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A Method of Designing Museum Ubiquitous Visitor Model

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Abstract

Museum ubiquitous visitors need personalized services according to their requirements. For providing personalized services to the museum's ubiquitous visitors, this paper presents the museum Ubiquitous Visitor Model. The Museum Ubiquitous Visitor Model is designed by combining ubiquitous Visitor Personal Information (VPI), Essential Context-derived Reasons (ECR), and Interests of the ubiquitous visitors. For designing the museum Ubiquitous Visitor Model, the information about ubiquitous visitors is obtained both implicitly and explicitly. The context information of the museum's ubiquitous visitors is collected implicitly and deduced into Essential Context-derived Reasons (ECR). The ubiquitous visitor's Interest is obtained implicitly from his/her history of exhibit information museum services access. On the contrary, VPI is obtained explicitly through the pre-visit registration process. Museum Ubiquitous Visitor Model (UbiVM) as cases characterize the tuple of multifaceted information about ubiquitous visitors which enables the system to understand their requirements to provide personalized services. We conducted simulation with the available accuracy of ECR and the history of exhibit information museum service access. The simulation results show that the accuracy of the museum Ubiquitous Visitor Model increases with the increase in the accuracy of ECR and the available history of exhibit information museum service access of the ubiquitous visitors. The designed Ubiquitous Visitor Model also decreases the system resource usage and the number of requests to the museum exhibit information server.

Keywords: *Museum ubiquitous visitors, ECR, Interests, Ubiquitous visitor personal information, Museum ubiquitous visitor model*

1. Introduction

Providing personalized museum services to the ubiquitous visitors has gained increasing attention over the past few years [1][2][3][4][5][6][7]. Museum ubiquitous visitors are the visitors who are free to access their personalized services anywhere, anytime through any possible mobile or fixed devices without any requests or interventions. Moreover, often due to difference in interests, levels of understanding, and other personal, contextual factors, etc., museum ubiquitous visitors have individual requirements of services [8][9][10]. For providing such unobtrusive and personalized services, it is essential to acquire the context information and the interest of the museum's ubiquitous visitors and to recognize the services that they required in the museum [1][3]. As illustrated in [Figure 1], one museum ubiquitous visitor may be interested in a historical exhibit information museum service, whereas the other may be interested in scientific exhibit information museum service. Additionally, the professional

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ubiquitous visitor may need to exhibit information at advanced level of detail, whereas a school kid ubiquitous visitor may need identical exhibit information in lesser detail. These individual requirements such as exhibit information of interests, at different levels of details, or in a variety of formats, etc., introduce new challenges to provide personalized services to the museum ubiquitous visitors [11][12][13][14][15][16]. However, for providing personalized services relevant to an individual ubiquitous visitor, the system relies on the museum *Ubiquitous Visitor Model*.

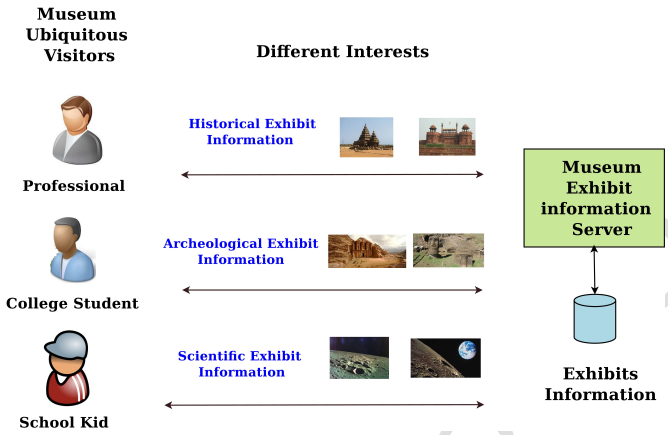

Figure 1. Individual requirements of museum ubiquitous visitors

1.1. Proposed idea

This work presents the designing of the museum *Ubiquitous Visitor Model.* For designing the proposed model, information about the museum's ubiquitous visitors is obtained both implicitly and explicitly. The system implicitly obtains ubiquitous visitor's *Interests* from their history of exhibit information museum services access. Further, *ECR* has deduced implicitly from context information of the museum's ubiquitous visitors. On the contrary, museum ubiquitous *Visitor Personal Information (VPI)* is obtained explicitly through the pre-visit registration process, and accordingly a unique-id is assigned to the ubiquitous visitors. Next, Interests, *ECR,* and *VPI* of the ubiquitous visitor are combined to design the *Museum Ubiquitous Visitor Model. Museum Ubiquitous Visitor Model (UbiVM)* as cases characterize tuple of multifaceted information about the museum's ubiquitous visitors and enable the system to provide personalized services. The proposed method is simulated with an available accuracy of *ECR* and the history of exhibit information museum service access. The simulation results show that the accuracy of the museum *Ubiquitous Visitor Model* increases with the increase in the accuracy of *ECR* and the available history of exhibit information museum service access of the ubiquitous visitors. The designed *Ubiquitous Visitor Model* also decreases the system resource usage and the number of requests to the museum exhibit information server.

