RFID-Enhanced Museum for Interactive Experience

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Abstract. Visitors to physical museums are often overwhelmed by the vast amount of information available in the space they are exploring, making it difficult to select personally interesting content. Personalization solutions can provide the required user-centered interactivity between the visitors and the museum websites or museum guide systems. Recommender systems are among the most successful personalization technologies, as they have already been incorporated to solve similar problems in e-commerce, where users have a lot of choices to select a product. However, developing recommender system for museums is more challenging, because in contrast to e-commerce, museums and their exhibits exist in a physical world. Therefore, we need a hardware technology to provide us the required infrastructure to observe and model the environment and user activities. Radio-frequency identification (RFID) technology is among the best solutions for this issue, because it is cheap, fast, robust, and available everywhere. In this paper, we describe the vision of our project called RFID-Enhanced Museum for Interactive Experience (REMIX), which aims to developing a personalization platform for museums based on RFID technology and advanced recommender-systems algorithms.

Key words: Recommender System, Museum, RFID, Web application

1 Introduction

Visitors to physical museums are often overwhelmed by the vast amount of information available in the space they are exploring, making it difficult to select personally interesting content. To address this problem, personalization solutions are required in order to provide user-centered interactivity between the visitors and the museum exhibits. Such personalized solutions can be involved to assist visitors during their visit (online case) as well as to enhance their post-museum exploration (offline case), e.g., the interaction that visitors have *after* their visit when they can explore the museum's web site and find additional information for the exhibits they are interested for. The advantages of personalization solutions of this form, compared to the involvement of human guides, are their feasibility, efficiency, and lower cost.

Recommender systems (RS) are among the most successful personalization technologies, as they have already been incorporated to solve similar problems in e-commerce. Recommender systems guide users in a personalized way to interesting or useful objects in a large space of possible options [16]. For example, to provide answers to questions, such as "which movie should I see?" or "what book should I read?". We have too many choices and too little time to explore them all and the exploding availability of information makes this problem even tougher. Therefore, RS is today an essential part of any electronic shop, such as Amazon, eBay, and Netflix.

Developing recommender system for museums is, however, more challenging than in the case of e-commerce, because in contrast to e-commerce, museums and their exhibits exist in a physical world. The application of recommender systems in the context of *artificial* museums guides can be performed in several ways depending on the nature of an artificial guide, which may vary from a sophisticated robot to a common mobile device (e.g., smart phone). Moreover, we need a hardware technology to provide us the required infrastructure to observe and model the environment and user activities. Radio-frequency identification (RFID) technology is among the best solutions for this issue, because it is cheap, fast, robust, and available everywhere. Finally, algorithms for the generation of recommendations should take into account the location of exhibits and the physical distance between them.

In this paper, we describe the vision of our project called RFID-Enhanced Museum for Interactive Experience (REMIX), which aims to developing a personalization platform for museums based on RFID technology and advanced recommender-systems algorithms. Our emphasis is on explaining the novel features of the REMIX architecture, which significantly differentiate it from other applications with similar objectives. We also provide details about the challenges faced by RS algorithms in this new context. We examine two major cases: i) the online and the ii) offline case. In the online case, visitors are able to get recommendation for exhibits during their visit. Meanwhile, their movements are tracked non-intrusively[1] by RFID sensors placed on exhibits. In the offline case, after leaving the museum, the visitors can connect to a personalized web-based application which provides additional information about their actions inside the museum, about the exhibits they have been interested for, and recommendations for potentially interesting exhibits that they can see in future visits. Moreover, the tracked information can help the museum's management to understand the behavior and preferences of its visitors and shape evaluation metrics for, e.g., the popularity of exhibits according to their position in the museum, in order to reshape policies or design effective campaigns for the future.

The general aim of the ongoing REMIX project is the development of a system that will advance state-of-the-art research results from the emerging and increasingly affordable field of wireless RFID [1] technologies and from the field of recommender systems in the application area of museums. Based on the expected results of REMIX, museums will be able to provide to each visitor a

[1] preserving all aspects of visitors' privacy

personalized learning experience and the sense of belonging to the museum's community, which can be extended over multiple visits and between visits via a Web application that will be developed by the REMIX project. All these factors can significantly help to increase both the number of visitors and the quality of services they are provided by the museum.

2 Related Work

In this section, we provide a brief summary of existing applications of personalized solutions for museums, and we detail the innovative aspects of the proposed REMIX system.

