Enhancing the Interactivity of Learning-Guide Systems with RFID

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1. Introduction

Many countries, including Taiwan, have over the last few years been actively promoting digital archives programs. Recent advances in information science and computer technology has opened up novel new means in which the general public can enjoy and be educated on historical and cultural relics that are important parts of a country's national heritage. New technologies has led to a growing number of extensive digital databases for artifacts such as pictures and visual art, writings, records, and other cultural objects. Researchers have therefore started to explore new ways in which these digital databases can be associated with the actual relics such that the knowledge and understanding of these objects can become more accessible to the general public.

Currently, many exhibition centers employ professional guides that explain the objects on display, answer questions and provide guided tours. Although such services are effective, pedagogic and promoting social interaction, it is limited by the human resources available and is therefore usually offered during peak hours and for groups with a minimum number of participants. Exhibition centers and museums therefore often provide self-service prerecorded audio guides to increase accessibility. Visitors carry portable audio players, on loan from the museum, and listen to the prerecorded guide through headsets as they walk through the exhibition. Such guides usually provide sufficient information about the objects on display. However, the static nature of the prerecorded guided tours means that the visitors need to view the exhibitions in a particular order and this restriction leaves little room for visitor participation and interaction [3]. Furthermore, visitors have different expectations and interests, and some visitors may be too impatient to complete their tours. Some museums employ digital audio devices that allow the users to enter a set of digits matching digits displayed next to an artifact. This allows users to manually control the playback order. More advanced audio guides have been proposed, such as Sotto Voce [21], which promotes social interaction where visitors eavesdrop others' personal audio guide. This study targets indoor guides, as outdoor guides pose different challenges [20, 23].

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Radio Frequency Identification (RFID) is a wireless communication technology that has been successfully applied to various fields such as transportation, distribution, supply chain, telemedicine, etc. RFID technology was used during World War II to identify airplanes as friend or foe, but was then forgotten for many years. Because the electronic tags have been expensive, RFID technology has not until recently become widely embraced. In 2003, Wal-Mart, the leader of retail business in United States started using RFID technology and incorporated an extensive RFID system in their storehouse and circulation. This event was picked up by others resulting in the RFID market rising rapidly and catching wide attention. The price of electronic tags is decreasing, and the RFID technology is now widely applicable and about to become acceptable for all kinds of fields.

RFID systems can be classified as non-contact and automatic identification technology that consists of two components – RFID readers (also called interrogators) and electronic tags (also called transponders). Unlike traditional bar-code system, RFID systems can carry dynamic as well as static data. According to different kinds of electronic tags, the functionality and memory size vary. Traditional bar-codes are reliant on an unobstructed label face of the codes because they need to be scanned to identify the digital data, and it takes a while to identify the traditional bar-codes. On the other hand, with RFID systems, tags can be hidden and there is no need to pay attention to the label face. As long as the tags are in the range of the radio wave that the RFID reader sends out, the information in the tags can be accessed and identified, and they can be identified rapidly through the radio wave. If there is more than one item, traditional bar-code must be scanned sequentially. In contrast, multiple tags can be read simultaneously.

We propose a novel interactive mobile guiding environment, where PDA's and both UHF and HF RFID technologies [6] are used to overcome the static nature of prerecorded guides and the code-entry effort of older interactive digital audio guides. In addition, the interactive learning infrastructure includes a wireless network and the system makes use of data mining and information retrieval technology [4]. The combination of RFID and wireless connectivity also allow remembering tools [22] to be realized such that visitors can review their visit remotely via the web at a later time. The proposed system allows an art museum to provide all its related artifact data or questionnaires to the visitors by equipping each artifact with an electronic tag. The long-distance RFID reader allows art galleries to promote exhibitions and attract visitors to the "hidden treasures" of less popular areas [8]. The system also recommends viewing routes for visitors. These recommendations are obtained by performing Apriori-like collaborative filtering on the individual viewing records [13, 14].

Our system is different to previous RFID-based guide systems [16, 17, 24] as two separate RFID systems that employ the HF and the UHF frequency bands respectively are used in parallel. The HF RFID system is used to increase personalization service and to attract visitors to specific artifacts [9]. The visitors do not have to wait long for the system to respond once they approach the target artifact as the HF tag instantaneously communicates with the system such that the related information is provided to the visitors without intervention [5, 11]. The long-distance UHF RFID reader, positioned at a strategic location within the museum, reads the UHF tag attached to the PDA of the visitors and is used to promote less-known artifacts.

