Gamifying cultural experiences across the urban environment

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Gamifying Cultural Experiences Across the Urban Environment

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Gamifying Cultural Experiences Across the Urban Environment

Abstract

New media and devices are offering huge possibilities for the enhancement and the enrichment of heritage experiences, improving the users' involvement. In particular, tourists equipped with their mobile devices are invading cultural attractions, sharing pictures and comments (together with hashtags and geo-localized positions) on social networks. These represent an unofficial source of data, which can be integrated with the official ones provided by GLAM (Galleries, Libraries, Archives, and Museums) and cultural heritage institutions, enriching them. At the same time, travel planners and mobile applications related to cultural heritage can play an interesting role in the development of smart cities, when they are integrated each other, engaging the user in touristic and entertainment activities, letting him/her be a source of cultural resources.

This work focuses on equipping users (citizens and tourists) with a system providing support in computing personalized urban paths across cultural heritage places (monuments, palaces, museums, and other points of interest (POIs) related to cultural heritage in the urban environment) and in sharing multimedia resources about POIs, by exploiting gamification elements with the aim of engaging citizens and tourists. A mobile application prototype has been implemented, showing the feasibility of the proposed approach and exploiting crowdsourcing activities as a source of information for cultural places and works of art.

Keywords

Smart city; cultural heritage; gamification; crowdsourcing; microservices; personal travel planner

1. Introduction

The wide diffusion of smart objects (including smartphones, tablets, smart watches) is profoundly affecting our daily life, changing our habits and the way we conduct all our activities, from communicating to learning, from working to spending free time, and so on. In this context, urban infrastructures, connectivity, and Internet of Things are supporting and enhancing the application and the achievement of smart city paradigms [1]. As a consequence, we are witnessing the proliferation of several mobile applications devoted to support the users in all those activities in the smart city context. In such a scenario, a key role is played by mapping services (e.g. Google Maps) and travel planners (e.g. OpenTripPlanner, Graphhopper), which support users in exploiting urban paths computed by similar algorithms, on the basis of similar characteristics (i.e. time, distance, means of transport, etc.). Generally, such kind of applications shows some lacks in terms of personalization, in fact, the user cannot set any preferences in terms of: health and fitness issues, personal and street safety, air quality (pollution, dust and pollen, etc.), user interface and interaction (which can be strongly affected by the use of context [2, 3]), and so on.

Another interesting topic which can get great benefits from exploiting mobile applications on smart devices and from user's preferences mechanisms is the cultural heritage one, related to touristic activities. In particular, geolocalization sensors can play a strategic role in this context, enhancing available functionalities and services [4]. Moreover, in the cultural heritage context, information collected from tourists and citizens [5] by means of their mobile devices [6], also thanks to their activities on social networks, could be integrated with the data coming from the official sources (such as data coming from municipalities, touristic offices, museums, public administrations and institutions, private foundations, etc.), enriching the whole amount of available resources and knowledge [7]. Again, personalization on the basis of users' preferences could offer great benefits in this field.

Indeed, the increasing diffusion of mobile devices have contributed to the use of crowdsourcing also in geo-spatial context [8], changing the way the information are produced, used and stored [9]. Tourists equipped with their smartphones are invading cultural attractions, taking pictures and selfies, sharing posts, hashtags [10], and their geo-localized position, tagging friends and places. In this way, they are populating and enriching social networks with such digital media (sometimes within specific events planned or supported by cultural institutions or by social media communities, such as the Wiki Loves Monuments[1] and the Digital Invasions[2] initiatives). These new contents could be exploited by cultural institutions, tourism offices, public entities, and private foundations, with the aim of monitoring activities related to their goods and places on social media. In particular, the use and the collection of pictures coming from social networks, from IoT and cloud contexts can play a significant role, where the "traditional user", who just consume and exploit contents is replaced with a new kind of figure, who is not just a mere consumer, but also a producer of contents [11], at the same time. These new users are called *prosumer*.

In this work, we present a microservices based system architecture [12]. In particular, we focus our attention on how to define and to manage users' preferences, detailing the Preferences Layer of a microservices-based architecture, and driving the personalization of route computation according to their preferences and needs [13, 14]. Personalized paths let the user move across preferred cultural heritage places and Points Of Interest (POIs) in the city [15]. A prototyped application for smart devices has been thought to let the user enjoy multimedia resources about the points of interest s/he is visiting, providing additional data (i.e. pictures, comments, reviews), enriching the information available for those POIs, thanks to crowdsourcing activities and to gamification mechanisms in a personalized fashion [15]. Basically, through applications (mobile and web-based ones) based on our architecture, a user can: (i) visit and explore the urban environment without a specific given path, while enjoying the description and the information about POIs in the nearby, according his/her current position, which are available in the application. The user can provide additional data about such POIs, sharing pictures and so on; (ii) request a generic urban path from a starting point S to a destination D. The user can set preferences for specific points of interest s/he wants to visit, or let the layer customization use preferences already stored in her/his profile. Hence, the initial purpose of this project is to provide a system that can handle user's preferences, by driving him/her, within a generic urban area, among the monuments and other important points of interest in terms of cultural heritage, meeting her/his preferences and needs. Our system is structured around the orchestration of 5 main phases:

1. Request and preference analysis: personal data, as well as users' preferences and needs are collected and stored, with the aim of identifying and proposing suggestions about contents related to cultural heritage, works of art, and related points of interest in the urban environment.
2. Calculation of points of interest, and related gamification information on the various datasets. At this stage, it is necessary to identify data sources. We have specifically taken into account two main different types of data sources: official (coming from local entities and public administrations, such as municipalities, regions, ministries, departments, tourist offices, including also data already available on mapping and navigation services,

[1] https://www.wikilovesmonuments.org/
[2] http://www.invasionidigitali.it/en

such as Google Maps and Open Street Maps) and unofficial ones (collected by means of crowdsourcing and crowdsensing activities, involving citizens and tourists).

3. Processing the personalized route through a routing engine. Given a georefined map and a possible additional data set (such as GTFS - General Transit Feed Specification - for public transport data), a path from a starting point S to a destination D is computed, going across or through all points of interest resulting from the previous step [16]. Any routing engine can be exploited for this step, in particular, we have used an OpenTripPlanner (OTP) instance in the prototype we have developed.
4. Presentation of the proposed route to the user and activation of the crowdsourcing mode. The path is represented on a map (typically by using a mobile application or a web-based service, just like Google Maps or Open Street Maps); each POI with some missing features is marked and shown in the map so as to let the user be aware of the possibility of earning points by providing some of the missing information (in terms of data or details about POIs which are not available from official sources of information or from previous crowdsourced data). It is worth mentioning that our system does not propose only POIs with some missing information: it proposes the POIs according to the user's preferences, even if there are plenty information about them. Gamification mechanisms have been exploited so as to push users to contribute by adding data for those POIs with less information than the other ones, hence the system will not recommend remote POIs, out of the user's path, because the whole path is limited according to user's preferences in terms of time and distance.
5. Post-processing of data received by the user (i.e. crowdsourced data, thus details and information about the POIs, shared pictures, comments, etc.) and reintegration into the dataset.

This work has been done within the SACHER project [3](Smart Architecture for Cultural Heritage in Emilia-Romagna, which is co-funded by the Emilia-Romagna Region through the POR FESR 2014-2020 fund - European Regional Development Fund). Hence, we have based our prototype on official data sources about cultural heritage in the Emilia-Romagna Region and its cities. An experience prototyping session has been conducted by involving end-users, and this paper discusses the results of a qualitative analysis.