1.2. Organization of the paper

The rest of the paper is organized as follows. Section 2 discusses some of the related work. Section 3 describes the museum Ubiquitous Visitors and the formation of *Essential Context-derived Reasons (ECR)*. Section 4 explains the ubiquitous visitor's interests obtained from the history of exhibit information museum service access. Section 5 presents the method of designing the museum *Ubiquitous Visitor Model*. Section 6 provides an example of *Ubiquitous*

Visitor Model of a professional ubiquitous visitor. Section 7 presents the simulation results, followed by the conclusion and the future work in Section 8.

2. Related work

Providing personalized services to the museum's ubiquitous visitors is explored from several perspectives in the literature. The research community has focused on many aspects of personalization (e.g., exhibits information of interests, tailored exhibit information) [7][8][9][10][11][12][13][14][15][16][17][18][19][20][21], in determining the museum ubiquitous visitor's interests [22][23][24], and in designing the museum ubiquitous visitor models [25][26][27][28][29][30]. The survey on developing personalized services in museums is discussed in [31]. In [32], the potentials and challenges for the mobile media in museums are described to support visitors in navigation, to provide personalized information, and to increase the attention towards exhibits in museums.

Rutledge et al. [23] have used an interactive dialog-based approach to collect museum ubiquitous visitor's interest. The visitors rate their interested and non-interested items for relevant artifacts to be provided. Hippie's [33] system has used both explicit and implicit methods to collect information about visitors and to set up a visitor model. The visitors are observed using position aware devices based on their attention towards objects. The position and the time spent at that position indicates the visitor's interest.

Some of the challenges in personalized museum tours are discussed in [20]. The proposed work has focused on on-line and off-line learning of the user model. In an off-line setting, the visitor fills the questionnaire and scores the artifacts, based on which the tour is constructed. In an online setting, the system receives feedback from the visitor for the presented artwork during the tour. Bohnert et al. [34] have used explicit visitor ratings to recommend tours in a museum. In [26], a non-intrusive model of visitor's interest is proposed to provide personalized services. The time spent by the visitor at exhibits is considered as indicative of museum ubiquitous visitor's interests. In [35], the framework is presented to assist museum visitors to enrich the tour experience. The interests and knowledge of the museum visitors are obtained explicitly (through registration) and used to adapt the artwork information for children to senior researchers. The interests and the levels of understanding of the visitors are determined by analyzing the information accessed by the visitors.

In [25], the visitor model mediation mechanism is used to obtain ubiquitous visitor's interests. For determining interests, simulated experience using the trip planning system is considered with a case-based user model representation. The visitor model mediation mechanism extracts the list of attractions that visitor has browsed and obtains the text descriptions of the interesting attractions from the knowledge base. Berkovsky et al. [36] have considered visitor interests as a four-point scale with no interests to high interests to provide personalized summaries to the museum visitors. The aspect-based representation of user models is used to generate personalized summaries. For a given aspect the amount of information provided is proportionate to the visitor's interest. The MNEMOSYNE [37] system builds profiles of interests by passively observing museum visitors for personalized content delivery. To build the profile of interests, the system maintains a record of the artworks that visitors have observed during their visit.

An augmented reality system Ec(h)o [38] has considered museum ubiquitous visitor's information in a dynamic manner according to the visitor's interaction and designed a visitor model. The visitor's interest is obtained from the visitor's movement in the exhibition and the visitor's interaction with the system. The ontologies are used to describe the visitors, contents

of objects, and the environment. Bright et al. [39] have described a MyMuseum guide that explicitly collects information about the preferences of museum ubiquitous visitors. The visitor model is designed by asking visitors about the goal of their visit followed by stereotypical assumptions. For the personalization in the museum, the authors in [28] have discussed the need for a visitor model with interests, knowledge, personal characteristics, and other contextual aspects to select the most appropriate information contents. The visitor model is presented to represent the visitor's interests and the context of their visits.

In [26], Bohnert et al. have considered viewing time at a given exhibit as the measure of interests. The interest and transition models are designed to provide personalized recommendations based on the interests of the visitor and locations in the museum. The interest model lists the exhibits which are of more interest to the visitors based on the observed viewing times concerning the viewing times of other museum visitors. The transition model is used to predict the next exhibit of interests. Later, both of these models are used to predict: (i) a set of exhibits that the visitor might be interested in, and (ii) an ordered sequence of exhibits that the visitor would like to visit. In [40], the interests and situations of visitors are combined to provide personalized services in the museum. The visitor model is defined as a set of situations with their corresponding visitor profiles. An indirect profiling method [41] is used to provide personalized museum visits according to the visitor's interests, visiting style, available time, etc. A short questionnaire or quiz is used to create an indirect profile to obtain the visitor's characteristics, interests, and visiting contexts.

