Connecting the museum to the city environment from the visitor's perspective

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Received 17 July 2019
Revised 25 September 2019
Accepted 30 September 2019

Abstract

Recommendation systems are widely used in tourism in order to provide people personalized suggestions that would make their trip memorable. Nowadays, mobile assisted guided tours based on recommendation services are used in museums to enhance visitors ' experience. However, all those systems have been designed to target indoor or outdoor museum visits. Is it feasible to design a system that supports mobile services that connect a museum visit to artworks situated outdoor in the city environment? Is it possible to connect the artworks of a city center to the exhibits of a museum? In this work, we attempt to give a first answer to such questions proposing and implementing a set of services that connects the museum to the city public space. In order to show the strength of the implemented services, we present a basic usage scenario along with a first system evaluation showing positive results.

Keywords Museum, Public space, Recommendation systems, Combined recommendation

Paper type Original Article

1. Introduction

In the context of the fast-developing field of digital technologies and their application on cultural heritage (CH), this work proposes a system that enhances the interaction between museum space and public space. The starting point is the idea that although we initially tend to think of the museum as an organization restricted in a building with exhibits presented behind glass cases [1], there are cases where museums can 'extend' beyond their building. Such museums are connected to the city, the city space or to open air space. At the most basic level, the collections of an art museum can be displayed in its sculpture garden, as with The Kröller-Müller Museum (https://krollermuller.nl/). It boasts the second largest Van Gogh collection in the world, masterpieces by other modern masters and also one of the largest

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Publishers note: The publisher wishes to inform readers that the article "Connecting the museum to the city environment from the visitor's perspective" was originally published by the previous publisher of Applied Computing and Informatics and the pagination of this article has been subsequently changed. There has been no change to the content of the article. This change was necessary for the journal to transition from the previous publisher to the new one. The publisher sincerely apologises for any inconvenience caused. To access and cite this article, please use Koukoulis, K., Koukopoulos, D., Tzortzi, K. (2019), "Connecting the museum to the city environment from the visitor's perspective" Applied Computing and Informatics. Vol. 18 No. 3/4, pp. 221-234. https://10.1016/j.aci.2019.09.001. The original publication date for this paper was 05/10/2019.

Applied Computing and Informatics
Vol. 18 No. 3/4, 2022
pp. 221-234
Emerald Publishing Limited
e-ISSN: 2210-8327
p-ISSN: 2634-1964
DOI 10.1016/j.aci.2019.09.001

sculpture gardens in Europe in an outdoor gallery occupying an area of 25 ha. At a wider scale, in museums that display the work of local artists, the collections might not be limited to those displayed in their galleries but 'include' their artworks spread out in the city. An excellent example is the scattered work of Caravaggio in Rome. In a more complex way, the collections of museums which deal with archaeology, ethnography or social history, and of city museums in particular, "extend" beyond their walls as they belong to a wider cultural landscape, to which they are strongly connected. But we should not stick in a specific example. Maybe City Museums are more suitable for our scope. The Museum of Volos City (http://www.vmoc.gr/), which presents the daily activity of the city inhabitants from the 19th century until today, uses as interpretative means not only those included in its permanent display, but also a series of thematic sonic itineraries in different parts of the city. In all these cases, the sense of place is of critical significance as it constitutes "the frame of reference for collections, interpretation and visitors" [2]. Also, the Stockholm City Museum was the base for exploring the city combining the traditional guided tours inside the museum with explorations at city parts targeting museum education with positive results [3].

Reflecting the idea of the 'museum content' being in the physical building, a lot of work is being done with mobile guided tours or recommendation systems targeting the exhibitions within the museums or artworks in the public space (artworks will refer to exhibits outside a museum and are points of interest - POIs). But the paper raises the underexplored questions: what about the artworks that may be related in some way with the museums and are cited in the city public space or within the boundaries of a city? How can a museum be connected to its host city? Can the use of mobile devices enhance this relation and intensify the 'sense of place'? Can there be any advantages to this interaction? Can it be achieved with the use of smart mobile devices? What are the key components of a system supporting this functionality?

