

# Fuzzy Sets in E-Commerce: Targeted Advertising and Catalog Search

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Electronic Commerce (E-Commerce) is rapidly becoming an important means of transacting business. This activity takes advantage of the confluence of communication and computing technologies provided by the internet. Among some of the notable features available as a result of this confluence, are the real time connection of entities in widely separated locations, the processing and storage of large amounts of information and the skillful use of multi-media interfaces. E-commerce itself spans a wide range of interactions including business to business, business to consumer (individual) and individual to individual.

Fuzzy set technologies, with its abilities to provide a formal representation of the kinds soft humanlike conceptualization and reasoning will be able to make many very useful contributions to the development of such a human centered endeavor as E-Commerce. Clearly the searching for services and products will benefit from the facility of linguistic descriptions and partial matching. The rapidly developing business to business activity of automated procurement will benefit from the kinds of intelligent decision systems that can be constructed using fuzzy technology. We have focused on the application of fuzzy technologies two areas E-Commerce, targeted marketing and catalog search.

On the internet, as in the case of radio and television advertising is supporting a relatively cost free distribution of information and entertainment. It has emerged as a primary mode of revenue generation on the Web and as such has become an important part of E-Commerce. Banner and other type of attention getting types of advertising are being extensively used. Because of the internet's ability to instantaneously process information an important distinction exists between web based advertising and advertising in other media, that being the web's ability to provide user specific or targeted advertising. One focus of our research has been on the use of fuzzy intelligent agents to help potential advertisers make decisions regarding visitors to a web site. Two decisions of importance to an advertiser are whether a visitor to a web site is a good person to advertise too and

secondly, if so, how to advertise to this person, i.e. what products and what mode. One framework for addressing these decisions can be based upon the use of pattern recognition based methods. Specifically we see an agent residing at a website, representing a potential advertiser, having a collection of "patterns" relating the qualities of prototypical visitors and their appropriateness for various modes of advertising. By matching the knowledge available about the visitor with the patterns stored the agent is able to make an informed decision as to what if any kind advertisement to present to the visitor. Central to such a system is the procedure for matching the qualities and attributes of the visitor to the site with those of the prototype patterns stored by the resident agent. Here we see great potential for the use of kinds of partial matching techniques available in the the theory of fuzzy logic.

The key component here is the intelligent agent that resides at the website whose function is to make the decisions for the advertiser. The capacity of the agent depends upon the type of information that is available about the visitors to the website, here data mining will be useful. In the following we shall describe the use of fuzzy systems modeling for the construction of these types of intelligent agents.

A fuzzy systems model consists of a collection of  $n$  rules of the form

$$\text{If } V_1 \text{ is } A_{i1} \text{ and } V_2 \text{ is } A_{i2}, \dots \text{ and } V_p \text{ is } V_{ip} \\ \text{then } U \text{ is } B_i.$$

The  $A_{ij}$ 's and  $B_i$ 's are fuzzy subsets over the domain of the corresponding variable, generally these fuzzy subsets are representations of linguistic values.

The purpose of the fuzzy systems model is to determine the value of the consequent variable for a given manifestation of the antecedent variables. Essentially a fuzzy system model can be viewed as a knowledge based representation of the functional relationship between the antecedent variables, the  $V_i$ 's and  $U$ , that is  $U = f(V_1, V_2, \dots, V_n)$ . The decision making mechanism of such a model is straight forward and simple. Assume we have a manifestation of the input variables,  $V_j = x_j^*$  the process

used to determine the value of the consequent variable is as follows:

1. Calculate the firing level of each rule as

$$\lambda_i = \text{Min}_{j=1, \dots, p} [A_{ij}(X_j^*)]$$

2. Calculate the unique output of the model as a weighted average of the firing levels and the consequents

$$y^* = \frac{\sum_{i=1}^n \lambda_i b_i}{\sum_{i=1}^n \lambda_i}$$

We now turn to the use of this technology for the construction of the intelligent agents. In the framework of the construction of intelligent agents for advertising decisions the  $V_i$ 's, the antecedent variables, would be used to indicate relevant characteristics useful in describing a visitor to a site. The consequent variable  $U$  would correspond to a variable indicating the amount the advertiser would be willing to pay to advertise to the visitor, their bid. As we shall see each of the rules making up the knowledge base will correspond to the description of a prototypical visitor to a site along with the appropriate bid for this type of visitor.

Let us consider the construction of such an intelligent agent for use by an advertiser. In building the model we shall use a classification of potential visitors to this site, into five categories. The five categories we shall use are: very good, good, moderate, poor and very poor. These categories will indicate the potential of a visitor as a purchaser of the services the owner of the intelligent agent is selling.

Furthermore, we should associate with each category an appropriate bid. In particular

Category	Bid
Very Good	$u_1$
Good	$u_2$
Moderate	$u_3$
Poor	$u_4$
Very Poor	$u_5$

where  $u_i > u_j$  if  $i < j$ . Thus in the above we are indicating that for a person who is a good candidate for their services the appropriate bid is  $u_2$ .

If we shall assume that there are two characteristics available informing us about the visitors to this sight, age and income, the following table provides a fuzzy partitioning of these characteristics which describes our view of potential customers based on these variables

old	very poor	poor	moderate
middle age	very poor	moderate	good
young	poor	good	very good
very young	poor	moderate	very good
	low income	middle income	high income

Using this table we can obtain a fuzzy systems model.

- if age is *old* and income is *low* then  $U$  is  $u_5$
- if age is *old* and income is *middle* then  $U$  is  $u_4$
- if age is *old* and income is *high* then  $U$  is  $u_3$
- if age is *middle* and income is *low* then  $U$  is  $u_5$
- if age is *middle* and income is *middle* then  $U$  is  $u_3$
- if age is *middle* and income is *high* then  $U$  is  $u_2$
- if age is *young* and income is *low* then  $U$  is  $u_4$
- if age is *young* and income is *middle* then  $U$  is  $u_2$
- if age is *young* and income is *high* then  $U$  is  $u_1$
- if age is *very young* and income is *low* then  $U$  is  $u_4$
- if age is *very young* and income is *middle* then  $U$  is  $u_2$
- if age is *very young* and income is *high* then  $U$  is  $u_1$

While advertising can be seen as a process of a "seller looking for an appropriate buyer" many other aspects of the web and its use in E-Commerce involve a "buyer looking for an appropriate product." The whole issue of searching for information and services on the web is of this nature. More specific to E-Commerce is the problem of searching product catalogs for merchandise.. Here we desire to provide a system in which a user can specify their desires in a way that is most natural for them and then try to match this with a description of products available in the catalog. Here again the ability to perform the types of partial matching available in fuzzy logic is needed.

#### Related Publications

- [1]. Yager, R. R., "Intelligent agents for World Wide Web advertising decisions," International Journal of Intelligent Systems 12, 379-390, 1997.
- [2] Yager, R. R. and Filev, D. P., Essentials of Fuzzy Modeling and Control, John Wiley: New York, 1994.