

## **COLLECTeR Europe 2006**

Proceedings edited by  
Petra Schubert and Daniel Risch

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# **Collaborative Electronic Commerce Technology and Research**

## **Background of COLLECTeR Europe 2006 in Basel, Switzerland**

The COLLECTeR series of conferences (<http://www.collector.org/>) was established to link research centres at universities to form a basis for collaborative research in Electronic Commerce.

### **Conference Topic 2006: Collaborative Business**

The “networked economy” challenges organizations to consider the use of Collaborative Business, namely the combined deployment of groupware and e-business infrastructures. Mobile computing technology and collaboration support have reached a level that makes a seamless integration of communications and data processing economically feasible. This constitutes our notion of Collaborative Business: the timely bundling of communication, coordination, and collaboration activities.

The focus of COLLECTeR Europe 2006 is on new forms of Customer Relationship Management (CRM) – including mobile CRM – that cover the whole value chain and use new working modes. This concerns questions related to the optimisation of channels, the improvement of customer acquisition and retention, and after-sales contacts and services.

### **Aim**

COLLECTeR Europe 2006 is a forum for researchers to present and discuss their current and ongoing work. In order to stimulate a lively discussion the number of participants is limited to approx. 30 people. The aim of the event is to bring together researchers and practitioners to discuss foundations and industry potentials of Collaborative Business. This includes the exploration of the effective deployment of novel technologies and services.

### **Contributions are grouped into sessions covering the following topics:**

- Digital archiving, privacy and property rights
- Personalization
- Markets and business processes
- Mobile and ambient business
- Communities and Work Group Collaboration
- Social systems
- Security devices and secure communication

All paper submissions to COLLECTeR Europe 2006 represent the original work of the authors. There were no rigid guidelines regarding paper size for the final research papers. We asked to submit between 6 and 8 pages.

The social event, the conference dinner, lunches and breaks were sponsored by Ecademy, the National Network of Excellence of the Swiss Universities of Applied Sciences for E-Business and E-Government.

Basel, June 2006

Petra Schubert and Daniel Risch

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# Recommending Products with a Fuzzy Classification

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## Abstract

*Recommender systems are becoming more and more important for online shop systems. A recommender system suggests potentially interesting products to customers. However, shop administrators typically want to influence the recommendations due to the fact that not all products have the same value for the shop. The shop administrators therefore prefer to recommend products with a higher product value. This paper starts by suggesting a fuzzy classification to precisely calculate the value of the products. Afterwards the calculated product values can be utilized to influence a recommender system to suggest products with a higher value more often.*

## 1 Introduction

In the last years, the number of recommender systems used in online shop systems has strongly increased and is becoming an important success factor for electronic commerce applications [Manber/Patel/Robinson 2000, Schubert/Koch 2002]. A recommender system can be utilized to suggest similar, related or potentially interesting products for a given customer. Most recommender systems use the collaborative filtering method in order to provide personalized information. Thereby implicit and explicit information of a customer, like past orders or viewed products, is used to calculate recommendations.

A lot of work in the field of recommender systems focuses on how to calculate appropriate recommendations for given customers [Balabanovic/Shoham 1997, Resnick/Varian 1997, Burke 2002, Adomavicius/Tuzhilin 2005]. These recommendations do not necessarily match actual business needs as e.g. for a shop administrator, not all products are equally valuable. There are items one would like to recommend more intensely than others because of higher margins or remaining items on stock. Therefore, shop administrators are keen to – at least slightly – influence the output of recommender systems to better match business needs.

In this paper we propose an approach to solve the problem mentioned above. We start by examining typical attributes that influence the value of an item from a shop adminis-

trator's perspective. These values may include profit margin, turnover or service quality. Then we will introduce a classification system based on fuzzy logic to classify all products. Fuzzy logic, unlike statistical data mining techniques such as cluster or regression analysis, enables the use of non-numerical values and introduces the notion of linguistic variables. Using linguistic terms and variables will result in a more human oriented querying process that is important, as shop administrators are typically not technicians.

The main advantage of fuzzy classifications compared to classical ones is that elements are not limited to one single class but can be assigned to several classes. Furthermore, each element has one or more membership degrees, which illustrate to what extent this element belongs to the particular classes it has been assigned to. The notion of membership gives a much better description of the classified elements and also helps to find the potential or the possible weaknesses of the considered elements.

