Spare Parts Storage Improvement with Association Rules

Wimalin S. Lasiritaworn, Nuttakarn Singtorn, Pirakit Tapeng

***Abstract*—This paper presents an application of association rule, one of the most widely used data mining algorithms, to improve spare parts storage in motorcycle repair shop. As there are approximately 290 parts to be stored, there are difficulties in storing and retrieving parts in the storage room. Spare parts are stored in the room based on part code which is a number indicating type of part, product type and materials type. Storing spare parts by this part code has some potential problems, for instance it does not provide information regarding parts that are frequently used together which might results in parts often requested together to be stored separately. This research applies association rules, to improve shelf allocation in spare parts storage room. After improvement, the time used to search for spare part was founded to be reduced significantly.**

***Index Terms*— spare parts, data mining, association rules, clustering algorithms**

I. Introduction

MOTOCYCLE is one of the most popular method of transportation in developing countries, where public transportation is still in developing stage. Motorcycle cost only 1/10 in comparing to car. Moreover, it is convenience and fast even in bad traffic. More than 90% of motorcycle are manufactured in Asia. Thailand is among top ten countries that exported the highest dollar value worth of motorcycles. Thailand produced approximately two million of motorcycles a year (Fig. 1)

Fig. 1. Number of motorcycle produced in Thailand from 2000 to 2013

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Thailand's motorcycle industry is large and cover a complete range of service staring from production, distribution, sales and after sales service. Our case study company is one of the motorcycle sales and service stores located in the northern part of Thailand. This research focused on motorcycle repair shop which provides service such as routine checkup and repair.

The main problem found in this department was at spare part storage room. As there are approximately 290 spare parts to be used, the spare part storage room is very packed. Spare parts are stored on shelf based on part code which is a series of numbers indicating type of spare part, product type and material type (Fig. 2).

Fig. 2. Spare part storing based on part code

However, using part code to order part on shelf has some potential problems. For example, it takes long time for both storing and retrieving of parts as part code dose not to takes into account of relationship between parts that are usually requested together.

Association rules is one of the most applied data mining techniques. Initially, it is used for market basket analysis in which items that customer buys or itemset is analyzed to find relationship between purchases. Market basket analysis is based on the theory that customers who by a certain group of items are more likely to buy another group of items. For example, customers who buy computer are more likely to buy antivirus software. Certain knowledge is used for various purposes for example, cross-selling, marketing or catalogue design.

In this research, Association rules is applied to find the relationship between parts in order to identify parts that are likely to be retrieved together. These parts should be located close to each other on the shelf. The new shelf allocation based on association rules are compared with the existing method that arrange parts based on part code using the criterion of time it takes to storing and retrieving parts.

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II. LITERATURE REVIEW

Association rule is one of the most important techniques for data mining. It is a method for searching recurring relationship in data[1]. Let $I = \{i_1, i_2, \ldots, i_n\}$ be a set of items. Association rules is defines as $A \Rightarrow B$, where $A \subset I$, $B \subset I$, and $A \cap B = \varnothing$ [2].

Support and *Confidence* are typically used to measure if the rules are 'strong'. Support suggested how often the item-set occurred. It is calculated from the proportion of transactions in the databased which contain the interested itemset. Confidence is the indication of how often the rule has been found to be true and can be calculated as follows

$$confidence(A \Rightarrow B) = \frac{support(A \cup B)}{support(A)} \quad (1)$$

Strong rules are those that satisfy both minimum support threshold and minimum confidence threshold.

Association rules are often used for market basket analysis but there are also report of success case of applications in other field for example financial[3, 4], medical[5, 6], and educational[7].

III. RESEARCH METHODOLOGY

A. Data collection

First of all, current process of spare part storing and retrieving was studied by using process flow chart. This chart was used to identify the problem in the process. It was found that the main problem occurred in this motorcycle repair shop was that spare parts searching and retrieving is too long. To solve this problem, a new shelf allocation is designed based on association rules.

In this work association rules are used to identify spare part group that are usually requested together. In order to do this spare part request documents were collected (Fig. 3).

