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Contributions to the design of mobile applications for visitors of Botanical Gardens

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Abstract

Botanical Gardens are among the most visited touristic attractions, offering scientific, educational, cultural and leisure activities to preserve and enhance heritage and disseminating specialised knowledge on science and history. There are several mobile applications (apps) to support visitors of Botanical Gardens, which explore augmented reality technologies to enrich their experience. Our work aims to systematize a set of requirements that must be considered in the development of these apps. We have applied them in the development of an app for a Botanical Garden available for Android and iOS. Preliminary data analysis of the use of our app revealed some characteristics of the visitors and the preferred tours. Meanwhile we are evaluating our app by conducting a user study.

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1. Introduction

The JBT (Jardim Botânico Tropical) Garden, located in Lisbon, has a unique botanical collection, with more than 600 species from several continents, specializing in tropical and subtropical flora. Despite the undeniable botanic vocation of this Garden, there was already in this place historical buildings and statuary, dating from the seventeenth century to the twentieth century. It is located in a monumental area and is visited by a varied audience, such as, families with children, tourists, students, and botanical experts. Offering mobile digital applications provides information to the visitors and enhances their experience and involvement with the environment without introducing physical artifacts.

Several cultural and tourist entities already provide these applications that explore mobile and Augmented Reality (AR) technologies to create interactive, immersive, and engaging visiting experiences. These apps normally complement the existing tools, like paper maps and signboards, and provide detailed information about the garden, guided thematic tours, maps showing the position of the visitor and providing navigation, and AR and multimedia experiences enabling visitors to experience new forms of entertainment. Additionally, to simplify the development of this type of apps several frameworks have been proposed providing components to support mobile applications for a variety of places, indoor or outdoor, including parks and gardens, shopping malls, or even cities and to support AR and multimedia experiences [17, 18].

However, limited attention has been dedicated to organize and systematize the requirements and challenges associated with the development of interactive mobile applications to support visits to Botanical Gardens. For instance, how to select the themes of tours, what are the characteristics of tours, what points of interest (PoIs) are interesting and essential, how to decide what type of information to associate to a PoI (e.g., text, sound, audio, video, AR experience) and how to provide the visitor with an informative, educational and engaging experience.

Our main contribution is the proposal of a set of requirements for this type of applications and to answer to these challenges, organizing them in four main categories, namely, the objectives, contents and its organization and presentation, enabling technology, and other non-functional requirements. We have applied these requirements in the development of the JBT app for Android and iOS for a specific botanical garden, but we argue that these guidelines could be generalized to other public parks and gardens, with similar objectives.

This paper is organized as follows: section 2 discusses related work. Section 3 presents our contribution for requirement analysis for apps of Botanical Gardens, whose application to the development of the JBT app is described in section 4. Section 5 overviews the JBT app and provides the results of the preliminary evaluation. Finally, section 6 presents conclusions and future work.

2. Related work

Nowadays, many gardens offer mobile applications to their visitors that include detailed information about the garden, guided thematic tours, maps showing the position of the visitor and providing automatic routing, and AR and multimedia experiences enabling visitors to explore the garden in a more flexible and engaging way. A detailed analysis and comparison of the features and technologies used in mobile city guides, mobile apps oriented for museums and botanical gardens can be found in [15].

There are many applications oriented for gardens and public parks on Google play and Apple store, but the most relevant in the botanical domain are: the Kew Gardens app [12], the Jobim Botanic app [22], and the Royal Botanical

Garden Sydney app†. These three applications have in common the basic functionalities but, they clearly present differences in terms of objectives, category, design, interaction modes, content type (e.g. text, images, audio, video) and in technological details; some privilege content and others navigation. The Kew app [12] offers a map with PoIs, GPS navigation and an AR experience that overlays directions on the image of the camera, QR codes to present information about specific elements and a feature that allows the visitor to share pictures on Flickr and receive notifications recommending places to visit. The Jobim Botanic app [22] comprises an extensive set of features, such as, a curated set of garden tours, tools for saving and sharing notes and photos taken while using the app, and a 360º view of PoIs, provided as an alternative to AR experiences. The Royal Botanical Garden Sydney app† provides a navigation tool and a curated set of tours with various themes. In addition, the user can filter the PoIs by type, or create a tour based on their favorite ones. It is also possible to write notes, record video and audio about certain PoIs and share them on social media. This app includes an AR experience that overlays 3D models of plants whose drawings are in planar posters in exhibition.

