Personalized Product Recommendation through Interactive Query Management and Case-Based Reasoning

Francesco Ricci[1]
ricci@itc.it

Fabio Del Missier[1,2]
delmisfa@units.it

[1]eCommerce and Tourism Research Laboratory, ITC-irst, via Sommarive 18, Povo, TN 38050 Italy
[2]Department of Psychology, University of Trieste, via S. Anastasio 12, Trieste, TS 34134 Italy

ABSTRACT

This position paper describes a line of research developed at eCTRL to design personalized recommender systems. The approach integrates in a novel way content-based and collaborative filtering techniques, case-based reasoning and an HCI perspective to system evaluation and user modeling. The approach was used to develop and test a system prototype that helps the user to construct a travel plan by recommending promising items or by proposing entire plan templates. The system aids the user to specify a query that winnows out unwanted products in electronic catalogs and then sorts the results according to a case-based similarity metric. A case is a rich hierarchical data structure containing a user's profile information and all the items previously selected by that user. If the search fails, the system supports the refinement of the query, interacting with the user in a mixed-initiative approach. The system has been empirically evaluated with a sample of potential users and it is currently undergoing a tighter test in a new experimental effort, that makes use of detailed log data, user satisfaction questionnaires and cognitive modeling of interaction sessions.

Keywords

Pesonalization, recommendation systems, case-based reasoning, human-computer interaction, cognitive modeling.

RECOMMENDER SYSTEMS AND PROBLEM STATEMENT

E-commerce web services make use of recommender systems to suggest interesting and useful products and to provide consumers with information that is intended to support their decision processes [14, 13]. Recommender systems research is mainly motivated by the need to cope with information overload, lack of user knowledge in a specific domain, optimization of cost-benefit trade-off and minimization of interaction cost. Building real world recommenders is extremely effortful, requiring careful elicitation of user requirements, task analysis, development and tuning of the recommendation algorithms, design and test of the graphical user interface.

This complex process is presented in [11], with specific reference to a leisure travel recommender devised to suggest a well-suited bundling of travel components (locations, accommodations, attractions, activities and events). In this position paper we want to focus our attention on the basic recommendation technology that we have developed, describing its general aspects, showing its wider applicability and outlining the first results of an extensive empirical evaluation that is currently being conducted.

The fundamental goal of our recommendation technology is to help the user choose products contained in several electronic catalogues (databases), taking into account various kinds of wants and needs in an efficient way. This is accomplished by reducing as much as possible the user's cognitive effort devoted to the information search and supporting effective decision strategies. The final outcome is to increase the looker to buyer conversion rate.

APPROACHES TO RECCOMMENDATION IN E-COMMERCE APPLICATIONS

Recommenders are based on the implicit assumption that user's needs and preferences can be converted/mapped into product selections, using the appropriate algorithms and the knowledge embedded in the system [10].

Burke describes three different types of recommendation approaches: (a) collaborative-filtering or social-filtering; (b) content-based and (c) knowledge-based [3]. Given that any recommender relies on some form of knowledge (though simple), we will mark a boundary only between collaborative-based and content-based systems.

In content-based filtering, the user expresses needs and preferences on a set of attributes and the system retrieves the items (contained in a catalogue of products) that match the description. The results are typically sorted according to the degree of matching to the user query. Although content-based filtering may also make use of past queries to build a user profile (i.e. a sorted list of the more important product features for a specific user [6]), this approach ultimately stresses the importance of the preferences collected during a specific recommendation session. Case-based reasoning recommendation has often been viewed as a variant of content-based approaches, in which the problem description comprises the user needs and preferences and the solution is given by the items retrieved. The major drawback of the

content-based approach is its excessive compliance with the explicit needs specified in the user query. This does not allow putting a bit of variability in the suggestions [16]. Moreover, the design of a focussed and effortless interaction dialogue, both able to make explicit the user needs and to produce meaningful advises, has been always considered a major issue. This has motivated a great deal of research on conversational case-based reasoning [7, 8], non-standard (order-based) retrieval approaches [2], query tweaking [4], attribute selection methods [15] and structured case retrieval [5].

The collaborative-based approach [1] collects user ratings on currently proposed products and/or previously purchased items to infer the similarity between users. In this way the system can suggest to the user a set of novel products, that have been highly ranked or already bought by similar users. Collaborative approaches are effective in suggesting interesting and items and, since they rely on machine learning techniques, the quality of the recommendation improves over time. On the other hand, collaborative-based methods require a huge number of user ratings before producing satisfactory recommendations and they are not able to take into account specific (session-dependent) user needs, since the user is not directly involved in the process. Furthermore, collaborative filtering can be directly applied only to standardized products (i.e. items sold in the same form to many users, such as books, movies or CDs). Other kinds of products far less amenable to collaborative-based recommendation (e.g. travels, cameras, cars) [9].