This work extends the proposed system in [4,20] that was targeting at the provision of preservation, management and dissemination functions in a museum in order to facilitate the actions and interactions of the persons that are involved in museum's everyday life. Here, we are interested in the offering of recommendation services to visitors, which can be accessible through their mobile devices as parts of a mobile app, satisfying the need of connecting the museum space to the public space of a city considering the city as an extension of the museum. To our knowledge, such a system does not exist. In Section 2, we present the current work related to recommendation systems in tourism and CH emphasizing, where it is possible, in museums. Also, in Section 3 we indicate a list of system requirements drawn out of several existing recommendation systems. In Section 4, we present a brief description of the host system along with the required changes that have been made in order to facilitate the new proposed services. In our effort to demonstrate the proposed services, we describe two real case scenarios in Section 5. A first evaluation using the Cognitive Walkthrough methodology, along with a comparison that traces the drawbacks and advantages of the implemented framework is presented in Section 6 followed by results discussion. Finally, we present our conclusions and point out some future work in Section 7.

2. Related work

We live in an era where information overload appears to be a dominative factor. A person, more and more, uses technology in her/his everyday life. This fact along with the complexity of the modern world causes her/him to get overwhelmed by information throughout her/his routine. This problem's solution can be based on recommendation systems (RS). Their use reduces the size of information that must be processed in order for a decision to be made. RS are used for a number of daily activities including transportation and entertainment. For example, Google (https://www.google.com/maps) provides recommendations for a route and

Netflix (https://www.netflix.com/) recommends films or television series to its users. However, such corporations use RS to maximize profits and minimize risk possibility [5]. The main objective for the users of an RS is to produce meaningful recommendations [6]. Of course, we must point out that there is some criticism related to the use of RS mainly pointing out the argument that they might shape users' preferences [7].

The usage of recommendation techniques has been widely adopted in the field of tourism [8] and CH [6]. Mobile tour guides gain acceptance and provide experience alike traditional guided tours due to the research development in recommenders, ambient intelligence and pervasive computing: "tourists using a mobile information system discovered four times more sights and stayed at them twice as long" [30]. In the process of developing an RS, a number of elements should be considered: the type of available data, the used filtering algorithm, the chosen model, the employed techniques, the sparsity level of the database and the desired scalability, the system performance, the objective and the desired quality of the results [9]. The available data can also incorporate social, personal and environmental contextual parameters that can be captured easily due to the new developments in web technologies, wireless networking, mobile computing and social networking [8]. RS filtering algorithms can be based on collaborative, demographic, content-based or hybrid filtering [9].

A list of tourist services is provided in [8]: (a) Attraction (POIs) recommendations are provided to the user with the use of a map or list. Context parameters like time, already visited places, mobility pattern, weather, user mood, transportation mode and social environment are considered. (b) Tourist services recommendations are provided. Constraint-based filtering is usually applied in this category. (c) Collaborative user-generated content and social networking services for the offering of unexpected attractions. (d) Routes and tours recommendations based on current technology are provided (like GPS, Cell-id, RFID). (e) Personalized multiple days tour planning provides a set of attractions to the users. In [10] the location is the key factor for a collaborative filtering-based RS for restaurants. iTravel is also based on collaborative filtering (especially interested in other user ratings) and it has been created for recommending travel attractions [11]. Collaborative filtering has been used in [12] to recommend related POIs to a user based on preferences of other users having similar interests in similar contexts. Tourist@ is a mobile, location-aware, content and collaborative based RS that provides recommendations related to leisure and cultural activities on site [13]. The PersTour system can be used for creating a customized tour route for tourists where the visit durations and the recommended POIs are based on their preferences, like the desired starting/ending location and the tour duration [14].

Even though RSs have been used in tourism for a long time, they have appeared in the CH domain relatively recently [6] with promising results [16]. They usually provide services for indoor guided tours [15,17], outdoor guided tours [23] or both (separately but not combined) [19,26]. In [15] the authors describe a real-time indoor routing system that provides personalized tours based on the user's position and interests. iMuse [17] is a mobile system that provides context aware information services like self-defined and predefined tours. SMARTMUSEUM [19] provides separate guiding services for outdoor and indoor tour exploiting users' locations. Those services offer personalized access to various information based on specific scenarios. In [26] authors provide context-aware recommendation services uniformly managing heterogeneous multimedia data coming from several web repositories. In [25] the researchers propose a context-aware hybrid recommendation strategy (a goal is to create dynamic visiting paths) based on Big Data, using users' and target items' parameters. Additionally, [23] presents a RS of personalized activity sequences that facilitate the decision-making process of an event joining. The approach of [23] deals with the cold start problem targeting future events that have limited lifetime.

