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Designing of dynamic labor inspection system for construction industry

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ABSTRACT

Labor inspection services in many countries are not able to carry out their roles and functions. They are often understaffed, underequipped, undertrained and underpaid. In addition, workplaces vary enormously, especially in the construction industry. A labor inspectorate must build its policies and deploy its resources in accordance with the variations. Ranking workplaces from worst to best is perhaps the most straightforward way for managing labor inspectorates. This study employed 10-fold cross-validation in analyzing 715 fatal occupational injuries in the Taiwan construction industry. Accident reports during the period 1999–2008 were extracted from case reports of the Northern Region Inspection Office of the Council of Labor Affairs of Taiwan. Based on association rule mining, this article then involves 2 databases, including an occupational accidents database and a workplaces database, to present a dynamic labor inspection system for the construction industry. Besides the factors contributing to accidents, the factors about working groups, workplaces and working conditions have been considered in this article. Finally, the proposed system is applied to 2 cases to illustrate how it can effectively indicate potential hazardous working conditions and high-risk workplaces in practice. The system not only provides a support for labor inspection planning, but also makes inspection strategies more effective and flexible in changeable conditions surrounding the workplace.

1. Introduction

Due to the diverse and complex nature of work tasks, trades, and environment, as well as the temporary and transitory nature of construction workplaces and workforces, the construction industry is dynamic and hazardous (Kines, 2002). Therefore, the risk of occupational injuries in the construction industry is far greater than in a manufacturing based industry (Larsson & Field, 2002; Sawacha, Naoum, & Fong, 1999). The huge losses of human and economic resources caused by occupational accidents have become a serious problem.

In Taiwan, occupational safety is the responsibility of the employer, while the occupational safety and health laws are enforced by the Council of Labor Affairs under the Executive Yuan. The inspectors are mandated to carry out site visits without prearranged appointments to inspect work situations, working hours, construction safety, or any aspect of accident risk. They are also mandated to verify the existence of sufficient occupational health services for all employees (Yränheikki & Savolainen, 2000).

The inspectors seek to change worker behaviors by raising the expected penalties for non-compliance. On the other hand, they may take a more flexible approach. They may assist in helping workers adapt work systems to meet production demands at the same time as redressing compliance problems. Both modes can usefully be evaluated by their capacity to achieve lasting improvements in workplace conditions given constrained organizational resources (Weil, 2008). The quality and quantity of inspectors are fundamental elements of Labor inspection services.

Nevertheless, Labor inspection services in many countries are not able to carry out their roles and functions. They are often understaffed, underequipped, undertrained and underpaid. In fact, many government labor inspectorates face diminishing budgets, shrinking staff, the continued growth of the workforce, and a growingly complicated regulatory environment. Indeed, changes in external conditions surrounding the workplace, including the growth of subcontracting and independent contracting, the use of temporary employment agencies, and the fissuring of the traditional employment relationship, have made the problem more complicated. The fundamental problem facing labor inspectorates arises from constrained organizational resources. The key task faced by all labor inspectorates, then, is how to deploy those resources most effectively. Ranking workplaces from worst to best is perhaps the most straightforward way for managing labor inspectorates (Weil, 2008).

Accident analysis is applied to identify factors of high-risk workplaces and to develop strategies for injury prevention (Harper

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& Koehn, 1998). Also, it can be used to rank high-risk workplaces. For example, if we learned from occupational accidents that a pipeline project is a most dangerous project on rainy days on weekends, we have learned that the most risky jobs and hazardous working conditions are encountered working on pipelines on rainy days on weekends. Then, we can target pipelines for weekend inspections and can save inspections, on other jobs, for other time. In this article, accident analysis is employed in extracting applicable association rules in order to indicate high-risk workplaces.