The remainder of the paper is structured as follows. Section II briefly presents some works related to crowdsourcing and gamification techniques applied in the cultural heritage field. Section III provides a description of the System Architecture. Section IV presents a prototype of mobile application (named CICE), implemented on the basis of such architecture, describing two specific personas and related usage scenarios and detailing gamification mechanisms we have exploited. Section V reports the results we have obtained by involving users in an experience prototyping session. Finally, Section VI concludes the paper highlighting some final remarks and future work.

2. Background and Related Work

Since the late 90s' the potential of new media has improved many areas, cultural heritage being one of them. This has occurred in various forms. An example is the reconstruction, based on 3D modeling, of archaeological sites or lost monuments and cultural heritage due to war conflicts (just like Palmyra site in Syria) or due to natural disasters (just like tsunamis or earthquake [7]). Thanks to crowdsourcing and to motion technique, used for the reconstruction of a 3D model, it has been possible to reconstruct a model of Plaka Bridge, a 19th-century stone one-arch bridge in Greece, that collapsed during the floods of 1st February 2015. In this project, acquired images are uploaded from different kind of users, with

[3] http://www.eng.sacherproject.com/

the result that they have different resolution, perspective, distance and brightness. Thus, it has to be considered that they are also snapped in different seasons and times.

Researchers also investigated how transcription is even more important, in historical documents, than the uniqueness of most of these documents and the preservation of their contents is essential for historical and cultural reasons. Transcribing handwritten documents through optical character reader (OCR) technologies is not always enough and is far from perfect. Crowdsourcing and human experts' revision emerged as a powerful tool in order to obtain a correct transcription. Another use of crowdsourcing in cultural heritage context regards tagging or captioning images. Despite advances in the field of content-based image retrieval, human intake recovers the higher semantic level within cultural heritage image databases, gradually shifting users from passive consumer to pro-active users (manipulating data, improving information retrieval, etc.) [17].

Crowdsourcing is a flexible model that can be applied to a wide range of activities among which adding content to maps like in [4], where it has been developed an application that suggests LPOI (Local Point Of Interest) around the user, through geolocation. Flickr was used to retrieve resources and Wikipedia was used in order to add information. Once the LPOI are chosen, the system computes and displays the suggested path.

Every photo retrieved from Flickr is considered as "candidate" until it reaches a majority vote, thanks to users' feedback. Then, such a picture becomes eligible of being (or not) displayed whenever a search result encompasses the related LPOI. The purpose of this project is to get users' feedback to improve results displayed by the system.

In this context, another concept that can play a key role is gamification [18]. In particular, gamification is recognized as a mechanism that lets people feel motivated and engaged in contributing to the system [19]. In fact, gamification has a positive impact on crowdsourcing, both from qualitative and quantitative points of view, levering on intrinsic and extrinsic motivation to push the user in becoming an active member of the system community [19, 20].

3. Our System Architecture

This section describes the details related to the system architecture. We will first show a general overview motivating the main goals of our solution, then we will introduce more details related on our scenario focusing in particular on microservices devoted to manage functionalities at the basis of users interaction with the system. For any additional details, a more complete description of the whole architecture can be found in [12].

Summarizing the goal of our architecture is twofold.

1) Act as an enabler platform, namely validate and enable each new service that want to join this platform, which have to be complaint to the platform rules
2) Provide microservices orchestration support in order to coordinate all the services exposed

This platform was designed [23] for the creation of urban mobility services but can be customized to manage more targeted types of services such as interfacing and orchestration of different data sources.

The microservice paradigm is at the basis of the design of our architecture, letting it work on different and distinct phases [9]. The idea behind such a paradigm is that any function, that can be seen and managed as an independent service, have to be considered as a single microservice. A more complete service will be the result of a proper orchestration of those microservices.

The main advantage of this solution is that we can obtain an extremely modular and distributed architecture [12, 23].

The distributed feature is a consequence on the usage of technologies such as containerized and virtualized microservices. A platform composed of an orchestration of microservices can be broken into smaller components or cluster of components to regain control over the architecture. Due to its independence this components can be easily spread among different computational resources or networks, according to the workload required. We can then implement small changes and add individual features with microservices by extending a single or set of components and deploying them. This kind of distributed compositionality becomes its greatest strength. As described in [24], even the internal components of the software are autonomous services, independent components conceptually deployed alone with dedicated technologies, both software and hardware. This means that this architectural style does not foster or forbid any particular programming, but it provides a partition structure of the component the developer has to follow.

Since all the components of a microservice architecture are microservices, its distinguishing behavior derives from the composition and coordination of its components via messages. Thus, the core of a microservice platform will be the orchestration phase, namely the composition of microservices, tools, and processes invoked, and the connection and automation of workflows that create the final service [25].

However, the microservice paradigm introduces also new challenges and enlarges known threats. The distributed programming nature is at the same time its main advantage and disadvantage [26]. However, it has been chosen as development paradigm for the ease with which it was possible to disassemble the various stages in independent services. In this way, it could be potentially used later for other architectures. With this enabler services paradigm in order to effectively support our vision of data management platform with the aim of providing personalized paths in an urban environment, we envision the creation of an ecosystem of reusable components within such an Architecture. In this context, standardized services can efficiently combine: (i) heterogeneous data sources (such as official information about cultural heritage coming from municipalities, tourism offices, GLAMs, etc., available transport options, and real-time data regarding vehicles and infrastructures, as shown in Figure 1), (ii) a layer of personal preferences manager, and (iii) a data wrapper manager.

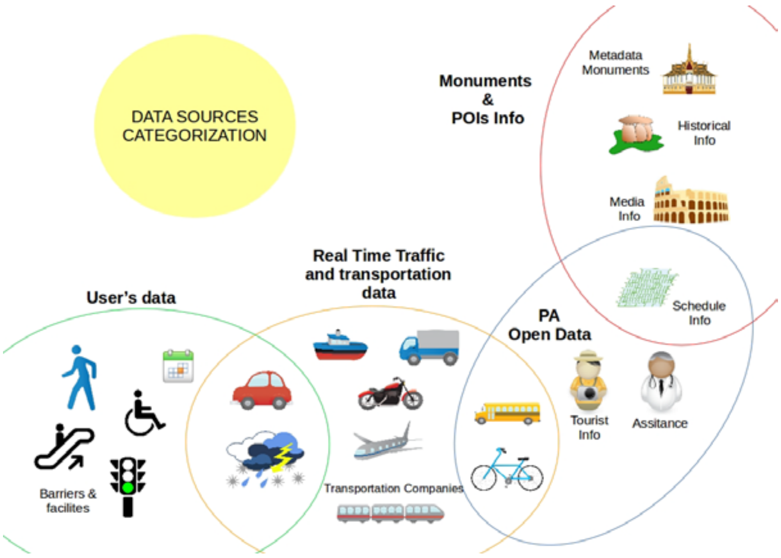

Figure 1.Data heterogeneous sources

In particular, the architecture hosts services to standardize and control access to the various data sources, both institutional and user-provided, to enable crowdsourcing of users' report, associating provenance metadata and reliability scores to them, to collect and process crowdsensing information gathered through devices [21, 22], etc. in an overall effort of opening data and standardizing the interfaces to access them. Figure 2 shows the proposed preferences layer architecture.