The Exploratorium [2] is a hands-on science museum in San Francisco that uses the eXspot system, developed in cooperation with the University of Washington's Computer Science and Engineering Department and Intel Labs Seattle. It is intended to support, record, and extend exhibit-based, informal science learning. Its users can bookmark their exhibits of preference, create photographs (use their RFID tags to activate cameras), and access them later via the museum's kiosk or via the internet.

The Museum of Science and Industry in Chicago [3] opened a new 5,000-square foot permanent exhibition called "NetWorld" where visitors use RFID technology to learn about the Internet. First, they design personal avatars that are stored in the exhibition's network. Then, using their NetPass cards (with embedded RFID chips), the avatars accompany them throughout the exhibition, interacting with them as they learn about bits, packets, and bandwidth. With each new exhibit, the network stores visitors' ID numbers and displays their avatars to help them through new experiences. To avoid issues of personal data privacy, no personally identifiable information is collected when the cards are issued.

At the Vienna Museum of Technology [4], RFID has been used in an exhibition on the future of virtual reality. Visitors purchase a card at an admissions desk, take it to a card-reader terminal, and create a personal profile that includes preferred language, favorite color, nicknames, and other low-security identifiers. The interaction metaphor represents a digital backpack for collecting multimedia clips. Visitors take their cards to any number of card-reader terminals in the museum.

The Museum of Natural History in Aarhus [5] in Denmark, uses RFID technology in an exhibit called "Flying," which includes birds tagged with RFID chips. In this exhibit, visitors carry RFID readers and scan tags attached to birds. Scanning a bird results in the presentation of associated text, quizzes, audio, and video to the visitor.

The Tech Museum in San Jose [6], implemented RFID technologies in "Genetics: Technology with a Twist" exhibition in 2004. Earlier this year, it launched the "NetP1@net Gallery" where visitors create personalized Web pages with photographs and images from their visits to the museum, then use their RFID numbers to retrieve the page anytime on the Web.

2.1 Innovative aspects of the REMIX project

Similar to the aforementioned existing approaches, REMIX project involves RFID technology for monitoring visitors. However, the it contains several innovative aspects, which differentiate it from existing approaches. These innovative aspects are analyzed as follows:

1. The information system of REMIX monitors visitors not only for the purpose of retrieving this information but also for analyzing it using data mining technologies. As explained, the transfer of state-of-the-art algorithms from the research field of data mining will allow the museum to better capture the preference of users and provide advanced functionalities, such as the recommendation of exhibits for forthcoming visits.
2. The monitored information will be personalized via a Web application that will provide to each visitor data about the visits and also will encapsulate the data mining results, such as the recommendations.

3 The Architecture of REMIX

In this section we describe the overall architecture of the REMIX system, whereas the main component, i.e., the recommender system, will be explained in the following section.

3.1 The RFID monitoring system

Radio-frequency identification (RFID) is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it [17].

An RFID system consists of a tag made up of a microchip with an antenna, and an interrogator or reader with an antenna. The reader sends out electromagnetic waves. The tag antenna is tuned to receive these waves. A passive RFID tag draws power from the field created by the reader and uses it to power the microchip's circuits. The chip then modulates the waves that the tag sends back to the reader, which converts the new waves into digital data [18]. This mechanism is shown in Fig.1.

There are two kinds of RFID tags: active and passive. Active tags have a transmitter and their own power source (typically a battery). The power source is used to run the microchip's circuitry and to broadcast a signal to a reader (the way a cell phone transmits signals to a base station). Passive tags have no battery.

Instead, they draw power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna. Semi-passive tags use a battery to run the chip's circuitry, but communicate by drawing power from the reader. Active and semi-passive tags are useful for tracking high-value goods that need to be scanned over long ranges, such as railway cars on a track, but they cost more than passive tags, which means they can't be used on low-cost items. (There are companies developing technology that could make active tags far less expensive than they are today.) End-users are focusing on passive UHF tags, which cost less than 40 cents today in volumes of 1 million tags or more. Their read range isn't as fartypically less than 20 feet vs. 100 feet or more for active tagsbut they are far less expensive than active tags and can be disposed of with the product packaging [19].

