Information Retrieval and Folksonomies together for Recommender Systems

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Abstract. The powerful and democratic activity of social tagging allows the wide set of Web users to add free annotations on resources. Tags express user interests, preferences and needs, but also automatically generate folksonomies. They can be considered as gold mine, especially for e-commerce applications, in order to provide effective recommendations. Thus, several recommender systems exploit folksonomies in this context. Folksonomies have also been involved in many information retrieval approaches. In considering that information retrieval and recommender systems are siblings, we notice that few works deal with the integration of their approaches, concepts and techniques to improve recommendation. This paper is a first attempt in this direction. We propose a trail through recommender systems, social Web, e-commerce and social commerce, tags and information retrieval: an overview on the methodologies, and a survey on folksonomy-based information retrieval from recommender systems point of view, delineating a set of open and new perspectives.

Keywords: Information Retrieval, Folksonomy, Recommendation, e-commerce

1 Introduction

The advent of social Web has significantly contributed to the explosion of Web content and, as side effect, to the consequent explosive growth of the information overload. So, users need a computer-supported help in order to choose what to buy, how to spend their leisure time, how to select among several options: this help is historically offered by Recommender Systems (RS). RS automate specific strategies with the goal of providing affordable, personal, and high-quality recommendations, and so supporting online users, specially in electronic commerce, in decision-making, planning and purchasing processes. The attention of the international scientific community on RS is active and is largely demonstrated by the significant number of conferences, workshops, books, surveys and special issues on this research area (see in particular two recent books [1,2] and two surveys [3,4]).

In the past, in the mid 1990s, the first RS in e-commerce provided recommendations based mainly on specific attributes of the products or on aggregated

data of purchases, such as the top overall sellers on a site, the demographics of the customer, or the analysis of the past buying behavior of the customer as a prediction for future buying behavior [5]. These systems used only a small subset of the available information about customers, and they substantially provided not-personalized recommendations. Examples of these generation of RS for e-commerce were provided in Amazon, eBay, Moviefinder.com, Reel.com, Levis or cdnow.

Currently the extensive use of social applications is emphasizing the central role of users and their (cor)relations, in spite of the previous methodologies in the major part applied only on products and purchases: the focus is on the customer profile, her preferences, needs, and feedbacks, the reputation of buyers and sellers, the relationships established between user communities and sub-communities, and last but not least the personal way of each user to classify the huge amount of information at her disposal, applying on it a set of freely chosen keywords, called tags. The social tagging activity generates *folksonomies*, which play a strategic role in the generation of recommendations. As a consequence, specific attention is given to that part of e-commerce dedicated to the use of social aspects, the so-called *social commerce* [6].

Historically, RS and Social Web have been closely interconnected, and the use of folksonomies in RS is widely recognized as a core subject [3]. Nevertheless, another relevant research area has been often associated to RS: *Information Retrieval* (IR). IR and RS appear siblings, share similar objectives, and similar measures (even for evaluation). Both IR and RS are faced with similar filtering and ranking problems. In [7], the author argues, for example, that RS is not clearly separated from IR. The individualized criteria that RS try to achieve probably are the core differences between RS and IR [1].

This work proposes an overview on the methodologies, and a survey of folksonomy-based IR from RS point of view. Through the study of RS and IR and their evolution due to social web (with particular attention to folksonomies), this work underlines the complementarity between these two research areas, delineating the currently applied contributions of IR for RS, but also identifying which IR techniques and approaches could be exploited to improve RS in e-commerce context.

The paper is organized as follows. Section 2 presents the basic concepts and techniques related to RS. Section 3 compares information retrieval basics and recommender system ones. Folksonomy and social Web are then described in Section 4 in order to show their positive impact. Finally, Section 5 proposes a survey of integration approaches between folksonomy, IR and RS in order to improve recommendations, and a set of perspectives, in order to show the real potential of such integration.

2 Basics of RS

The increasing volume of information on the Web is the main motivation for RS: they support users during their interaction with large information spaces, and

direct them toward the information they need. RS model user interests, goals, knowledge, and tastes, by monitoring and modeling the (implicit or explicit) feedbacks provided by the user. A traditional classification [8] of RS is based on how item suggestions are generated and distinguishes three categories: (a) *CF (Collaborative Filtering)* uses social knowledge to generate recommendations. It may be further differentiated into: Model-based approaches, which build a probabilistic model for predicting the future rating assignments of a user, on the basis of her personal history; Memory-based approaches, which use statistical techniques for identifying the users, called neighbors, with common behaviour (user-based approaches) or items evaluated in a similar way by the community (item-based approaches); (b) *CB (Content-based)* analyzes past user activities looking for resources she liked; it models the resources by extracting some features (for example, topics or relevant concepts) from documents. The user profile is then defined describing what features are of interest for the user. The user relevance of a new resource is computed by matching a representation of the resource to the user profile; (c) *HF (Hybrid Filtering)* combines CB and CF approaches.