The result of our implementation of this service enabler architecture is a preference data platform that can orchestrate a set of microservices that manage several crowdsourcing, crowdsensing and custom personal data in order to provide smart mobility solution.

In particular, we can see this preference data platform as a preference layer, which interferes between the typical request of a common travel planner (e.g. OTP Analytics) and its response, intercepting the call and editing it based on a user preference processing.

The architecture is structured around the orchestration of five main phases, which will be detailed in the following subsections:

1. Request and preference analysis.
2. Calculation of points of interest, on the basis of users' preferences; exploiting gamification techniques to engage users in providing crowdsourced data, enriching the whole dataset.
3. Processing the route through a routing engine.
4. Presentation of the proposed route to the user and activation of the crowdsourcing mode.
5. Post-processing of data received from the user and reintegration into the dataset.

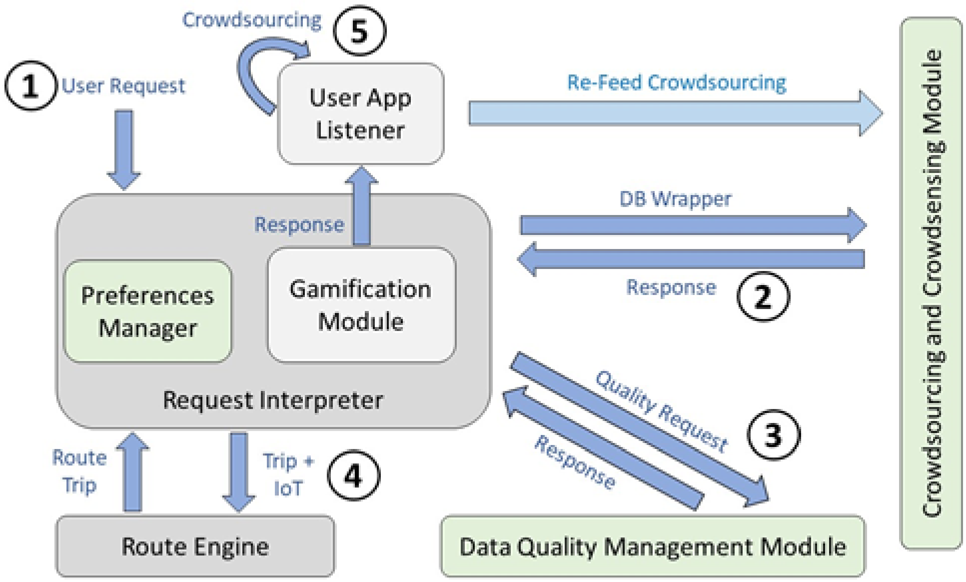

Figure 2. Preference Layer Architecture

3.1 Request phase

The request phase is the first step that a mobility services require. In this phase we have to interpret the user request and elaborate it in order that the orchestrator can be invoked in the most efficient way.

Through applications (mobile and web-based ones) based on our architecture, the user can make a request for a generic path from a starting point S to a destination D. The user, as we will later show in the following section, has two possible choices. S/He can specify preferences for points of interest s/he wants to visit, or let the layer customization use preferences already stored in her/his profile.

In fact, our architecture follows the MyData Philosophy as regards the management of personal information of users [27]. MyData is a technology born in Finland whose purpose is to create an efficient and above all safe solution for the management and storage of personal data. The basic idea is to have a personal dataset called Personal Data Vault (hereafter PDV), where all the personal data of a user are properly stored. However, this dataset is accessed through a specific request, previously authorized, specifying needed data and format, so that the requesting service is not provided with rough and sensitive data, but only with the most appropriate result from a suitable data aggregation and processing algorithm. More details regarding this technology can be found in [28, 29].

The Preferences layer (as shown in Figure 2) then supports an authorized MyData engine, which, if no preference is specified, will be invoked to have the corresponding user profile. However, if the user specifies some preferences, (i) they are processed in a general way by the layer and then (ii) they are possibly integrated with the personal profile from the PDV. The purpose of these two phases is to generate and produce a single profile-request where the preferences are specified according to the format we use. This pre-processing step will then serve to calculate the various categories of preference and the weight to associate with each of them.

3.2 Points of Interest Search

Once the user's preferences are processed, the layer searches for the points of interest that match the request. It is necessary at this stage to better identify the data sources. Points of interest are calculated by invoking multiple data sources for several reasons. As stated earlier, the initial purpose of this project is to provide an architecture that can handle user's preferences, by driving him/her, within a generic urban area, among the monuments and other important points of interest in terms of cultural heritage.

We have specifically taken into account two main different types of data sources: official (coming from local entities and public administrations, such as municipalities, regions, ministries, departments, tourist offices, and so on) and unofficial ones (collected by means of crowdsourcing and crowdsensing activities, involving citizens and tourists).

In particular, as regards the official data sources, we have drawn our attention to the available resources related to the cultural heritage of the Emilia-Romagna Region (where Bologna is placed) as a case study. Thus, our system can communicate with the following official and authoritative data sources:

- the SACHER Project (http://www.eng.sacherproject.com/);
- the Emilia-Romagna Cultural Heritage Open Data project (http://www.patrimonioculturale-er.it/webgis/);
- Bologna Open Map (http://dati.comune.bologna.it/bolognaopenmap?language=en);
- Google Maps.
- Open Street Map.

The DB wrapper is able to communicate with this Data Sources and provide a JSON structure, which is quite simple and includes the information needed to categorize monuments, palaces, museums or other points of interest related to cultural heritage, together with information about their geographical position and geo-referenced data.

A fragment of the JSON code obtained from the search query, where geo-references are categorized by the type of monuments (according to the user's preferences) can be found in http://www.cs.unibo.it/~mirri/cicerone/json1.html.

Again, in this phase we have a twofold purpose. The first goal is obviously to look for points of interest, and this is accomplished by means of a deep search through all the datasets where the results are unified, eliminating duplicates and errors. Secondly, the list of corresponding matching POIs is analyzed, to identify those ones with missing metadata, related media and multimedia, additional relevant information.

This does not concern the geo-reference features, but documentation related to the specific POI and it includes data such as photos, timetables, accessibility for people with disabilities, real-time crowding, partial closures, etc.

The resulting POIs are indeed ordered and marked based on the missing features, so that they are recognizable once the path is calculated. At each missing feature is assigned a score that will be used on the fourth stage, to start the gamification phase. The final result is similar to the one shown at http://www.cs.unibo.it/~mirri/cicerone/json2.html. At this stage, the list of matching points of interest is ready to be exploited as an input to the route planning engine.

3.3 Routing Trip Elaboration

The bottom level planner depicted in Figure 2 is an engine implementing routing algorithms that, given a geo-refined map and a possible additional data set (such as GTFS public transport data), computes a path from a starting point S to a destination D, going across or through all points of interest resulting from the previous step.

Any routing engine can be exploited for this step, in particular, we have used an OpenTripPlanner (OTP) instance in the prototype we have developed. The result of the OTP processing is another JSON file (a fragment is shown in http://www.cs.unibo.it/~mirri/cicerone/json3.html).

It is worth noting that, at each POI, the necessary intermediate points are added to graphically map the path in the next step. Note that for each point, the corresponding ID is stored in such a way that it can memorize the association between the point and the information calculated in the previous steps, both in terms of interesting features of the POI, and lack thereof (to involve the user in providing them).