In everyday business life, many examples can be found where fuzzy classification would or at least could be useful. In customer relationship management (CRM) for instance, a standard classification would sharply classify customers of a company into a certain segment depending on their buying power, age and other characteristics. If the client's potential of development is taken into account, the clients often cannot be classified into only one segment anymore, i.e. customer equity [Blattberg et al. 2001]. Other examples are risk management in an insurance company or client's credit worthiness in a bank. In the latter case, studies have shown that using sharp classifications, clients with almost similar risks were classified very differently. Also the opposite happened. The judgement of customers with clearly different properties was very similar.

In this paper we propose not to apply a fuzzy classification on customers but on products. The results of this classification can then be used to influence the output of a recommender system in a way that recommended items, on the one hand, match customer preferences and, on the other hand, are most valuable from a shop administrator's perspective.

The remainder of the present paper has the following structure: Section 2 defines the notion of product value and introduces the fuzzy classification concept applied to products. After a short introduction to the different types of recommender systems, Section 3 exposes two different approaches allowing the integration of the product values in recommender systems. Section 4 gives a conclusion and an outlook.

## **2 Fuzzy Classification of Products**

A typical shop offers a large number of different products. A classification of these products based on different attributes like margin, quality or turnover can be used to gain further information and to optimise the offered product range. For customers, it has been shown that a fuzzy classification can be used to calculate an individual customer value [Meier et al 2005]. Based on these findings we assume this approach to be a promising way to gain product values as well.

### **2.1 Product Value**

For the shop administrator, the product value may vary based on diverse characteristics like current and future demand, expected margin and turnover as well as quantity in stock. The product value is quite similar to the customer value as it predicts the fu-

ture return on what a shop administrator knows by now. In the case of customers, a company is typically interested in strengthening the relationships with promising customers having a high customer value [Werro/Meier/Mezger 2005]. This can be achieved for example by assigning personalized discounts or by giving special conditions [Werro/Stormer/Meier 2005]. The same argumentation can be used for products. Typically, the product value for the offered products varies. The reasons are a number of product attributes including:

- **Margin:** The margin is one of the most important attributes for shop administrators. The margin is the difference between purchase price and selling price. Typically this value differs from product to product. The shop administrator is normally more interested in selling products with a high margin.
- **Quality:** The quality of the product is another very important attribute. When a low quality product is sold, the chances for service costs are higher compared to a high quality product. Therefore, the shop administrator will try to sell products with a high quality to avoid service costs.
- **Size:** Size could be another important attribute. For large products, a big effort has to be done in order to send it to a customer. This includes packing, providing a logistics enterprise that transports the product and final billing. Additionally, large products occupy a greater amount of the inventory space.
- **Supplier Charge:** In brick and mortar stores, suppliers often pay for putting their products on an emphasized place. The shop administrator could retrieve a supplier charge for recommending their products.
- **Stock:** The amount and kind of items on stock influence the interest of the shop administrator to recommend products. A shop administrator is much more interested in selling items he has on stock than in reordering certain items for individual customers.

Note that these attributes may vary from shop to shop and that for concrete examples other attributes could become even more important. Note also that it is not the aim of this paper to define different product attributes that are of importance to a shop administrator. It is only important to understand that different products in the product range typically vary in their product value.

## 2.2 Fuzzy Classification with Linguistic Variables

The fuzzy classification principle is based on the context model proposed by Chen [1998]. In this model, a context is added to every attribute defined over a domain. A context is a partition of the domain of an attribute into equivalence classes. The definition of the equivalence classes on the domain of the attributes leads to a multi-dimensional classification space.

Throughout this paper, a simple example of product classification is used. In this example, products are evaluated by only two attributes, margin and quality. In addition, these two qualifying attributes are partitioned into two equivalence classes. The pertinent attributes and contexts are:

- *Margin in percent:* The attribute's domain is defined by  $[0,50]$  and is divided into two equivalence classes  $[0,25]$  and  $[26,50]$ . The first class implies a low margin, the second class a high margin.



- *Quality*: The domain of the attribute quality can be categorized in 4 categories (top, medium, sufficient, poor). The equivalent classes are (top, medium) for good quality and (sufficient, poor) for bad quality.

