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Multi-View Data approaches in Recommender Systems: an Overview

(Invited Paper)

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Abstract

This paper overviews an assortment of recent research work undertaken on recommender system models based on using multiple views of user and item-related data across the recommendation process. A summary of representative literature on multi-view recommender approaches is provided, describing their main characteristics, such as: their potential to overcome most common shortcomings in conventional recommender systems, as well as the use of data science, learning techniques and aggregation processes to combine information stemming from multiple views. A tabular summary is provided to facilitate the comparison of the similarities and differences among the surveyed works, along with commonly identified directions for future research in the topic.

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Keywords: Recommender Systems; Collaborative Filtering; Clustering; Multi-View Data; Multi-View Recommendation; User Similarity; User Trust; Aggregation Functions

1. Introduction

As the availability of digital information, resources and on-line content continuously increases, users have access to a wealth of information. The sheer volume and variety of content available however can make it difficult for them to find information that suitably meet their needs. In these circumstances, Recommender Systems (RS) arose to overcome such challenges, nowadays playing an important role in myriad e-commerce, personalization and decision-making domains [2, 9]. There exist a vast array of applications of RS, ranging from the most widely known scenarios

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(recommending products, movies, music, etc.) to much more specialized domains, e.g. recommending best practices for urban resilience [32] and urban sustainable development initiatives.

As recommender, decision support and Web systems have progressed and improved in terms of sophistication and connectivity with other systems, the quantity and quality of feature data available to RS to make recommendations has also expanded and improved dramatically [23]. Moreover, the ever-increasing explosion of readily available information about users and items in the Internet make it more necessary than ever before to incorporate and combine multiple views or dimensions of such information (e.g. ratings, social trust, textual and multi-media information) in the processes typically undertaken by conventional recommender models [19, 20, 32]. This may not only improve recommendation accuracy and quality, but also might in some cases alleviate some of the most frequently found shortcomings and vulnerabilities in recommender approaches. Unsurprisingly, several scholars have recently focused their efforts on recommender domains in which multiple views of information shall be exploited meaningfully to produce more accurate recommendations amid diverse situations. Such approaches are in most cases referred to as *multi-view* RS methods [13, 19, 27, 29]. Whilst there is no shortage of literature surveys on major or more generic families of RS approaches, such as Collaborative Filtering (CF) or content-based [7, 10, 46], to our knowledge no theoretical work has been undertaken to date on specifically gathering and compiling a summary of representative research on multi-view RS models and methods.

This paper focuses on RS research based on the use of multi-view data approaches. In particular, we provide a concise overview of recent recommender system approaches characterized by integrating multiple views of user and item-related data at various stages of the recommendation process. The summary of related literature provided consists of 14 selected works handling multiple views of data. Aspects such as the management of common limitations and drawbacks in conventional recommender systems, the employment of data science and learning techniques for knowledge extraction, and the use of flexible aggregation strategies to combine information from multiple views, are particularly pointed out. A tabular comparison of similarities, conclusions in common and differences among the surveyed works is also presented, along with commonly identified directions for future research in the topic.

This paper is organized as follows: Section 2 reviews some basic preliminares on RS and aggregation operators. Section overviews the 14 selected works on multi-view based RS approaches, highlighting their most relevant characteristics on the collection, use and fusion of multiple views of data across the recommendation process. Finally, Section 4 concisely summarizes both common and differentiating aspects among the reviewed works and points out some directions for future research on multi-view RS.

2. Preliminaries

2.1. Basic Concepts on Recommender Systems

RSs attempt to filter items to users, by predicting a rating value for unseen items by such users so as to filter and rank the "best" unrated items in terms of their prediction value. Examples of existing RS techniques include, but are not limited to:

- *Content-based*: They recommend items that are similar to those positively rated by the user [26].
- *Collaborative filtering (CF) based*: They recommend items positively rated by similar users to the target user [15, 39]. CF approaches can be further classified into two subtypes [46]:
  - *Model-based CF*: These approaches use user-item rating information to learn a prediction model.
  - *Neighborhood-based*: The approaches use user-item ratings to directly predict ratings for unseen items, based on identifying the most similar users to the target user.
- *Knowledge-based*: They suggest items based on inference on the user needs and preferences [9].
- *Demographic*: They provide recommendations based on the demographic profile of users [41].
- *Context-aware*: They consider contextual information (location, time, etc.) in the recommendation process. Context-aware recommender systems are typically hybridized with other techniques, such as CF [2].
- *Clustering-based*: Commonly viewed as a variant of CF methods, clustering-based recommendation models create a overall similarity-based clustering of the user space (e.g. based on rating information), instead of determining the neighbors or most similar users to a target user [19].