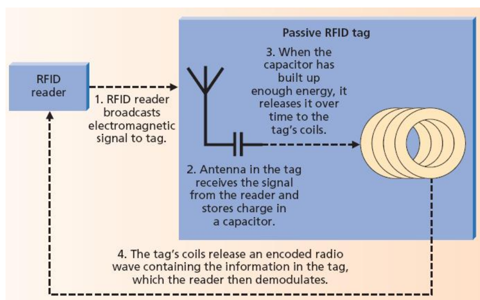

Fig. 1. Simplified view of data transfer in passive RFID tags

The proposed RFID subsystem in the REMIX architecture will monitor the interaction of visitors with exhibits, will consist of three main components:

1. The RFID reader package mounted on the exhibits: A plastic-molded package containing a mote for control and radio connectivity, a low-power RFID reader with range of few centimeters (e.g., 20 cm), and some indicators (e.g., LED) to allow visitors understand the state of the package. For power supply, there exist two main options. The first is to have each RFID reader package powered by rechargeable batteries and the second is to have it connected to constant power supply. The first option allows more flexible installation and relocation of the RFID reader package, whereas the second comprises a cheaper solution. In any case, the size of the RFID reader package will be small in order to be portable and easy to mount on the exhibits.
2. The RFID tags carried by visitors: Visitors can obtain and carry an RFID tag that will allow them to interact with the RFID reader packages mounted on the exhibits. To help visitors easy carry them, the RFID tags can be contained within laminated cards that are ease to wear around the neck. Other solutions will also be examined, like enclosing the RFID tags within bracelets. Whenever visitors want to "bookmark" an exhibit, i.e., record it

as visited, they can swipe their RFID tag at the vicinity of the corresponding RFID reader that will perform the recording.

3. The wireless network connecting the RFID readers: The RFID reader packages are connected through a wireless network with a base station. Transmitted information will be sent over mote radio (operating at specific frequency, e.g., 433 MHz). The base station will contain a server that maintains the database where transmitted information is recorded.

The functionality of the proposed RFID monitoring system is explained as follows: The RFID reader packages that are mounted on the exhibits continuously monitor their vicinity for the presence of RFID tags. When a visitor approaches an exhibit at close distance (e.g., 20 cm) , then its RFID reader package reads the RFID tag of the visitor and sends the ID of the tag to the base station via the wireless network. Along with the ID of the tag, the RFID reader package also transmits the ID of the exhibit and the current time. This constitutes the "bookmarking" information that will record the view of the exhibit by the visitor (Figure 2).

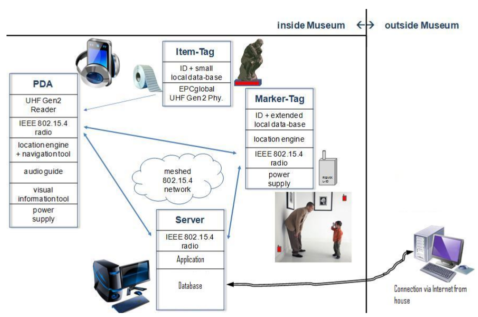

Fig. 2. The functionality of the proposed monitoring system

Visitors can obtain their RFID tags at a kiosk at the museum's entrance. They may perform a simple registration procedure, by providing some additional low privacy information (like email address or favorite color, pet name, etc.), which will increase the security in case the RFID tag is lost, and by receiving some guidelines about the use of their RFID tags. It has to be noticed that the use of RFID tags by the REMIX project offers several advantages compared to alternative solutions. RFID tags offer a low-cost and lightweight solution that permits the unobtrusive view of the exhibits.

3.2 Information system for recording and analyzing the monitored information

Information that is going to be transmitted by the RFID monitoring system through the wireless network has to be recorded at the base station. One of the main components of the information system that will be developed by the

REMIX project is a database in the base station that will contain the following information:

1. Data about the exhibits: Each exhibit that has a mounted RFID reader package will be represented in the database. The recorded fields will be the ID of the exhibit (unique identifier for each exhibit that will serve as the primary key), the name of the exhibit, and additional description, like historical and geographical information pertinent to the exhibit. Moreover, for each exhibit in the database there will be maintained a corresponding amount of information that will be delivered through the web application for post-museum exploration. This information may contain multimedia material, such as photographs or video, hypertext, and links to outside articles, such as Web encyclopedias.
2. Data about the visitors: After each visitor is registered and receives an RFID tag, the database will store the ID of the RFID tag and possibly additional information about the visitor. This additional information may be the email address of the visitor, or other low-privacy information, such as a question and answer that the visitor will propose ("what is your favorite color?"). Such low-privacy information will serve to protect visitors' privacy, because by using only the ID that is written on the RFID tag for accessing the information stored for each visitor may present a risk in case the RFID tag is lost (the ID will be clearly written on the RFID tag). The REMIX project intends to perform a user-study through which the optimal policy (i.e., selection of the type of complementary low-privacy information) for preserving the privacy of stored information will be decided. In any case, it has to be clarified, that no information that violates visitors' privacy (such as names, place of residence, telephone numbers, etc.) will be maintained.
3. Data about the interaction of visitors with exhibits: The information about the exhibits that each visitor interacts with during a visit will comprise a relationship between the two aforementioned data types, i.e., the data about exhibits and the data about the visitors. More precisely, for each interaction the database will store the ID of the exhibit, the ID of the RFID tag, and the date and time of day that this interaction happened. Please notice that these pieces of information are going to be available to the database at the base station, because the will be transmitted through the wireless network by the RFID reader packages on the exhibits. It is important to note that the aforementioned design at the conceptual level follows the principles of relational database development. However, due to the expected rapid flow of information about interactions in the database, the REMIX project will consider special design options at the physical level of the database, to cope with the requirement for fast updating due to the streaming information entering the database as the visitors continuously interact with the exhibits.

