Products Recommendation in a B2C E-Commerce Using Fuzzy Logic

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Abstract — **Customer is the most important success factor for Business to Costumer (B2C) e-Commerce. There are two important ways have been used nowadays which are data mining and live customer support. These two ways are effective and reliable, but each one has its own problem.In this paper, an intelligent algorithm developed to replace these two methods with fuzzy rules. The fuzzy rules are generated from history data mining and an expert converts that data to rules.The solutions made through designing and implementing two databases, one for the fuzzy memberships and the other for the e-Commerce catalogue system. Then using PHP programming language, a script made to deal with these databases and link between them, then read data and process them using fuzzy logic to generate a recommendation to the customer.The algorithm is applied to three kinds of products, and the results are compared with Amazon site and give high agreement.**

Index Terms —**E-commerce service; B2C; Fuzzy logic, Products Recommendation**

I. INTRODUCTION

In the 21st century, e-Commerce might not be able to guarantee making money for the company, but a company, which doesn't think about the issue of commerce, will definitely face the problem of competence deficiency [1].

One of the most important types of e-Commerce, classified according to the nature of the supplier and client, is **Business to Consumer (B2C)**. In this type that consumer accesses the system of the supplier [2].

Extensive research has been done investigating the role of trust in online purchase intention and behaviors, and the difference between initial and repeat trust formation and maintenance [3].

On the other hand, much research on the area of recommendation systems has focused on improving recommendation accuracy and computational performances. Recommendation systems have achieved great success in generating accurate and personalized recommendations to their customers [4].

The two important ways have been used nowadays which are data mining and live customer support [5]. The motivation of this paper aims is to replace the data mining methods and human live support by an intelligent system that uses the fuzzy logic, that use rule base made by a human expert, to generate a recommendation to the customer.

In other words, this project aims to design an expert e-Commerce System (EECS) that helps the customer who browses a site to make the right decision, which means reducing the cost and time for the e-Commerce sites' owners.

II. SOLUTION STEPS

In this work, an **Expert E-Commerce System** (EECS) was designed, that helps the customer who browses a site to make the right decision.

The proposed system operation depends on fuzzy rules generated by a human experience in an e-Commerce support. So it will work just like data mining method and human resources customer support together, which means reducing the cost and time for the e-Commerce sites' owners.

Solution steps to achieve this goal can be summarized as follows:

- Development of a general fuzzy variable maker that takes the values from a web form and saves it into a database.
- Design and implementation of an e-Commerce catalogue using PHP programming language and MySQL database server.
- Making shopping cart script that deals with guests and users, by using sessions' technique.
- Integrating the stored fuzzy variable into the general fuzzy maker system.
- Finally, applying the proposed system to real data collected from Amazon.com.

III. PROPOSED EECS MODEL

Fuzzy logic is the core of the EECS, besides database (DB) to read and write data. First a fuzzy variable maker system is made to be a general system that uses standard membership functions S, PI and Z values [6]. Then, these values are used by a fuzzy function programmed to integrate the e-Commerce site with fuzzy. Figure (1) shows the main components of the proposed system and relations between them.

Admin area block represents the input for the catalogue, by adding categories and products to the catalogue database (DB). Product catalogue block and shopping cart are related in some table fields in the DB. The combination rounded by the dotted rectangle represents the standard e-Commerce system. On the other side of the block diagram there is the fuzzy component of the EECS system. The fuzzy variable maker is the input of the fuzzy DB and the rule base is flat files.

The following subsections will give a brief description for the main component of the EECS.

A. EECS Product Catalogue Database

DB is used to store information and the products of DB, and consist of two tables, products and categories. The use of categories table is to give flexibility to the system by adding more categories in the future.

The database of the e-Commerce system consists of 5 tables; these tables can be divided into 3 main types:
- Catalogue tables, which are: Products and Categories.
- Shopping cart tables, which are: shopping cart table and purchase list.
- Users table that that contains the information of registered users.

Purchase list are the same as shopping cart table; the difference is that this table holds values of the purchased items while the shopping cart holds the values of the products added by customers before purchasing them.