Even with several existing approaches in the literature, the new approach of designing of museum Ubiquitous Visitor Model is still needed as providing personalized services to the museum ubiquitous visitors is a compelling future to enhance their visiting experience. The proposed method with the dynamic construction of the museum Ubiquitous Visitor Model improves the relevance of personalized services for the individual requirements of the ubiquitous visitors.

3. Museum ubiquitous visitors

The services are provided to the museum's ubiquitous visitors by collecting their context information and interest. In addition to providing exhibit information of interests to the visitors at their understanding level, basic services like catering and other amenities are also needs to be provided to enhance the overall visiting experience. To achieve this, context information of the museum's ubiquitous visitors is collected and combines with multiple combinations to deduced into Essential Context-derived Reasons (ECR) [42][43]. ECR provides a wider perspective for the system to accurately understand the museum's ubiquitous visitor's requirements and to provide required services. Further, Visitor Profile Information is collected at the time of the visit of visitors during registration. Later, the system learns Interests of the ubiquitous visitors for the subsequent visits based on the history of exhibit information museum service access. In the following section, we describe the museum's ubiquitous visitor's interest and the designing of the Museum Ubiquitous Visitor Model. Some of the notations and their meaning used in the designing of museum's Ubiquitous Visitor Model are described in [Table 1].

Table 1. Notations and their meanings

Notations	Meaning
$N_{URL_{e_i}}$	Number of times the related webpage/URL of exhibit information museum services e_i availed by the ubiquitous visitors
$Avg(N_{URL})$	Average number of exhibit information museum service URL availed by the ubiquitous visitors
URL	The set of URLs of exhibit information museum services availed by the ubiquitous visitors
$TD_{URL_{e_i}}$	The time duration of the availed exhibit information museum service URL_{e_i}
$Size_{URL_{e_i}}$	Size of the exhibit information museum services availed from URL_{e_i}
$TD_{URL_{e_i}}/TD_{URL_{e_i}}$	Ratio of the time durations and the size of exhibit information availed from URL_{e_i} by the ubiquitous visitor
$Avg(TD_{URL_{e_i}}/TD_{URL_{e_i}})$	Average of the ratio of the time durations and the size of exhibit information availed from URL_{e_i} by the ubiquitous visitor
k	Number of similar ubiquitous visitors who in the past have availed identical URL_{e_i}
$U = \{u_i; 1 \leq i \leq k\}$	Set of k similar ubiquitous visitors $sim(u_i, u_j) \geq 0.6)$ with new ubiquitous visitor u_j
UbiVM	Museum Ubiquitous Visitor Model
VPI	Ubiquitous Visitor Personal Information
ECR	Essential Context-derived Reasons of a museum ubiquitous visitor
Interests	Interests of a museum ubiquitous visitor
$UbiVM_{pr1}$	Museum Ubiquitous Visitor Model of a professional
VPI_{pr1}	Visitor Personal Information of a professional ubiquitous visitor
ECR_{pr1}	Essential Context-derived Reasons of a professional ubiquitous visitor
$Interests_{pr1}$	Interests of a professional ubiquitous visitor
V_{pr1}	Unique-Id of a professional ubiquitous visitor
wt_{e_i}	Weight indicating Interests of the Museum Ubiquitous Visitors in URL_{e_i}

4. Museum ubiquitous visitors interest

Museum ubiquitous visitors may have an individual sense of importance and curiosity which is considered as a personal interest of the ubiquitous visitors. Museum ubiquitous visitor's interests usually differ due to differences in their personal characteristics such as age, understanding levels, professional qualifications, etc. Interests of museum ubiquitous visitors enable the system to provide personalized services by emphasizing an individual [19][23][26][33][35]. The system explicitly or implicitly extracts museum ubiquitous visitor's interest through direct inputs, ratings, questionnaires, by monitoring visitor activities or from the history of service accessed [33]. For our work, we determine the interests of the ubiquitous visitors by considering the history of formerly accessed exhibit information museum services of the visitors, as described follows.

4.1. Ubiquitous visitors history of exhibit information museum service access

The system monitors and maintains the record of past activities of the ubiquitous visitors in the form of a history of exhibit information museum service accessed as shown in [Table 2]. The history represents the detailed log of ubiquitous visitors which consist of Unique-Ids, professional qualifications, the time duration of exhibit information access, size of the availed exhibit information, the extracted URLs or web pages of formerly availed services (indicating interests), the level of details of the availed exhibit information (indicating an understanding levels of the ubiquitous visitors), etc., depending on the system requirements.