A challenge in the evaluation of RS systems concerns the measuring of users' satisfaction [18,19,24,26]. In [18] authors propose a user model for recommendations in museums using

psychological, physical and social variables that affect user satisfaction and enjoyment. In [24] the focus is on maximizing the satisfaction of the proposed recommendations. User satisfaction is strongly related with the Quality of Experience (QoE) [27–29] when dealing with systems dedicated to museums. In [29] there is an effort to understand the visitors' behavior within CH spaces, especially targeting their optimal visiting time along with the maximization of their perceived satisfaction. In [28], visitors' common characteristics and interests are exploited to create a personalized social recommendation system targeting the maximization of QoE.

3. System requirements

The proposed system implements a hybrid approach to offer a set of recommendation services. The used recommendation algorithm is based on specific personal, social, and contextual parameters. In order to calculate the user's route, we firstly consider the starting and ending positions of the user-visitor. When a visitor subscribes into the system, she/he is asked to provide some personal data including age and visiting purpose (like leisure or education aiming). Social parameters are parameters that come from other users that used the system, like preferred artworks or artworks ratings. The contextual parameters used are related to time limitation, artwork relevance, transportation medium and artwork locations. Environmental parameters are not taken into account currently. However, we are going to incorporate such parameters to the RS in the future combining them with the user preferences. For example, the user is going to need more time for her/his route when it is a rainy day.

The implemented recommendation algorithm provides differentiated services depending on the visitor location. To calculate the proposed tour when the visitor is in the museum, the RS firstly cares about the visitor's selected city artwork(s). When in the city, the system cares mostly to generate a pleasant route to the museum taking into account user's available time and profile, along with transportation medium.

The main challenge in this work is to present services for the connection of the museum to the city and not the presentation of a state-of-the-art RS. A first set of system requirements were presented in [4,20]. Based on the system goals, the features of RSs for tourism and museums studied in Section 2, the restrictions of the host system, and the personal, social, and contextual parameters taking into account by the presented system, we ended up in a list of requirements for the proposed recommendation solution:

- An indoor guided tour should be combined with an outdoor tour.
- The recommendation system should consider the visitor's location, the transportation medium, the type of the desired tour and the available time of the user.
- The recommendation services should be provided by the smart app.
- Routes should be re-calculated when a parameter changes (for example, when a visitor stays at an artwork for a longer period of time).
- Cold start may be the usual case. Museum visitors and tourists are not everyday users of such systems. They are likely to visit a city or a museum once and need recommendations only on their first visit.

4. System architecture and implementation technologies

The host system consists of three distinct modules (Figure 1): data module, application module and authorization manager. Data Module contains all the required databases and a

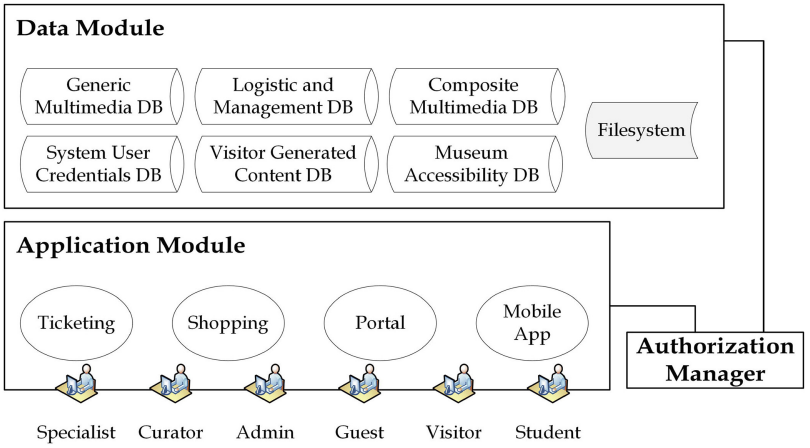

Figure 1.
System architecture.

filesystem. It is the module that hosts all system data. Authorization Manager works as the mediator between data and user services. Application Module hosts all the mobile and portal services allowing users to interact efficiently and successfully. There is also a subsystem that provides commercial services. Trustworthiness is served with the use of an extended version of the role-based access control model (RBAC).