3.4 User's Trip

In the fourth step, the path is ready to be exploited by the user, following all the references made in the previous phases. At this stage, there is a first update of user's preferences within the corresponding PDV. Specifically, the computed path is saved and stored, together with all the relevant marks on the points of interest required and calculated. It is important to make a first update at this stage, rather than at the next ones because it is not certain whether the user will (want to) interact later.

The path is represented on a map (typically by using a mobile application or a web-based service, just like Google Maps or Open Street Maps); each POI with some missing features is marked and shown in the map so as to let the user be aware of the possibility of earning points by providing some of the missing information.

Each feature then instantiates a listener, which basically is a web hook that starts and waits for possible interaction from the user. This interaction includes several possible different actions as:

- Add/Update a description.
- Add/Update a picture or general media information.
- Submit a review.
- Report a problem.

3.5 Crowdsourcing re-feed

At this stage, the user can enjoy the required path with the relevant points of interest, add the missing data from the recommended points of interest, earn scores and gain bonus points. These data are again intercepted by the preference layer and will be used in two ways. Firstly, user's preferences and history will be updated a second time within the corresponding PDV. Secondly, the layer will feed the dataset by updating the new data derived from the user's interaction.

These five steps are the result of 5 different procedures orchestrated by our preferences layer. The strength of this solution lies in the fact that the procedures are not strictly dependent on the data sources, their structure or source but exclusively from the wrappers used to recover them, which can be seen as services enabled by the same platform. This makes the layer extremely agnostic from data sources and led to the possibility of being reused and customized for the creation of different types of services (e.g. smart health care) where the management and the interaction between data constitute its core.

4. Our Prototype

We have designed and developed a prototype mobile application, on the basis of the architecture described above, with mentioned data sources, with the aim of integrating official data and crowdsourced data, about cultural heritage. Such a mobile app, named CICE has been designed with the aim of supporting tourists, citizens, and visitors in wandering around the city of the Emilia-Romagna Region, across the points of interest related to cultural heritage, showing their details, and in expressing their preferences and personalizing their routes. CICE stands for "Collabora Impara Condividi Esplora" (in Italian language) and can be translated as “Collaborate Learn Share Explore” in English.

It has been developed by using the Ionic framework, the Firebase platform, and the Leaflet library, as a responsive mobile application. A screenshot of CICE user interface is depicted in Figure 3.

On the basis of the described preference architecture, CICE interact with such a preference layer. By means of CICE interface, the user can set some preferences in terms of time frame to spend during the visit, categories of favorite points of interests (i.e., type of cultural heritage, ages, styles, etc.), starting position and destination of the path.

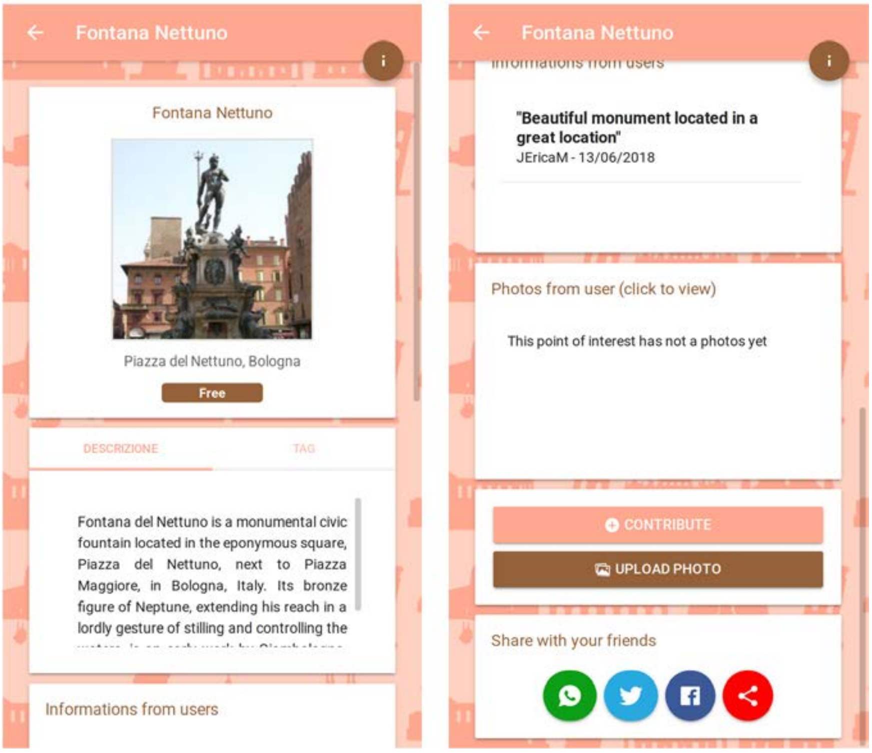

Figure 3. A screenshot from our prototype CICE, showing details about a POI

4.1 Personas and Scenario

This subsection presents two personas and related scenarios in the city of Bologna we have defined with the aim of describing the main functionalities of our prototype.

John stops over in Bologna during his travel by train from Venice to Florence. He has to wait 3 hours for his connection, so he decides to use CICE to plan a small visit in Bologna, by walking, during which having lunch in a traditional tavern, since he wants to taste Tortellini.

John exploits the geolocation function, defines the starting point and the destination of his path (that are the central railway station of Bologna), sets up information about the maximum duration and distance (see Figure 4) and about his preferences in terms of cultural heritage. In this case, John declares his preferences about squares and fountains, together with traditional homemade pasta. John uses preferences related to this specific trip, since he heard about a famous fountain in Bologna, recently restored. The proposed path is shown in Figure 5.

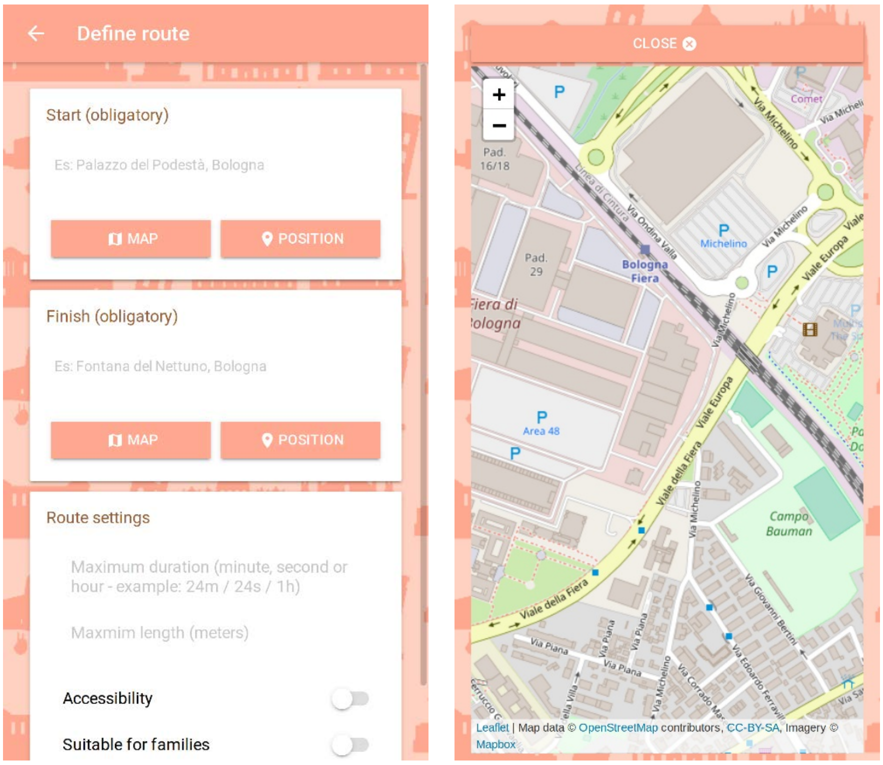

Figure 4. Screenshots from our prototype CICE, showing details about selecting the starting point and the destination of a path