AR contents may be of various types; an interesting example can be found in an app conceived for an historical place with a luxurious garden, classified as a Cultural Landscape by UNESCO, where narrative videos about the architectural heritage and stories from the past, recorded with real actors, are the contents of some AR experiences [2]. As a matter of fact, mobile applications integrating AR and multimedia experiences allow a richer and more interactive way to explore the garden/museum in playful and educational activities [10]. A study conducted with the AR application created for the People's Museum in Melaka, Malaysia, concluded that playfulness expectancy, content relevance, performance, effort and social influence positively affect the users' behavioural intention to use the AR mobile app [19]. The role of AR integrated in games with educational purposes has also been studied in urban parks. In the Gaia Biological Park, the results emphasize the improvement of the visitors' experience and the dissemination of scientific knowledge [18]. On the other hand, in Aveiro, the EduPark app revealed the motivation to autonomously learn about diverse interdisciplinary themes [14]. Nonetheless, some difficulties were reported with the use of mobile devices, such as requiring an internet connection, its slowness, and the increased battery consumption [13]. In the evaluation of the AR Perpetual Garden App, of the Carnegie Museum of Natural History [8, 9], perceived learning received high rates, showing that users can learn while interacting with the app. AR experiences rely on technology to present contents. To find out if it is technology or the content that most impresses the users, Tzima et al. conducted a study with an AR app focused on routes with historic buildings and sculptures in Ioannidis [21]. The results showed that half of the users choose both, less choose "content" and even fewer choose "technology", concluding that the most important factor is how technology and content are combined.

There are several mobile apps with diverse features to support visitors of Botanical Gardens. Our main contribution in this paper is to present a systematization of the requirements analysis that must be considered in the development of such applications.

3. Requirements analysis for mobile applications of Botanical Gardens

This section focuses on the analysis of non-functional requirements of mobile applications for Botanical Gardens visitors. Based on [5], we distinguish four main categories of requirements specific for this kind of applications, namely, objectives, contents, enabling technology, and other non-functional requirements, as detailed next.

3.1. Objectives

The literature identifies objectives such as balancing education and recreational aspects, and providing a deeper knowledge of the garden [5, 7, 22], which, in effect, determine the other requirements in this section.

† https://play.google.com/store/apps/details?id=com.specialistapps.rbgs

3.2. Contents

Mobile applications for Botanical Gardens visits identify tours that include remarkable PoIs the visitor should fully enjoy in the garden. To define the contents of the mobile application, designers start by identifying the themes of the tours, their characteristics and corresponding PoIs.

Themes of tours. Themes that are common to all Botanical Gardens are flora, fauna and the history of the garden [5]. But, each garden has its very own characteristics, so, the identification of these themes should be performed by a team comprising different stakeholders, namely curators and researchers of the garden [22], visitors and tourist guides acquainted to the preferences of the visitors. Traditional guidebooks are valuable initial sources of information about the gardens. Other sources of information are printed books [22], visitors surveys [22, 5] and affinity diagram sessions [5, 6]. The themes of tours are also related to the target audience considering age, interests and goals. Examples of target audiences are families, groups of basic or high schools' students, generic tourists and thematic tourists (e.g., particularly interested in flowers or bird-watching).

Characteristics of tours. The tours comprise the routes and the PoIs. To define the routes, we need to identify their criteria, namely:

- *Duration*: define the number of PoIs and/or extension of the routes considering, for instance the areas of the garden that are covered, so that visitors can experience a good overview, while minimizing the walking distances;
- *Format of the routes*: avoid repetitions of points, define a circular or one-way topology depending on the number and location of entrances and exits in the garden;
- *Accessibility and safety*: consider the variability of visitors' age and possible mobility restrictions;
- *Strategic points*: define the points that all tours must include, such as souvenir or coffee shops, or expositions;
- *Positioning system restrictions*: avoid locations with weak signal, such as areas densely covered by tree leaves which reduce the signal strength of wireless networks, namely Wi-Fi and GPS (see more details in Section 3.3).

Points of interest. Taking the same approach as defined for the themes of the tours, the identification of PoIs should involve different kinds of stakeholders. In addition, we consider the following set of criteria to define PoIs:

- *Location*: should be easily distinguished from the route, avoiding overcrowded areas, and within a short distance to the route to not justify visitors moving inside protected areas.
- *Characteristics*: should correspond to well preserved specimens or items, with aesthetic value. For instance, in what concerns botanic elements, the specimens should exhibit their natural physiognomy, i.e., without pruning that might have significantly changed the natural form of the species.
- *Relevance*: should be relevant in the sense that belong to the main collections of the garden, have scientific, cultural, and historical importance, and are captivating to the target audience.
- *Diversity*: should comprise elements representative of all the collections of the garden, for instance, plants and animals from distinct species, taxonomic groups, different geographical origins, or historical elements illustrative of distinct epochs of the garden's history.

The information about each PoI can be provided to the visitor resorting to diverse digital formats, namely text, images, sounds, videos, taking advantage of AR and multimedia experiences as detailed in Section 3.3. The sources of information include websites, books [22], and curators.

3.3. Enabling technology

Technological requirements identify the features of the software tools that contribute to meet the objectives of the mobile app [5]. Additionally, we decided to consider the inclusion of AR and other multimedia experiences, an advantageous feature in mobile applications for Botanical Gardens' visitors, as pointed out in [5]. We have also identified two additional aspects for which Botanical Gardens raise specific requirements: positioning and maps.

