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The Use of Recommender Systems in Decision Support—A Case Study on Used Car Dealers

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***Abstract*—**This research focuses on the use of a recommender system in decision support by means of a used car dealer case study in Bangkok Metropolitan. The goal is to develop an effective used car purchasing system for dealers based on the above premise. The underlying principle rests on content-based recommendation from a set of usability surveys. A prototype was developed to conduct buyers' survey selected from 5 experts and 95 general public. The responses were analyzed to determine the mean and standard deviation of buyers' preference. The results revealed that both groups were in favor of using the proposed system to assist their buying decision. This indicates that the proposed system is meritorious to used car dealers.

***Keywords*—**Recommender Systems, Decision Support, Content-Based Recommendation, used car dealer.

I. Introduction

RECOMMENDER systems are information filtering system that aids users in predicting rating or preference of an item under users' consideration. The systems offer users alternate selections without having to work out all the details by themselves. As overwhelming information explosion renders searching, extraction, analysis, and processing hideous and formidably time-consuming operations, recommender systems become a favorable decision tool or assistant to off-load such undesirable tasks. Worse yet, activities involving human are inevitably subject to human errors that can lead to poor or wrong decisions.

Perhaps the main driving factor of this research work stems from a new tax exemption for first-time new eco-car buyers [9], allowing up to B100,000. The offer is valid from September 16, 2011 to December 31, 2012. The implications of such regulatory tax allowance are two folds. First and foremost, first-time buyers are rushing to cash-in. This is one of the biggest financial drains on average income individuals who, without such exemption, might just settle for a used car. In other words, as the demand for used car plummets, some used car dealers are on the verge of bankruptcy. Second, when the dust settles, reality sets in. Average buyers can hardly make ends meet as the accumulated financial burden multiplies. Foreclosures become the next prevalent legal action. Those cars will find their way to fill the used car lots.

The above arguments are vital to call for solutions that will ease or, to the extreme measure, bail those first-time buyers out of financial crisis. The proposed system is one means to match the needs of the buyers and used car dealers. It is hoped that the system will lessen national economic burden to some degree.

This paper is organized as follows. Section II recounts some important related work. Section III elucidates development fundamentals and analysis of the proposed system stakeholders. A case study on used car dealers is conducted as part of the experiment in Section IV. The results so obtained and some final thoughts are given in Section V.

II. Related Work

This section describes the principal prior works that form the basis of the proposed approach. Recommender systems have been deployed in various e-Commerce activities [1] in recent years. The domain of applicability is quite extensive, covering a wide array of areas from multimedia rating systems [3], [6], research reading lists [2], [5], books [7], etc. The underlying principles rest on three popular methods, namely, content-based, collaborative filtering, and hybrid. Maneeroj and Takasu [4] proposed hybrid recommender systems that used latent features. This research adopted the content-based approach since the nature of problems under investigation lent themselves to this approach. A content filtering [8] technique was also employed to simplify the proposed system usability as used car business was relatively new to such software tool application.

III. Proposed Approach

The proposed approach extracts and filters data pertaining to the items, used cars in this case, selected by the buyers, such as the characteristics or features of the items being selected, the criteria on which the item is selected, etc. The procedure typically proceeds as follows:

- collect user's historical profile based on the features of the preferred items.
- determine the relation between the user and the preferred items.
- establish a weight factor for each item using the above relation and features.
- choose the item that closely matches the user's choice in accordance with preference, features, and weight.

Several used car dealers in Talingchan District of Bangkok were chosen since this area was the largest congregation of used car dealers in Bangkok Metropolitan. The findings were of interesting in many respects:

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A. The recommender systems turned out to be an effective filtering tool that met many used car dealers.
B. Subjective quantification called for two prerequisite input data to be made available in order for the system to operate properly, namely, (1) rating score of the used car dealer which is a single criterion given by the buyers. The score is quantified by conventional 5-point Likert Scale, where 1 represents least satisfactory and 5 represents most satisfactory, and (2) features that describe the used car dealer to be taken into consideration by the buyers for their visitation, such as general showroom appearance, salesmanship, acquaintance, and personal preference. Notice that all the features are highly subjective that preclude them from typical statistical or quantitative assessment procedures.