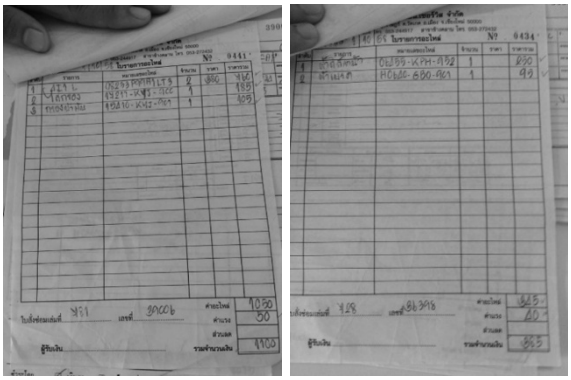

Fig. 3. Examples of spare part request document

Part code consists of three groups of numbers and alphabets for example, 17211-KYJ-900. The first set of number, indicates type of spare parts. The next three letters indicate type of product in which this part belongs to and the last three digits indicates material type. In this case 17211 refers to air filter, KYJ refers to 'Honda Click' product and 900 means that this part is made of copper.

There are very large number of different part code. Creating association rules based on individual code might not be possible. As a result, individual part codes are grouped into part type. For example, air filter regardless of product and material type are grouped together and considered as one item. There are in total of 90 types of spare part types considered in this work. Example of part code grouping are provided in Table 1. For example part code 31500-KPW-901, 31500-KPW-911, 31570-KPW-901 and 31500-KPN-901 are grouped into "Battery".

TABLE I
PART CODE GROUPING EXAMPLES

Battery	Front Brake	Brake	Air filter
31500-KPW-901	53175-KWN-901	06455-KPH-952	17211-KYJ-900
31500-KPW-911	53175-KET-921	06430-KPH-900	17210-KZL-930
31570-KPW-901	53175-K26-901	06430-KVB-900	17210-K16-900
31500-KPN-901		06435-KPP-T01	17210-KFL-850
		06455-KWB-601	17210-KYT-900
		06430-KFL-850	17210-K26-900
		06435-KZZ-901	17211-KPK-900
		06455-KPP-902	17210-KVB-T00
		06455-KW6-844	17210-KWW-640
		06455-KVB-912	17210-KVB-930
		06455-KVB-T01	17210-K16-960
			17210-KWN-900
			17210-K04-930

B. Association rules implementation

Association rules generation consist of two steps. First, frequent itemset or the set of item that satisfy minimum support is generated. Numbers of algorithms are available for mining this frequent set, for example Apriori Algorithm, TreeProjection and FP-Growth algorithm. In this research, FP-Growth algorithm was applied. This algorithm generates frequent pattern by constructing the frequent-pattern tree (FP-tree). Advantages of FP-growth algorithm is that it only needs to read database file twice, while Apriori reads database every iteration, so FP-Grown is much faster than Apriori.

The second step is the association rule generation. Frequent itemset that satisfy minimum support in the first step is used to generate rules by firstly for each frequent pattern p, general all non-empty subset. Then for every non-empty subset s, output the rule $S \Rightarrow (p\text{-}s)$ if the confidence of the rule calculated from support(p)/support(s) is more than or equals to minimum confidence.

In this research, RapidMiner Studio 6.0 software was used to identify frequent itemset and association rules generation. Minimum support was set to 35% and minimum confident was set to 80%.

C. Shelf allocation

After strong rules are discovers. New shelf allocation is designed using the principle that items that are associated to each other should be placed close together.

IV. RESULTS AND DISCUSSION

A. Storage room layout

Spare part storage room and shelf is shown in Fig. 4. The size of storage room is 5×7 meters. Large spare parts are stored against the wall of the room and small parts are stored on shelf in the middle of the room.

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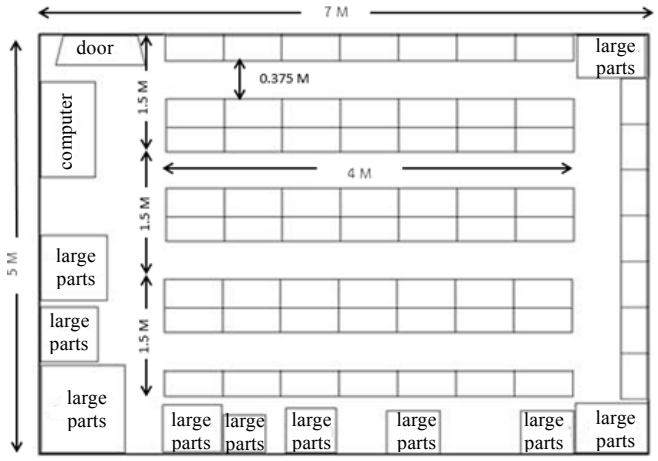

Fig. 4. Layout of shelves in storage room before improvement

B. Data table for association rule mining

Table 2. is an Example of data table used for association rule mining. The first column is transaction identification number (TID). The rest of the columns are corresponded to the type of spare part available. As there are a total of 90 types of spare part, the data table consists of 91 columns (90 types + 1 transaction ID). Each TID is corresponded to one spare part request. The type of spare part that is requested in that transaction contains value of 1 otherwise the value is 0.