B. Catalogue Admin Area

In Fig. 1, one arrow from the admin area to DB is shown just to describe that the admin area represents the INPUT of the products to DB. Actually admin area also reads some data from DB when the webmaster needs to edit a product, the script reads the product details from the DB then edits the info he wants to save. So, just the changed info will be saved using UPDATE query to the DB.
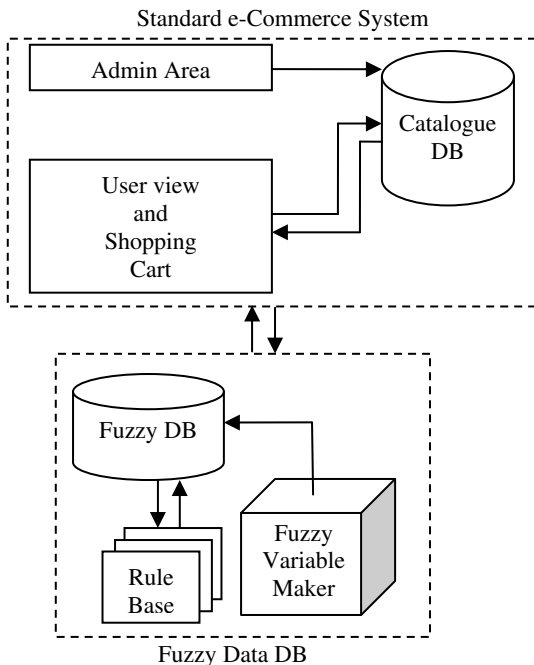

Fig.1. EECS Block diagram

C. EECS User View and Shopping Cart

In this work, the flow diagram of a user's view of a catalogue is shown in Fig. 2. While the shopping cart built depends on the session technique that PHP supports and relation to products of the catalogue made to make a general shopping cart independent of the product type or class.

The shopping cart work depends on saving added product in the DB with session id of the user browsing the site.

Shopping cart in this work uses two tables in the DB, shopping cart and purchase list. The steps that the customer moves through to purchase a product are shown in Fig. 3.
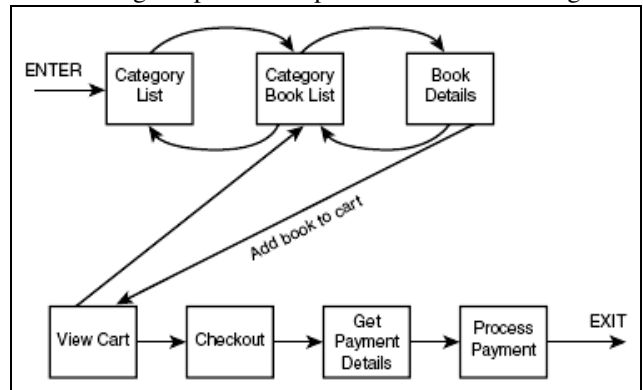

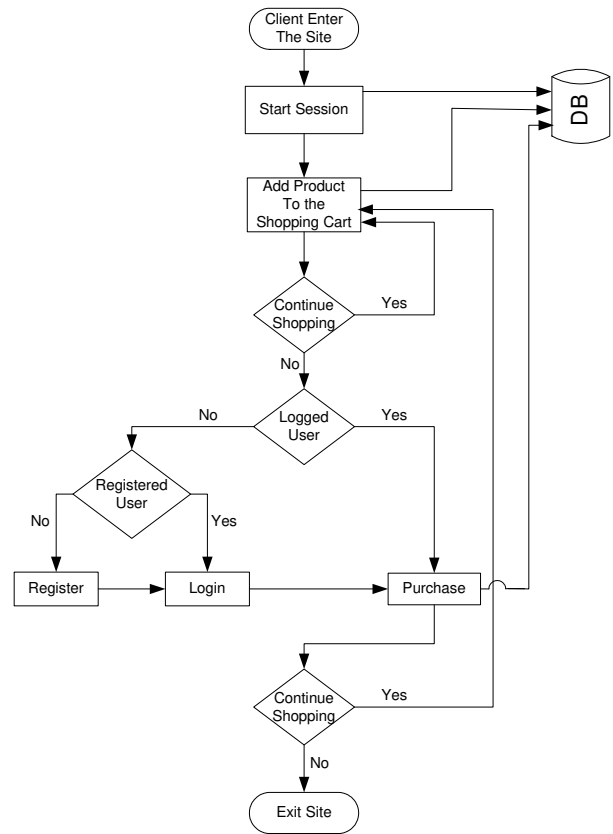Fig. 2. A user view of a catalogue system

