Argument-based mixed recommenders and their application to movie suggestion

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ABSTRACT

Recommender systems have become prevalent in recent years as they help users to access relevant items from the vast universe of possibilities available these days. Most existing research in this area is based purely on quantitative aspects such as indices of popularity or measures of similarity between items or users. This work introduces a novel perspective on movie recommendation that combines a basic quantitative method with a qualitative approach, resulting in a family of mixed character recommender systems. The proposed framework incorporates the use of arguments in favor or against recommendations to determine if a suggestion should be presented or not to a user. In order to accomplish this, *Defeasible Logic Programming* (DeLP) is adopted as the underlying formalism to model facts and rules about the recommendation domain and to compute the argumentation process. This approach has a number features that could be proven useful in recommendation settings. In particular, recommendations can account for several different aspects (*e.g.*, the cast, the genre or the rating of a movie), considering them all together through a dialectical analysis. Moreover, the approach can stem for both content-based or collaborative filtering techniques, or mix them in any arbitrary way. Most importantly, explanations supporting each recommendation can be provided in a way that can be easily understood by the user, by means of the computed arguments. In this work the proposed approach is evaluated obtaining very positive results. This suggests a great opportunity to exploit the benefits of transparent explanations and justifications in recommendations, sometimes unrealized by quantitative methods.

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1. Introduction

Recommendation systems are support mechanisms that assist users in their decision-making process while interacting with large or complex information spaces. Most recommender systems are aimed at helping users to deal with the problem of information overload by facilitating access to relevant items (Maes, 1994). Recommenders attempt to generate a model of the user or user's task and apply diverse heuristics to anticipate what information may be useful. In order to come up with recommendations, conventional recommender systems rely on popularity indices or on similarity measures between users or contents, computed on the basis of methods coming from the social science, the information retrieval or the machine learning communities.

The human–machine interaction observed in existing recommender methods is particularly rigid. Such services do not provide mechanisms for easily reformulating the criteria under which a recommendation will be based. This means that once a particular recommendation technique is adopted and a set of parameters' values are assigned (which are typically established by the recommendation system's configuration), the user does not have the possibility of naturally introducing new preferences for the system to consider or of indicating how to combine various facts and rules for generating recommendations. Decisions about user preferences are mostly based on heuristics, which rely on ranking previous user choices or gathering information from other users with similar interests. In other words, existing recommender systems do not provide an interaction mechanism to deal in a natural and methodical way with users' preferences in complex environments.

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Another central weakness in most current methods of recommendation is the lack of transparency. Most on-line recommender systems act like black boxes, not offering the user any insight into the system logic or justification for the recommendations. This is due to the fact that the quantitative methods adopted by most existing recommender systems do not have a clean underlying model that is easily understandable in a final user level. This makes it hard to provide users with a clear explanation of the factors and procedures that led the system to come up with certain recommendations. As has been shown by previous studies (*e.g.*, Sinha & Swearingen, 2002; Tintarev & Masthoff, 2007) users prefer recommendations if they can understand the reasons why these recommendations are presented. Certainly, a recommendation is more compelling if the user is aware of and agrees with the reasons supporting why the recommendation was presented than if it emerges from a black box. In addition, by offering a justification a system is providing additional useful information to its users about related topics or items that they may be unaware of.

Another problem faced by recommender systems is that users' preference criteria generally involve incomplete and potentially inconsistent knowledge about the domain. This is due to the fact that users preferences are dynamic and typically change as time evolves or as new material becomes available for analysis. Because the quantitative approaches adopted by most recommender systems are not equipped with a mechanism to revise previous conclusions, the changing nature of users preferences is poorly dealt with. Adopting a more qualitative approach by augmenting recommendation with classical logic inference will not solve the above mentioned issues, as it will often lead to contradictory conclusions, which are problematic unless treated appropriately.