TABLE II
EXAMPLE OF DATA TABLE FOR ASSOCIATION RULE MINING

TID	Battery	Tire	Lubricant	…	Air filter
1	1	1	0		0
2	1	0	1		0
3	0	1	1		1
…					
30	0	1	0		1

C. Rapid Miner process for implementing association rule

RapidMiner Studio 6 process used to implement association rule is shown in Fig. 5. RapidMiner process is a collection of "operators". Each operator performs specific task and sent the output out to the next operator. "Read CSV" is the first operator in the process used to load data table into the workflow. "Numerical to binominal" operator operator transforms 1 and 0 into TRUE or FALSE. "FP-Growth" operator was used to find frequent itemset that satisfy minimum support of 35% and finally "Create association rule" operator generate association rule that pass minimum confidence of 80%.

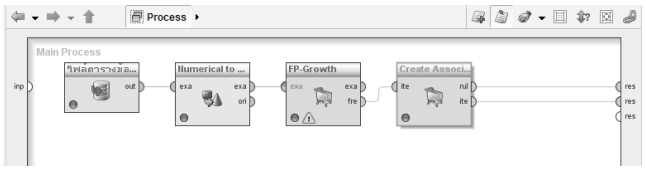

Fig. 5. Rapid miner process for spare part association rule analysis

D. Strong association rules

Strong rules are rules that suggest strong relationship between items. Example of strong rules, their support and confidence found is given in table 3.

TABLE III
EXAMPLES OF STRONG RULES

Rule no.	Premises	Conclusion	Support	Confidence
1	Lubricant	Lamp and switch	0.774	0.857
2	Lamp and switch	Lubricant	0.774	0.889
3	Tire	Lubricant	0.645	0.909
4	Tire	Lamp and switch	0.613	0.864
5	Air filter	Lamp and switch	0.581	0.900
6	Air filter	Lubricant	0.548	0.850
7	Brake	Lubricant	0.548	0.850
8	Brake	Lamp and switch	0.548	0.850
9	Lubricant, tire	Lamp and switch	0.548	0.850
10	Lamp and switch, tire	Lubricant	0.548	0.895

Premise or an antecedent is an item or itemset found in the data. Conclusion or a consequent is and item or itemset that rule number 1 in table 3 can be explained that if Lubricant is requested, then lamp and switch is also requested. This rule has support of 0.774, which means that 77.4% of transaction in database contains lubricant and lamp and switch together. Confidence of 0.857 means that 85.7% of the transactions that request lubricant, lamp and switch are also requested.

Fig. 6 shows relationship between frequent itemset. Items that are requested together most frequently are Lubricant and Light and switch.

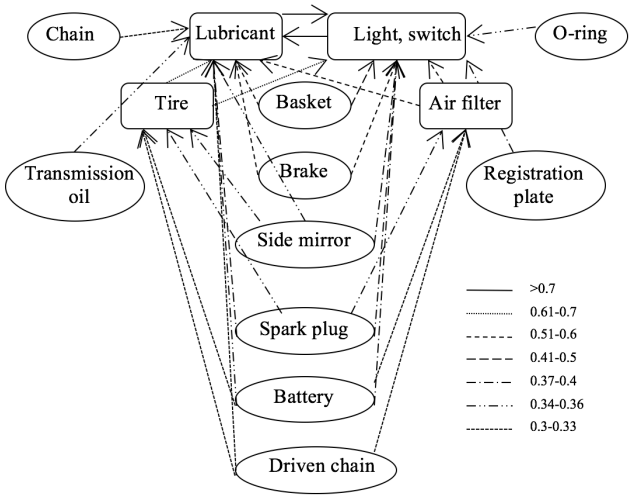

Fig. 6. Relationship among frequently requested spare parts

E. Storage room shelf allocation

Fig. 6 was considered in the improved storage room shelf allocation. The strongest rules which are lubricant and light and switch is assigned first into the shelf close together and close to the door of the storage room. Then the spare parts with lower support were assigned next. The new layout can be found in Fig. 7.