To obtain as much satisfaction coverage of the buyer and dealer, a multi-criteria requirement consideration was established as the baseline for recommendations. These requirements included make, model, class, budget/price, years in business, and web site. All information had to be correct and up-to-date to be qualified for recommendation consideration. The final recommendations were made available in two groups. The first group exhibited the top five dealers that match or rank the highest based on the rating score. The second group contained dealers that did not make the first group but somehow matched the user's specific needs.

Item rating analysis was conducted on 100 participants that were classified in 2 groups, namely, 5 used car experts and 95 used car buyers. Simple statistics were employed in this new and unexplored area of application as mentioned earlier. They are arithmetic mean and standard deviation of users' rating. The former can be computed from Equation (1) as follows:

$$\bar{x} = \frac{\sum x}{n} \quad (1)$$

Standard Deviation can be computed from Equation (2) as follows:

$$SD = \sqrt{\frac{n\sum x^2 - (\sum x)^2}{n(n-1)}} \quad (2)$$

IV. Experiments

A prototype of the proposed used car dealer recommender systems was developed based on the following system configuration:

- MySQL database management systems
- php web development language
- Adobe Dreamweaver and Adobe Photoshop as GUI builders
- Apache web server
- Google Chrome browser
- FileZilla file transfer tool

The prototype so developed was intended to fill the gaps where many existing used car web sites did not furnish meaningful information to help buyers make their decision. Fig. 1 depicts the general information given by a typical used car web site. The buyers must do their own homework to arrive at a decision which might not suit their financial portfolio.

Fig. 1 Mapping nonlinear data to a higher dimensional feature space

Design of the prototype encompasses a reference software architecture which is divided into two subsystems, namely, administrator and user subsystems. Each of which performs typical services as shown in Fig. 2.

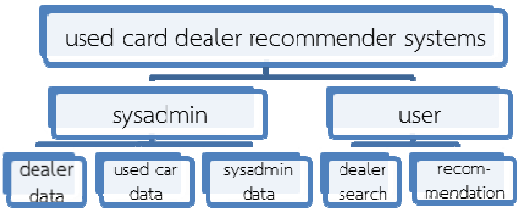

Fig. 2 The proposed recommender systems reference software architecture

Fig. 3 shows the proposed used car recommender systems. Buyers can alternately browse the top five most popular dealers for comparable selections as shown in Fig. 4.

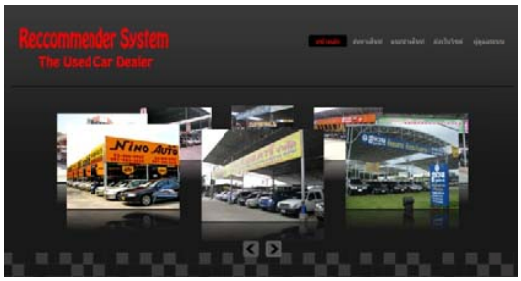

Fig. 3 Used car recommender systems

Fig. 4 Top five popular dealers

Fig. 5 Used car recommendation page

Operational details of the proposed recommender systems are procedurally depicted in Fig. 5 and 6. Top five matching results are shown in Fig. 7, while the overall results are given in Fig. 8. Users can delve into comparative recommended itemized details as shown in Fig. 9. Fig. 10 shows the administration screen where all information can be administered as needed.