Fig. 3. Shopping Cart Implementation

D. Fuzzy Variable Maker Database and Script

Equations (1)-(3), represent the standard functions S, PI, and Z of the fuzzy sets used in this work [4]:

$$S(\mu,a,c) = \begin{cases} 0 & \mu \le a \\ 2\left(\dfrac{\mu-a}{c-a}\right)^2 & a < \mu \le \dfrac{a+c}{2} \\ 1-2\left(\dfrac{\mu-a}{c-a}\right)^2 & \dfrac{a+c}{2} < \mu \le c \\ 1 & c < \mu \end{cases} \quad (1)$$

$$Z(\mu,a,c) = 1 - S(\mu,a',c') \qquad (2)$$

$$PI(\mu,a,c) = \begin{cases} S(\mu,a,c) & \mu \le b \\ Z(\mu,a,c) & b < \mu \end{cases} \quad (3)$$

Where

μ : input variable.

b : center of the *PI* function.

a, c : Start and end of the standard membership functions.

The fuzzy variable maker is a web page containing a dynamic form that can be customized on the fly by setting the number of **PI**s then filling the form with values and saving them in DB in order to use them in the future for any type of application which needs fuzzy membership. The relation in the DB is shown in Fig. 4.
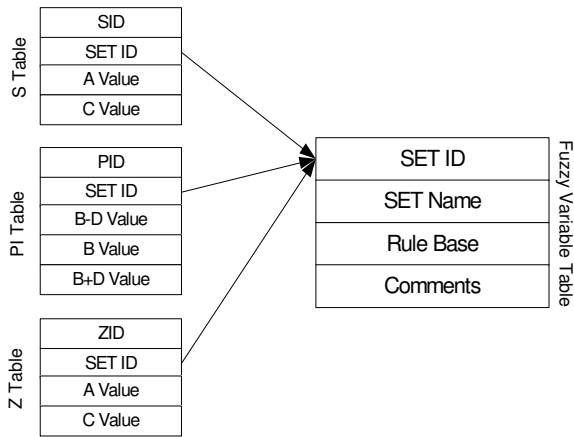

Fig. 4. Table relationships for fuzzy variable maker system

The rules in this work are made by a human experience in an e-Commerce support. So the rank was classified into three levels which are: bad, good and excellent and price into three levels: cheap, suitable and expensive as a study cases.

In summary, the full system contains two databases, relations between each table and others in the two databases shown in Fig. 5.
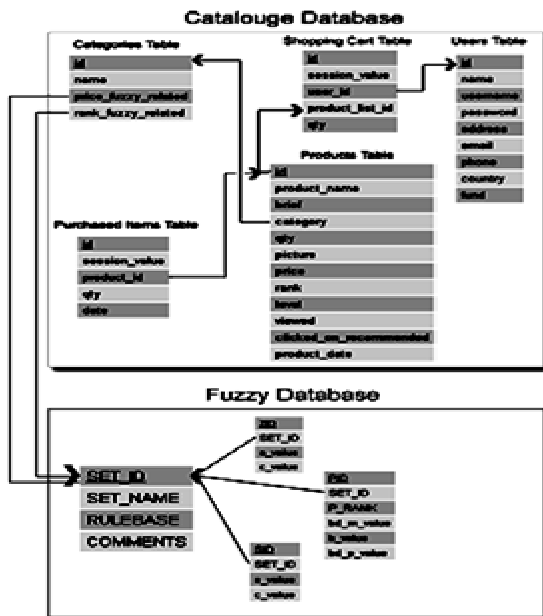

Fig. 5. Database Relations

IV. EECS OPERATION

The operation describing the EECS system consists of the following:

- Client browsing a category
- Client click on a product link
- Product details read by the system are: (Product Id, Product Name, Product Category, Available quantity, Product picture, Product price, Product rank, Product level, and Product date)
- The system passes the product Id to a function called: recommended
- The function recommended reads the product category, and then reads the related fuzzy variables and rule base for that category.
- Then the function applies the *S*, *Z* and *PI* functions for the Price and Rank which return 4 values.
- Defuzzify these values using center of gravity (COG) defuzzification according to equation (4) [7]:

$$\text{output} = \frac{\sum_{i=1}^{M} \mu_{A_i}(y_i) \times y_i}{\sum_{i=1}^{M} \mu_{A_i}(y_i)} \qquad (4)$$

Where M is the number of fuzzy rules, yi is the center of fuzzy set Ai, which is a point in the universe of discourse, and µAi is the membership value of the fuzzy set Ai.

The one value output will compared with values assigned to each product by the admin and taking the nearest value.

Return the Id of that product to display it as the recommended product.