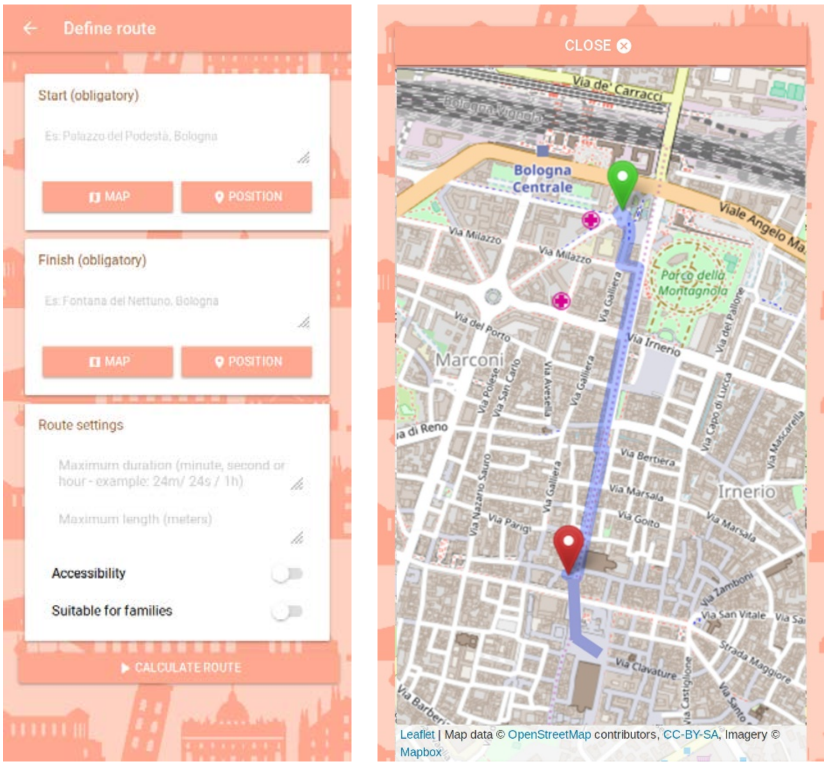

Figure 5. A screenshot from our prototype CICE, showing selection about maximum time and distance and accessibility needs and a screenshot from our prototype CICE, showing the personalized path proposed to John

In particular, this path has got the same starting point and destination, a maximum duration of 2 hours and half. Across this path, CICE guides John in visiting the Fountain of Neptune, the Sala Borsa Library, and Piazza Maggiore, the main square of the city. During the path, CICE involves John in taking and sharing pictures of the Fountain of Neptune, so as to enrich data coming from unofficial sources.

As a second persona, we consider Jane, which is going to have an afternoon off, after having a business meeting in Bologna. She decides to have a walk to enjoy some of the churches in Bologna old town, eating a dinner in one of the best pizzeria in town (according to recommendation and rating systems on social networks), while she is reaching the Central Station to come back home. In CICE, she chooses the starting point corresponding to her position, while her destination is the central railway station. She sets up information about the maximum duration and distance and about her preferences in terms of cultural heritage. In this case, Jane declares her preferences about churches, together with traditional Italian food. The proposed path is depicted in Figure 6. CICE proposes the following list of places to visit:

- (i) Basilica di San Francesco,
- (ii) Chiesa di San Salvatore,
- (iii) Basilica di San Petronio,
- (iv) Basilica di Santo Stefano,
- (v) Cattedrale di San Pietro.

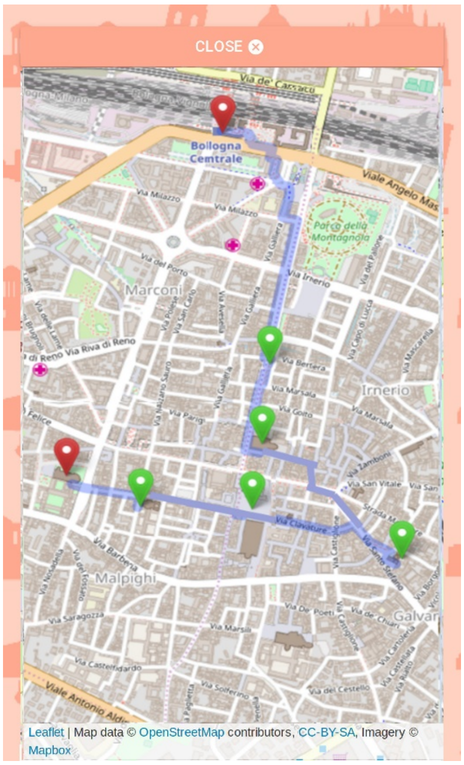

Figure 6. Jane's path proposed by CICE

During the visit, CICE notifies some tags that can be added to the churches (e.g. accessibility for people with disabilities, availability of guided tours and visits, availability of Wi-Fi. connection, availability of toilettes, services for babies, etc.). CICE lets the user also add information about the specific time devoted to the visit for each specific POI, enriching the whole system and improving the personalization settings and the computations related to the personalized routes.

4.2 Gamification Strategies

As already mentioned in Section 3, our application implements gamification strategies with the aim of increasing the engagement of the users in contributing in the system. In particular, four main categories of game mechanics have been included in the prototype:

- *points*: each task and activity performed by the user is associated with a specific score (points). These measurable evidences of an accomplishment can be used to obtain badges and to rise in the ranking (leaderboard);
- *achievements*: rewards that the users earn when they perform a certain task in the app. In particular, achievements are awarded based on the number of times the user performs a specific task, considering defined milestone (such as 10 photos uploaded, or 20 comments shared);
- *badges*: digital distinctive representing a special accomplishment or a skill the user earned. Obtaining a badge is a indicator of accomplishment or mastery of a skill. Badges can be unlocked based on the points gained or the accomplishment of a special task;
- *leaderboard*: a global ranking to challenge the users in competing between them, based on the collected points.

The tasks that allow a user to collect points, badges and achievements are related to three typologies of content:

- *photos*: user is encouraged to upload photos related to the specific POI;

- *text information*: free text can be inserted and shared with the community to enrich the database of information with details and increasing the density of the datasets. It can be a new review/report or an update of a previous one;
- *tags*: labels that can help other users to easily figure out the main characteristics of a cultural/historical POI, such as accessibility and target (e.g., children, family or adults).

In the user profile interface is it possible to visualize all the data related to the users, such as position in the global ranking, points, badges and achievements (see Figure 7). Moreover, it is possible to personalize an avatar representing the user, another interesting approach to exploit for engaging the user in the system (as displayed in Figure 8).