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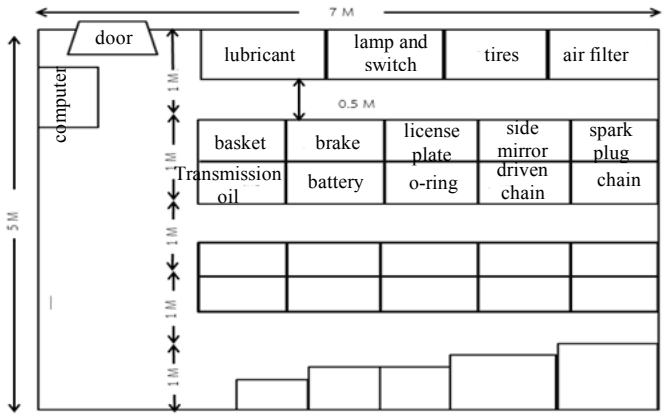

Fig. 7. Layout of shelves in storage room after improvement

Time to retrieve spare parts before and after improvement was recorded. Before improvement, it takes approximately 5.56 minutes to search for spare part. After improvement, the time was reduced to 1.54 minutes. This equals to 72.3% reduction.

V. Conclusion

This paper attempts to solve the problem occurred in storage room in a motorcycle repair shop. Parts are stored in that room according to part code. However, this part code does not takes into account of items that are frequently used together which results in item that are usually requested together to be store separately. As a result it takes long time to search and find items.

This paper solved the mention problem by applying association rules to identify relationship among parts that are usually requested together and use this relationship to re-organized storage shelf so that parts that are usually requested together were stored in adjacent shelf. The result after improvement show that the time for part retrieval has decreased significantly.

This work even though achieved good result, yet there are still possibilities for further improvement. Other problems occurred at the storage room are that the storage space in this room is not fully utilized as part code does not take into account of the size of spare part which results in storing part of different size on the same shelf. Moreover, if there is a new spare part which as part code in between existing part code, in order to provide storage space for this new part, all parts that has part code after the new part has to be moved. Finally expensive parts should be stored in a separated shelf that better prevent them from damage.

Clustering algorithms, another widely applied data mining algorithm, could be used to classify parts into groups based on multiple criteria such as spare parts size, price and frequency of use. By taking into account of spare part size, space utilization could be maximized and by taking into account of spare part price, expensive parts could be stored more appropriately. Therefore, the comparison between association rules and clustering algorithm to improve spare part storage is interesting and challenging take to further improve the result.

References

[1] S. Kotsiantis and D. Kanellopoulos, "Association rules mining: A recent overview," *GESTS International Transactions on Computer Science and Engineering,* vol. 32, pp. 71-82, 2006.

[2] J. Han and M. Kamber, Data Mining: Concept and Techniques. San Francisco, CA: Morgan Kaufmann, 2006.

[3] J. Mongkolnavin and S. Tirapat, "Marking the Close analysis in Thai Bond Market Surveillance using association rules," Expert Systems with Applications, vol. 36, pp. 8523-8527, 5// 2009.

[4] S. H. Na and S. Y. Sohn, "Forecasting changes in Korea Composite Stock Price Index (KOSPI) using association rules," Expert Systems with Applications, vol. 38, pp. 9046-9049, 7// 2011.

[5] M. Karabatak and M. C. Ince, "An expert system for detection of breast cancer based on association rules and neural network," Expert Systems with Applications, vol. 36, pp. 3465-3469, 3// 2009.

[6] M. Karabatak and M. C. Ince, "A new feature selection method based on association rules for diagnosis of erythemato-squamous diseases," Expert Systems with Applications, vol. 36, pp. 12500-12505, 12// 2009.

[7] H. İ. Yalin, F. Adiloglu, H. Boz, S. Karataş, F. Ozdamlı, Z. Abdullah, et al., "World Conference on Educational Technology Researches - 2011Mining significant association rules from educational data using critical relative support approach," Procedia - Social and Behavioral Sciences, vol. 28, pp. 97-101, 2011/01/01 2011.

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