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Towards a Collaborative Filtering Framework for Recommendation in Museums: from Preference Elicitation to Group's Visits

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Abstract

Recommendation systems based on collaborative filtering methods can be exploited in the context of providing personalized artworks tours within a museum. However, in order to be effectively used, several problems have to be addressed: user preferences are not expressed as rating, items to be suggested are located in a physical space, and users may be in a group. In this work, we present a general framework that, by using the Matrix Factorization (MF) approach and a graph representation of a museum, addresses the problem of generating and then recommending an artworks sequence for a group of visitors within a museum. To reach a high-quality initial personalization, the recommendation system uses a simple, but efficient, elicitation method that is inspired by the MF approach. Moreover, the proposed approach considers the individual or the aggregated artworks' ratings to build up a solution that takes into account the physical location of the artworks.

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1. Introduction

When it comes to museums, curators design exhibitions with a linear narrative and wearable audio guides are optionally available to provide information to the visitors. This setting is generally very static and the user has to decide whether to follow the suggested paths or to autonomously select the artworks to visit[1]. In this context, Recommendation Systems (RSs) are a natural and technologically ready solution for providing customized tours. Several current attempts are trying to design systems to provide to tourists personalized visiting paths as generated by an RS[2,3,4]. However, employing RS in this scenario is still challenging due to (1) the physicality of the domain, (2) the user profiling and cold start problem, and (3) the presence of groups of people visiting together the museum.

In this work, we presented a general framework of a recommendation system to be used in a museum. Our starting hypothesis is that collaborative filtering approaches, as the Matrix Factorization, can be deployed within museum environments to provide the expected user's ratings on new artworks starting from a preference elicitation

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process that requires only few interaction steps with the user. Moreover, the Internet of Things (IoT) vision of smart museums, could allow to dynamically update the user preferences from implicit behavior analysis by localizing a visitor with respect to artworks [1]. Artworks viewing times can be mapped into a common user-item ratings matrix, but in order to obtain high-quality initial recommendations, an RS must be provided with an efficient and effective process for gathering information about new users. The proposed approach aims at recommending a sequence of artworks physically located in the space, both in the case of a single visitor and of groups. In particular, the satisfaction that a group of visitors will have as a result of a sequence depends, in part, on how the artworks were ordered during the path. Hence, the proposed approach considers the individual or the aggregated artworks' ratings [5,6] while building up the solution in order to predict the satisfaction of each visitor at the end of the visit. The proposed approach is tested on prototype implementation for a simulated museum environment.

2. A Collaborative Filtering Approach for Museum Tour Recommendation

Typically, in museums, recommendation systems are modeled as content-based filtering systems [7] that suggest similar items to those already appreciated in the past by the user. However, those approaches require an effort in providing the semantic information associated with each artwork, but also the explicit acquisition of information necessary to build the user profile. Instead, when such preferences are obtained online by the user visiting style, there is the risk to recommend only things that are similar to the viewed ones.

On the other hand, approaches that are based on Collaborative Filtering requires a user-item matrix of the ratings expressed by other users on the artworks collection in order to provide recommendations. Our starting hypothesis is that in the IoT vision of smart museums, such matrix can be obtained by localizing visitors with respect to physical objects [1], and so artworks viewing times can be, potentially, mapped into a user-item ratings matrix. With this assumption, collaborative filtering approaches can be deployed within museum environments.

Here, we rely on Matrix Factorization (MF) [8] for providing recommendations. The idea behind MF is the existence of some latent factors that determine how a user will rate an item. This method has become very popular in recent years, as it ensures high scalability and accuracy, also it guarantees a lot of flexibility to adapt to different real situations. In its basic model, the MF models map both the users and the items with an array of f latent factors, so that the user-item interaction is modeled as a scalar product in this space. Therefore, each item i is associated with a vector $\overline{q}_i \in \Re^f$, and each user u is associated with $\overline{p}_u \in \Re^f$. For a given item i (or user u), the j-*th* component of $\overline{q}_i$ (or $\overline{p}_u$) measures how the item (user) has that particular factor j. This quantity can be positive or negative.

2.1. Preference Elicitation

The design of an elicitation method implies making decisions that affect both the effort required to the user for expressing his/her preferences and the recommendations' accuracy. One of the most common used approach in RSs to generate a user preference profile is to rely on the new user to express his/her preferences by rating a fixed number of items. However, this is not an efficient way to convert the workload carried by the user in recommendations as it involves a high user's cognitive effort. It is usually more desirable to start offering the recommendations to the visitors as soon as possible, hence minimizing intrusiveness for the users.

The proposed elicitation method is inspired by the MF algorithm as proposed in [9], since it does not rely on specific metadata that for a museum may not be available. The aim is to use some selected latent factors to create few items sets for which the user have to express his/her preferences (See Figure 1b). The sets are formed by items (called seeds) which represent low and high values of a specific latent factor f. This method consists of the following steps: firstly, to extract f latent factors from the user-item matrix and to assign to each item the vector $\overline{q}_i \in \Re^f$ in the f-dimensional space; then to choose the seeds to display to the user. After a number of interactions between the user and the system, the vector representing the user u preference is placed in f-dimensional space of latent variables.

For each considered latent factor, the seeds selection is carried out on the basis of three criteria:

- *Popularity*: in order to ensure that the user is able to vote the proposed items, only popular items have to be selected (e.g., items that were rated by many users).