Table 2. History of Exhibit Information Museum Service Access of Ubiquitous Visitors

Ubiquitous Visitor-Id	Age Group (years)	Professional Qualifications	…	No of Visits	Size of Availed Information	Time Duration of Service used	Level of Availed information	Exhibit Information Museum Service URLs
V_{pr_1}	30-50	Professional	…	35	50 MB	8 min	Advanced	svinfo_l3.pet.iisc.ac.in
V_{sk_1}	8-16	School Kid	…	45	35 MB	3 min	Advanced	scinfo_l1.pet.iisc.ac.in
…	…	….	…	…	…	…	…	…
V_{cs_1}	16-30	College Student	…	30	25 MB	2 min	Advanced	archinfo_l2.pet.iisc.ac.in
V_{pr_n}	30-50	Professional	…	18	11 MB	1 min	Advanced	bioinfo_l2.pet.iisc.ac.in

Arch: Archaeological; SV: Swami Vivekananda; Sc: Scientific; moon: Moon; e_i: Exhibit

Here, the number of visits indicates the visit to the particular URL of the exhibit information museum services, not the physical visit to the museum. In literature, several studies have discussed about multiple visits of the ubiquitous visitors with family, friends, and colleagues to the museum [44][45]. From the history of exhibit information museum service accessed, the system analyzes the interests and the levels of details with which ubiquitous visitors have formerly used the exhibit information. Interest of the ubiquitous visitor is determined based upon the most common URL (or web pages) of previously availed exhibit information museum services from their history database. In other words, the history database represents the ubiquitous visitor's interests in some set of exhibit information museum services. To determine the recent interests, the system maintains an updated exhibit information museum service access history database of the ubiquitous visitors. Gradually, during the exhibit information museum service usage, the system appends the new entries and deletes the obsolete entries and updates the history of exhibit information museum service access by the ubiquitous visitors.

To determine the museum's ubiquitous visitor's Interests, we have used an ample number of visited URL/webpages of the exhibit information museum services. We have used the Melbourne Museum dataset available in [46][47], and created a database of history of access of exhibit information museum services of six months of durations from the URL of exhibit information museum services visited by more than the hundreds of ubiquitous visitors. For our work, we limit 100 visits for each webpage or URL of exhibit information museum services and extract the interests of the ubiquitous visitors.

Ubiquitous visitor's Interests is expressed as an associated weight in a set of URLs of exhibit information museum services $URL = \{URLe_i : 1 \leqslant i \leqslant n\}$, mined from the available history of the exhibit information museum service access of the ubiquitous visitors as given by Equation 1.

$$Interests = \{\langle URLe_1, wte_1\rangle, \langle URLe_2, wte_2\rangle, \dots, \langle URLe_n, wte_n\rangle\} \quad (1)$$

where, 'n' represents the number of $URLe_i$ of exhibit information museum services available from the history database and wte_i represents the associated weights of interests of the museum ubiquitous visitors in $URLe_i \in URL$.

With a known history of formerly accessed exhibit information museum services, we determine exhibit information museum service interests of the ubiquitous visitors by calculating weight wte_i as given by Equation 2. To calculate weights, the history of exhibit information

museum service accessed is analyzed including the number of visits, the duration of the exhibit information accessed, the size of the availed exhibit information, and the depth or level of the requested exhibit information. The system analyzes these parameters and determines the interests and the understanding levels of the ubiquitous visitors. For instance, depending on the number of visits to a particular URL/webpage of exhibit information museum services $URLe_i \in URL$, the first part $\frac{N_{URLe_i}}{Avg(N_{URL})}$ indicates the interests of the ubiquitous visitors in $URLe_i$ of the exhibit information museum service. Here, $\mathrm{Avg}(\mathrm{N_{URL}})$ represents the average number of exhibit information service URL availed by the ubiquitous visitors, which is evaluated as the ratio of total number of URLs visited to the number of unique URLs visited by the visitor.

Likewise, depending on the time duration of exhibit information museum service access and the size of the availed exhibit information, the second part $\frac{TD_{URLe_i}/Siz_{URLe_i}}{Avg(TD_{URL}/Siz_{URL})}$ indicates the levels of details of formerly availed exhibit information. The longer the time duration of visit to a particular exhibit information $URLe_i$, the more the visitor is considered to be interested. Otherwise, visitor is likely to spend lesser time, if not interested in a particular $URLe_i$. However, sometimes visitor may spend lesser time due to the lesser size of exhibit information available on that particular URL. Thus, to evaluate visitor's interest more appropriately, we normalize the time duration of the availed exhibit information by the size of the exhibit information as TD_{URLe_i}/Siz_{URLe_i}. Here, $Avg(TD_{URL}/Siz_{URL})$ represents the average of the normalized time durations of the availed exhibit information from $URLe_i$by the ubiquitous visitor, which is evaluated as the ratio of total of normalized time duration of URLs visited to the number of unique URLs visited by the visitor. In case, exhibit information museum service is used for the longer duration and with a larger size of the availed information that indicates the advanced understanding levels of the ubiquitous visitors.