The HF frequency band RFID system is based on ISO 15693 passive electronic tags, RFID readers and middleware. The passive ISO 15693 tags are not reliant on power. Consequently, there is a limited transmission distance, which makes them readable within a given radius of an artifact. Furthermore, passive tags are especially suitable for exhibitions because of their ubiquitous attributes – namely, compact size, long life, no need for maintenance, and low cost [12].

Visitors' PDAs are equipped with electronic EPC class 1 UHF tags. UHF frequency band RFID readers are installed at strategic locations throughout the exhibition venue. These are typically locations that receive fewer visitors and need to be actively promoted. Information read from an EPC class 1 electronic tag, attached to a visitor PDA, is immediately transmitted to the server middleware. Next, the middleware determines which visitor the tag belongs to and then delivers promotional information about the given exhibition via the wireless network to the visitors' PDAs.

2. Exhibition recommendation

The exhibition centers generally group artworks according to themes or type, such as photographs or Chinese ink-water paintings, in different sections. Occasionally, artworks are put together for a particular artist for his/her commemoration or to present a retrospective angle of the artist.

Data mining is an emerging technology that extracts useful information or patterns from large databases, data warehouses or other storage repositories. Data mining is also a field bringing together techniques from machine learning, pattern recognition, statistics, databases, and visualization, etc.

2.1 Mining association rules

Association analysis involves finding association rules from data stored in databases. Association rules relate the associations of attribute-value frequently appearing in the given dataset. A traditional example of association rule mining is the market basket analysis. The process finds associations from grocery selection of a customer in the basket and then discovers the purchase behavior of customer.

Normally, two steps are required to extract the association rules from databases.

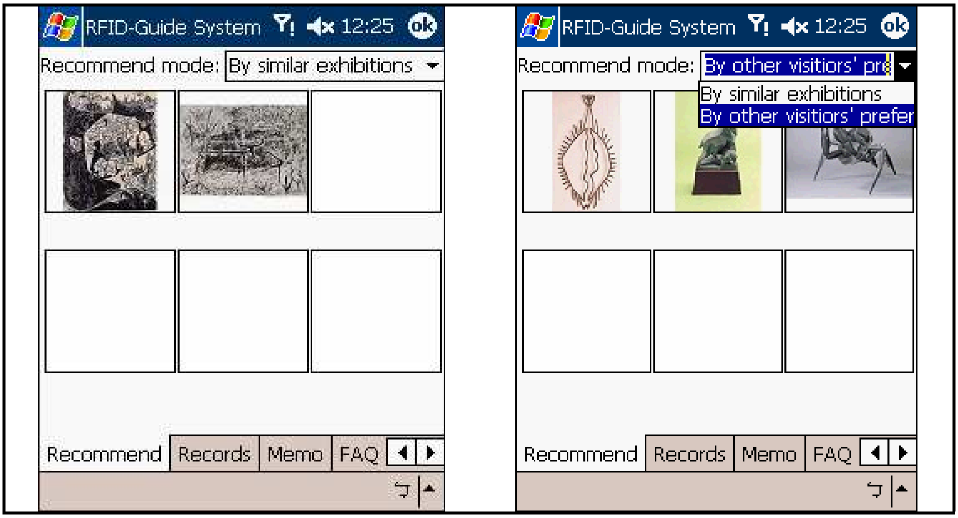
1. Find the sets of large itemsets: The first step is to find all the itemsets and supports of these itemsets must be larger than a predefined minimum support (threshold). The minimum support is usually defined by domain experts and is case dependent.
2. Generate strong association rules from large itmesets: By applying both support and confidence values to the large itemsets, strong association rules can be solicited. For example, the rule "item_C $\Rightarrow$ item_D [*support* = 25%, *confidence* = 50%]" means that 25% of transactions show that both item_C and item_D were bought together, and there are 50% of chance that if people bought item_C then they will buy item_D too.

The Apriori algorithm [14] can be applied to get large inter-itemsets. However, the processing cost of the first two iterations (i.e., obtaining L_1 and L_2, representing large 1-itemset and large 2-itemset, respectively) dominates the total mining cost. The reason is that a low minimum support induces a very large L_1, which in turn results in a huge number of itemsets in C_2 (i.e., candidate 2-itemset). This problem is even more severe when mining inter-transaction association rules. Tung et al. proposed the FITI algorithm that first finds the frequent intra-transaction itemsets and then generates the inter-transaction itemsets from the frequent intra-transaction itemsets. The work reduces the number of candidates and therefore improves the mining efficiency [25]. Lu et al. employed EH-Apriori to reduce

