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# Discovering competitive intelligence by mining changes in patent trends

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ABSTRACT

Obtaining sufficient competitive intelligence is a critical factor in helping business managers gain and maintain competitive advantages. Patent data is an important source of competitive intelligence that enterprises can use to gain a strategic advantage. Under existing approaches, to detect changes in patent trends, business managers must rely on patent analysts to compare two patent analysis charts of different time periods. The discovery of change of trends currently still needs laborious human efforts and no efficient computer-based approaches are available for helping this task. In this paper, we propose a patent trend change mining (PTCM) approach that can identify changes in patent trends without the need for specialist knowledge. The proposed approach consists of steps including patent collection, patent indicator calculation, and change detection. In change detection phase the approach firstly excavate rules between two different time periods, comparing them to determine the trend changes. These trend changes are then classified into four categories of change, evaluated with change degree and ranked by their change degree as the output information to be referred by decision makers. We apply the PTCM approach to Taiwan's semiconductor industry to discover changes in four types of patent trends: the R&D activities of a company, the R&D activities of the industry, company activities in the industry and industry activities generally. The proposed approach generates competitive intelligence to help managers develop appropriate business strategies.

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## 1. Introduction

For a competitive organization, competence management is critical to organization development and even to survival issue. Complete competence management generally consists by processes including competence identification, assessment, acquisition and knowledge usage (Berio & Harzallah, 2007). But before the four processes of competence management, a more perspective issue is to determine which competence to obtain. To accomplish this task, competitive organizations need to keep tracing the trends of competence change and find potential elements which may substantially improve the organization competitiveness. Unfortunately, most competences—especially competitive intelligence, are neither structured nor quantifiable. So how to effectively discover the trends of change among these abundant unstructured valuable data like intelligent properties, or more precisely say patents, will be very essential to an organization to "lock on" the target competences to obtain. For instance of patent data, they embody technological novelty and serve as important sources of competitive intelligence with which enterprises gain strategic advantages (Stembridge & Corish, 2004). Patents directly represent the competitive intelligence of an industry. Any variation on patent trends in an industry as a whole will directly influence the research and development strategies of all involved enterprises. It emerges when a novel technique developed or when a revolutionary product (or parts) are invented. To maintain a leading position in the highly competitive business environment, enterprise managers need comprehend key intelligence properties of their own organization, of their competitors, and of the environment in which they operate. By analyzing patent data, managers can evaluate and understand trends in the development of technologies and plan suitable strategies (Stembridge, 2005).

There has been a great deal of researches on patent data analysis, and several applications, such as patent map, patent citation analysis, and patent indicators, have been developed (Breitzman & Mogee, 2002; Brockoff, 1991; Chang, 2005; CHI-Research; Dou, Leveillé, Manullang, & Dou, 2005; Dürsteler, 2007; Kim, Suh, & Park, 2008; Reitzig, 2004; Yang, Akers, Klose, & Yang, 2008). Most of these studies and tools use statistical methods to analyze patent data in a specific period, and represent patent trends by visualization graphs and tables. However, these tools fail to express changes in patent trends over two time periods. A patent map visualization method proposed by Kim et al. (2008) overcomes drawbacks of conventional patent maps; it enables user to understand the

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progresses of technologies, but it cannot provide a clear insight into the changes in patent trends for different periods. In real scenario, experts still have to identify changes in patent trends by comparing charts/tables for different periods. This task is laborious and there still has no corresponding automatic tools to help accomplish this work.

Changes in patent trends represent movements in the direction of technology development. For example, suppose a company X has its patents mainly on field A in 2003 and 2004. If the company's main field of patents in 2005 and 2006 has became field B, we can say the technology development direction of company X has changed from A to B. To capture changes in patent trends in different periods, this study proposes an approach which identifies patent trend changes with absence of specialist knowledge. These changes are ranked with change degree which is introduced in this paper. We combine association rule change mining (Song, Kim, & Kim, 2001) with patent indicators (Brockoff, 1991; CHI-Research) to develop a technique called patent trend change mining (PTCM), which transforms patent documents into a rule format and then identifies the most frequent rules. The frequent rules represent a patent trend in a specific period and thus, we can observe changes in patent trends by comparing the frequent rules of two time periods. The patent trends of four different business levels are discussed in this study: one in enterprise scope and three in industrial scope. We analyze each level of changes revealed by the proposed method, and these changes are classified, evaluated and ranked as the output.