To derive fuzzy classes from sharp contexts, the qualifying attributes are considered as linguistic variables, and verbal terms are assigned to each equivalence class [see Zimmermann 1992]. With the help of linguistic variables, the equivalence classes of the attributes can be described more intuitively (see Fig. 1). In addition, each term of a linguistic variable represents a fuzzy set. Each fuzzy set is determined by a membership function  $\mu$  over the domain of the corresponding attribute (see Fig. 2)

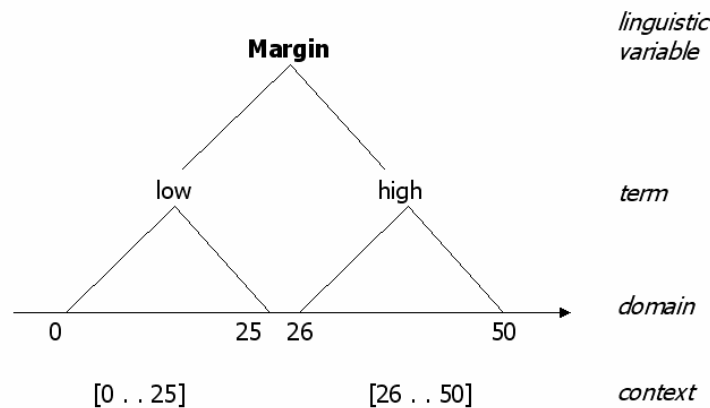


Fig. 1: Concept of linguistic variable

As margin is a numeric attribute, its membership functions  $\mu_{\text{high margin}}$  and  $\mu_{\text{low margin}}$  are continuous functions defined on the whole domain of the attribute. For non-numeric attributes like quality, step functions are used; the membership functions  $\mu_{\text{good quality}}$  and  $\mu_{\text{bad quality}}$  define a membership grade for each term of the attribute's domain. In this example, the shop administrator has to choose the right quality for each product. Another way for automatically assigning the quality to the products would be to measure the return rate of the products. In this case, the quality would be a numeric attribute expressing the percentage of returned product.

The definition of the equivalence classes of the attributes margin and quality determines a two-dimensional classification space shown in Fig. 2. The four resulting classes C1 to C4 could be characterized as 'Best Product' (C1), 'Off-grade Product' (C2), 'Less Profitable Product' (C3), and 'Non-ideal Product' (C4).

Fig. 2 shows an example with a possible product (DVD Le Doulos). With a sharp classification, this product would be classified only in class C1. However, with a fuzzy classification, this product belongs to all classes at the same time, namely (C1:30%, C2:25%; C3:25%; C4:20%).

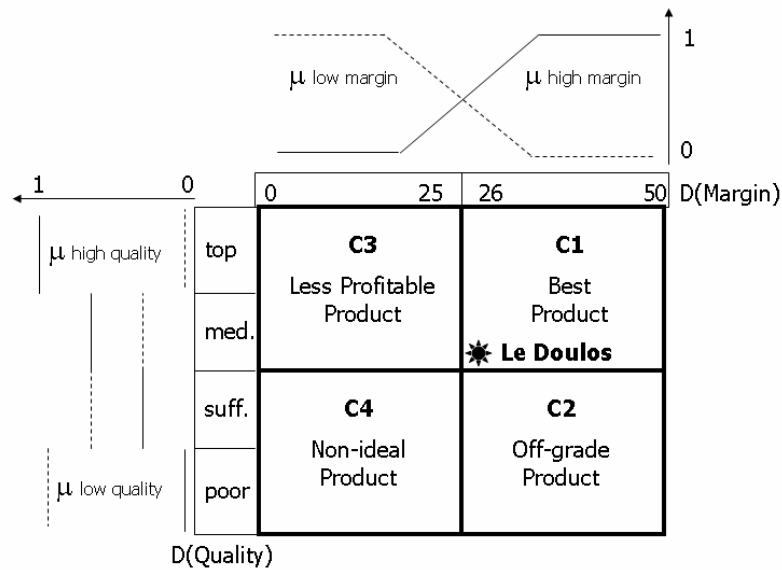


Fig. 2: Fuzzy classification space defined by margin and quality

The product value can now be easily derived from the fuzzy classification. Indeed the membership degrees of the products in the different classes can precisely determine the values they deserve. For that purpose, a rating between 0 and 1 can be associated with each fuzzy class: for instance C1 gets a rating of 1, C2 a rating of 0.66, C3 a rating of 0.33, and C4 a rating of 0. The product value can then be calculated by the aggregation of the value of the classes it belongs to in proportion to its membership degrees. The value of the DVD Le Doulos therefore is:

$$(1 * 0.3) + (0.66 * 0.25) + (0.33 * 0.25) + (0 * 0.2) = 0.3 + 0.165 + 0.083 + 0 = 0.55$$