The recording of the monitored information about the interactions between visitors and exhibits will be valuable for retrieval purposes. Through a Web application that will be developed by the REMIX project, the visitors will be able to retrieve information about the exhibits they visited and “bookmarked” with the use of their RFID tags. Nevertheless, the information that is recorded about the interactions between visitors and exhibits can serve an additional purpose that is valuable for the museum. Thus, the museum can apply data mining techniques over the database contents and analyze the nature of repeat visits and visitors preferences. For the information system of the REMIX project, we will consider the development of an analysis module that will provide personalization services through a system that will generate recommendations for further visits [10, 11] both for the online and the offline case.

Providing recommendations during the current visit (online case) or for future visits (offline case) deepens visitors’ experience beyond a single visit, increase their satisfaction, and provide them motivation for multiple visits. The information system of the REMIX project will perform the analysis of visitors’ preference and provide recommendations for exhibits that can be visited in further visits. The functionality of the involved recommender systems and the prediction algorithms for identifying exhibits that have not been visited so far but may interest the visitor in future visits, will be analyzed in more detail in the following section.

Besides providing recommendations to visitors, the information system of REMIX will process the tracked information for providing the following services to museum’s management:

1. Mining sequential patterns [7, 8]: The exhibits with which a visitor interacts during one visit can be represented as a sequence, ordered by the time of interaction. By transforming the information about all interactions into a collection of sequences, the REMIX project will discover sequences of interactions that tend appear more frequently that the rest sequences. Such discovered sequences, which are called sequential patterns, reveal correlations between the exhibits and disclose information about visitors’ preferences. For example, a sequential pattern can be the following: ”The sequence of visits Egyptian golden mask (1000 B.C) Egyptian sculpture of young woman (1500 B.C) Egyptian papyrus fragment (1200 B.C.) is performed by the 35 of visitors”. From such a sequential pattern the museum can understand that these 3 exhibits are preferred to be visited by a significant amount of visitors. Therefore, the museum may relocate these exhibits and put them, e.g., in the same corridor and in the indicated order starting from the entrance of the corridor. Moreover, the correlation between these exhibits can be further exploited by the museum to promote new exhibits. For instance, assuming that the museum has recently acquired a new related exhibit (e.g., an Egyptian weapon), it can place it between the aforementioned exhibits, with the motivation that visitors will often tend to follow the route between these exhibits and, thus, to visit the new exhibit that is promoted by the museum.
2. Mining temporal patterns [9, 14]: When analyzing information about interactions between visitors and exhibits, valuable information can be revealed from time-related information that is stored in the database along with each interaction. In the information system of the REMIX project we will develop

data mining technology to discover temporal patterns. For instance, the system can discover the "life-cycle" of new exhibits, e.g., that they visitors pick their interest about a new exhibit 3 weeks after its first appearance, and that it is kept to be visited more frequently than older exhibits for about 3 additional months. Another type of interesting temporal pattern is the discovery of trends. The information system of the REMIX project will provide the data mining functionality of exploring information about visits with respect to time at different granularities (e.g., per week, month, season, etc.) and allow the analysts (users of the information system) to discover temporal patterns. For example, after the presentation of the new collection with Roman frescos, the total number of visits to the exhibits of this collection was increased by a factor of 55 compared to the average number of visits to other permanent exhibits one week before. With such patterns the museum can directly evaluate the reaction of visitors to its policies.

