
A Revisit to The Identification of Contexts in Recommender Systems

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Abstract

In contrast to traditional recommender systems (RS), context-aware recommender systems (CARS) emerged to adapt to users' preferences in various contextual situations. During those years, different context-aware recommendation algorithms have been developed and they are able to demonstrate the effectiveness of CARS. However, this field has yet to agree on the definition of context, where researchers may incorporate diversified variables (e.g., user profiles or item features), which further creates confusions between content-based RS and context-based RS, and positions the problem of context identification in CARS. In this paper, we revisit the definition of contexts in recommender systems, and propose a context identification framework to clarify the preliminary selection of contextual variables, which may further assist interpretation of contextual effects in RS.

Author Keywords

Context; Contextual; Context-aware Recommendation

ACM Classification Keywords

H.3.3 [Information Search and Retrieval]: Information filtering; H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction and Motivation

Recommender systems (RS) have been well developed in the past decades as an effective solution for information overload. Context-aware recommender systems (CARS) [2] emerged as a novel type of RS which adapts to users' preferences in different contextual situations. The fundamental assumption of CARS is that a rating for an item is a function not just of the user and the item, but also of the context in which the item is evaluated. User's preferences on a given item may vary from context to context. For example, you may choose a different movie if you are going to see movies with kids other than parents.

As a result, how to incorporate contexts into RS is always a research question in this domain. However, prior to that, which variables should be considered as contexts is still under question. Currently, several CARS recommendation algorithms [3, 7, 8] have been developed but very few research went back to discuss the definition of contexts. And researchers simply blend user profiles, item features and other variables together to consider them as contexts, which further creates the confusion between context-based and content-based RS. The definition and exploration of context is not only related to the selection of contextual variables in RS, but also relevant to the interpretation of contextual effects based on the outcomes or findings in the experiments. It is obvious that the academic area focuses more on the development of effective CARS algorithm, but ignore the identification of contexts and interpretation of contextual effects in recent years.

In this paper, we summary the current research and usage of contexts in RS and propose a framework to identify, use and analyze the contexts in order to further assist development CARS algorithms and interpret the contextual effects afterwards.

Related Work

Actually contexts have been studied in various disciplines, such as ubiquitous computing, contextual advertising, information retrieval, etc, where the definition differs which result in different understanding of contexts among those areas. In CARS, the earliest research papers [5] may bring us to look back upon more than ten years ago; however, the field has yet to agree on the definition of context. Several researchers simply blend user profiles (e.g., gender), item features (e.g., genre) and other variables together and consider all of them as contexts, which further creates confusions between the context-based and content-based RS. The most commonly used definition and also accepted in CARS is the one given by Abowd et al. in 1999 [1], "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." This definition hardly limits the set of variables that can be taken into account, and it is still ambiguous without clear guidelines to select appropriate variables in RS.

Apparently, the definition and selection of contexts is a domain-specific problem, where classification of contextual variables is a typical way to put different variables in categories but it is still not general enough and not flexible to interpret the contextual effects. The debate or discussion may be finally ended by the idea proposed by G. Adomavicius, et al. [2], where they introduce a two-part classification of contextual information based on two considerations: what a recommender system knows about a contextual factor and how the contextual factor changes over time. This analysis yields six possible classes for context factors, as

shown in Figure 1. So, the topic on context identification in this paper actually falls into the *fully observed static* category, which points out the problem how to identify or select contexts from a set of known variables.

How Contextual Factors Change	Knowledge of the RS about the Contextual Factors		
	Fully Observable	Partially Observable	Unobservable
Static	Everything Known about Context	Partial and Static Context Knowledge	Latent Knowledge of Context
Dynamic	Context Relevance Is Dynamic	Partial and Dynamic Context Knowledge	Nothing Is Known about Context

Figure 1: Classification of Contextual Factors

Context Identification Framework

We design the structure of activity and utilize the components of activity to explain how we identify and further use contexts in RS, which can be depicted by Figure 2, where we define two activities: listening to music (e.g., Pandora) and watching movies (e.g., Netflix).

There are simply three components or elements involved: subject which is the user, object which is the item ¹, and the action itself (i.e., listening or watching), where this structure can be generally applied to other domains, such as tourism, restaurant, etc. Based on this structure, we believe that contextual variables can be identified from the attributes of those three elements – the user profiles, item features and the attributes of the action itself, which can be described by Table below.