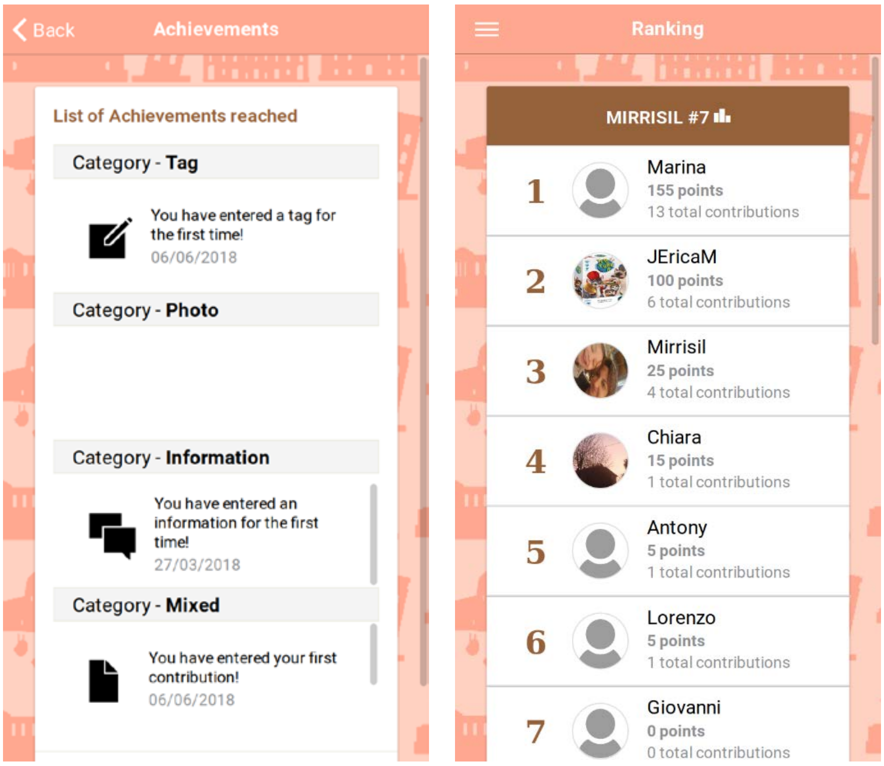

Figure 7. The list of obtained achievements (on the left) and the leaderboard (on the right) screenshots

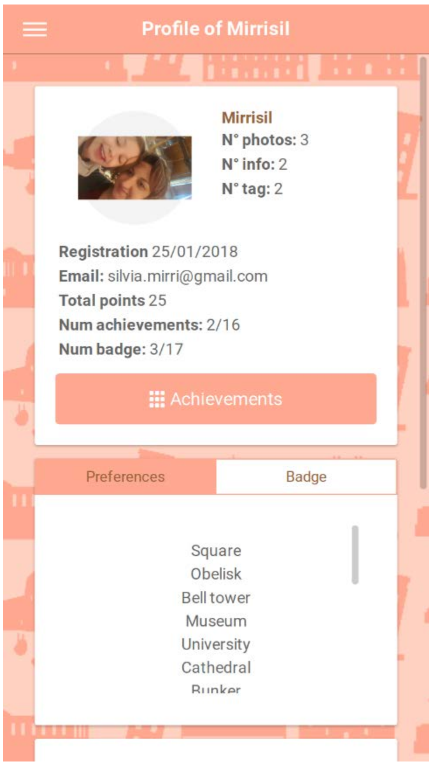

Figure 8. The user profile screenshots, including information about earned badges and achievements (on the left) and contributions (on the right)

5. Evaluation

To evaluate the system, we performed an experience prototyping session [30] in the city of Cesena, followed by a post-experience questionnaire, so as to collect both qualitative and quantitative data.

5.1 Experience prototyping

We involved 20 users in experience prototyping sessions, with the aim of grasping insights (inspiration, confirmation or rejection of ideas) related to the use of the application in-the-field. The age of participants ranged from 22 to 34 year-old, with 9 males and 11 females, including students (from the computer science and psychology departments) and staffs of the University. During each session, one facilitator assisted the user in order to take notes and records, following the think aloud protocol. The path to follow was the same for all the users, to avoid bias due to the different length of the selected paths and the number of points of interest in the specific area. In particular, we asked users to perform a path starting from the Department of Engineering and Computer Science (S) to the Bonci Theater (D), in the Cesena city. Our algorithm suggested users to visit other two POIs (the Malatestiana library and the Masini fountain), with a path total length of less than one kilometer. In average, the sessions lasted 35 minutes (the shortest one was 28 and the longest one was 45). At the beginning of the session, we asked users to install our application in their Android phones (prerequisite to participate at the study).

Thanks to the experience prototyping sessions, some interesting insights emerged. For example, considering the gamification strategies, one user suggested to make all the badges visible (but disabled) from the beginning, so as to spur the user to collect and unlock them. Some comments where related to the general app, such as the suggestion to provide not only cultural/historical information about the POI, but also open timing and ticket price. Another interesting suggestion was the one to include meta-data (such as date, timing and name of the POI) related to the photos collected in the user's personal gallery, in order to keep record of the visited points of interest.

5.2 Post-experience Questionnaire

To collect quantitative data about the prototype, we asked users, engaged in the experience prototype, to fill a questionnaire. The questionnaire included different sections, with a total of 26 items: i) a first section with general questions (gender, age, occupancy, interest in cultural heritage); ii) a section including general items about the application (functionalities, enjoyment); iii) some items asking specific questions about the interfaces of the prototype (graphic layout, simplicity, interactivity); iv) a few questions related to gamification and the used game mechanics (effectiveness); v) a couple of items related to the crowdsourcing activity (interest in sharing tags, photos, comments and reports). In details, the questionnaire is made of 12 open questions, 8 of them using a 4 values Likert scale, and the renaming ones (14 out of 26) are multiple choice questions. All the 20 users answered to the questionnaire.

The outcome reveals that almost all the users enjoyed and found interesting the idea behind the application (among these, also two users who declared to be not so interested in cultural heritage). That it is also confirmed by the number of users who claimed that they would install and use the application if available on the market (16 out of 20). Moreover, 18 out of 20 agree (or strongly agree) on the sentence “The system involves the user in contributing, being a part of the community” (see details in Figure 9).

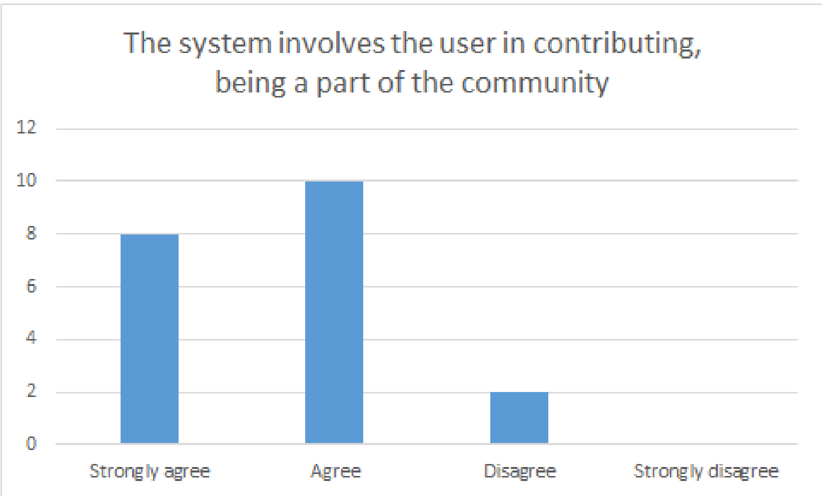

Figure 9. Answers obtained by participants about their involvement in contributing to the system, being a part of the community

Considering the gamification techniques as a tool for engaging users in crowdsourcing (see pie chart in Figure 10), 11 users declared they felt more engaged in contributing thanks to the gamification techniques (but that they would contribute in any case), 4 users said that they contributed only because of the gamification, 3 users claimed to feel the importance to contribute for the community (not for gamification-related motivations), and, finally, 2 users didn't feel engaged at all in sharing data.