The full details of the (Recommended) circle are shown in Fig. 6 which contains the full fuzzy work of the project.
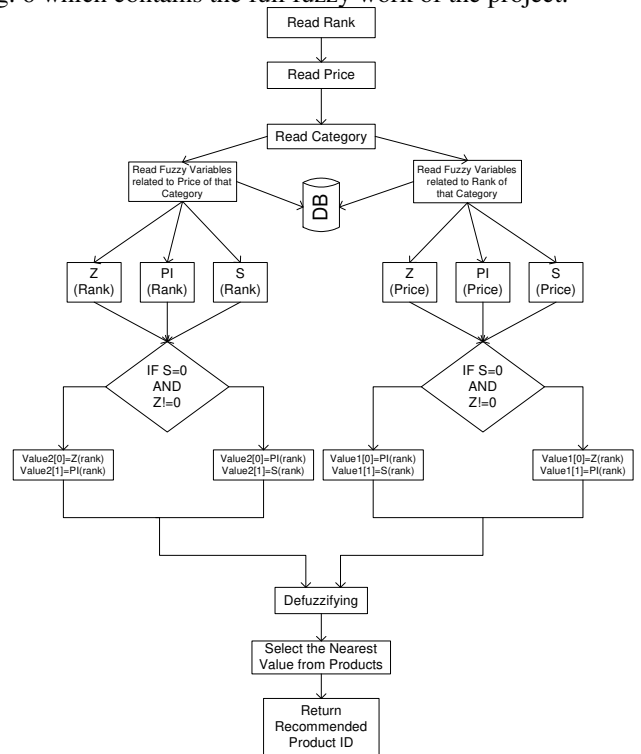

Fig. 6. Recommended function flowchart

V. EECS IMPLEMENTATION AND PRODUCT VIEW

The data that the project applies are real data gathered from Amazon.com, for test proposes. The data are divided into 3 main categories; each category contains two sub categories. The nature of these data is fully different from the others. They categorize and their sub categories are:

Books (PHP and JavaScript)

Digital cameras (Cameras under 2 mega pixels, and Cameras between 2-3 mega pixels)

Video games (Adventure games, and Car racing games)

The product view is the page that contains the development of this project. The work flow is as follows:

Step1: User clicks on a product link.

Step2: The script reads the product Id value using GET method then reads the product details.

Step3: The script reads the price and rank fuzzy related values related to the category of the product.

Step4: Apply the fuzzy formulas to the price and rank values according to their fuzzy values.

Step5: The results now are two fuzzy values for price and two fuzzy values for the rank, the defuzzifying formula will be used.

Step6: The product with the nearest fuzzy value to the result is selected.

Step7: View the details of the product and the recommended product.

VI. SIMULATION RESULTS

Tables (II, III) and (V, VI) alternatively show the result of books category with there rulebase described in Table I and IV, respectively. The two rulebases are the same in the number of inputs and output, but the range of result is different (3 areas for the first one and 5 areas for the second).

The most important thing that may take attention in results is that for some products, the recommended one is the product itself. This is one that proves that the results are right, because of the wide range of data which are different in prices, levels and ranks, there should be a suitable product(s) that can satisfy wide range of customers.

VII. CONCLUSIONS

The following points summarize the main conclusions in this work:

- Cost effective comes as an important benefit of using expert system in e-Commerce. In live customer support, there is a need to employ senior advisor (expert) or even more than one to be online always, while in this method, the experience of the senior advisor will be used in the test operation only for a period of time. Then the rules can update themselves.
- ECCS can be used for unlimited products in unlimited categories, this comes from separating the fuzzy membership values from the products table, i.e. new values can be added and updated always and updating anytime.
- ECCS is fast and easy to integrated, because it doesn't need huge data to read and take a decision.

Excellet	1	2	2

TABLE II

RESULT OF APPLYING RULEBASE 1 ON BOOKS CATEGORIES AND COMPARING THEM WITH A SIMPLE DATA MINING (DEPENDING ON PRICE)

PRODUCT NAME	Data Mining (Sorting product order by price)	Project Result
Advanced PHP Programming	9	10
XML and PHP	8	5.1245
Professional PHP5	7	10
PHP Professional Projects	10	5.0712
PHP and MySQL for Dynamic Web Sites: Visual QuickPro Guide	1	10
MySQL and PHP From Scratch	3	2
Beginning PHP 5 and MySQL: From Novice to Professional	5	10
PHP/MySQL Programming for the Absolute Beginner	4	5.6846
PHP and MySQL for Dummies with CDROM	2	2.3936
Beginning PHP, Apache, MySQL Web Development	6	5.1245