the number of candidate inter-itemsets [26]. Pei et al. [27] employed a projection scheme in the PrefixSpan algorithm where the customer sequences (transactions) were projected into overlapping sets called projected databases such that all the customer sequences in each set have the same prefix that corresponds to a frequent sequence (itemset). The underlying principle of the PrefixSpan is that, instead of projecting sequence databases by considering all the possible occurrences of frequent subsequences, the projection is only based on the frequent prefixes. This holds because any frequent subsequence can always be found by growing a frequent prefix. The advantages of the PrefixSpan algorithm are (1) no candidate sequence needs to be generated; and (2) the projected databases shrink [27].
The visitors' viewing history is continuously recorded as visitors browse the exhibition using the mobile guiding system. Information stored in the database includes timestamps for the various viewing events, the particular contents viewed, and the details browsed for particular artifacts [14]. Once a substantial amount of data has been collected a data mining algorithm is used to discover association rules between artifacts and the artists. These association rules are subsequently used to suggest useful exhibition-related information to future visitors. For example, assume the system generates an association rule as follows:

If "**Little Flying Phoenix** (Sculpture, Yang Yuyu)" and "**Suckling Lamb** (Sculpture, Ju Ming)," then "**Field Laboring** (Print, Yang Yuyu)."

Then, if a visitor inquires information about the 'Little Flying Phoenix' by Yang Yuyu and the 'Suckling Lamb' by Ju Ming, the system automatically recommends the information about the 'Field Laboring' by Yang Yuyu to the visitor as shown in Figure 1(a).



(a) The user can select different recommendation modes. (b) The other recommendation mode.

Fig. 1. Exhibition recommendation.

2.2 Collaborative filtering

Information about visitors is used to perform collaborative filtering [2]. Recommendations are created according to groups of visitors with similar and related interests and preference.

Item-based filtering is a strategy where the connection between items is identified according to visitors' selections, preferences, and browsing patterns. This technique is commonly employed on e-commerce web sites where, for example, warehouse retailers collect information about products purchased by customers. Next, the connection between purchased products and customers' purchasing habits are then estimated. Finally, the warehouse retailers can recommend additional and relevant products when the customer purchases certain items.

	Big Pot	Square Dish	Revolve	Soul-box II	Moon Bowl
Visitor A	1	1	0	0	1
Visitor B	0	1	0	1	1
Visitor C	0	0	1	0	0
Visitor D	1	1	0	0	0
Visitor E	1	0	0	1	0

Table 1. Collaborative filtering example.

Table 1 shows an example of collaborative filtering where artifacts viewed by a visitor are assigned 1 and artifacts that are not visited are assigned 0. In this example, the viewing patterns of visitor *A* and visitor *D* have the highest similarity. Therefore, artifacts viewed by visitor *A* that has not yet been viewed by visitor *D* should be recommended to visitor *D*. The similarity between visitors and artifacts, and the most suitable information of the exhibition for recommendation can be calculated as follows [15] where the similarity of viewing patterns between two visitors *a* and *b* is denoted by *sim(a,b)*:

$$sim(a,b) = corr_{ab} = \frac{\sum_{j=1}^{N}(p_{aj} - \overline{p}_a)(p_{bj} - \overline{p}_b)}{\sqrt{\sum_{j=1}^{N}(p_{aj} - \overline{p}_a)^2}\sqrt{\sum_{j=1}^{N}(p_{bj} - \overline{p}_b)^2}}, \quad (1)$$

N is the total number of exhibitions, p_{aj} is visitor *a*'s rating on the exhibition *j*, and $\overline{p}_a$ is visitor *a*'s average rating on all exhibitions. Let $H = \{h_1, h_2, ..., h_m\}$ be the set of visited exhibitions by visitor *c*. The query likeness score *QLS(c,j)* of visitor *c* on a new exhibition *j* is determined by [15]:

$$QLS(c,j) = \frac{\sum_{i \in H}(p_{ij} - \overline{p}_i) \times sim(c,i)}{\sum_{i \in H} sim(c,i)}. \quad (2)$$

When viewing artifacts in one section, visitors may miss artworks of interest on display in other locations of the museum or artwork currently not on display at all. Museums usually have limited real-estate to display artifacts, and therefore have to rotate the artifacts on display during different exhibitions. The recommendation system therefore emphasizes exhibitions from different sections that have been viewed by other visitors during previous exhibitions. These exhibitions may be in different styles but from the same creator or exhibitions with the same style but in a different category [7]. Artifacts not on display can therefore be viewed on the PDA via the recommendation system as shown in Figure 1.

The system also provides a directory map to help visitors easily navigate to the recommended item when recommended artifacts are on display in different locations to where the visitors presently are (see Figure 2).