### 3 Connecting a Product Classification with a Recommender System

To connect the results of a product classification with a recommender system, two different strategies can be explored:

- Use the product classification results to reorder the ranking list
- Integrate the value of a product classification directly in a recommender system

After a small introduction to recommender systems, the two different integration strategies will be demonstrated.

#### 3.1 Recommender Systems

Recommender systems can be classified in three groups based on the approach used to generate the recommendations [Adomavicius/Tuzhilin 2005]:

- Content-based filtering approach
- Collaborative filtering approach
- Hybrid approach

For the content-based filtering approach attributes are assigned to each product. By using information retrieval techniques on those attributes it is possible to derive the similarity between the products, so that two products with common attributes have a

high grade of similarity [Basu/Hirsh/Cohen 1998]. The advantage of content-based filtering is the possibility of precisely defining relations between products, namely for cross or up-selling. However this advantage comes up at a high price. On the one hand, this approach requires the manual definition of a great number of additional information, e.g. keywords and attributes for each product. This information should be permanently up-to-date. On the other hand, the content-based filtering uses complicated data mining techniques to generate the personalized information.

In contrast to content-based filtering, the collaborative filtering approach only needs information about the user interaction and transaction such as products ratings, orders or clickstream information in order to provide recommendations. All of this information is continuously provided by the users when browsing the websites, buying or rating products. Another major difference is that the collaborative filtering approach is based on customer context information. So the strength of this approach is its full automation and its user-based semantic. However this approach requires a certain amount of data in order to provide valuable results, i.e. the number of customers and more important the quantity of users' transactions (often called the cold start problem and the first-rater problem).

The third class of recommender systems uses a hybrid approach which is a combination of the content-based and the collaborative filtering [Burke 2002]. This approach combines the advantages of having a precise description of the relationships between the objects based on the keywords and on the users' interactions. This allows pertinent recommendations from the beginning with a continuous improvement over time by gathering and using more and more users' information.

### **3.2 Reorder the Ranking List**

The results of most recommender systems are a list of top- $n$  products that could be used for a certain recommendation where  $n$  can be freely chosen by the shop administrator. If, for example, the shop administrator chooses the value 5 for  $n$ , a recommender system returns the top 5 recommended products for a certain user. It is now possible to reorder this list by using the product values gained from the product classification. In Fig. 3, the 5 recommended products are reordered accordingly to their values. In this example, the product DVD Léon is moved from the top rank to rank four due to its lower product value compared to the other products. Using this approach, it is even possible to calculate the top  $m$  products (with  $m > n$ ), reorder the ranking list and omit the last  $m-n$  products. In this case, products with the lowest value won't be recommended at all.