$$wt_{e_i} = \frac{N_{URLe_i}}{Avg(N_{URL})} + \frac{TD_{URLe_i}/Siz_{URL}}{Avg(TD_{URL}/Siz_{URL})} \quad (2)$$

Also, the interests of a new ubiquitous visitor (whose history of exhibit information museum service accessed is not available), is determined from the interests of the cluster of ubiquitous visitors sharing similar profiles. This is because most of the ubiquitous visitors with resembling profiles have similar interests under similar situations [48]. Thus, for a new ubiquitous visitor, we cluster the exhibit information museum service accessed history database of a group of ubiquitous visitors who shares similar profiles and calculates the relative weight wt_{e_i} of interests. For clustering nearest neighbor algorithm is used which determines the similarity between the different ubiquitous visitor profiles [49]. The cluster is formed by considering a group of ubiquitous visitors whose profiles show similarity above 0.6 with the profile of a new ubiquitous visitor. The reasons for considering the cluster of ubiquitous visitors with similarity above 0.6 are twofold: i) Ubiquitous visitors for their different visits may have varied interests of exhibit information museum services; ii) Few ubiquitous visitors even with similar profiles may exhibit dissimilar interests at different instances of time. This ensures a viable history of exhibit information museum service access available for the new ubiquitous visitors.

Further, based upon the similarity among different profiles of the ubiquitous visitors, we determine the cluster to which a new ubiquitous visitor belongs tno.Accordingly, we extract the history of exhibit information museum service accessed of those k similar ubiquitous visitors $U = \{u_i : 1 \leqslant i \leqslant k\}$. Next, we compute the average weight wt_{e_i} that represents interests of new ubiquitous visitor mined from the history of exhibit information museum service accessed of those k similar ubiquitous visitors as given by Equation 3.

$$wt_{e_i} = \frac{1}{|U|}\sum_{m \in U} n_{m_{URL_{e_i}}} \left[\frac{N_{URL_{e_i}}}{Avg(N_{URL})} + \frac{TD_{URL_{e_i}}/Siz_{URL_{e_i}}}{Avg(TD_{URL}/Siz_{URL})}\right] \quad (3)$$

where, $U = \{u_i : 1 \leqslant i \leqslant k\}$ represents the set of k similar ubiquitous visitors with similarity SIM (ui, uj) ≥ 0.6 with the new ubiquitous visitor uj.

$$n_{m_{UR\ e_i}} = \begin{cases} 1\ if\ the\ ubiquitous\ visitor\ 'm'has\ accessed\ URL_{e_i} \\ 0\ otherwise \end{cases} \quad (4)$$

These extracted exhibit information museum service interests are further used to design the museum Ubiquitous Visitor Model.

5. A method of designing a museum ubiquitous visitor model

To provide personalized services to ubiquitous visitors, we design the museum *Ubiquitous Visitor Model*. The *Ubiquitous Visitor Model* characterizes the multifaceted aspects of the ubiquitous visitors which are essential for the system to understand their distinct requirements and to provide exhibit information museum services relevant to an individual. For designing the museum Ubiquitous *Visitor Model*, the information about the ubiquitous visitors is obtained both implicitly and explicitly. The ubiquitous *Visitor Personal Information (VPI)* such as name, qualifications, understanding levels, and available time is obtained explicitly during the museum ubiquitous visitor's pre-visit registration process and a unique-id is assigned to the ubiquitous visitor. On the contrary, the interests of the museum ubiquitous visitor are implicitly obtained using the history of exhibit information museum services accessed by the visitors as discussed in Section 4 and *ECR* is also obtained implicitly as described in Section 3.

The relevance of exhibit information museum services that need to be provided is largely depends on the information covered in the ubiquitous visitor model which may be application dependent [11][51]. Thus, we design the museum Ubiquitous Visitor Model (UbiVM) as cases with a tuple of multifaceted information obtained by combining VPI, ECR, and Interests of the ubiquitous visitors as given by Equation 4.

$$UbiVM = \{\langle VPI\rangle, \langle ECR\rangle, \langle Interests\rangle\} \quad (5)$$

The dynamic construction of the museum Ubiquitous Visitor Model specifies ubiquitous visitor's requirements to a greater extent. The variation in the museum Ubiquitous Visitor Model represents the variation in the individual requirements of the ubiquitous visitors over time. Ubiquitous Visitor Model is further used to provide pro-active and tailored exhibit information museum services to the ubiquitous visitors and to enhance their service experience.