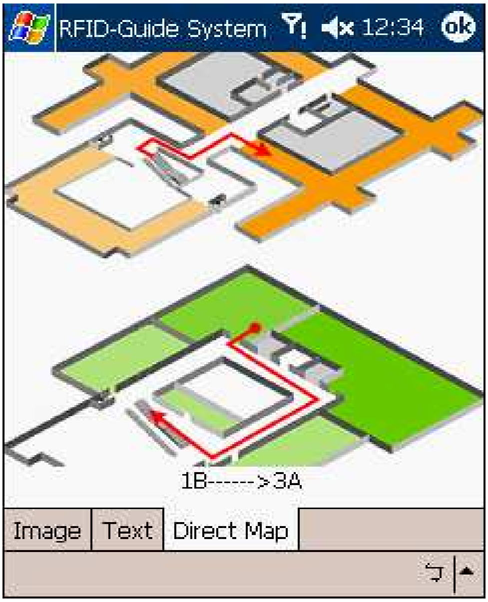


Fig. 2. Exhibition directory map.

3. System implementation

The architecture of the mobile guide system is illustrated in Figure 3. The mobile guide infrastructure comprises PDA clients, RFID readers, a wireless network and EPC class 1 electronic tags.

Each exhibition sign in the exhibition center is fitted with a unique ISO 15693 passive electronic tag. These tags are read by the PDA RFID readers allowing the artifact to be identified. Detailed content associated with the identified item is then downloaded via the wireless network and presented on the PDA together with a FAQ or a questionnaire. In addition, the electronic tag read by the RFID also identifies the whereabouts of the visitor allowing their movements to be tracked [1]. The back-end server is managed by exhibition centre personnel who have to update the database each time an exhibition is changed. They also provide answers to questions posted by visitors.

Traditional prerecorded guides require the visitors to follow prewritten scripts and fixed routes around the items on display. This is problematic for visitors who are unable to keep up with the explanations, visitors who wish to deviate from the tour and explore the exhibition on their own, and sometimes, visitors are unable to find the exhibitions because they are unfamiliar with the floor plan, misunderstand the guides, or the museum is so crowded such that physical movement and vision is restricted. The user-friendly interface helps overcome these limitations and difficulties as it provides a more convenient environment for the visitors to browse the artworks and exhibitions.

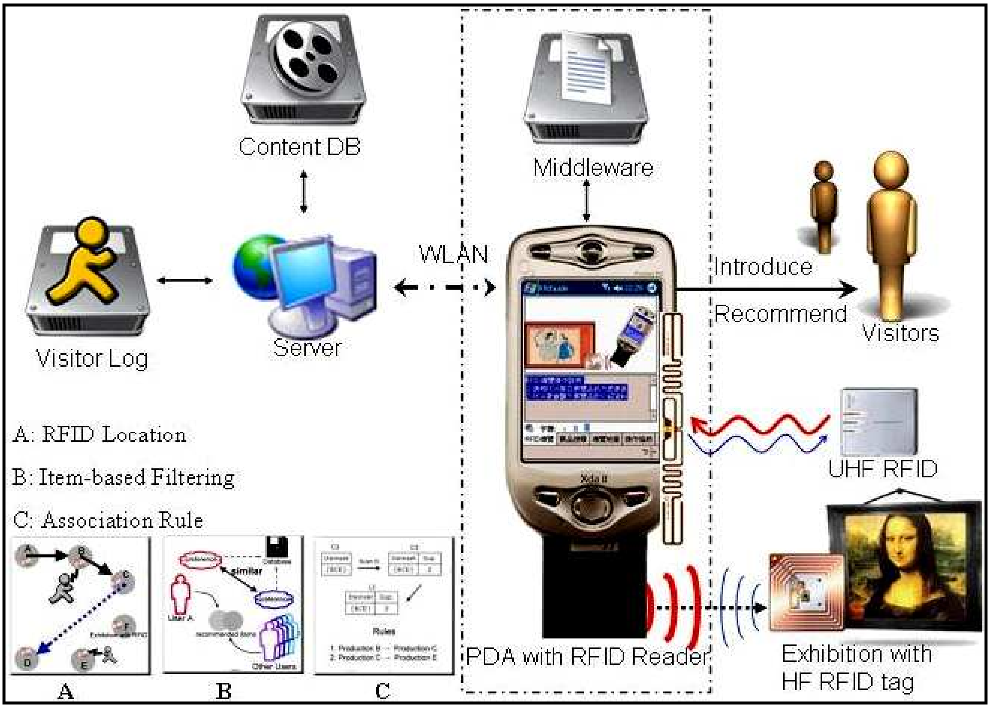


Fig. 3. The architecture of the RFID guide system.