ENHANCING RECOMMENDATION AND PERSONALIZATION: THE ECTRL APPROACH

Taking into account the limitations of both content-based and collaborative-based approaches we have designed a novel hybrid collaborative/content-based recommendation method.

The approach is shaped by the following requirements:

- Products may have a complex structure, and the final recommended item can be an aggregation of more elementary components. For instance a trip may be composed of a flight, an accommodation and a ticket for a baseball match.
- Both short-term preferences (related to a situation-dependent goal) and long-term stable preferences should influence the recommendation. Given that short-term preferences often arise from compelling needs, they should dominate long-term preferences. For instance, if the user is currently searching for a business flight, the system must demote the influence of his/her previous history of 'no frills' flights.
- The recommendation method should fit the ubiquitous form-based/feature-based search interfaces adopted by the majority of e-commerce web systems. This would allow a seamless integration of the recommender into the existing systems.
- The lack of an initial database of user interactions or of a set of selling records should not prevent the application of the method. Furthermore, both occasional and registered users should be able to get valuable recommendations.

In our approach a case is a single user-recommender interaction session, comprising the whole information provided by the user during the session, the selected products and (if the user is registered) a set of personal preferences and information. The recommender system stores the cases in a repository (case base) in addition to the catalogues of products (databases). All the input features provided by the user during an interaction session can be divided in two categories: content features and collaborative features. Content features can be constrained in user queries and are used as product descriptors in the catalogues. For instance, rating and parking availability are content features in a hotel description. Conversely, user nationality and preferred transportation means, being not part of the description of the products, are collaborative features.

In a first interaction phase, the user provides the recommender with collaborative and content features. The former are used to compute similarities among recommendation sessions and the latter to query the catalogue databases. A query built using the content features is performed on the appropriate catalogue to extract a relatively small set of candidate items. These content constraints are strict: if the query cannot be appropriately satisfied, because it would yield no items or too many items, the recommender suggests query changes (relaxation and tightening) that will produce an acceptable number of results [12]. These functions of the recommendation method are content-based and rely on a conversational and mixed initiative model.

In a second interaction phase, the results obtained from the refined query are sorted. The recommender searches for similar interaction sessions, using all the collaborative features previously entered by the user. After the retrieval of a small set of similar recommendation sessions, the system sorts the result items according to a double similarity computation. A score for each item is computed by maximizing the product of the case similarity and the item similarity. The similarity between the current case and a retrieved case (case similarity) is based on the collaborative features. The similarity between the result item and the item of the same type contained in a retrieved case (item similarity) relies instead on the content features. The result items are finally presented to the user in decreasing score order.

This approach enables content features to dominate the selection process and to determine which items will compose the result set. But the collaborative features are exploited to order the result set, highlighting some items that seem to be promising (similar to the ones selected by other users in an analogous context).

EXPERIMENTAL EVALUATION, HCI PROCESS MODELS AND SYSTEM DESIGN

The system has been empirically evaluated with a sample of potential users and it is currently undergoing a tighter test in a new experimental effort, that makes use of detailed log data, user satisfaction questionnaires and cognitive modeling of interaction sessions.

The first experimental study compared a travel recommendation system, developed following our hybrid

approach, with a baseline system. The baseline system was identical to the recommendation-enhanced version, with the exception of the support functions for the query management and the similarity-based and case-based sorting. Participants were randomly assigned to two groups, corresponding to the baseline and recommendation-enhanced systems. They were given a short task explanation and they were invited to interact freely with the system, for a fixed time period, in order to be acquainted with it. Then they were asked to perform the task of planning a travel in Trentino.

The results showed a significant decrease from the baseline system to the recommendation-enhanced system in the number of queries, items browsed by the user and total interaction time. Furthermore, the participants using the recommendation-enhanced system selected items placed significantly nearer to the top of the visualized result list. This means that they probably had to examine fewer items before finding an appropriate option. These results offered a preliminary support for the effectiveness of the hybrid recommendation method in aiding the user find well-suited items in a complex information search and decision task. Other analyses, conducted on the interaction and navigation traces, were also able to point out some minor problems in the interface design, which produced some sub-optimal interaction behaviors. Thus, the hints acquired in this way provided valuable directions for further interaction design.

We are currently carrying out a more complex study that will subject the system to a tighter test and allow us to: (a) rule out potential alternative explanations of the first study results; (b) collect additional data on the participants' satisfaction with the system, the proposed recommendations and the final choices; (c) test a first cognitive model of the user-recommender interaction.

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