Modeling Activation Processes in Human Memory to Improve Tag Recommendations

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ABSTRACT

Social tagging systems enable users to collaboratively assign freely chosen keywords, so-called tags, to resources. These tags can then be used for navigating, searching, organizing and finding content, and serendipitous browsing [5, 6]. Hence, tags have become an essential instrument of Web 2.0, the social Web, assisting users during these activities. While in social tagging systems users can freely choose keywords for their bookmarked resources, they have to create a set of descriptive tags on their own, which can be a demanding task [9].

As a solution, a variety of tag recommender algorithms, such as Collaborative Filtering, FolkRank or Pairwise Interaction Tensor Factorization, have been proposed. Tag recommenders suggest a set of tags for a given user-resource pair based on previously used and assigned tags and aim at helping not only the individual to find appropriate tags but also the collective to consolidate the shared tag vocabulary [9]. Furthermore, Dellschaft & Staab [3] have shown that personalized tag recommenders can increase the indexing quality of resources, making it easier for users to understand the information content of an indexed resource based on its assigned tags.

Although current state-of-the-art tag recommender approaches perform reasonably well in terms of recommender accuracy, most of them are designed purely data-driven. As a result, they are based on either simply counting tag frequencies or computationally expensive calculation steps (e.g., calculating user similarities or factorizing entities). Hence, these approaches typically ignore important insights originating from cognitive research of how people draw on information (e.g., word or tags) in their memory, which is essential for the design of tag recommenders, that should attempt to mimic the user's tagging behavior. Thus, in this work we aim to better understand and improve tag recommendations using a model of human memory that accounts for these insights.

Therefore we draw on formalisms of the cognitive architecture ACT-R [1], a rational approach towards human memory, to predict a user's tag choices based on the user's tagging history and the current semantic context, i.e., the resource to be tagged. Our evaluation results yield convincing evidence that the computationally very efficient ACT-R equations allow to explain substantial variance in users' future tag choices and to significantly outperform well established tag recommender approaches.

Approach. When users categorize and tag resources on the Web (e.g., photos), they draw on their semantic-lexical memories to retrieve corresponding memory units. Understanding the cognitive processes involved can help to predict individual tagging behavior [10] and to model phenomena on the collective level, such as the emergence of stable tag distributions [4]. To make appropriate memory units quickly available, human memory is very adaptive and tunes the activation of its units to statistical regularities of the environment (e.g., [2]): The more useful a memory unit has been and the stronger it is related to the current context (i.e., environmental cues), the higher is its activation level and hence, probability of being retrieved.

We assume that these activation processes also determine a user's tagging behavior and that the usage probability of a tag can be derived from estimates of its activation in the user's memory. According to [1], the activation of a tag should depend on at least two variables: i) the general usefulness of a tag in a user's tagging history and ii) its associations to the current context, i.e., to elements of the resource to be tagged. This means that a memory unit is more likely to be brought into consciousness, if we use it often and if it fits the current topic (i.e., the resource to be tagged).

According to the activation equation, which is part of the declarative module of the cognitive architecture ACT-R [1], the usefulness of a memory unit i is given by its base-level activation and its associative activation. Whereas the base-level activation quantifies the general usefulness of the memory unit i by considering how frequently and recently it has been used in the past, the associative activation tunes the base-level activation of i to the current context. Thus, our novel tag recommender approach presented in this work estimates a tag's reuse probability as a function of usage fre-

quency and recency in the user's past (base-level activation) as well as of the current semantic context (see [7, 8]).

Evaluation & results. Using four real-world folksonomies gathered from bookmarks in BibSonomy, CiteULike, Delicious and Flickr, we show how a tag recommender that implements activation processes in human memory, by considering frequency, recency and semantic context, outperforms conventional "most popular tags" approaches and another existing and very effective but less theory-driven, time-dependent recommendation mechanism. Additionally, by combining our approach with a resource-specific frequency analysis, our algorithm outperforms other well-established algorithms, such as Collaborative Filtering, Tensor Factorization or FolkRank in terms of recommender accuracy and runtime.

Summed up, in this work, we demonstrate how effective principles of recommender systems can be designed and implemented if human memory processes are taken into account.

Acknowledgments: This work is funded by the Know-Center and the EU-IP Learning Layers (Grant Agreement: 318209). The Know-Center is funded within the Austrian COMET Program - Competence Centers for Excellent Technologies - under the auspices of the Austrian Ministry of Transport, Innovation and Technology, the Austrian Ministry of Economics and Labor and by the State of Styria. COMET is managed by the Austrian Research Promotion Agency (FFG).

Keywords

tag recommendations; social tagging; human memory theory; ACT-R

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