A more general taxonomy has been proposed in [9], where current recommendation technologies are discussed considering three dimensions:

1. the **Recommendation Algorithms** dimension includes discussed *CF, CB, HF recommenders*, and also adds *KB (Knowledge-based)* recommenders, that use domain knowledge to generate recommendations.
2. the **User Interaction** dimension includes: (a) *Conversational RS*, which directly interact with the user by asking her to give feedback (Candidate/ Critique systems) or to answer questions (Question/Answer systems); (b) *Single-shot RS* where each interaction is used for suggesting recommendation independently;
3. the **User Models** dimension includes the *Persistent User Model*, which deduces the user interests and preferences from user inputs accumulated over the time, and the *Ephemeral User Model*, which infers the intentions/interests of the user solely on input from the current session. In [4], the authors have recently highlighted the centrality of the user model and its specific importance in the e-commerce field, both for Web browsing and purchase recommendation.

3 IR and RS

RS and IR can be considered as siblings, since they share the same objectives. This section compares IR and RS techniques focusing on their similarities.

Basics of IR. Salton in 1968 [10] defined IR as a field concerned with the structure, analysis, organization, storage searching, and retrieval of information. The objective of IR is to provide information corresponding to (matching) a need expressed by the user (query). Research was devoted, for the most part, to propose techniques to represent both documents and users' information needs and to

match these representations. The different steps of the IR process are described in [11]. The most important steps of this process are related to the indexing step and the evaluation: the *indexing step* is related to the way information is described. It is based on various theoretical models, such as the well-known Vector Space Model (VSM) [12], probabilistic model [13], and language model [14]. In addition to these models, in order to distinguish the importance of various features that describe the document, weighting schemes have been proposed like tf.idf [15] and bm25 [16].
The *evaluation of matching* between a document and a query. To evaluate such a matching, many measures have been proposed associated to a given model. For instance the cosine measure is commonly associated to the well-known vector space model.

Relevant documents (those that match the most the query) are then displayed to the user through a common ranked list visualization.

Comparison between IR and RS. IR systems and RS are very close fields. Kumar and Thambidurai [4] argue that "The different [Recommender] systems use various methods, concepts and techniques from diverse research areas like: Information Retrieval, Artificial Intelligence, or Behavorial Science" . Burke in 2007 [7] underlines that "a recommender system can be distinguished from an IR system by the semantics of its user interaction. A result from a recommender system is understood as a recommendation, an option worthy of consideration; a result from an IR system is interpreted as a match to the user's query. RS are also distinguished in terms of personalization and agency. A recommender system customizes its responses to a particular user. Rather than simply responding to queries, a recommender system is intended to serve as an information agent." As underlined in [7], this latter distinction is more and more blurred because nowadays IR systems integrate personalized features and new criteria in addition to strict "matching" (using tags, social networks...). Furthermore, RS are based on information filtering techniques that have been considered since 1992 as close to IR techniques [17]. This latter paper also presents two figures illustrating the similarities between these two techniques. So, as a consequence IR and RS are two fields that share techniques: indexation models and similarity measures like the famous PageRank algorithm used by Google have been adapted to RS [18]. At the same time, CF techniques have also been integrated in IR process [19]. As a conclusion, IR and RS, having the same objective, are similar at a general point of view.

4 Social Web and its Impact on IR & RS

During the last years the advent of Social Web has greatly changed the role of the Web users, providing them with the opportunity to become key actors, to share knowledge, opinions and tastes thanks to the interaction through on line media.

End users are playing an increasing active role within the recommendation process in several fields, and in particular in the e-commerce; in fact, both their

choices and feedbacks on purchased items, and the folksonomies generated on them improve and enrich the recommendation process. Recently a new trend of e-commerce, the *Social Commerce*, has grown, leveraging Web 2.0 technologies and on line social media like blogs, web forums, virtual communities, and social networks. In the social shopping tools the customer ratings, their reviews, recommendations and referrals are fundamental to create a trusted environment. In particular, Social Commerce highlights two relevant aspects: the *friendship relations*, typical of social networks like Facebook, and the *word-of-mouth*, that generates the viral marketing. This is generated when customers promote a product or service by telling others about their positive experience with it [20].

In this context users contribute each other to the sale of goods and services due to their positive and negative feedbacks, reviews, ratings and testimonials regarding their past and present experiences [21].

Examples of relevant Social Commerce are the on-line purchase clubs, as Buy Vip and Vente-privee, the Facebook shops, like Wishpot, and the the online social coupon services, where promotional coupons are sold to customers for having discounts on several different items and services. See for example Glamoo and Kgb Deals.