A prototype of the system has been implemented using free internet technologies. An Apache server is used to host the filesystem, the MariaDB for the system's databases and the Web services that were implemented with the use of PHP in order to facilitate the secure data access. Single page Application Technologies were applied for the portal implementation using Angular6 (https://angular.io/). The mobile app was implemented with the Ionic Framework (https://ionicframework.com/). The prototype was built to implement some basic usage scenarios. End-users can access the system using their own equipment. Users' can access the portal using any device that offers internet browsing capabilities. They can download and install the app at any android portable device that has an internet connection. The end-user's portable equipment should be better capable of connecting to a fast internet service (4G) in order to access the video files without any disturbances.

4.1 Users

Six types of users are supported by the system: specialists, curators, administrators, guests, visitors and students. The first three roles are the Personnel Group and the three last ones are the Internet Users Group.

- Specialists are artists, creators, scientists that are responsible for the creation of primitive museum data. Specialists gather information about the artworks that are outside the museum in the city space and store them in system databases.
- Curators are responsible for content publishing, along with the selection and management of the specialist team. Also, the curators are responsible for finding all the city artworks that may have a connection to the museum and may interest visitors. Additionally, curators assign artworks to specialists.
- Administrators assign roles and have the responsibility for the system.
- Guests are the unregistered users that can access only a part of the system services as well as basic information.

- Visitors are registered users who can access data for on-site or virtual visitors and get personalized services like guided tours.
- Students are registered users who can access visitors' services and data. They are also allowed some extra functionality like viewing the comments and the generic data of the specialists.

Visitors and students can also feed the system with artwork information related to the museum.

4.2 Content classification

Specialists create generic content, along with users leading to the creation of the Composite content. The database content consists of audio, texts, images, position data and video. The main identity is the exhibit. Data attributes associated with the exhibit is categorized in *content-based* (like exhibit images or position), *context-based* (like videos of the excavations) and *model-based* (like the estimated time calculated by curators for the personalized tours). Content is stored in a set of databases obeying certain rules of Museology Discipline and in a filesystem that hosts any unstructured information (like the curator's annotation information about an exhibit). System databases are:

- Generic Multimedia DB contains primitive data provided by specialists for both museum exhibits and outdoor artworks.
- System User Credentials DB contains user preferences and authentication information.
- Composite Multimedia DB contains composite content and information regarding personalized museum tours. Also, it hosts information about the estimated time that is required for the transition of the visitors from one artwork to another with several transportation mediums for supporting outdoor recommendation.
- Logistic and Management DB contains museum information data as well as commerce and ticketing functionality data.
- Visitor Generated Content DB contains internet user's data and data produced by system algorithms (like the personalized routes and the time that a visitor spends in front of a specific exhibit or outdoor artwork).
- Museum Security DB contains access log information.

4.3 System services

The front end of the system is composed of a portal and a mobile app. The services are classified based on the user group role they are addressing.

Core Services are needed for both personnel and internet users. They are dealing with security and system management:

- Authentication and registration are based on a login/password process allowing users to access services according to their roles.
- Authorization is supported with the implementation of the used RBAC model.
- Administration serves the management of the system supporting role provision and report creation.

Internet Users Services are related to information dissemination, logistics, learning and personalization:

- Social Media Publishing service is about posting exhibit information on social media.

- Viewing service provides content to the user by executing database queries.
- Searching service is differentiated depending on the user role (guest, visitor and student search).
- Game service completes the educational part of the system.
- Ticketing and shopping service support the museum logistic and commercial part.
- Personalized tours service provides in-museum guided tours to the visitors.
- Location service is provided to visitors and students to facilitate the personalized in-museum tours.
- Adding content is provided to visitors and students and enables them to upload exhibit information.