3.1 RFID guiding

The digital content is prepared by the exhibition center staff. The multimedia contents include textual explanations, digitally recorded audio, graphical illustrations and short video clips. Each entry in the content database is linked to the identifier of the encased electronic RFID tag that is attached to the sign of the physical artifact on display together with RFID guiding marks that help visitors know where to point the RFID reader.

Visitors simply move the RFID equipped PDA close to the RFID guiding mark to read the discernment code of the electronic tag. The middleware identifies the content associated with the discernment code which then can be displayed in the PDA as shown in Figure 4. Visitors do not need to input textual queries. Text input is particularly difficult, error-prone and time-consuming on handheld devices [18, 19]. Further examples from an art gallery in Taipei county are shown in Figures 5-8.

Museum may employ multiple RFID-tags and guide marks around popular artifacts that attract many simultaneous visitors. For instance, RFID-tags could be placed on both sides and beneath a wall mounted piece, or in all four directions, or more, around some items on a pedestal.

(a) HF RFID reader. (b) ISO 15693 passive electronic tag.

Fig. 4. The RFID-based guide system.

Fig. 5. A painting with a RFID-enhanced information plate.

Fig. 6. The visitor moved the handheld computer close to the information plate. The RFID-reader picks up the ID of the painting.

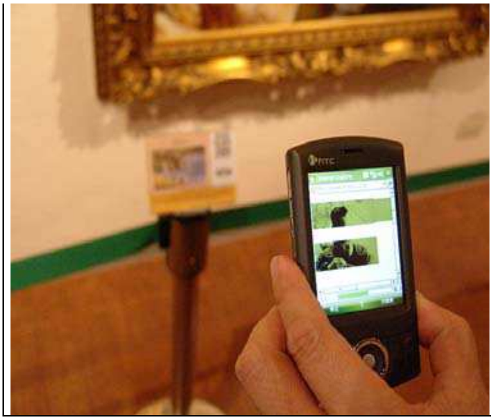


Fig. 7. Information about the painting is downloaded from a server via the wireless network.

Fig. 8. The visitor browses the downloaded information.

3.2 Discovering "Hidden Treasures" with UHF RFID

The mobile guiding system is designed to help visitors explore the exhibitions freely according to their personal interests and preferences. The system allows visitors' viewing patterns to be recorded and these records can subsequently be analyzed by the exhibition staff such that future exhibitions can be improved. The layout of the exhibition can be changed by placing popular and famous objects at strategic locations such that visitors have to walk past and discover lesser known objects, in a similar manner to which merchandise are strategically placed in modern supermarkets. However, we also exploit UHF RFID to actively attract visitors to less popular objects.

Imagine for instance a painting on display in the exhibition depicting two people touching hands on a shadowy background. Uninformed visitors may only catch a brief glimpse of the painting, judge the painting unimportant and then move on. However with the UHF RFID installed, the system could for instance raise the visitors' attention by delivering the message "What is it in their hands?" as they walk past the painting.

When visitors are in the vicinity of a less popular artifact with an UHF RFID reader installed, the UHF RFID reader identifies the UHF electronic tag attached to the PDA device carried by the visitor and transmits the information to the back-end server. The server identifies the wireless network IP address of the PDA with this particular tag. Then the message can be sent to the PDA and reported to the visitor as shown in Figure 9. Consequently, visitors are more likely to discover that the two people in the painting are holding a dandelion in their hands and to realize that the painting is conveying the happiness associated with the arrival of spring.

3.3 Multimedia streaming

Multimedia presentations, such as video and audio, are presented to the visitors on their PDAs (see Figure 10). However, most PDAs have limited storage capacity and the multimedia content is therefore hosted on the server, instantly encoded and streamed over the wireless network before it is decoded and presented to the visitors on their PDAs. This also simplifies maintenance of the system as only the server needs to be updated and not each of the individual PDAs.

In addition to admiring the beauty of the artworks, the visitors may also gain insight into additional relevant information through the presentations, such as the complexity of the creation process. Hopefully, this makes learning more entertaining and fun.