3.3 Personalized Web application for post-museum learning experience

Among the main goals of a museum is the designing of learning experiences for its visitors by enlightening them about subjects like nature, history, art, or science. A key aspect to enhance the learning process of visitors is the involvement of Web activities. This will link the exhibits in the museum with further concepts that can be found in the personalized Web pages. These pages match the preferences of each visitor and offer post-museum learning experience, i.e., extended beyond the visits to the museum.

For the aforementioned reasons, the REMIX project will develop a personalized Web application that will retrieve information stored in the database of the base station and create personalized Web pages for each visitor. A visitor can logon to the personalized Web pages by using as user-name the ID of the RFID tag (the ID will be written on the tag) and as password other provided information, like an email address. In the personalized Web pages, a user can see information about the visits, such as dates, hours, etc., the exhibits visited at each visit, and additional teaching material, like Web links to online encyclopedia articles related to the visited exhibits and further descriptions of the exhibits (e.g., detailed historical context). All these additional pieces of information will be maintained for each exhibit in the database. For an example of such a personalized page, please refer to Figure 3.

The proposed Web application will offer significant advantages to visitors that want to elaborate further the knowledge they acquire from the museum's exhibits. It is ideal for pedagogical activities, like a class visiting the museum. As the teacher of the class will not have adequate time during the visit to analyze all visited exhibits, the proposed Web application will allow the teacher in the following days in the class to continue the discussion and exploration of their visit, to assign home works based on the exploitation of additional information, etc.

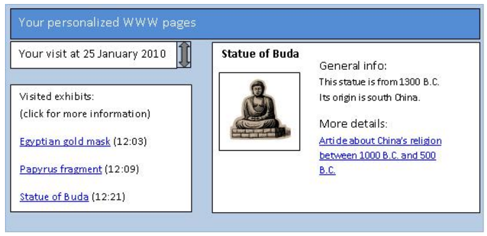

Fig. 3. A personalized web page

Finally, the personalized Web pages will accommodate the recommendations of exhibits that can be viewed in forthcoming visits. This way, the visitors are motivated to visit the museum often and each time they can adjust their preferences according to their available time, knowing that they can continue the exploration of the museum in following visits by planning them ahead through the use of recommendations.

4 Recommender Systems for Museums

In this section, we first describe the main methods that are used by recommender systems, and next we describe how the consideration of spatial processes addresses the new challenges that are introduced when applying recommender systems in museums.

4.1 Recommendation Algorithms

Most recommendation methods fall into two categories: Memory-based algorithms and Model-based algorithms [16]. Memory-based algorithms store rating examples of users in a training database. In the predicating phase, they predict the ratings of an active user based on the corresponding ratings of the users in the training database that are similar to the active user. In contrast, model-based algorithms construct models that well explain the rating examples from the training database and apply the estimated model to predict the ratings for active users. Both types of approaches have been shown to be effective for collaborative filtering. In this subsection, we introduce Aspect Model (AM) and Matrix Factorization (MF) from model-based algorithms and nearest-neighbor as a memory-based approach.

Nearest-Neighbor Nearest-Neighbor method is centered on computing the relationships between items or, alternatively, between users. The item-oriented approach evaluates a users preference for an item based on ratings of neighboring items by the same user. A products neighbors are other products that tend to get similar ratings when rated by the same user. For example, consider the movie Saving Private Ryan. Its neighbors might include war movies, Spielberg movies, and Tom Hanks movies, among others. To predict a particular users rating for Saving Private Ryan, we would look for the movies nearest neighbors that this user actually rated [23].

Aspect Model Aspect model is a probabilistic latent space model, which models individual preferences as a convex combination of preference factors [20, 21]. The latent factors $z \in Z = \{z_1, z_2, ..., z_k\}$ is associated with each pair of a user and an item. The aspect model supposes that users and items are independent from each other given the latent factor. Therefore, the probability for each rating tuple (m, u, r) is computed as following:

$$p(r|m,u) = \sum_{z \in Z} p(r|z,m)p(z|u) \tag{1}$$

in which $p(z|u)$ stands for the likelihood for user u to be in class z and $p(r|z,m)$ stands for the likelihood of assigning item m with rating r by users in class z. In order to achieve better performance, the ratings of each user are normalized to be a normal distribution with zero mean and variance as 1 [21]. The parameter $p(r|z,m)$ is approximated as a Gaussian distribution $N(m_z, s_z)$ and $p(z|u)$ as a multinomial distribution.