Personnel Services are targeting specialist and curators:

- Generic content management helps specialists to provide data in the system regarding museum's exhibits.
- Composite content management facilitates curators to create and manage visitors' content.
- Composite data annotation service helps specialists perform annotations on their generic data and curators perform the same action on both generic and composite data.

In this work we focus on services that help the connection of the museum with the outdoor artworks. Thus, several services adapt adequately:

- Location service is extended in order to automatically recover the visitor's location in the city.
- Personalized tours service is a recommendation-based service which is fragmented in subservices. The indoor subservice deals with the calculation of personalized tours based on the content attributes and user's preferences, while presenting similar artworks that exist in the city to a museum visitor. The visitor can add these artworks to a list that will contain all the artworks. Also, it is responsible to keep in a list of the user's preferred artworks in order to be visited later. The user can use the outdoor subservice to start a tour to the city having as a starting point the museum and as an ending point an artwork that the RS chose to be his terminal point. The parameters for the RS are always the artwork attributes and user's personal preferences. When the user is in the city, the RS calculates a route having as ending point the museum based mainly on user's preferences.
- Generic content management also facilitates the outdoor artworks.
- Location service is extended to support GPS data for outdoor artworks.

5. Basic usage scenarios

As a means to demonstrate the strength of the proposed recommendation services, a basic usage scenario is provided. It concerns the Christos Capralos Sculpture Museum in Agrinio, Greece which was chosen as the case study for the core system due to the existence of Capralos sculptures on the streets of Agrinio. The implemented system provides a series of services to visitors (Figure 2a and b).

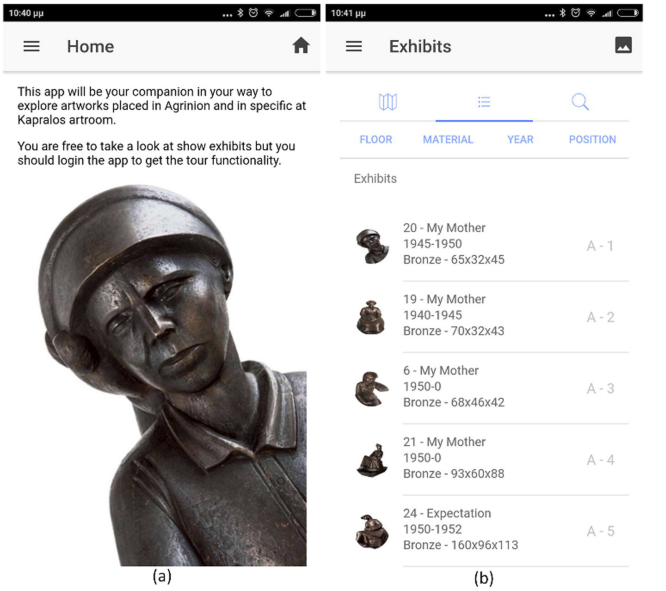

Figure 2.
eMuseum: (a) home screen, (b) list of museum exhibits.

5.1 From the museum to the city

The visitor is in the museum wandering around the exhibits using the personalized tour. The aim of this service is to recommend to the visitor a walk around the city aiming at specific artworks that are in the city open space. In the mobile app, there is already a service that displays the details of the exhibits.

The visitor stands in front of an exhibit. Using the app, she/he can get information in the form of image, video, audio and text (Figure 3a). Choosing a location from the menu in the top of the screen, she/he can access details about the exhibit position and reach other already implemented services which can help her/him in her/his tour inside the museum (Figure 3b).

The entry point for the new service is placed there in the icon menu at the top of the screen as a city map icon (Figure 4a). Choosing that icon, the visitor has the option to see "similar art in the city" (Figure 4b). A list of artworks then appears. She/he can choose either to visit now the artwork or to save it for later (Figure 4b). By choosing to visit an artwork now, a screen with a direction drawn on a map appears. By choosing to save it for later, the artwork is saved in her/his preferred list of artworks. She/he can choose to visit the stored artworks whenever she/he wants.