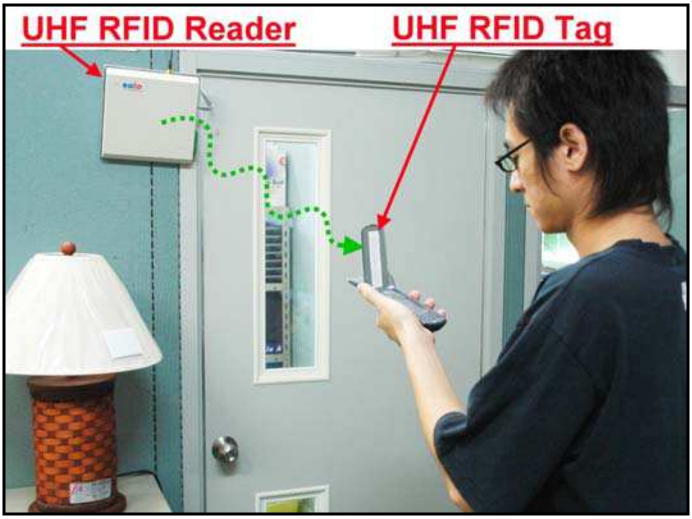


Fig. 9. RFID promotion.

(a) The video streaming function. (b) Playing the video.

Fig. 10. Multimedia streaming.

4. Evaluation and analysis

An evaluation experiment was set up to assess the effectiveness of the mobile guide. The purpose was to examine the stability of the system, to acquire users' opinions about the system and to identify potential problems. HF electronic tags were attached to the back of photographs of historical and cultural relics. After having completed the interactive guided tour the participants were asked to complete a questionnaire. In addition, the proposed system was compared to existing guide systems.

4.1 Results of the experiments

A total of 133 questionnaires were collected. The results of the six-part questionnaire can be summarized as follows. (1) 82.7% of the users think that the system is interesting. (2) 78.1% of the users enjoy learning using the mobile guiding system. (3) 75.9% of the users believe that it is suitable to use such a system in exhibition centers. (4) All users agree that it is uncomplicated to manage this system and do not require any prior learning for operation. (5) 84.2% of the users liked the recommendation function. (6) Some parents suggested including artifact-related games for children to promote fun learning.

Other observations include: (1) The RFID guiding function can correctly read and respond to 100% of the information delivered from the exhibitions. (2) There was a system delay of approximately one second after an RFID electronic tag was read. (3) The RFID recommendation system yields a success rate of 94.7% in recommending interesting exhibitions to other visitors. (4) Without the multimedia streaming technology, it takes on average three seconds to download a two-minute video before it can be played. The multimedia streaming technology efficiently partitioned the video such that the perceived downloading delay diminished.

The ubiquitous nature of RFID technology allows RFID tags to be successfully read although they are hidden out of sight. Consequently, the visual appearance of artifacts on display are not affected or disturbed as they are with conventional signs and posters [11]. There is an interaction distance of approximately 15 centimeters between the HF RFID tag and the reader and this was found to be a reasonable distance. If the distance is too large, the reader may simultaneously detect multiple tags and the system will be unable to resolve which artifact the user is actually browsing.

However, the reading distance of the UHF frequency band RFID is much larger. If there are two, or more, visitors within the interaction range, there will be a collision between the UHF electronic tags. Furthermore, during the experiment we found that the UHF frequency band RFID is affected by moisture. Most visitors put the UHF RFID tickets in their pockets. These tickets did not operate accurately when they were too close to the human body and were affected by human moisture. The UHF electronic tag was; therefore, attached to the PDA instead. This has greatly improved the operational accuracy of the UHF subsystem, but it also helps reduce costs as the UHF electronic tags can be reused.

4.2 Guide system comparison

Most guide systems can be categorized as being either designated guide systems or active guide systems. A designated guide system includes stationary components such as exhibition labels and information kiosks. Exhibition labels contain simple and general exhibition-related textual information. On the other hand, an information kiosk is a powerful multimedia workstation which can be placed in each section to provide interactive responses to exhibition inquiries. Although, a kiosk is a powerful information resource it somewhat is inconvenient, as users must move away from the artifact in order to use the kiosk.

Active guide systems include professional guides, brochures, prerecorded audio, and digital mobile guide systems. Professional guides are individuals that have been trained by the exhibition center to escort visitors around the exhibition while explaining the details of the artifacts on display. Due to limited budgets and few staff professional guided tours are often only provided during certain peak hours or need to be pre-booked. Brochures and booklets that contain information about the exhibition are often distributed to visitors when they purchase tickets or enter the exhibition centers. Prerecorded audio guides force the visitors to view the exhibitions in a particular order. Digital mobile guide systems, such as digital voice players or PDAs, provide enhanced interaction to users. Visitors can obtain exhibition-related content by entering the artifact name or ID number into the system as they move to each exhibition on display.

Table 2 presents a comparison of the different strategies discussed herein according to five key objectives, variable cost, and the simplicity of updating the information.

