Web Personalization Based on Fuzzy Aggregation and Recognition of User Activity

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ABSTRACT

This article addresses Web personalization based on the analysis of individual user activity. However, human behavior is characterized by uncertainties that should be considered in the personalization algorithms. Fuzzy logic allows taking into account different types of uncertainty. Therefore, the paper presents a method for Web personalization based on fuzzy aggregation and recognition of user activity. The advantages of this approach are (1) the ability to use two types of fuzzy integrals without using the necessary expert set of fuzzy measures and (2) covering all stages of the personalization from aggregation of a single user’s query parameters to aggregation of an individual user’s profiles in a single parameter of group of users.

Keywords: Choquet Fuzzy Integral, Fuzzy Aggregation, Fuzzy Measure, Sugeno Fuzzy Integral, Web Personalization

INTRODUCTION

The story of the Web began with an essay written by Vannevar Bush, “As We May Think” published in July, 1945 in the Atlantic Monthly (Bush, 1945). In this essay, Bush described the theory of Memex a proto-hypertext system that was later developed into the World Wide Web.

Today the Web is increasing exponentially and now this phenomenon is more than just a hypertext. The Web began to acquire elements of intelligence. One such element is the ability to adapt to a particular user. For example, the Google search engine allows one to personalize the search based on user search history (Sullivan, 2009). Online marketing and advertising are also becoming more individualized, aimed separately at each user (consumer) (Chiu, 2001; Markellou, Rigou, & Sirmakessis, 2009). Flexible security personalization approaches will allow an Internet or Web service provider to negotiate with its clientele to an agreed-upon personalized security policy (Yee & Korba, 2008). Interface designers suggest using the personality concept, which helps build a personal user’s model based on the interests of individuals (Casas et al., 2008).

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Verma, Verma, and Bhatia (2011) provide an overview of research articles in the field of Web personalization. According to Verma, Verma, and Bhatia (2011), Web Personalization is defined as the process of customizing the content and structure of a web site to the specific and individual needs of each user taking advantage of the user’s navigation habits.

Today, the main methods for Web personalization are data mining techniques which use clustering algorithms. Clustering is widely used in fields such as machine learning, information retrieval, etc. According to Marmanis and Babenko (2009) the problem of identifying groups of users naturally lends itself to the use of clustering methods. Data clustering can also be used to generate user profiles based on information about the activity of each user and then for the formation of groups of users based on their profiles. But current clustering methods do not take into account all the factors for successful application in many real tasks. Instead, extensive experimentation with the pattern recognition methods is combined with intensive automatic machine learning which yields both approach and knowledge for resolving a lot of sophisticated problems.

Adapting to a particular user is a difficult task because it is necessary to take into account inherent human uncertainty since man is unstable and spontaneous by nature. Many uncertainties of different kinds are present in the global network; for example, Web pages appear and disappear, the context of search keywords is constantly changing. Therefore, a search on the network is indistinct by its nature. In order to work with this uncertainty using computers it should be formalized in any way. Fuzzy logic allows us to take into account different kinds of uncertainties. Fuzzy clustering of the users’ profiles can be used to construct fuzzy rules and conclusions in order to modify queries. The results can be used for knowledge extraction from users’ profiles for marketing purposes (Loia et al., 2010).

However, the simple application of fuzzy logic to personalize the web may not lead to desired results, because it simplifies the actual picture of the user’s preference. One of these simplifications is the usage of the weighted arithmetic mean operator for the aggregation of several criteria when each criterion is assigned a weight yet interaction between the criteria is not taken into account (Marichal, 2000b). The use of the Sugeno and Choquet fuzzy integrals with respect to fuzzy measure allows us to consider such interactions within the model (Grabisch, 1996). But in this case there is a problem of identification of fuzzy measures. This problem is caused not only by exponentially increasing complexity of fuzzy measures based on the criteria number, but by lack of clear understanding of the essence of fuzzy measure concept as well (Grabisch, 1996). Usually this problem is solved by means of significant simplification of the model and applying various support tools aimed for the identification of fuzzy measures (Takahagi, 2000; Wu & Zhang, 2010) or by identifying fuzzy measures without expert’s presence. For example, the Sugeno fuzzy integral is used to aggregate the search results received from the various search engines on the Web (Cui & Feng, 2005).

In this paper, an approach to personalization in the network using a recognition method based on aggregation of data sources involving the Sugeno and the Choquet fuzzy integrals is suggested. The difference between this approach and existing ones lies in the ability to use the Choquet integral without the necessary expert set of fuzzy measures (which is almost impossible in real systems), to cover all stages of the personalization starting from aggregation of single user’s query parameters and ending with aggregating of individual user’s profiles to a single parameter of a group of users. First, we address the necessary concepts and definitions of fuzzy integrals. Second, we turn to the procedure of forming the users’ profiles (a user’s profile is an information set which involves queries, email, habits, etc.). The paper concludes with an explanation of user profile recognition method and experimental results.
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