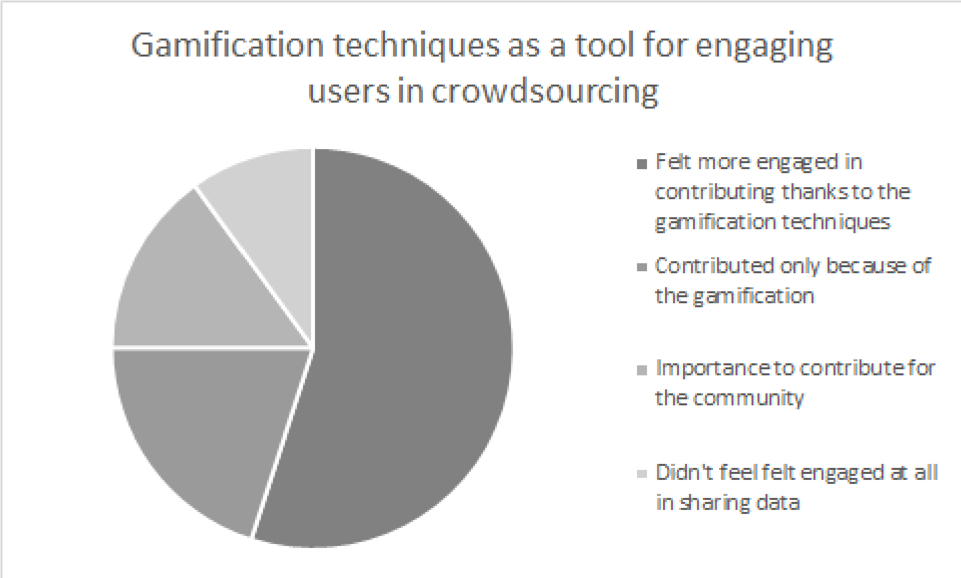

Figure 10. Answers obtained by participants about the use of Gamification techniques as a tool for engaging users in crowdsourcing

All the users enjoyed the interfaces of the prototype, in fact, only one participant disagreed the sentences "I've enjoyed the system interface and user interaction" and "The way the information about the POIs are visualized in the map is clear" pointed out weaknesses in the user interface, while the other 19 over 20 selected positive value in the 4 values Likert scale (see charts in Figure 11 and Figure 12).

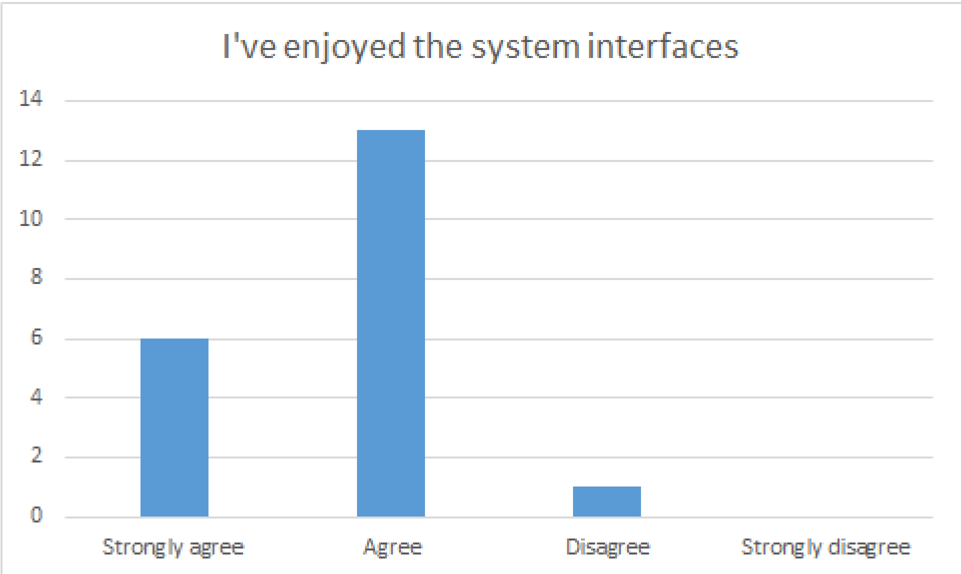

Figure 11. Answers obtained by participants about their appreciation of the system interfaces

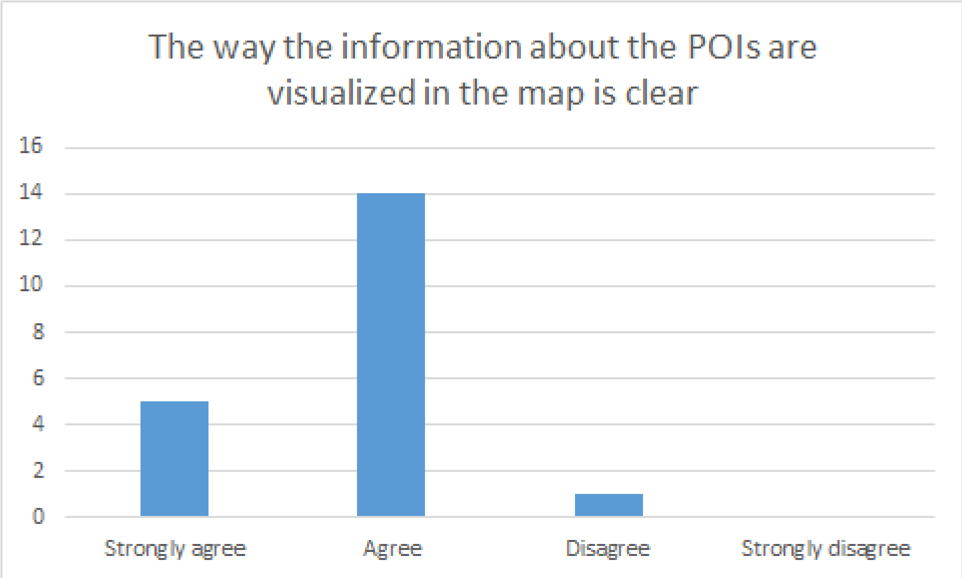

Figure 12. Answers obtained by participants about the clearness of the POIs information visualized in the map

All the collected data (qualitative and quantitative) positively enforce our intuition to exploit official data sources, voluntary crowdsourcing, gamification strategies to provide personalized paths to visitors and citizens to explore and learn about the cultural heritage of a specific area.

6. Conclusion

In this paper, we presented a system, based on a microservice architecture, devoted to let the users set specific preferences and settings and to compute personalized routes across cultural heritage in an urban environment. The system integrates many and different data sources, mainly based on open data, provided by official entities (such as public and local administrations, e.g. municipalities, touristic offices, regions, etc.). Moreover, it integrates gamification strategies and crowdsourcing to engage and involve users in being part of the community and enriching the global dataset. This paper details the gamification elements and mechanisms we have adopted in the prototype for mobile devices we have developed. An evaluation campaign with users has been conducted by means of an experience prototyping session, showing the feasibility of our approach.

