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Forecasting technology success based on patent data

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ABSTRACT

A novel method for forecasting technology success based on patent data is proposed. Four criteria, technology life cycle, diffusion speed, patent power, and expansion potential are considered for technology forecasting. Patent power and expansion potential are considered as technology scope indicators. A data fusion algorithm is applied to combine the results obtained from different criteria. The usefulness and potential of the proposed forecasting approach has been demonstrated using all U.S. patents related to three technologies, namely thin film transistor-liquid crystal display, flash memory system, and personal digital assistant. The results obtained from these patents demonstrate that the personal digital assistant technology is preferred over other technologies. Investments in thin film transistor liquid-crystal display and flash memory system technologies have equal priority.

1. Introduction

Decisions related to investments in any technology are affected by different factors such as marketing, human resources, location, etc. Prediction of benefits from investment in a new technology is of great interest. Forecasting the success of future technology is key to the decision makers. Because, knowing or predicting the success of invested technology provides important clues, such as the current technology life cycle of the technology under consideration, diffusion potential and technology scope. In technology and business, it provides planners to choose the right strategies for the future (Kassicieh and Rahal, 2007). Therefore, the future technology success should be predicted prior to investment decision.

Patent data may be used to predict the success of technology when analyzed in the context of technology life cycle (TLC), diffusion potential, and technology scope (patent power and expansion potential). The future technology success of the investment alternatives has not been forecasted based on patent data in the context of these four criteria in the literature so far. To fill this gap, the answer to the question of how future technology success for investment alternatives can be forecasted is researched in this paper. Therefore, a novel method based on patent data is proposed to forecast technology success.

There is a need to develop a technology forecasting (TF) method to predict future technology success. In this paper, TLC phases, initiation, growth, and saturation, are used with (i) the diffusion potential of the technology to determine possible acceptance, and with (ii) technology scope to determine the strength of the relationship of the technology with other technologies. It should be noted that patent power and expansion potential are used as indicators of technology scope. The total number of International Patent Classification (IPC) codes included in retrieved patents is divided by the total number of

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patents for the measurement of patent power (see expression (2)). In addition, the total number of different IPC codes found in the retrieved patents is also considered as expansion potential.

Patents are an objective indicator for technology forecasting (Chang et al., 2009). They also provide up-to-date and reliable knowledge for the identification of technological trends (Yoon and Kim, 2012a). In addition, they are useful in forecasting technology (Campbell, 1983) and technology decision-making (Jaranyagorn and Ngavej, 2012). Ernst (1997) showed that patent data was suitable for TF. Although there is a lack of quantitative approaches that are proposed for forecasting the future of technology, some studies have also suggested a quantitatively-based TF method. In the present study, patent analysis is used to quantitatively forecast the future state of technology. In addition to patent analysis, we also use the Condorcet method, which was developed by Condorcet (1785), to combine different results from each considered criterion and to prioritize technologies. The Condorcet method, which is sometimes called the Condorcet voting algorithm, is a data fusion method that ranks different results generated from different data resources. Each technology is considered a candidate and each criterion is considered a voter in this method.

The remainder of this paper is organized as follows. The literature relating to technology forecasting studies, technology life cycle, technology diffusion, technology scope and the technologies being evaluated are discussed in Section 2. Following the literature review, a new technology forecasting method is introduced in Section 3, with application of the method being presented in Section 4. The final section will draw conclusions and propose directions for future research.

2. Literature review

The literature surveyed in this paper is grouped into three parts: studies for technology forecasting; literature review of criteria and the technologies being evaluated.

2.1. Technology forecasting

Patent-based technology forecasting (TF) methods reported in the literature are summarized in Table 1.

Various multi-criteria decision-making approaches were applied for selection of TF methods. For example, Intepe et al. (2013) selected the most appropriate TF method for 3D television technology using a TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. Cheng et al. (2008) compared TF methods for the development of new materials using the fuzzy AHP (Analytical Hierarchy Process) method. A detailed discussion of TF can be found in (Balachandra (1980a,b), Levary and Han (1995), Lemos and Porto (1998), Coates et al. (2001), Mishra et al. (2002), Firat et al. (2008), and Miller and Swinehart (2010)).

Different types of methods were used to forecast the future of the technologies. Among them are; Monte Carlo simulation for televisions (Linton and Yeomans, 2002), grey theory for Taiwan's opto-electronics industry (Lin and Yang, 2003), multiple regression, linear regression, and the growth curve for airplane technology (Lamb et al., 2010), multiple regression models for wireless communication technologies (Patino et al., 2010), bass diffusion model for residential energy management technology (Daim et al., 2010), bass diffusion model for pulsed electromagnetic field therapy as a technology (Pretorius and Winzker, 2010), and Brownian agent-based technology forecasting for Korea's software (Shin and Park, 2009). Harell and

Table 1
Patent forecasting studies.

Author(s) (year)	Technology	Method(s)
Altuntas and Dereli (2015)	Telecommunication technology	DEMATEL method and patent citation analysis
Altuntas et al. (2015)	Database theory and its application	Weighted association rules
Choi and Jun (2014)	Humanoid robot system	Bayesian patent clustering
Li et al. (2014)	Green energy	Patent analysis and simulation model
Chang et al. (2014)	Dental implant	Patent analysis
Ranaei et al. (2014)	Low emission vehicle	S-curve
Jun and Lee (2012)	Nanotechnology	Neural networks
Jun et al. (2012,b)	Biotechnology	Association rules, time series analysis and k-means clustering
Yoon and Kim (2012a)	Silicon-based thin film solar cells and umbrellas	Property–function analysis, network analysis and TRIZ trend analysis
Chiu and Ying (2012)	Building-integrated photovoltaic (BIPV)	Logistic growth model
Lee et al. (2012)	Display	Pareto/NBD (negative binomial distribution) model and gamma–gamma model
Chen et al. (2011)	Hydrogen energy and fuel cell	Logistic growth model
Trappey et al. (2011)	Radio frequency identification (RFID)	S-curve
Jun (2011a)	Database theory and application	Association rules
Jun (2011b)	Image and video technology	Association rules and self-organizing map
Chen et al. (2010)	Hydrogen energy and fuel cell	Bibliometric analysis and growth curve
Jun and Uhm (2010)	Bio-technology	Frequency time series model
Cheng and Chen (2008)	Nanosized ceramic powders	Logistic growth model
Karakan and Koc (2008)	Isolation technology in white goods sector	Pearl curve and technology substitution model
Daim et al. (2008)	Data storage	Bibliometric trend analysis, grow curve and technology cycle time
Yoon and Park (2007)	Thin film transistor-liquid crystal display (TFT-LCD)	Morphology analysis and conjoint analysis
Daim et al. (2006)	Fuel cell, food safety and optical storage	Bibliometric analysis, grow curves and system dynamics
Ernst (1997)	Computerized numerical control (CNC)	Patent analysis