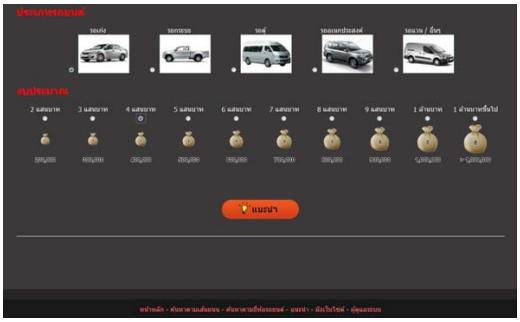

Fig. 6 Feature selection

Fig. 7 Top five recommended dealers

Fig. 8 Overall recommended results

Fig. 9 Details of recommended items

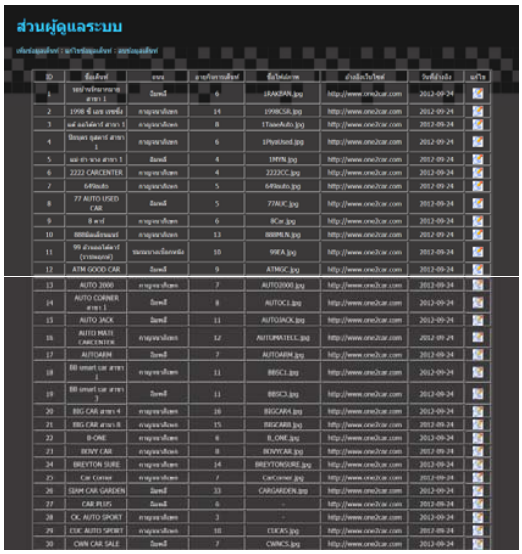

Fig. 10 Sysadmin database

To gauge the extent of how general public are aware or accept used car recommender systems, a set of questionnaire were distributed to measure how well people compare the proposed used car recommender systems with other item recommender systems, such as movie, book, TV program, etc. The result ratings are summarized in Table I and II, respectively.

TABLE I
USED CAR EXPERTS' RATING

Rating	Arithmetic mean	Standard deviation
Other recommender systems	3.200	0
Proposed used car recommender systems	3.173	0.125
Overall rating	3.180	0.113

TABLE II
CAR BUYERS' RATING

Rating	Arithmetic mean	Standard deviation
Other recommender systems	3.341	0.077
Proposed used car recommender systems	3.373	0.155
Overall rating	3.365	0.144

V. DISCUSSION AND CONCLUSION

As abundant information from the proposed recommender systems is made available for car buyers to decide the choice of used car to buy, the car buyers seem to be in favor of the systems with high mean and low standard deviation, regardless of whether they are working on ordinary items or used car. This is evident from the mean of other and proposed recommender systems which remain relative close, while the standard deviation is small. However, the buyers exhibit a slightly higher preference to recommender systems as shown in Fig. 11. Thus, car buyers and experts are indifferent in their preference rating. A closer look into some high income potential buyers indicates that the lack of information on used car dealer poses a big problem in search for a desired used car, having the mean of 3.556 and standard deviation of 0.882. Fig. 12 depicts their response to this aspect. The *t*-confident interval of buyers' opinion on used car dealers' profile is 0.087 at 0.05 significance level. All these imply that content-based approach offers a comprehensive information coverage for building used car recommender systems.

Fig. 11 Rating comparison

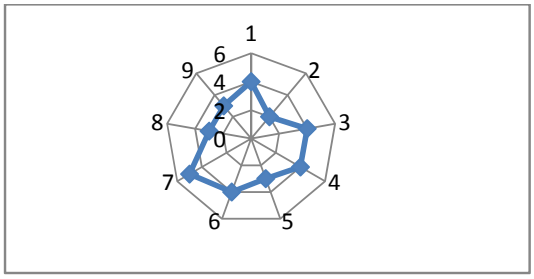

Fig. 12 High income potential buyers' response

The retrospective benefits for dealers of the proposed recommender systems are also as important as the direct benefits for buyers. As such, some future work can be instituted to enhance this proposed recommender systems from the following standpoints:

- The geographical dispersion of dealers and buyers offers other supplementary methods to content-based method, for instance, demographic-based or knowledge-based methods.
- Additional ontology may be required to arrive at more efficient users' preference matching algorithms.
- More purposive use could be categorized for finer grained processing to yield more accurate recommendations, for instance, buy, sell, or consignment of used cars.
- The systems should not limit their coverage to Talingchan District, but expand to other rural and provincial areas.

As the main driving factor stated earlier, the ultimate purpose of the proposed recommender systems application is to help used car dealers boost their sales and somehow to alleviate the eminent economic deficit caused by the new car buying sprees.

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