	0.051

Table 5. Conditional probabilities of the number of inventors.

Parents			Probability				
Of Registration	ADI		≤2.6	2.6 - 4.2	4.2 - 5.8	5.8 - 7.4	>7.4
0	≤0.2		0.392	0.584	0.007	0.007	0.007
0	0.2 - 0.4		0.546	0.385	0.001	0.065	0.001
0	0.4 - 0.6		0.626	0.295	0.075	0.001	0.001
0	0.6 - 0.8		0.490	0.329	0.167	0.006	0.006
0	>0.8		0.167	0.812	0.006	0.006	0.006
1	≤0.2		0.392	0.392	0.007	0.2	0.007
1	0.2 - 0.4		0.462	0.410	0.052	0.063	0.010
1	0.4 - 0.6		0.3638	0.225	0.081	0.054	-
1	0.6 - 0.8		0.347	0.303	0.065	0.238	0.044
1	>0.8		0.404	0.323	0.135	0.108	0.027

Table 6. Conditional probabilities of PCT.

Parents		Probability	
Of Registration	ADI	0	1
0	≤0.2	0.980	0.019
0	0.2 - 0.4	0.932	0.067
0	0.4 - 0.6	0.738	0.261
0	0.6 - 0.8	0.822	0.177
0	>0.8	0.983	0.016
1	≤0.2	0.788	0.211
1	0.2 - 0.4	0.925	0.074
1	0.4 - 0.6	0.900	0.099
1	0.6 - 0.8	0.954	0.045
1	>0.8	0.997	0.002

Table 7. Conditional probabilities of the number of applicants.

Parents		Probability		
Of Registration	ADI	≤1.6	1.6 - 2.4	>2.4
0	≤0.2	0.782	0.012	0.205
0	0.2 - 0.4	0.963	0.034	0.002
0	0.4 - 0.6	0.958	0.039	0.002
0	0.6 - 0.8	0.817	0.172	0.010
0	>0.8	0.978	0.010	0.010
1	≤0.2	0.974	0.012	0.012
1	0.2 - 0.4	0.988	0.011	-
1	0.4 - 0.6	0.988	-	-
1	0.6 - 0.8	0.997	0.001	0.001
1	>0.8	0.915	0.055	0.028

Table 8. Conditional probabilities of the number of IPC.

Parents			Probability			
Of Registration	ADI	B	C	F	G	H
0	≤0.2	0.007	0.007	0.007	0.007	0.969
0	0.2 - 0.4	0.001	0.001	0.001	0.065	0.930
0	0.4 - 0.6	0.001	0.148	0.001	0.185	0.663
0	0.6 - 0.8	0.006	0.006	0.006	0.167	0.812
0	>0.8	0.006	0.006	0.167	0.006	0.812
1	≤0.2	0.007	0.2	0.007	0.007	0.776
1	0.2 - 0.4	0.010	0.021	-	0.105	0.861
1	0.4 - 0.6	-	0.045	-	0.207	0.746
1	0.6 - 0.8	-	0.087	-	0.152	0.758
1	>0.8	0.135	0.027	0.054	0.162	0.619

Table 9. Precision of total patents data.

		Predict	
		Rejected	Registered
Actual	Rejected	17	70
	Registered	12	332

tional application were used as input variables for this analysis. In order to verify the validity, 90% of raw data was categorized as training set and that of 10% as testing set. Also, this accuracy of the model in total data was shown to be about 80.97%. Furthermore, reliance between each variables and status of registration were visually ensured by the network and it was able to forecast registration and rejection through probability.

I expect this research to become a guide to forecast research on registration and rejection of further patent data. The following research enables to increase the accuracy of forecast model about patent registration and rejection on various technologies by using patent data as variables to analyze index of various technology. Also, this research used TAN which is formed to tree form between variables among many different forms of Bayesian network such as GBN, NBN etc. Hereafter, performance of various forms of Bayesian network need to comparative analysis by technology. Furthermore, grafting various assortment data mining techniques like neural network, SVM, decision tree should be needed for further research.

6. Acknowledgements

This work was supported by the National Research Foundation of Korea Gran funded by the Korean Government (MEST) (NRF-R1A4007-2011-0026953).

REFERENCES

- [1] C. H. Lee, "States of AMOLED Display Technology," *Optical Science & Technology*, Vol. 15, No. 4, 2012, pp. 29-35.
- [2] W. H. Cho, "2012 Second-Half Outlook Report," KDB Daewoo Securities Research Center, 2012, pp. 1-29.
- [3] Korea Intellectual Property Office, "Patent and Information Analysis," 2007, pp. 46-58.
- [4] K. Henning and T. Ulrike, "Chinese Regional Innovation Systems in Times of Crisis: The Case of Guangdong," *Asian Journal of Technology Innovation*, Vol. 17, No. 2, 2009, pp. 101-128.
- [5] Y. H. Tseng, C. J. Lin and Y. I. Lin, "Text Mining Techniques for Patent Analysis," *Information Processing & Management*, Vol. 43, No. 5, 2007, pp. 1216-1247.
- [6] B. W. Lin, C. J. Chen and H. L. Wu, "Predicting Citation to Biotechnology Patent Based on the Information from the Patent Documents," *International Journal of Technology Management*, Vol. 40, No. 1, 2007, pp. 87-100.
- [7] S. H. Jun, S. S. Park and D. S. Jang, "Technology Forecasting Using Matrix Map and Patent Clustering," *Industrial Management & Data Systems*, Vol. 115, No. 5, 2012, pp. 786-807. [doi:10.1108/02635571211232352](https://doi.org/10.1108/02635571211232352)
- [8] W. G. Jung, S. S. Park and D. S. Jang, "Patent Registration Prediction Methodology Using Multivariate Statistics," *IEICE Transactions of Information and Systems*, Vol. 94, No. 11, 2011, pp. 2219-2226. [doi:10.1016/j.eswa.2010.09.099](https://doi.org/10.1016/j.eswa.2010.09.099)
- [9] C. H. Kim, S. P. Park and Y. H. Ko, "Strategic Management of Intellectual Property," Korea Invention Promotion Association, Seoul, 2011.
- [10] A. A. Aljumah, M. G. Ahamad and M. K. Siddiqui, "Predictive Analysis on Hypertension Treatment Using Data Mining Approach in Saudi Arabia," *Intelligent Information Management*, Vol. 3, No. 6, 2011, pp. 252-261. [doi:10.4236/iim.2011.36031](https://doi.org/10.4236/iim.2011.36031)
- [11] D. Heckerman, "A Tutorial on Learning with Bayesian Networks," Microsoft Research Advanced Technology Division Microsoft Corporation, Washington, 1995.
- [12] J. Y. Lee and Y. J. Choi, "Network Identification of Major Risk Factor Associated with Delirium by Bayesian Network," *The Korean Journal of Applied Statistics*, Vol. 24, No. 2, 2011, pp. 323-333.
- [13] A. M. Carvalho, A. L. Oliveira and M. F. Sagot, "Efficient Learning of Bayesian Network Classifiers: An Extension to the TAN Classifier," *AI'07 Proceedings of the 20th Australian Joint Conference on Advances in Artificial Intelligence*, 2007, pp. 16-25.
- [14] Korea Institute of Patent Information, "Patent Analysis Method for Technology Roadmap," 2005, pp. 93-95.
- [15] L. Soete and S. Wyatt, "The Use of Foreign Patenting as an Internationally Comparable Science and Technology Output Indicator," *Scientometrics*, Vol. 5, No. 1, 1983, pp. 31-54. [doi:10.1007/BF02097176](https://doi.org/10.1007/BF02097176)