We are further investigating Game with a Purpose mechanisms, that will enrich our system, with the aim of better engaging users in providing and sharing additional data and resources related to the cultural heritage they meet during their routes. Thus, this would enforce the role of citizens, visitors, and tourists in acting as unofficial sources of information, improving the amount of available resources and supporting knowledge sharing activities. Another future work is based on the distribution of the proposed architecture in a cloud based one, by integrating in a deeper way the urban infrastructure [31], falling under the hat of Software as a Service (SaaS).

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References

[1] Melis, A., Mirri, S., Prandi, C., Prandini, M., Salomoni, P., & Callegati, F. (2016, September). Crowdsensing for smart mobility through a service-oriented architecture. In Smart Cities Conference (ISC2), 2016 IEEE International (pp. 1-2). IEEE.

[2] Callegati, F., Delnevo, G., Melis, A., Mirri, S., Prandini, M., & Salomoni, P. (2017, July). I want to ride my bicycle: A microservice-based use case for a MaaS architecture. In Computers and Communications (ISCC), 2017 IEEE Symposium on (pp. 18-22). IEEE.

[3] Mirri, S., Prandi, C., & Salomoni, P. (2014, July). A context-aware system for personalized and accessible pedestrian paths. In High Performance Computing & Simulation (HPCS), 2014 International Conference on (pp. 833-840). IEEE.

[4] Bujari, A., Ciman, M., Gaggi, O., & Palazzi, C. E. (2017). Using gamification to discover cultural heritage locations from geo-tagged photos. Personal and Ubiquitous Computing, 21(2), 235-252.

[5] Dusi, N., Ferretti, I., & Furini, M. (2017). A transmedia storytelling system to transform recorded film memories into visual history. Entertainment computing, 21, 65-75.

[6] Roccetti, M., Marfia, G., & Palazzi, C. E. (2011). Entertainment beyond divertissment: using computer games for city road accessibility. Computers in Entertainment (CIE), 9(2), 10.

[7] Stathopoulou, E. K., Georgopoulos, A., Panagiotopoulos, G., & Kaliampakos, D. (2015). Crowdsourcing lost cultural heritage. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2(5), 295.

[8] Heipke, C. (2010). Crowdsourcing geospatial data. ISPRS Journal of Photogrammetry and Remote Sensing, 65(6), 550-557.

[9] Mirri, S., Prandi, C., Salomoni, P., Callegati, F., Melis, A., & Prandini, M. (2016). A service-oriented approach to crowdsensing for accessible smart mobility scenarios. Mobile Information Systems, 2016.

[10] Furini, M., Mandreoli, F., Martoglia, R., & Montangero, M. (2017, January). The Use of Hashtags in the Promotion of Art Exhibitions. In Italian Research Conference on Digital Libraries (pp. 187-198). Springer, Cham.

[11] Roccetti, M., Ferretti, S., Palazzi, C. E., Salomoni, P., & Furini, M. (2008, January). Riding the web evolution: from egoism to altruism. In Consumer Communications and Networking Conference, 2008. CCNC 2008. 5th IEEE (pp. 1123-1127). IEEE.

[12] Melis, A., Mirri, S., Prandi, C., Prandini, M., Salomoni, P., & Callegati, F. (2017). Integrating personalized and accessible itineraries in maas ecosystems through microservices. Mobile Networks and Applications, 1-10.

[13] Salomoni, P., Mirri, S., Ferretti, S., & Roccetti, M. (2007, May). Profiling learners with special needs for custom e-learning experiences, a closed case?. In Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A) (pp. 84-92). ACM

[14] Ferretti, S., Mirri, S., Prandi, C., & Salomoni, P. (2016). Automatic web content personalization through reinforcement learning. Journal of Systems and Software, 121, 157-169.

[15] Delnevo, G., Melis, A., Mirri, S., Monti, L., & Prandini, M. (2017, November). Discovering the City: Crowdsourcing and Personalized Urban Paths Across Cultural Heritage. In International Conference on Smart Objects and Technologies for Social Good (pp. 132-141). Springer, Cham.

[16] Mirri, S., Prandi, C., & Salomoni, P. (2016, January). Personalizing Pedestrian Accessible way-finding with mPASS. In Consumer Communications & Networking Conference (CCNC), 2016 13th IEEE Annual (pp. 1119-1124). IEEE.

[17] Van Hooland, S. (2006, September). From spectator to annotator: possibilities offered by user-generated metadata for digital cultural heritage collections. In Immaculate Catalogues: Taxonomy, Metadata and Resource Discovery in the 21st Century, Proceedings of CILIP Conference.

[18] Prandi, C., Nisi, V., Salomoni, P., & Nunes, N. J. (2015, September). From gamification to pervasive game in mapping urban accessibility. In Proceedings of the 11th Biannual Conference on Italian SIGCHI Chapter (pp. 126-129). ACM.

[19] Morschheuser, B., Hamari, J., & Koivisto, J. (2016, January). Gamification in crowdsourcing: a review. In System Sciences (HICSS), 2016 49th Hawaii International Conference on (pp. 4375-4384). IEEE.

[20] Prandi, C., Roccetti, M., Salomoni, P., Nisi, V., & Nunes, N. J. (2017). Fighting exclusion: a multimedia mobile app with zombies and maps as a medium for civic engagement and design. Multimedia Tools and Applications, 76(4), 4951-4979.

[21] Bujari, A., Licar, B., & Palazzi, C. E. (2012, January). Movement pattern recognition through smartphone's accelerometer. In Consumer communications and networking conference (CCNC), 2012 IEEE (pp. 502-506). IEEE.

[22] Prandi, C., Ferretti, S., Mirri, S., & Salomoni, P. (2015, March). Trustworthiness in crowd-sensed and sourced georeferenced data. In Pervasive Computing and Communication Workshops (PerCom Workshops), 2015 IEEE International Conference on (pp. 402-407). IEEE.

[23] Callegati, F., Gabbrielli, M., Giallorenzo, S., Melis, A., & Prandini, M. (2017, October). Smart Mobility for All: A Global Federated Market for Mobility-as-a-Service Operators. In ITSC2017-20th International Conference on Intelligent Transportation.

[24] Newman, S. (2015). Building microservices: designing fine-grained systems. " O'Reilly Media, Inc.".

[25] Dragoni, N., Giallorenzo, S., Lafuente, A. L., Mazzara, M., Montesi, F., Mustafin, R., & Safina, L. (2017). Microservices: yesterday, today, and tomorrow. In Present and Ulterior Software Engineering (pp. 195-216). Springer, Cham.

[26] Lea, G. (2015). Microservices security: All the questions you should be asking.

[27] Poikola, A., Kuikkaniemi, K., & Honko, H. (2015). Mydata a nordic model for human-centered personal data management and processing. Finnish Ministry of Transport and Communications.

[28] Antti Poikola and Kai Kuikkaniemi and Harri Honko (2016). MyData – White Paper. https://www.lvm.fi/documents/20181/859937/MyData-nordic-model/2e9b4eb0-68d7-463b-9460-821493449a63?version=1.0".

[29] MyData 2016. Advancing human centric personal data. http://mydata2016.org/

[30] Buchenau, M., & Suri, J. F. (2000, August). Experience prototyping. In Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques (pp. 424-433). ACM.

[31] Callegati, F., Cerroni, W., Contoli, C., & Santandrea, G. (2015, July). Implementing dynamic chaining of Virtual Network Functions in OpenStack platform. In Transparent Optical Networks (ICTON), 2015 17th International Conference on (pp. 1-4). IEEE.