The remainder of this paper is organized as follows. In the next section, we review literature relevant to this research, including association rule mining, change mining, patent analysis, and patent indictors. Section 3 provides an overview of our patent trend change mining (PTCM) technique. In Section 4, we describe the methods for mining changes in patent trends in detail. In Section 5, we investigate changes in patent trends in Taiwan's semiconductor industry. Then, in Section 6, we present our conclusions and directions for future research.

## 2. Background and related work

We begin this section by reviewing the definition of association rule mining used to discover trends in patent documents, and then present an overview of state-of-the-art change mining techniques. The third subsection contains an introduction to patent analysis. Then, in the fourth subsection, we discuss commonly used patent indicators.

### 2.1. Association rule mining

Data mining techniques have been widely used in various fields of information science (Chang, Lin, & Wang, 2009; Chen & Liu, 2004; Kuo, Lin, & Shih, 2007; Ngai, Xiu, & Chau, 2009; Yen & Lee, 2006). Association rule mining is a data mining technique used in various applications, such as market basket analysis. The technique searches for interesting associations or relationships among items in a large data set (Han & Kamber, 2001). Different association rules express different regularities that exist in a dataset; and two measures, support and confidence, are used to determine whether a mined rule is a regular pattern (Han & Kamber, 2001; Ian & Eibe, 2000). The support measure determines the probability that a transaction contains both the conditional and consequent parts of a rule, while the confidence measure is the conditional probability that a transaction containing the conditional part of a rule also contains the consequent part. The apriori algorithm (Agrawal & Skrikant, 1994) is typically used to find association rules by discovering frequent itemsets (sets of items), which are considered to be frequent if their support exceeds a user-specified minimum support threshold. Association rules that meet a user-specified minimum confidence can then be generated from the frequent itemsets.

In this work, we apply association rule mining to patent data to find patent patterns (rule patterns).

### 2.2. Change mining

The objective of change mining is to discover changes in two datasets (e.g., about customer behavior) belonging to different time periods. Change mining approaches can be classified as follows:

(a) *Decision Tree Models:* this method constructs decision trees for two datasets, and then identifies the differences by comparing the two decision trees (Liu & Hsu, 1996; Liu, Hsu, Han, & Xia, 2000).
(b) *Association Rules:* this method determines changes by comparing the association rules mined from two datasets (Song et al., 2001; Chen, Chiu & Chang, 2005; Liu, Hsu, & Ma, 2001). Users can decide the type of rule changes according to the similarities and differences between the rules in the datasets. There are several types of change mining patterns (Song et al., 2001; Chen, Chiu & Chang, 2005):
   - *Emerging patterns: The* concept of emerging patterns captures significant changes between datasets. An emerging pattern is a rule pattern whose support increases significantly from one dataset to another.
   - *Unexpected consequent changes: These* changes are found in newly discovered association rules whose consequent parts differ from those of the previous rule patterns.
   - *Unexpected condition changes: These* changes are found in a newly discovered association rules whose conditional parts differ from those of previous rule patterns.
   - *Added rules: These* are new rules that only exist in the present dataset.
   - *Perished rules: These* are rules that only exist in the previous dataset.

Association rule change mining techniques are used to analyze transaction data and discover changes in customer behaviour. In this work, we identify changes in patent trends from patent data.

### 2.3. Patent analysis

Rapid technological development has made it easier for companies to search and access patent documents. Many patent offices already allow free download of the abstracts and complete texts of their patents [e.g., WIPO (WIPO, 2007), USPTO (USPTO, 2007) and EPO (EPO, 2007)].

Several software tools and services have been developed in the patent field (Breitzman & Mogee, 2002; Dou et al., 2005; Dürsteler, 2007; Huang, Ke, & Yang, 2008). These tools analyze patents by classification, clustering, and statistical methods to find the relationships between patents with similar content/structure. The results of patent analysis are usually presented as graphs or tables, and provided to specialists, researchers, and R&D practitioners to help them plan their strategies.

Patent information can be analyzed either quantitatively or qualitatively (Huang et al., 2003). Quantitative measures are based on statistical processing, and indicate the level of patenting activity of an analytical unit (e.g., the number of patents owned by an assignee). Qualitative measures are calculated according to citation information and used to assess the quality of a patent.

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