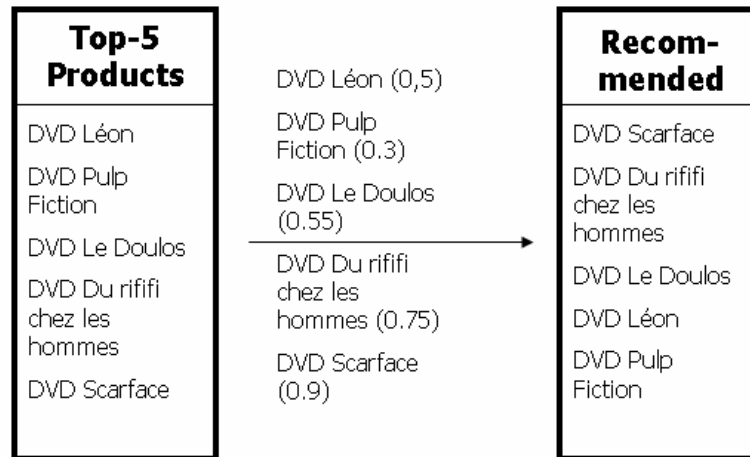


Fig. 3: Reordering of the recommendations based on the product values

### 3.3 Direct Integration

The second approach is to directly integrate the product value in the calculation of the recommender system. This is possible for collaborative filtering systems. These systems use as input the rating matrix  $R$  with the customers  $U$  in the row dimension and the products  $P$  in the column dimension. This two-dimensional matrix represents the relationships between users and products. Typically, the value  $r_{u,p}$  for each cell is based on implicit or explicit data gained from the customer, for example the product ratings. Each cell will contain a value between -1 and +1 representing the judgment of the customer for the product where -1 denotes a strong dislike and +1 a strong affection.

In a first step, the average product value  $pv_{avg}$  should be calculated. Then, for each cell  $r_{u,p}$  in the rating matrix, the product value  $pv_p$  is examined. The difference  $a = pv_p - pv_{avg}$  can be calculated and added to the value of each cell:  $r_{u,p} = r_{u,p} + a$ .

An example of this approach is shown in Fig. 4. The rating matrix on the left side contains 5 columns (for five products) and two rows (for two users). The average product value (0.6) is determined, after this the difference  $a = pv_p - 0.6$  can be calculated for each product and added to each value of the cells. The resulting rating matrix is shown on the right side. Note that products with a low product value (like DVD Pulp Fiction) resulted in a reduced rating (i.e. from 0.5, resp. 0.9, to 0.2, resp. 0.6) and products with a high product value (like DVD Scarface) came to a higher rating (i.e. from 0.1, resp. 0.6, to 0.4, resp. 0.9). A higher rating rises the chances of the products of being recommended.

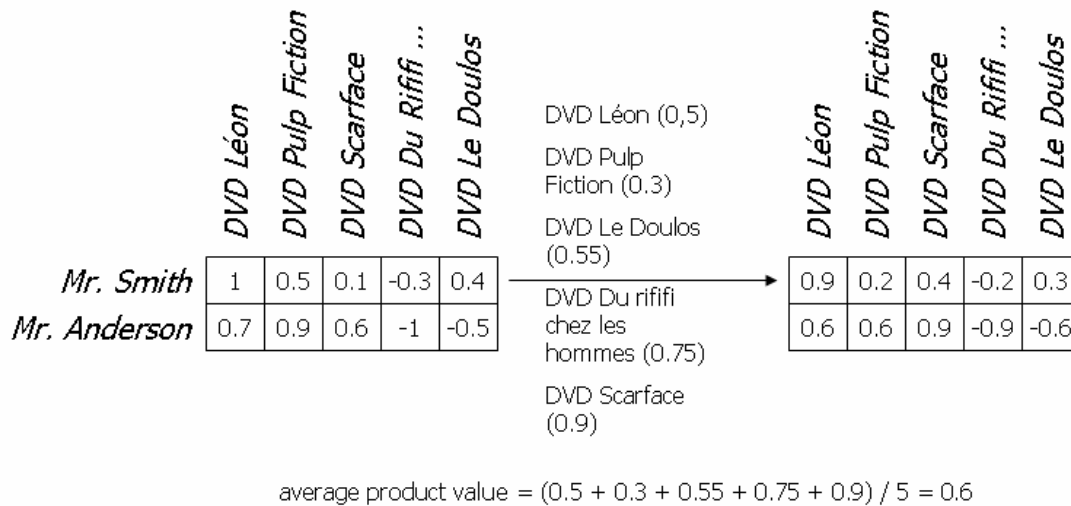


Fig. 4: Integration of the product values into the rating matrix

#### 4 Conclusion and Outlook

We showed that a fuzzy customer classification is a practical instrument to calculate the value of the customers [Meier et al 2005]. This paper described how the idea of a fuzzy classification could be used to calculate a value for each product. For a shop administrator, the product values have similar meanings like the customer values. One possible application for the product values is the integration within a recommender system. This paper showed two different strategies to accomplish this task.

However, the product values can be used for other applications as well:

- The shop administrator can determine problematic products. In our example, these products would reside in class C4. The shop administrator could think about removing these products from the offered product range.
- The product value is a good indicator when negotiating with the suppliers.
- The product value can also be used to determine possible discounts (cf. [Werro/Stormer/Meier05]). The shop administrator could offer higher discounts on products that have a high product value.

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