6. An example of museum ubiquitous visitor model of a professional

In this section, we provide an example of the museum *Ubiquitous Visitor Model* of a professional ubiquitous visitor. *Ubiquitous Visitor Model* of a professional visitor is designed by considering his/her *VPI*, *ECR*, and Interests. *VPI* of a professional ubiquitous visitor such as age, understanding level, available time, etc., is obtained with pre-visit registration process and a unique-id is assigned to the professional ubiquitous visitor. *ECR* of the professional ubiquitous visitor is obtained as discussed in Section 3. *Interests* of a professional ubiquitous visitor is obtained by considering history of exhibit information museum service access as shown in [Table 3].

Table 3. History of Exhibit Information Museum Services Access of a Professional Ubiquitous Visitor

Ubiquitous Visitor-Id	*Age Group (years)*	*Professional Qualifications*	*…*	*No of Visits*	*Size of Availed Information (MB)*	*Time Duration of Service used*	*Level of Availed information*	*Exhibit Information Museum Service URLs*
V_{pr1}	*30-50*	*Professional*	*…*	*70*	*35 MB*	*6 min*	*Advanced*	*svinfo.l3.pet.iisc.ac.in*
V_{pr1}	*30-50*	*Professional*	*…*	*45*	*35 MB*	*3 min*	*Advanced*	*svinfo.l3.pet.iisc.ac.in*
…	…	….	…	…	…	…	…	…
V_{pr1}	*30-50*	*Professional*	*…*	*30*	*25 MB*	*2 min*	*Advanced*	*archinfo.l3.pet.iisc.ac.in*
V_{pr1}	*30-50*	*Professional*	*…*	*18*	*11 MB*	*1 min*	*Advanced*	*archinfo.l3.pet.iisc.ac.in*

Arch: Archaeological; SV: Swami Vivekananda; Sc: Scientific; moon: Moon; e_i: Exhibit

From the history of exhibit information museum service accessed given in [Table 3], Interests of a professional ubiquitous visitor for *Swami Vivekananda* exhibit information museum service $UbiVM_{SV_{e_i}} = \text{svinfol}_3@\,pet.iisc.ac.in$ is obtained as follows.

$$wte_i = \left[\frac{70}{230} + \frac{6/35}{0.3}\right] \quad (6)$$

Similarly, with known history of exhibit information museum service accessed, Interests of a professional ubiquitous visitor in different exhibit information museum services are obtained as given below.

$$Interests_{pr_1} = \{< URL_{SV_{e_i}}, 0.87 >, < URL_{Sc_{e_i}}, 0.57 >, \ldots, < URL_{moon_{e_i}}, 0.14 >\} \quad (7)$$

Further, considering *VPI*, *ECR*, and *Interests*, the *Ubiquitous Visitor Model* of a professional visitor *($UbiVM_{pr1}$)* is defined by Equation 8.

$$UbiVM_{pr_1} = \{< VPI_{pr_1} >, < ECR_{pr_1} >, < Interests_{pr_1} >\} \quad (8)$$

For the particular instances of VPI, ECR, and Interests, the Ubiquitous Visitor Model of a professional visitor is given by Equation 9.

$$UbiVM_{pr_1} = \left\{\begin{matrix} < \mathrm{V_{pr_1}}, 5\text{ min}, \text{Advanced} >, \text{Professional standing at exhibit high battery smart phone}, \ldots, \\ \text{Professional with high WiFi bandwidth spending longer time looking for information} > \\ , < \text{Swami Vivekananda Exhibit} > \end{matrix}\right\} \quad (9)$$

Ubiquitous Visitor Model of a professional visitor specifies multifaceted aspects of his/her requirements and enables the system to provide personalized exhibit information museum services.

8. Simulation Results

In the simulation, we consider the museum Ubiquitous Visitor Model of a professional and school kid visitors. We evaluate the accuracy of Ubiquitous Visitor Model of a professional and a school kid visitor based upon the accuracy of ECR and Interests, i.e., the available history of exhibit information museum service access. The accuracy of Ubiquitous Visitor Model

(UbiVM) is evaluated as the ratio of the deviation of UbiVM from the true value of UbiVM to the true value of UbiVM as given by the following Equation 10. Further, based on the Ubiquitous Visitor Model, we also evaluate the number of requests to the museum exhibit information server and the corresponding system resource usage. The system resource usage is defined as the resources utilized by the system for providing tailored exhibit information to the ubiquitous visitors. For our work, we consider network bandwidth as the system resources usage, which is considered as the cost incurred by the system.

$$Accuracy\ of\ UbiVM = \frac{Deviation\ of\ UbiVM\ from\ Its\ True\ Value}{True\ Val\quad of\ UbiVM} \qquad (10)$$

For the simulation, we consider the history of exhibit information museum service access of both a professional and a school kid ubiquitous visitor, each with 300 entries. These 300 entries of history databases are created using the real dataset of the Melbourne Museum [46]. The simulation is executed over 200 experiments using Python scripts. During the experiment, the accuracy of ECR and the available history database are varied, and accordingly, the accuracy of the museum Ubiquitous Visitor Model is evaluated. Visitor Personal Information, which is obtained through the pre-visit registration process is considered to be accurately available. Thus, the variation in the accuracy of the museum Ubiquitous Visitor Model is observed corresponding to the accuracy of ECR and the available history of exhibit information museum service access.