In light of these problems, we propose to model users' preference criteria using DeLP (García & Simari, 2004), a framework for defeasible argumentation (Rahwan & Simari, 2009; Simari & Loui, 1992) based on logic programming that can effectively deal with incomplete and contradictory information. The use of DeLP allows to integrate dialectical reasoning into the recommendation process, which provides a reasoned basis for the items suggested to the user. In addition to offering a natural means to codify data about the recommendation domain, DeLP can deal effectively with the defeasible nature of reasoning patterns that typically arise in recommendation. Finally, an interesting feature of DeLP, that certainly is proven handy in recommendation settings, is that conclusions obtained through this formalism can be easily explained by the argumentative reasoning process. We will circle back to this feature of DeLP latter to show how it can be exploited to obtain natural language explanations of the reasons behind recommendations.

Despite its importance, the use of argumentation-enabled mechanisms in recommendation settings has not received much attention from the recommender systems' community. Nevertheless, in the last decade several advances in the area have been made, mostly from the theoretical point of view. The problem of empowering recommendation with argumentation has been previously addressed in Chesñevar, Maguitman, and González (2009). In that work the focus is set on a general characterization of *argument-based recommender systems*, described as user support tools where recommendations are based on arguments. That work presents a first general approach towards the use of DeLP as the basis of recommender systems. In particular, the system introduced in the present work can be seen as a particular instance of that general approach. An argument-based recommendation system for the music domain was introduced in Briguez et al. (2012), where a complete framework for achieving recommendations based on defeasible reasoning is presented. A particularly interesting feature of that framework is its use a twofold argument preference criterion, which enables to easily adjust the behavior of the systems towards different aspects. Nevertheless, the paper only introduces the theoretical aspects of the proposed

recommender system, without evaluating its performance. Moreover, although the use of argument-based explanations is mentioned as an advantage of the proposed recommender, there is no complete description of how these explanations can be provided. Finally, further theoretical analyses and simulations aimed at combining quantitative and qualitative aspects to generate argument-based news recommendations were presented in Briguez, Capobianco, and Maguitman (2013). In that work, both a theoretical investigation and simulations are presented, but there is no empirical analysis of the proposed system performance.

The work presented here can be seen as a confluence and continuation of the above-mentioned works, drawing some key points from them but also presenting new contributions. In particular, we extend previous results by describing a novel framework for the specific domain of movie recommendation. Therefore, we contribute to the research field of recommender systems in different ways. First of all, we propose a complete set of postulates accounting for both quantitative and qualitative aspects of the movie domain and describe how these postulates can be implemented by means of DeLP rules. Then, we present a careful investigation of the benefits of incorporating defeasible argumentation into the recommendation process. Also, an important difference between our work and the previous work in argument-based recommenders is that our proposal is empirically evaluated using real-world datasets. In order to complete our evaluations, we use an augmented version of the MovieLens dataset (Grouplens, 2013) and compute classical evaluation metrics to assess the effectiveness of the proposal. Moreover, the family of recommenders presented in this work are the first DeLP-powered real-world systems using a very large scale (10 M) dataset, thus setting a precedence on the applicability of massive argument-based applications. Finally, in this work we describe how to obtain complete explanations on the reasons behind recommendations, exploiting the coherent internal structure of arguments to generate a final explanation that is presented to the users as a natural language sentence. Such sentences can account for any type of explanation (*i.e.*, content-based, collaborative-based or preference-based explanations (Tintarev & Masthoff, 2007)) providing that they can be modeled by rules. To sum up, the main contributions of this work are the following:

- A novel, mixed approach to movie recommendation is presented. The proposed approach considers quantitative and qualitative aspects of the recommendation domain. These aspects are shown to be fully implementable in DeLP, and the benefits of the approach (*e.g.*, easily shifting from one aspect to the other) are discussed.
- An analysis is performed to study how different sets of postulates can be integrated to develop a family of recommenders with different predictive capabilities.
- It is shown how by changing a single feature of the framework (the argument preference criteria) we can go from content-based recommenders to collaborative filtering ones and the other way around, or even mix them in any way we prefer to develop hybrid recommenders.
- Some examples are provided on how recommendations are generated and how explanations can be built based on arguments.
- The proposal is evaluated using an augmented version of the MovieLens dataset (Grouplens, 2013).

2. Background

2.1. Recommender systems

Recommender systems are tools that assist users by facilitating access to relevant items, such as music, books, or movies, or to