Chapter 8.5

Web Content Recommendation Methods Based on Reinforcement Learning

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ABSTRACT

Information overload is no longer news; the explosive growth of the Internet has made this issue increasingly serious for Web users. Recommender systems aim at directing users through this information space, toward the resources that best meet their needs and interests. In this chapter we introduce our novel machine learning perspective toward the web recommendation problem, based on reinforcement learning. Our recommendation method makes use of the web usage and content data to learn a predictive model of users' behavior on the web and exploits the learned model to make web page recommendations. Unlike other recommender systems, our system does not use the static patterns discovered from web usage data, instead it learns to make recommendations as the actions it performs in each situation. In the proposed method we combined the conceptual and usage information in order to gain a more general model of user behavior and improve the quality of web recommendations. A hybrid web recommendation method is proposed by making use of the conceptual relationships among web resources to derive a novel model of the problem, enriched with semantic knowledge about the usage behavior. The method is evaluated under different settings and it is shown how this method can improve the overall quality of recommendations.

INTRODUCTION

The amount of information available on-line is increasing rapidly with the explosive growth of the World Wide Web and the advent of e-Commerce. Although this surely provides users with more options, at the same time makes it more difficult to find the "relevant" or "interesting" information from this great pool of information. This problem is commonly known as *information overload*: The state of having too much information to make a decision or remain informed about a topic. To address the problems caused by information overload, recommender systems have been introduced (Resnick & Varian, 1997). These systems can be defined as the personalized information technologies used to predict a user evaluation of a particular item (Deshpande & Karypis, 2004) or more generally as systems that guide users toward interesting or useful objects in a large space of possible options (Burke, 2002).

Recommender systems have been used in various applications ranging from predicting the products a customer is likely to buy (Shany *et al.*, 2005), movies, music or news that might interest the user (Konstan *et al.,* 1998; Zhang & Seo, 2001) and web pages that the user is likely to seek (Cooley *et al.*, 1999; Fu *et al.*, 2000; Joachims *et al.*, 1997; Mobasher *et al.*, 2000a), which is also the focus of this chapter. Web page recommendation is considered a user modeling or web personalization task (Eirinaki *et al.*, 2004). One research area that has recently contributed greatly to this problem is web mining. Most of the systems developed in this field are based on web usage mining which is the process of applying data mining techniques to the discovery of usage patterns form web data (Srivastava *et al.*, 2000). These systems are mainly concerned with analyzing web usage logs, discovering patterns from this data and making recommendations based on the extracted knowledge (Fu *et al.*, 2000; Mobasher *et al.*, 2000a; Shahabi *et al.*, 1997; Zhang & Seo, 2001). One important characteristic of these systems is that unlike traditional recommender systems, which mainly base their decisions on user ratings on different items or other explicit feedbacks provided by the user (Deshpande & Karypis, 2004; Herlocker *et al.*, 2000), these techniques discover user preferences from their implicit feedbacks, e.g. the web pages they have visited. More recently, systems that take advantage of domain knowledge, e.g. a combination of content, usage and even structure information of the web, have been introduced and shown superior results in the web page recommendation problem (Li & Zaiane, 2004; Mobasher *et al.*, 2000b; Nakagawa & Mobasher, 2003).

In this chapter we will introduce a different machine learning perspective toward the web recommendation problem, which we believe is suitable to the nature of the problem and has some intrinsic advantages over previous methods. Our recommendation method falls in the category of methods that aim at supporting user's short-term information needs on a single website by recommending web pages to the user based on their navigation, such as previous works presented in (Mobasher *et al.*, 2000a,b; Li & Zaiane, 2004; Nakagawa & Mobasher, 2003). The proposed recommendation method makes use of the web usage and content data to learn a predictive model of users' behavior on the web and exploits the learned model to make web page recommendations to the users (Taghipour *et al.*, 2007; Taghipour & Kardan, 2007; Taghipour & Kardan, 2008). We model the recommendation process as a Reinforcement Learning (RL) problem (Sutton & Barto, 1998) or more specifically a Q-Learning problem. For this purpose we have devised state and action definitions and rewarding policies, considering common concepts and techniques used in the web mining domain. Then we train the system using web usage logs available as the training set, by adapting a variation of Q-learning algorithm. Our recommendation method differs from the previous methods in which the purpose was to find explicit and static patterns or rules, e.g. association rules

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