During the simulation, we found that the increase in the accuracy of ECR enables the system to identify the exact requirements of the museum's ubiquitous visitors which increases the accuracy of the Ubiquitous Visitor Model. The increase in the accuracy of museum Ubiquitous Visitor Model with the increase in the accuracy of ECR of professional and school kid ubiquitous visitors is as shown in [Figure 2].

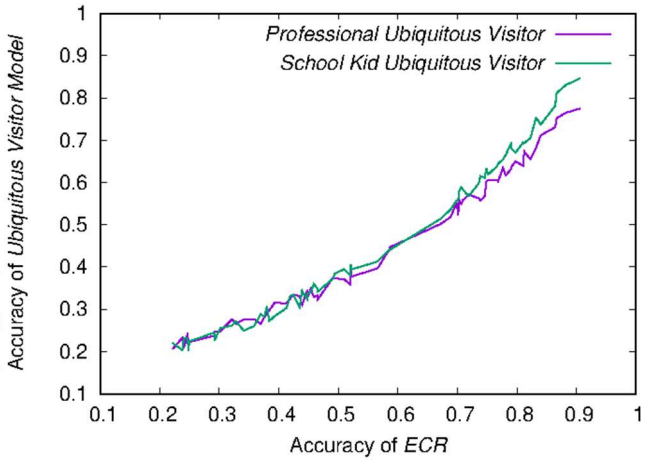

Figure 2. Accuracy of Ubiquitous Visitor Model Corresponding to the Accuracy of ECR

Next, we evaluate the accuracy of the Ubiquitous Visitor Model with the available history of exhibit information museum service accessed of the ubiquitous visitors. To obtain the exact Interest of the museum ubiquitous visitor, the history database needs to have a sufficient number of entries. The increase in the available history of exhibit information museum service access enables the system to determine the exact interests of the ubiquitous visitors which enhances the accuracy of the Ubiquitous Visitor Model as shown in [Figure 3].

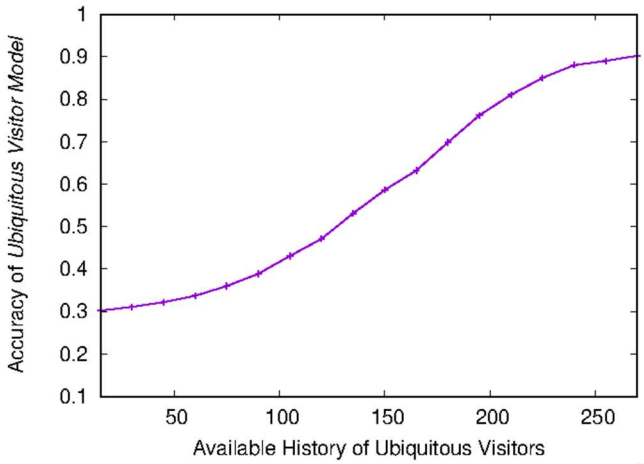

Figure 3. Accuracy of ubiquitous visitor model corresponding to the accuracy of ECR

Further, we evaluate the accuracy of the Ubiquitous Visitor Model of the professional and school kid ubiquitous visitors over 200 experiments. During the experiments, we found that for 90% accurately available ECR of the ubiquitous visitors and based on the history of exhibit information museum service access, the accuracy of the Ubiquitous Visitor Model of professional and school kid visitors varies from 0.80 to 0.95 as shown in [Figure 4].