Social Web and its impact on e-commerce become now available as new user knowledge, and offer great opportunities both for recommender technologies and IR techniques; these last in turn can positively stimulate the grow of social phenomenon, allowing more effective and personalized user interface.

4.1 RS and Social Web

Social tagging systems are recently receiving increasing attention from the scientific community: the growing number of scientific publications concerning this issue on one hand, and the development of real social tagging systems on the other, such as for example, BibSonomy, delicious, and Last.fm, confirm this tendence.

As deeply investigated in [3] through social Web applications users upload and share resources within a community, and mainly introduce personal and cheap classifications, applying on them specific tags. A tag is a term freely chosen by a user and it represents a meta data describing the item in order to be useful as a keyword to identify or to find later again a resource. The collection of all the tag assigned by a user constitutes her *personomy*, while the collection of all personomies in a system, is called *folksonomy*.

Due to the freedom of social annotation, it suffers from some limitations like (1) the *ambiguity* of tags which could be written using different lexical forms, (2) the *synonymy* or *polysemy* problem, (3) the different *levels of expertise* and *specificity* used for annotating resources. Nevertheless tags contain rich and potentially useful, social/semantic information, and their nature can be understood by analyzing the user motivations and goals in performing tagging activity. Using tags corresponds to a specific intent of a user, such as describe the aim of a resource, its content, the document type, some quality or property specification, the association of tasks to it as a self-reminder, and so on [22].

Tags are particularly used in social networks, social bookmarking applications, sharing systems, and recently also in the e-commerce field. In this extent the same *Amazon.com*, one of the bigger e-commerce applications, added to classical recommendations, a new recommendation mechanism based on the *amazon folksonomy*, generated by customer tagging activity. Introducing folksonomies as basis for recommendations means that the usual binary relation between users and resources, which is largely employed by traditional RS, changes into a ternary relation between users, resources, and tags, more complex to manage.

Different surveys [4,3] analyze the use of social tagging activities for recommendations, focusing their attention in particular on the following aspects:

- **RS improvement thanks to tags:** an interesting overview on social tagging systems and their impact on RS is presented in [23]; while a methodology to improve RS thanks to Web 2.0 systems and particularly to social bookmarking platforms is offered by [24]; moreover, the same work [25] provides a recommender system model based on tags.
- **Role of tag recommendation:** the system presented in [26] exploits a factorization model to propose personalized tag recommendations, while the work [27] illustrates a strategy used in a Web page recommender system exploiting affinities between users and tags. In addition to these affinities, [28] proposes a recommender system exploiting tag popularity and representativeness to recommend web pages.
- **Tags & User modeling:** since RS rely on a user model to generally personalize recommendations, [29] proposes an original way to enhance modeling to improve tag recommendation. In a general context, [30] and [31] also illustrates how tag activity can improve user modeling.

Nevertheless very few works highlight how to employ folksonomies in the field of e-commerce recommendation: for example, in the e-commerce area, [32] proposes a product recommender system based on tagging features. This leads us to think that further researches, evaluation studies and insights are needed.

4.2 IR and Social Web

In this section we introduce a state of art related to Social IR, i.e. IR that uses folksonomies. From IR point of view, tags and particularly the relations between tags have been studied as a novel knowledge base related to information exploited in IR process:

- As a pull approach, users retrieving information need to understand what information is available to identify which one is relevant to their need. Tag cloud has been used in this context to offer an original and improved visual IR interface [33,34]. Such an interface allows user browsing information. A more powerful visualization based on tag clusters [35] is considered as better than tag cloud.

– FolkRank [36] is a new search algorithm for folksonomies. It can also be used to identify communities within the folksonomy that are used to adapt information ranking. This algorithm is inspired from the famous PageRank model from Google. Information ranking (scoring) has also been studied according to query [37]. Another document ranking based on relations extracted from (user, tag, resource) is illustrated in [38].
– IR have also been improved thanks to folksonomies and two original measures [39] SocialPageRank that computes the popularity of web pages, and SocialSimRank that calculates the similarity between tags and queries.
– Query expansion based on tag co-occurrence has been studied in [40], [41], [42]. Results show that such an approach consistently improves retrieval performance.

5 Current and new perspectives

In previous sections we underlined that folksonomies have a real and positive impact on RS and IR even if only few works deal with the use of folksonomies to improve e-commerce. This section presents the potential contribution of IR to RS and then describes a set of trails we identified to improve recommendation using IR and folksonomies.