	RFID-based guide system	Assigned professional guides	Pre-recorded audio	Brochures
Response instantaneity	Very high	High	Lowest	Low (Self-searching)
Dynamic interaction	High	Very high	Lowest	Low
User-friendly interface	High	Very high	Lowest	Low
Abundant in content	Very high	High	Low	Very low
Information gathering	Very high	Low	Lowest	Very low
Fixed costs (training, etc)	High	Very high	Low	Very low
Cost for each service	Very low	Very high	Low	High
Update simplicity	Very high	Very low	Low	High

Table 2. Comparisons of guide systems.

5. Conclusions

An integrated interactive RFID guide system based on information retrieval, association rules, and personalized recommendation that assists visitors browsing an exhibition centers was presented. Visitors retrieve exhibition-related multimedia information by using RFID equipped PDAs. Recorded visitor viewing patterns can be subsequently analyzed and used to improve the exhibition to achieve more effective learning.

The database needs to be maintained such that it accurately reflects the physical artifacts on display at any given time. In addition, the question-and-answer function did not offer suitable answers to all questions. Thus, there are two directions for further improvements:
Tailored content: Users have different levels of knowledge and the contents of the exhibitions should be designed accordingly. Thus, contents tailored for different visitor groups such as children, young adults and senior visitors could greatly help improve the overall user experience.
On-line oracle: A computer system is no substitute for a real human expert. One can therefore use the wireless infrastructure to connect visitors to a real guide which can offer visitors an immediate remote on-line one-to-one guiding service.

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7. References

[1] P. Bahl and V.N. Padmanabhan, “RADAR: An in-building RF-based user location and tracking system,” *Proc. of IEEE Computer & Communications Societies*, Tel-Aviv, Israel, vol. 2, pp.775-784, Mar. 2000.
[2] D. Billsus and M.J. Pazzani, “Learning collaborative information filters,” *Proc. of Int. Conf. on Machine Learning*, Madison, WI, USA, pp.46-54, July 1998.
[3] M. Derntl and K.A. Hummel, “Modeling context-aware e-learning scenarios,” *Proc. of the 3rd IEEE Int. Conf. on Pervasive Computing and Communications Workshop*, Kauai Island, HI, USA, pp.337-342, Mar. 2005.
[4] K. Facer, R. Joiner, D. Stanton, J. Reid, R. Hull and D. Kirk, “Savannah: mobile gaming and learning,” *Journal of Computer Assisted Learning*, vol. 20, no. 4, pp.399-409, Sept. 2004.
[5] J. Hightower, R. Want and G. Borriello, “SpotON: an indoor 3D location sensing technology based on RF signal strength,” *UW CSE 00-02-02, Department of Computer Science*, *University of Washington,* Seattle, WA, USA, Feb. 2000.
[6] Y.-P. Huang and T. Tsai, “A fuzzy semantic approach to retrieving bird information using handheld devices,” *IEEE Intelligent Systems,* vol. 20, no. 1, pp.16-23, Jan./Feb. 2005.
[7] R.J. Mooney and L. Roy, “Content-based book recommending using learning for text categorization,” *Proc. of the 5th ACM Conf. on Digital Libraries*, San Antonio, TX, USA, pp.195-204, June 2000.
[8] L.M. Ni, Y. Liu., Y.-C. Lau and A.P. Patil, “LANDMARC: indoor location sensing using active RFID,” *Proc. of the IEEE Conference of Pervasive Computing and Communications*, Vienna, Austria, vol. 10, no. 6, pp.701-710, Nov. 2004.
[9] S. Poslad, H. Laamanen, R. Malaka, A. Nick, P. Buckle and A. Zipf, “CRUMPET: Creation of user-friendly mobile services personalized for tourism,” *Proc. of the 2nd Int. Conf. on 3G Mobile Communication Technologies*, London, UK, pp.28-32, Mar. 2001.
[10] R. Baeza-Yates and B. Ribeiro-Neto, *Modern Information Retrieval*, Addison-Wesley, Reading, MA, USA, 1999.

[11] R. Want, "Enabling ubiquitous sensing with RFID," *IEEE Computer*, vol. 37, no. 4, pp.84-86, Apr. 2004.

[12] R. Weinstein, "RFID: a technical overview and its application to the enterprise," *IT Professional*, vol. 7, issue 3, pp.27-33, May-June 2005.

[13] S. Zadrozny and J. Kacprzyk, "An extended fuzzy Boolean model of information retrieval revisited," *Proc. of The 14th IEEE Int. Conf. on Fuzzy Systems*, Reno, Nevada, USA, pp.1020-1025, May 2005.