Table 1: Example of Candidate Variables

Candidate variables	Examples
User Profiles	Age, Gender, Nationality, Mood, etc
Item Features	Movies (genre, director, language, etc), Music (album, singer, year, etc)
Action Attributes	Time, Location, Weather, Companions, etc

¹Object could also be users, e.g. social ties in Twitter

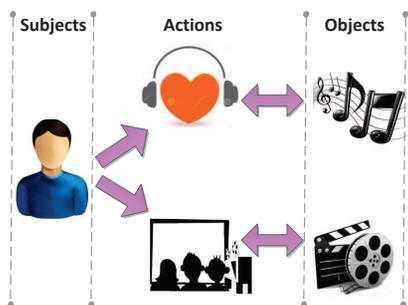


Figure 2: Activity Structure

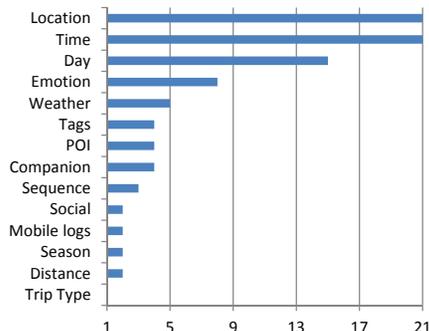


Figure 3: Usage of Contexts in Academic Publications

The underlying assumption of CARS is that users' preferences may change from contexts to contexts. In other words, the contextual variables may be switched to another when the user conduct the same action repeatedly (e.g. seeing the movie). For example, which variables may change if the user is going to see the movie? probably time, location, companion, which are typical contexts in CARS, and those variables may change every time when user perform the activity (i.e. watching movie in this example) again and again. From this perspective, contexts can be defined as "the variables which may change dynamically when the same activity is performed repeatedly". This coincides with the mainstream of the selection of contexts in RS according to a 10-year statistics [4] based on the context-aware publications in most popular top academic conferences (e.g., KDD, RecSys, UMAP, WWW, SIGIR, etc) as shown in Figure 3, where the x-axis denotes the total counts of each variable being considered as contexts, and the action attributes (e.g. time, location, etc) are the most popular ones.

However, some features in user profiles could be dynamic too. For example, emotion is a typical variable which may change from time to time, even if it is within the same action but different stages, e.g., applying CARS in the LDOS-CoMoDa movie data set [6] demonstrates that the users' moods in three stages (before, when and after seeing the movie) are the three most influential contexts among all candidate variables. Strictly, user age is dynamic too which will change every year. But apparently this feature is usually considered as a typical variable in content-based RS. From this perspective, we conclude that "some dynamic variables from user profiles could be considered as contexts too, where those variables are produced by the users and may change dynamically during the interactional process between the users and the items

when the action is performed". Other relatively static user profiles, such as the user gender and age, should be considered as the features to be used in content-based RS.

This pattern may not happen to item features very often, since item features are relatively static rather than dynamic. As a result, item features are usually considered as the ones utilized in content-based RS. However, the exception may exist in social networks (e.g. Facebook and Twitter), where the activity is to establish a social tie with another user account, where both subjects and objects are users. The social connections in shape of social graph could be considered as the object profiles (when object is a user), and this feature is usually dynamic, e.g. subject just followed a new object in social graph.

In conclusion, we finally define context as the set of variables from two parts: one is the attribute of actions, most of which are dynamically changed (e.g., location may be different when use watching movies); another one is partial variables from user profiles and item features, where those variables should have interactions within the activities and change accordingly during the process of the actions. Particularly, most object features may be considered as contents rather than contexts, unless it is in the domain of social networks, where the objects are users instead of items in other domains.

Conclusions and Future Work

In this paper, we point out the motivation and importance of identifying or defining the contexts in recommender systems, especially when it comes to the situation that some content-based variables are fused into the category of contexts in current research, which further creates confusions between content-based RS and context-based RS. Afterwards, we propose the context identification

framework based on the design of the activity structure. And finally we provide relevant analysis and conclude the new rules to identify contexts in RS. In future work, we would like to explore the interpretation of contextual effects based on those identified contexts in order to discover more insights from the usage of the contextual variables, and also compare or distinguish the effects based on the features being considered as contents in recommender systems.

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