Workplaces vary enormously in their scale, nature and factors affecting their activities, especially in the construction industry. A labor inspectorate must build its policies and deploy its resources in accordance with the variations in company and industry characteristics (Weil, 2008). Facing changing workplace conditions, inspection strategies must be flexible enough to revise the priority of the planned inspections. Besides, to avoid repetitive and redundant inspection, labor inspection progress, including daily workplace inspections and their outcomes, should be noted. For solving this problem a dynamic concept is introduced.

This article examines the characteristics of occupational injuries in the construction industry to identify the factors helpful in establishing inspection plans. Then, identifying data mining technology applicable, we employed 10-fold cross-validation in analyzing 715 fatal occupational injuries in the Taiwan construction industry. Finally, based on association rule mining, this article involves 2 databases to present a dynamic labor inspection system for the construction industry.

2. System architecture and methodology

2.1. Association rule preliminaries

Database technology is extensively used in many domains, including the domain of occupational accidents. The large volume and high dimensionality of accidents databases has led to a breakdown in traditional human analysis. Data mining provides techniques for analyzing data in large databases and can be used to recognize potentially useful patterns in the data (Zhang & Zhang, 2002). Association rule mining is an important task involved in data mining. It can be used to uncover interesting relations and potential associations in large databases. These rules are effective in discovering unknown relationships, and provide results that can serve as a basis for forecasting and decision making (Chae, Ho, Cho, Lee, & Ji, 2001; Chen, Tang, Shen, & Hu, 2005; García, Quintales, Peñalvo, & Martín, 2004; Jukić & Nestorov, 2006; Tsay & Chiang, 2005). Due to its proven effectiveness in discovering accident patterns (Cheng, Lin, & Leu, 2010; Liao & Perng, 2008; Mirabadi & Sharifian, 2010), association rule mining has been adopted in this article.

Agrawal, Imielinski, and Swami (1993) proposed a well known algorithm for constructing association rules in a transaction database. The problem of association rule mining can be defined as follows (Baralis & Psaila, 1997; Hsieh, 2004; Zhang & Zhang, 2002): let $I = \{i_1, i_2, i_3, \ldots, i_m\}$ be a set of m distinct items. Let D be a set of transactions that we call a transaction database. Each transaction T in D contains a subset of the items that are in I, such that $T \subseteq I$. Given an itemset $X \subseteq I$, a transaction T contains X if and only if $X \subseteq T$. An itemset X in a transaction database D has a support; we call this Support (X). This represents the proportion of transactions in D containing X. An association rule is an implication of the form $X \Rightarrow Y$, where $X \subseteq I$, $Y \subseteq I$ and $X \cap Y = \varphi$. An association rule $X \Rightarrow Y$ holds in D with support s%, if the probability of a transaction in D containing X and Y is s%, i.e.

$$\text{Support } (X \Rightarrow Y) = \text{Support } (X \cup Y). \quad (1)$$

Table 1
Summary of factors designated in this article.

Factors
Month (MON)
January
February
March
April
May
June
July
August
September
October
November
December
Day of the week (WEE)
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
The location of the project site (LOC)
Taipei County
Taoyuan County
Hsinchu County
Yilan County
Hualien County
Keelung City
Lienchiang County
The bid price of the project (BID)
Under NT$10,000,000
NT$10,000,000 - NT$100,000,000
NT$100,000,000 - NT$500,000,000
Over NT$500,000,000
Others
Number of building floors(BFL)
Under 5
6∼10
11∼14
Over 14
Construction phase of building (PHA)
Foundation
Basement structure
Overground structure
Early stage of decoration
Later stage of decoration
Almost done
Completion
Number of days after the last inspection (INS)
Under 60 days
Over 60 days
Public project (PUB)
Yes
No
The size of the supplier(SSI)
Under NT$1,000,000
NT$1,000,000 - NT$10,000,000
Over NT$10,000,000
Source of injury (SOU)
Other temporary work
Scaffolding
Ladder
Other environment
Roof
Structural Hole
Space
Temporary hole
Nature environment
Tool
Product and material
Vehicle and mechanical equipment
Construction equipment
Electrical equipment
Others

(*continued on next page*)