[14] J. Han and M. Kamber, *Data Mining: Concepts and Techniques*, Morgan Kaufmann Publishers, San Francisco, CA, USA, 2001.

[15] C.Y. Kim, J.K. Lee, Y.H. Cho and D.H. Kim, "VISCORS: A visual-content recommender for the mobile web," *IEEE Intelligent Systems,* pp.32-39, Nov./Dec. 2004.

[16] S. His and H. Fait, "RFID enhances visitors' museum experience at the exploratorium," *Communications of the ACM*, vol. 48, no. 9, pp.60-65, Sept. 2005.

[17] H. Hlavacs, R. Gelies, D. Blossey and B. Klein, "A ubiquitous and interactive zoo guide system," *Lecture Notes in Computer Science*, vol. 3814, pp.235-239, Nov./Dec. 2005.

[18] F.E. Sandnes and Y.-P. Huang, "Chord level error correction for portable Braille devices," *Electronics Letters*, vol. 42, no. 2, pp.82-83, Jan. 2006.

[19] F.E. Sandnes and Y.-P. Huang, "Chording with spatial mnemonics: automatic error correction for eyes-free text entry," *Journal of Information Science and Engineering*, vol. 22, no. 5, pp.1015-1031, Sept. 2006.

[20] K. Cheverst, K. Mitchell and N. Davies, "The role of adaptive hypermedia in a context-aware tourist GUIDE," *Communications of the ACM*, vol. 45, no. 5, pp.47-51, May 2002.

[21] P.M. Aoki, R.E. Grinter, A. Hurst, M.H. Szymanski, J.D. Thornton and A. Woodruff, "Sotto voce: exploring the interplay of conversation and mobile audio spaces," *Proc. of SIGCHI Conf. on Human Factors in Computing Systems*, Minneapolis, MN, USA, pp.431-438, Apr. 2002.

[22] M. Fleck, M. Frid, T. Kindberg, E. O'Brien-Strain, R. Rajani and M. Spasojevic, "From informing to remembering: deploying a ubiquitous systems in an interactive science museum," *IEEE Pervasive Computing*, vol. 1, no. 2, pp.13-21, Apr.-June, 2002.

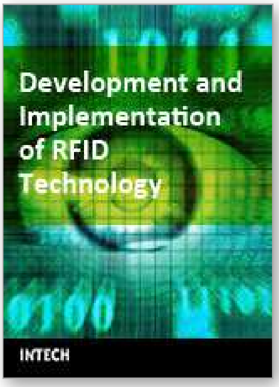
[23] K. Cheverst, N. Davies, K. Mitchell, A. Friday and C. Efstratiou, "Developing a context-aware electronic tourist guide: some issues and experiences," *Proc. of SIGCHI Conf. on Human Factors in Computing Systems,* The Hague, The Netherlands, pp.17-24, Apr. 2000.

[24] D. Raptis, N. Tselios and N. Avouris, "Context-based design of mobile applications for museums: a survey of existing practices," *Proc. of 7th Int. Conf. on Human Computer Interaction with Mobile Devices & Services*, Salzburg, Austria, pp.153-160, Sept. 2005.

[25] A.K.H. Tung, H. Lu, J. Han and L. Feng, "Efficient mining of intertransaction association rules," *IEEE Trans. on Knowledge and Data Engineering*, vol. 15, no. 1, pp.43-56, Jan./Feb. 2003.

[26] H. Lu, J. Han, and L. Feng, "Stock movement and n-dimensional intertransaction association rules," *Proc. SIGMOD Workshop Research Issues on Data Mining and Knowledge Discovery*, vol. 12, pp.1-7, 1998.

[27] J. Pei, J. Han, B. Mortazavi-Asl, J. Wang, H. Pinto, Q. Chen, U. Dayal and M.C. Hsu, "Mining sequential patterns by pattern-growth: the PrefixSpan approach," *IEEE Trans. on Knowledge and Data Engineering*, vol. 16, no. 11, pp.1424-1440, Nov. 2004.



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The book generously covers a wide range of aspects and issues related to RFID systems, namely the design of RFID antennas, RFID readers and the variety of tags (e.g. UHF tags for sensing applications, surface acoustic wave RFID tags, smart RFID tags), complex RFID systems, security and privacy issues in RFID applications, as well as the selection of encryption algorithms. The book offers new insights, solutions and ideas for the design of efficient RFID architectures and applications. While not pretending to be comprehensive, its wide coverage may be appropriate not only for RFID novices but also for experienced technical professionals and RFID aficionados.

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