5.1 Contribution of IR for RS

As underlined in [4], "RS are characterized by *cross-fertilization* of various research fields such as: Information Retrieval, Artificial Intelligence, Knowledge Representation, Discovery and Data/Text Mining, Computational Learning and Intelligent and Adaptive Agents". As a result IR and RS research areas are complementary and can participate together to improve recommendation quality. Many examples have already shown on the role of IR for improving RS. Here, we describe the most representative works in this field in order to propose new trails to make converging IR & RS.

Similarity measures. In order to achieve efficient filtering, a similarity value has to be computed between user and item features. In this domain IR has a big experience. So, for instance [43] proposes the reformulation of the performance prediction problem in the field of IR to that of the RS. Moreover [44] defines information channels used in CF as close to the IR vector-space model.

RS process replacement. Following an original direction, in [45] the authors investigate the possibility to reformulate a collaborative RS problem in an IR one. They use common IR process as a part of the RS process and show they obtain a decrease of the MSRE (Mean Square Root Error) rather than a real collaborative RS. This paper presents "an experimental investigation of possible relations between IR and RS".

Prediction. [43] analyzes how to adapt the query clarity technique to CF to predict neighbor performance, and then use the proposed predictor within a CF algorithm, enhancing the selection and weighting of neighbors.

5.2 Possible contribution of IR for RS

Previous section present recent works related to RS improvements using IR techniques. As we can see, these works are quite recent and many other trails could be investigated. Indeed, to achieve its aim an IR system relies on an effective information process: indexing. Recently, IR indexing schemes integrate external evidence sources (i.e. folksonomies and social networks) to characterize in a more precise way information content. Indeed, we can ascertain that the information raw content itself is not sufficient and today work consider more usage-based characteristics. Such work is emergent and huge trails in this scope have been identified. RSs may benefit from this evolution of IR indexing techniques and related similarity measures. Moreover another IR trend concerns the way IR systems model communities and users in a more contextual way. Such improvement allows IR systems to better meet users' needs and requirements and can be applied to RSs to enhance matching between users for instance. Next sections illustrates the most representative improvements that IR techniques can provide to RSs.

Data source selection issue. In [46], the authors point out that important issues for RS are the selection of the most appropriate information source to get the most relevant information to be recommended and the integration of the information. A response to the selection issue can be inspired by IR works such as GlOSS [47] that aims to better describe any source content to improve its selection. More recently, works related to integrated IR (sometimes called desktop search [48]) emerged bringing hints to address source integration issue. Such IR techniques may be applied to RSs to identify adapted information sources that could be suitable to compute more accurate recommendations. Furthermore RSs may compute more diversified recommendation list thanks to these various information sources and adapted IR similarity measures.

User & Item modeling. Personalized features are more and more developed in IR. For example, in the context of personalized search, folksonomy-based user and document profiles [49], [50] have been proposed to improve IR techniques. Such modeling could be adapted to RS in order to improve recommendation accuracy and more particularly the way the matching between users is computed thanks to adapted IR similarity measures. To limit the required resources and to decrease the number of processed tags, Peters et al. [51] for instance propose to only consider relevant tags called "power tags". In addition, some IR techniques have been proposed aiming at identifying user behavior and interests through implicit modeling [52] and determining the kind of information searched [48]. Such techniques could be integrated to RSs in order to improve contextual user modeling.

Cold-start issue. An important issue in RS concerns new users [53]. Indeed, RSs might have enough information related to a new user to recommend relevant information. In addition to IR user modeling techniques, community identification techniques applied to IR (i.e. [36]) can be used for instance as stereotypes in order to tackle cold-start issue.

5.3 Possible Evolution of RS for e-commerce

The improvement of RS allowed by IR (cf. section 5.2) can be directly applied to e-commerce context i.e. cold-start, scalability, similarity measures, user & item modeling. Other evolutions could be adapted to e-commerce to improve recommendations.

Filtering information issue. In order to improve content-based recommendations for e-commerce as explained in section 5.2, one might exploit semantic retrieval techniques to identify (filter) items to be recommended to a specific user. For instance, [54] describes a product IR system based on opinion mining or unlike [55] exploits an ontology to identify/filter products.

Data source selection issue. To improve data source selection for e-commerce, one might propose to associate metadata to common data sources for every product or product category. Such metadata could be based on tags, ratings or comments on these data sources.

6 Conclusion

Folksonomies in IR and RS are mostly considered as an additional knowledge base related to the relations between users, resources and tags. Through these relations, systems can improve for instance resource or user modeling. Such techniques are quite developed in IR field and would be quickly adapted to RS. Indeed, this is a high value-added knowledge base because coming from real users' activity.

In this paper, we proposed a perspective view of the convergence of folksonomy, IR and RS to improve recommendations related to information. Some trails are encouraging; as highlighted by [45], a full association between IR and RS could be envisaged. We identified a set of perspectives that compose our future research road-map towards the implementation of these trails in e-commerce context (i.e. considering product as a specific information).

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