TABLE III

RESULT OF APPLYING RULEBASE 1 ON BOOKS CATEGORIES AND COMPARING THEM WITH A SIMPLE DATA MINING (DEPENDING ON RANK)

PRODUCT NAME	Data Mining (Sorting product order by Rank)	Project Result
Advanced PHP Programming	10	10
XML and PHP	5	5.1245
Professional PHP5	9	10
PHP Professional Projects	2	5.0712
PHP and MySQL for Dynamic Web Sites: Visual QuickPro Guide	7	10
MySQL and PHP From Scratch	1	2
Beginning PHP 5 and MySQL: From Novice to Professional	8	10
PHP/MySQL Programming for the Absolute Beginner	6	5.6846
PHP and MySQL for Dummies with CDROM	3	2.3936
Beginning PHP, Apache, MySQL Web Development	4	5.1245

TABLE I RULEBASE 1

	Cheap	Suitabe	Expensie
Bad	0	0	2
Medium	0	1	2

TABLE I V RULEBASE 2

	Cheap	Suitabe	Expensie
Bad	0	1	3
Medium	1	2	4

Excellet	2	3	4

TABLE V RESULT OF APPLYING RULEBASE 2 ON BOOKS CATEGORIES AND COMPARING THEM WITH A SIMPLE DATA MINING (DEPENDING ON PRICE)

PRODUCT NAME	Data Mining (Sorting product order by price)	Project Result
PHP Professional Projects	9	5.3571
Advanced PHP Programming	8	10
XML and PHP	7	5.9010
Professional PHP5	10	10
Beginning PHP, Apache, MySQL Web Development	1	5.9010
Beginning PHP 5 and MySQL: From Novice to Professional	3	10
PHP/MySQL Programming for the Absolute Beginner	5	6.4038
MySQL and PHP From Scratch	4	3
PHP and MySQL for Dummies with CDROM	2	3.3936
PHP and MySQL for Dynamic Web Sites: Visual QuickPro Guide	6	7

TABLE VI RESULT OF APPLYING RULEBASE 2 ON BOOKS CATEGORIES AND COMPARING THEM WITH A SIMPLE DATA MINING (DEPENDING ON PRICE)

PRODUCT NAME	Data Mining (Sorting product order by Rank)	Project Result
PHP Professional Projects	10	5.3571
Advanced PHP Programming	5	10
XML and PHP	9	5.9010
Professional PHP5	2	10
Beginning PHP, Apache, MySQL Web Development	7	5.9010
Beginning PHP 5 and MySQL: From Novice to Professional	1	10
PHP/MySQL Programming for the Absolute Beginner	8	6.4038
MySQL and PHP From Scratch	6	3
PHP and MySQL for Dummies with CDROM	3	3.3936
PHP and MySQL for Dynamic Web Sites: Visual QuickPro Guide	4	7

REFERENCES

[1] H. Zhang and Y. Qiu, "Intelligent Automated Negotiation Mechanism in E-commerce," in *Proceedings of the International Conference on Advanced Intelligent Mechatronics,* Monterey, California, USA, 2005, pp. 1395-1400.
[2] V. Galant, "Blending E-Commerce Theory and Application," *The IEEE Computer Society*, Vol. 6, Issue 1, January 2005.
[3] Kong, W., and Hung Y. C., "Modeling Initial and Repeat Online Trust in B2C E-commerce," in *Proceedings of the 39th Hawaii International Conference on System Sciences*, 04-07 Jan. 2006, vol.6, pp. 120b-120b.
[4] Weng, L., Xu, Y. and Li, Y., "A Framework for E-Commerce Oriented Recommendation Systems," in *Proceedings of the International Conference on Active Media Technology (AMT 2005)*, May 2005. pp. 309-314.
[5] J. Castagnetto, H. Rawat, S. Schumann, C. Scollo, D. Veliath, *Professional PHP Programming*, Wrox Press Ltd, 1999.
[6] S. M. Bridges, and R. B. Vaughan, "Fuzzy Data Mining and Genetic Algorithms Applied to Intrusion Detection," *National Information Systems Security Conference (NISSC)*, Baltimore, MD, pp 16-19, October 2000.
[7] S. A. Ismaeel and K. M. Al-Jebory, "Adaptive Fuzzy System Modeling," *Eng. Technology*, vol.20, no.4, pp.201-212. 2001.

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