Matrix Factorization Matrix factorization is the task of approximating the true, unobserved ratings-matrix R by $\hat{R} : |U| \times |I|$. With $\hat{R}$ being the product of two feature matrices $W : |U| \times f$ and $H : |I| \times f$, where the u-th row w_u of W contains the f features that describe the u-th user and the i-th row h_i of H contains f corresponding features for the i-th item.

Matrix factorization models map both users and items to a latent space of dimensionality f [22]. In this space, user-item interactions are modeled as inner products. In the latent space, each item i is represented with a vector $h_i \in R^f$. The elements of h_i indicate the importance of factors in rating item i by users. Some factors might have higher effect and vice versa. In the same way, each user u is represented with a vector $w_u \in R^f$ in the latent space. For a given user the element of w_u measure the influence of the factors on user preferences. Different applications of matrix factorization differ in the constraints that are sometimes imposed on the factorization. The most common form of matrix factorization is finding a low-rank approximation (unconstrained factorization) to a fully observed data matrix minimizing the sum-squared difference to it.

The resulting dot product, $h_i^T w_u$, captures the interaction between user u and item i. This approximates user u's rating of item i, which is denoted by r_{ui}, leading to the estimate:

$$min \sum_{(u,i) \in k} (r_{ui} - h_i^T w_u)^2 + \lambda(\|h_i\|^2 + \|w_u\|^2) \tag{2}$$

in witch λ is the regularization factor, and k is the set of the (u, i) pairs for which r_{ui} is known (the training set).

4.2 Spatial Process

There is an essintial diffrence between recommender system for museum and web-based recommender systems. While web works in a virtual web environment, museum exist in the real world. This diiference could have advantage and disadvantage. In the physical world, there are constraints that do not exist in the virtual world. This issue, might restrict the recommendation algorithms. For example, visitor might not willing to vist an exhibit which is far from his current position in the museum specially in the last of his vistit because he is tired. In the other hand, the physical environment provides additional information which enables us to explore new methods which are not applicable for a recommender system working in a virtual environment.For example, in web-based recommender systems, in order to measure the similarity between items, the Euclidean distance is calculated. However, in a museum, physical distance between items have a meaning and there is no need to use other measurements such as Euclidean distance. Similar items could be grouped together is a same room or floor.

To address this issue, spatial process technique [12] is a suitable method which has recently been suggested for recommender systems in museums [13]. In addition to methods such as Matrix factorization [22], Aspect model [20, 21], and Nearest-Neighbor [23],we intend to investigate spacial process technique as well.

5 Conclusions

In this paper, we described our vision for the ongoing REMIX project. REMIX aims to developing a personalization platform for museums based on RFID technology and advanced recommender-systems algorithms. Museums invest human and financial resources to improve the learning experience that they offer to their visitors. However, with a large number of permanent exhibits and floor demonstrations, museums often more choices to the visitors than they can grasp in a single visit. Especially groups of visitors, like school students, tend to carefully observe only a small fraction of the exhibits, as younger visitors usually move fast from one exhibit to another[2]. Therefore, by rushing among the exhibits, visitors cannot fully explore the provided learning experience that the museum has designed for them.

By leveraging RFID technology and through the personalized Web application, REMIX allows a museum to deepen the visitors' learning experience, extend it beyond a single visit, and obviate the hurried visitor problem. Moreover, through the analysis of the data collected by the RFID monitoring system, the museum can study the nature of visits and the long-term preferences of the offered exhibits, and be in a position to provide better services to its visitors like, for example, recommendations for future visits. With all these means, the

[2] In such cases, the mean time of viewing an exhibit can be less than half a minute.

museum can increase the number of its visitors, the quality of its services, and to promote stronger relationships with its visitors, making them feel as members of the museum's community. Therefore, all the aforementioned results are expected to offer financial and cultural benefits to the museum, better exploitation of its resources. Another benefit is the possibility for additional exploitation of the Web personalized application within a business model that can promote advertising information at a regional and national level and e-commerce activities, such as the purchase of souvenirs, books, posters, etc.

The key-technology to attain the expected benefits of REMIX is personalization through the use of recommender systems. In this paper, we have described the new challenges resulting from the application of recommender systems in the context of a museum, and the main approaches we plan to develop for addressing these challenges.

The main point of our future work is the finalization of the software platform of REMIX, which will incorporate all the solutions described in this paper. Moreover, we plan to install REMIX in the Roemer Pelizaeus Museum (www.rpmuseum.de) in Hildesheim, Germany. This application of REMIX will provide the necessary benchmark for the evaluation of its usefulness.

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