5.2 From the city to the museum

The visitor is in the city center spending some time there. She/he starts the museum application in order to see information about the museum. The new service has an entry point in the main menu that is called "Directions" (Figure 5a). As soon as she/he taps on that service, a map appears with the position of the museum, along with the positions of artworks in the city (Figure 5b). Then, the potential museum visitor can choose among several different options. She/he can choose to be given directions to go directly to the museum or she/he can choose to be given directions to an artwork nearby or she/he can create a tour that contains all the artworks in the city combined with a tour inside the museum.

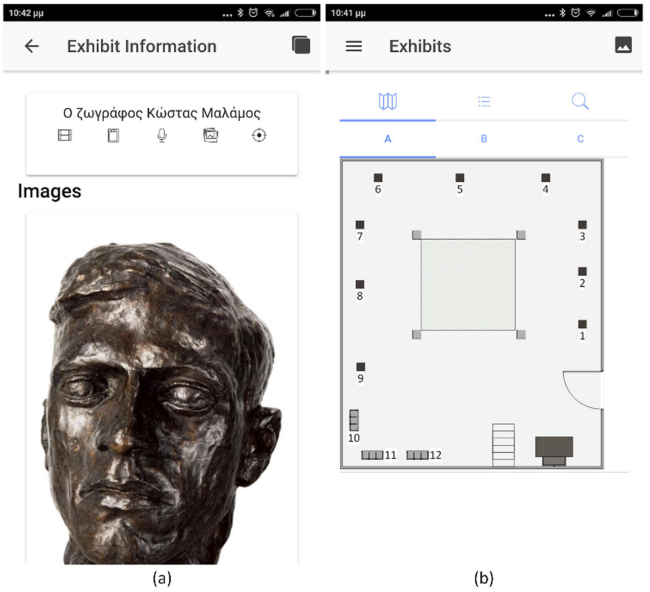

Figure 3.
eMuseum: (a) exhibit details, (b) museum floor map.

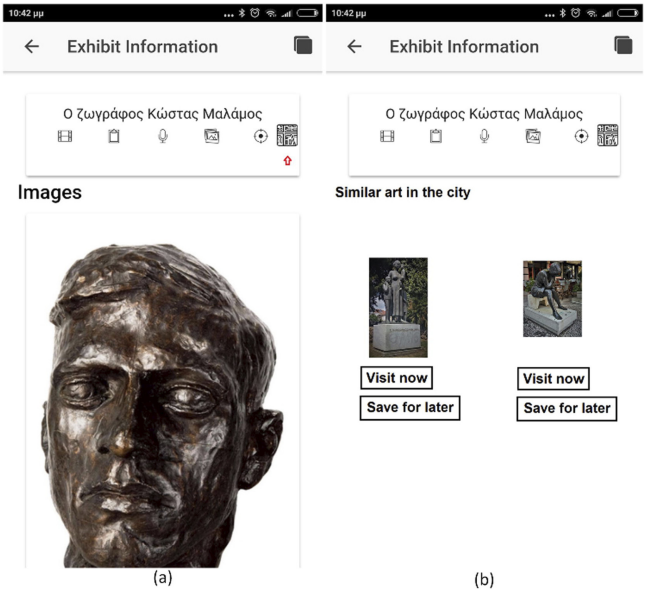

Figure 4.
In the museum: (a) Service entry point, (b) list of artworks with actions.

If the user chooses a single artwork and the museum, a map with directions is shown to the screen. If she/he taps on the "create tour button" a new screen appears. That new screen helps her/him to define her/his preferences in order to get the best fit recommended tour.

The recommendation system will be fed up with information in order for a personalized tour to be created (Figure 6a). Firstly, the visitor needs to check whether she/he wants to