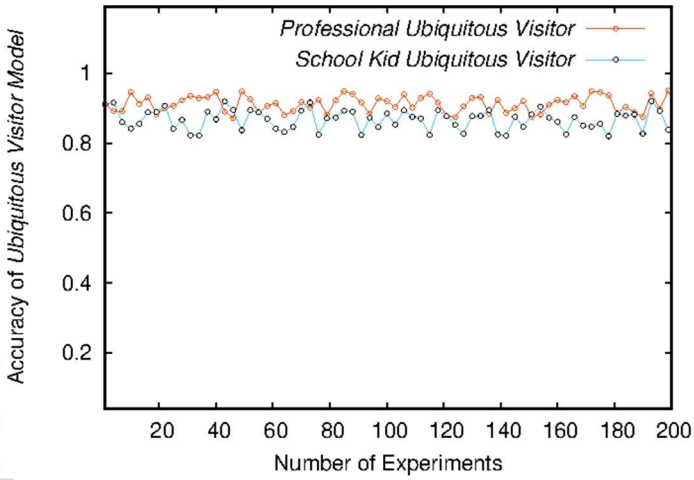

Figure 4. Accuracy of ubiquitous visitor model with the number of experiments

We also evaluate the number of requests generated to the museum exhibit information server and the corresponding system resource usage with and without considering the museum Ubiquitous Visitor Model. Here, without Ubiquitous Visitor Model is considered without ECR of the museum ubiquitous visitors. The increase in number of requests to the exhibit information server corresponding to the Ubiquitous Visitor Model of the visitors indicates the trade-offs between the consumption of system resources and the visitor annoyance while providing the required exhibit information.

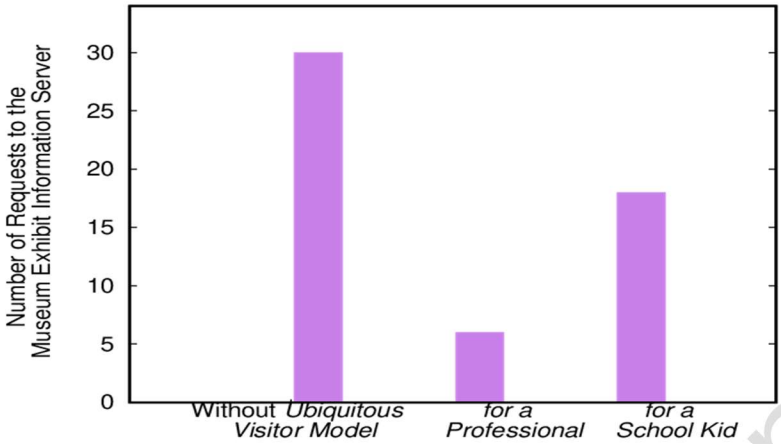

Figure 5. Number of requests corresponding to the ubiquitous visitor model of the visitors

With Ubiquitous Visitor Model, the museum's ubiquitous visitors obtain tailored exhibit information based on their requirements which leads to a decrease in the number of requests for exhibit information museum services. The decrease in the number of requests for exhibit information museum services decreases the wastage of system resources. For example, providing exhibit information with lesser details according to the individual requirements of school kid ubiquitous visitors. According to the Ubiquitous Visitor Model of the visitors, the trade-offs between the number of requests generated for the exhibit information museum services and the system resource usage are as shown in [Figure 5] and [Figure 6].

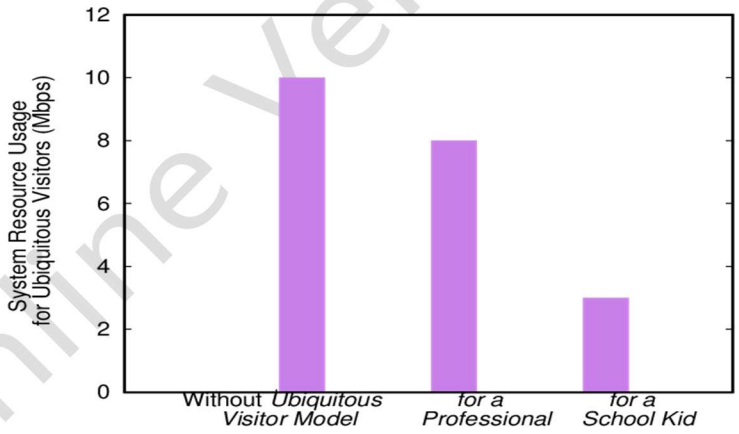

Figure 6. System resource usage according to the ubiquitous visitor model of the visitors

8. Conclusion and Future Work

The museum Ubiquitous Visitor Model (UbiVM) is proposed to provide personalized exhibit information museum services to the ubiquitous visitors. The museum Ubiquitous Visitor Model is designed considering Essential Context-derived Reasons, Interests, and museum ubiquitous Visitors Personal Information. The designed model as cases characterizes multifaceted information about the museum ubiquitous visitors such as understanding level, interests, available time, etc., to provide exhibit information museum services relevant to an individual. We conducted simulation with the available accuracy of ECR and the history of

exhibit information museum service access. The simulation results show that the accuracy of the museum Ubiquitous Visitor Model increases with the increase in accuracy of ECR and the available history of exhibit information museum service access of the ubiquitous visitors. The designed Ubiquitous Visitor Model also decreases the system resource usage and the number of requests to the museum exhibit information server. In the future, we consider group interests to provide exhibit information museum services for the group of visitors.

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