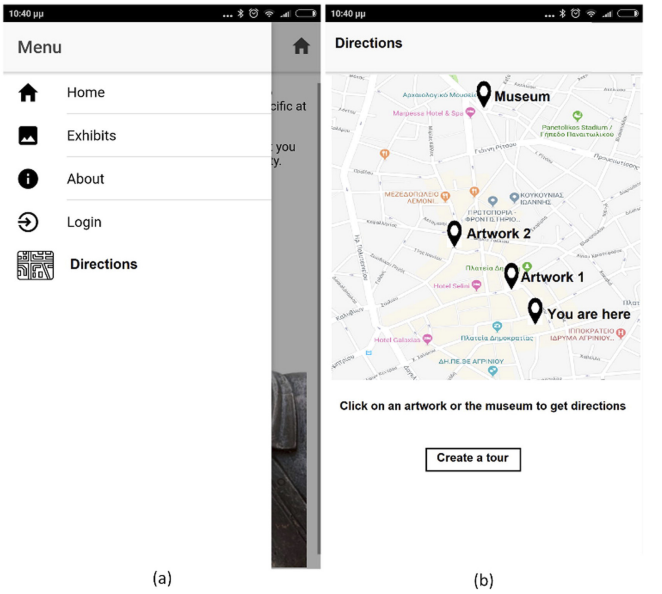

Figure 5.
Directions: (a) Service entry point, (b) map with artworks.

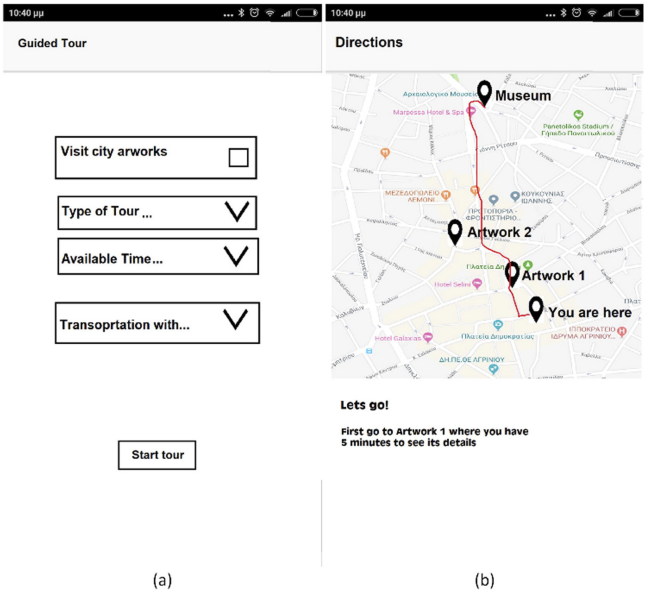

Figure 6.
Directions: (a) tour preferences, (b) a generated tour.

include in her/his tour the city artworks. Secondly, she/he must choose the type of tour (quick or thorough). For every artwork or museum exhibit, visit time is registered to the system (curator decides the time for a thorough or a quick visit of an artwork). Thirdly, the visitor needs to select her/his available time. Finally, she/he has to feed the system with the

transportation media she/he uses. She/he can choose "foot", "bicycle", "motorbike" or "car". Considering all the inserted parameters, the system calculates a recommended personalized tour for the visitor, as soon as she/he presses the "create a tour" button (Figure 6b). At each stop artwork details are shown to the user. If she/he spares more time on her/his way to the target or the artwork, the route is going to be recalculated.

6. Evaluation

6.1 Research methodology

The evaluation procedure involves two parts. The first part was conducted on the design stage in order to evaluate the proposed recommendation services. Firstly, in order to understand the end-user skills regarding the use of the proposed technology, we performed a survey. The target group was general population that may use the services selected randomly from the visitors of the Capralos Sculpture Museum: 23 females and 35 males 30–60 years old (with an average age 41.2 years old).

Continuing, we were evaluated the design of the proposed system services based on the cognitive walkthrough by Lewis et al. [21] because it can be applied in the first stages of a system implementation [22]. In the preparation stage we determined some tasks that the system should perform (the tasks are related to the scenarios presented in Section 5). Then, a group of museum technologies' experts read the system specifications and graded user actions. The absence of a service is indicated with 0 and grades from 1 to 4 are showing the amount of the users (user profile is based on our survey) that the specialists think that can be conversant with the specific actions (4 represents the highest number of users). In our evaluation, we have compared the proposed system with the SMARTMUSEUM system [19] (System A) and the PersTour system [14] (System B).

The second part of the evaluation was conducted to specify the drawbacks and advantages of the implemented framework comparing to other implemented systems [24,25] offering recommendation services (Table 2).

6.2 Results and discussion

The evaluation of the survey results reveals that only two participants didn't own a smartphone (3.6%). The majority of the participants (93.1%) were using social networks and they were familiar to downloading apps and using corresponding services. This suggests that most of the museum visitors could use the recommendation services we offer. A restriction in our survey analysis concerns the absence of elder people (over 60 years old). In order to handle this situation, the museum personnel could give them corresponding advices.

Table 1 displays the results from the analysis of museum technologies' expert answers concerning the behavior of the proposed system towards the fulfillment of the basic usage scenario presented in Section 5 compared to the behavior of two well-known systems: SMARTMUSEUM [19] and PersTour [14]. The proposed system gets the highest scores in most of the actions. It provides an app that permits the viewing of the museum content connecting it to specific artworks in a city center during user's city visit. This capability is not supported by SMARTMUSEUM and PersTour systems. On the other hand, SMARTMUSEUM and PersTour systems do not offer recommendations concerning artworks situated in the city to a user during her/his museum visit. The proposed system supports those recommendation services. This suggests that the proposed system mainly targets users that want to receive a unified tour guiding concerning a city center as extension of a museum environment.

Table 2 displays the evaluation results from the analysis of the implemented features of the proposed system compared to two well-known implemented systems [24,25] offering

Table 1. Walkthrough evaluation.

User can	Proposed System			System A			System B		
	E1	E2	E3	E1	E2	E3	E1	E2	E3
Get city POIs or artworks, while she/he is somewhere in the city	4	4	4	4	4	3	3	3	4
See the content of the museum, while she/he is in the city	4	4	3	0	0	0	0	0	0
Use the service with the mobile device	4	4	3	4	3	4	4	3	4
Get recommendations for city artworks or POIs while in museum	4	3	4	0	0	0	0	0	0
Put her/his preferences to get a recommendation	4	4	4	4	4	3	3	4	4
Get directions to a set of POIs or artworks	3	4	4	3	3	2	4	4	3
Get directions to a single POI or artwork	4	4	3	3	4	3	3	4	4

Table 2. Main features comparison. P is for the proposed system, S1 is [24] and S2 is [25].

Services offered	P	S1	S2
RS offers data from external repositories		✓	✓
RS offers data provided by visitors	✓		
RS offers data provided by specialists	✓		
RS involves data curated by specialists	✓		
RS provides dynamic visiting paths	✓		✓
The system includes a mobile app	✓	✓	✓
RS is visitor centered		✓	✓
RS is museum centered	✓		

recommendation services. The systems comparison (Table 2) reveals many differences. In our approach, the exhibit data provided to the visitors are curated by specialists and collected by themselves or specialists, while in S1 (system presented in [24]) and S2 (system presented in [25]) processed data are gathered from various repositories. Additionally, the proposed framework design and implementation is museum centered. It was based on the needs and feedback we received from the personnel and visitors of a real museum environment extending its functions within city space. However, in S1 and S2, the main objective is to provide recommendation services to the visitors of a region.

7. Conclusions

This work presents a set of mobile services attached to a museum framework that deliver recommendations to the visitors connecting the museum with the city space. Having as a starting point a museum artwork, a visitor, can end up easily to the museum and continue the tour there. Also, a visitor can continue the tour to the city placed artworks after having a museum visit. Following the recommended route, visitors, won't miss important artworks that exist in the city. Additionally, the visitor is able to discover artworks choosing her/his own personal constrains and preferences. However, we can't ignore the learning outcomes of this action. People will be able to absorb knowledge about artworks placed in the city enjoying their walk and maybe led to the museum. On the other hand, being in the museum, a visitor will have the opportunity to continue her/his journey to knowledge in the city space. The provided artwork information may vary depending on the profile of the visitor (student, tourist - simple visitor). Our services offer curated information created by specialists and visitors. Thus, we can easily control its quality. However, this can be efficient for small scale

museums. In an installation that concerns a large-scale museum, data is needed to be gathered not only from system users, but, also, from other existing repositories in order to reduce the work overload of the museum staff. Additionally, content gathered from social media can provide a different perspective to the visitor. In the future, we will study the use of the proposed recommending services in real conditions with students and tourists in order to explore their attractiveness and effectiveness in terms of QoE.

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