Augmented reality and multimedia experiences. The aim of introducing multimedia contents combined with AR experiences is to enrich the experience of the visitors, allowing them to observe "unseen" elements, that is, elements

that are not visible in the garden with the naked eye at the time of the visit. These contents are multipurpose: spread the several collections of the garden; have ludic, educational, or informative purposes that should be verified by specialists; may cover diverse intervals and epochs in time; or support navigation aids to find PoIs. Unlike multimedia experiences that do not require the combination with real images captured by the device's camera, one of the essential aspects of AR is tracking to superimpose virtual content over real environment views [4]. Tracking methods must be chosen appropriately for each AR experience offered: must be suitable for the open space of the garden, avoid adding items that are not natural in the garden, as fiducial marks, minimize the consequences of the possible lack of accuracy of the smartphone's sensors or require the use of high end devices that not all visitors possess.

Positioning systems. These systems determine the position of the users in an environment. The techniques used by these systems can be grouped in three classes: kinematic, visual, and wireless [11]. Kinematic techniques estimate user positions based on previously estimated or known positions by using accelerometers and gyroscopes. Visual techniques use images captured with the smartphone camera to determine user position by comparing them with reference images stored in a database. These reference images can be encoded using, for instance, Barcodes or QR-Codes. Finally, the set of wireless techniques includes RFID, Infrared, Beacons, or NFC, as well as Wi-Fi and GPS. Unlike indoor environment, GPS is adequate and widely used for outdoor positioning. However, gardens present a specific challenge for wireless techniques as leaves have a significant impact on the signal strength, restricting the definition of routes as they should avoid locations with reduced signal strength.

Maps. The tour component of mobile apps should provide a map to show the current position of the visitor and PoIs' location. If the garden has an official map, it is recommended to use it on the app to maintain consistency and avoid confusing the visitors. If such a map does not exist or does not have the required detail to support the clear identification of the information, it is important to analyze the possibility of resorting to digital maps provided by Google[‡], Apple[§] and Open Street Maps (OSM) [**], among others. Sometimes these maps do not include all important pedestrian paths or the shape and the paths are not positioned correctly. In these cases, it is necessary to decide between the cost of rearranging and correcting this information, continuing using the chosen digital map, or if exists, use our own vectorial map containing all the corrected paths, buildings, lakes and other remarkable elements that may provide positional references for the visitor.

3.4. Other non-functional requirements

Mobile applications for Botanical Gardens should also satisfy requirements related to the quality of the data to be provided to the users [3] and the quality of the software to be developed [16]. To find a good balance between perfectionism and development time, we recommend prioritizing the following requirements.

Data quality requirements. *Accuracy*, *completeness*, and *readability* are essential for the user to trust and use the mobile app: s/he must believe the data is correct and comes from a highly regarded source, covering all relevant aspects of the reality in the garden, and in one or more languages appropriate to the target audience.

Software quality requirements. *Reliability*, *usability,* and *accessibility* are fundamental for the acceptance of the mobile app: the app should work, without failures, before, during, and after the visit of the garden, it should be easy to learn, with minimum errors by the users, including users with special needs, and it should afford efficient operation, to keep user satisfaction high. Since there are two dominant platforms for mobile app development, *portability* would also be desirable, but, from our experience, that was unfeasible to achieve due to significant differences in user interface features, programming models, and system libraries.

[‡] https://developers.google.com/maps/documentation/android-sdk/intro

[§] https://developer.apple.com/maps

[**] https://www.openstreetmap.org

4. Requirements analysis of the JBT mobile application

This section presents the requirements analysis for our mobile app according to the categories detailed in Section 3.

4.1. Objectives

The JBT organizes scientific, educational, cultural and leisure activities aiming to preserve and enhance heritage, as well as disseminating specialized knowledge on tropical science and the history and memory of science and technology during a remarkable period of the History of our country. The main objective of the JBT app is to complement these activities and provide an interactive experience between the visitor and the Botanical Garden, combining both cultural and educational contents, with innovative forms of touristic entertainment. The JBT app acts mainly as a helping guide for visitors providing information about the main PoIs, and provides AR and multimedia experiences to enrich the experience of the visitors.

4.2. Contents

Themes of tours. The team that conceived our app includes curators, researchers, and academics from multiple disciplines (e.g., botany, ornithology, geographic engineering, history, design), and domains (e.g., in tropical botanic species, bird species, bryophytes and lichens and history of the garden), tourist guides and end-users. To identify the themes of the tours and the target audience, we used several practices, namely brainstorming meetings, interviews with domain experts, and workshops with all the members of the design team. The content inventory was accomplished with discussion sessions with experts.

The themes of tours in the JBT app are: a) “Trees you must see”, the mandatory theme of a botanical garden; b) “Garden with history”, a theme included due to the rich history related to the implantation area of the garden and where exists a relevant collection of historical buildings and statuary from the 17th to the 20th centuries; c) “Birds”, this theme is valuable since we can observe more than 50 bird species in the garden, some of them uncommon in urban areas, and is appealing for a wide target audience, specially for tourists keen on the observation of birds; d) “Biosensors”, the rational for including this theme is owed to the fact that the garden presents a large number and diversity of bryophytes and lichens, and they are very poorly known organisms by non-specialists, being excellent environmental bio-indicators.

We identified three main groups of users of the JBT app: students and experts; tourists; and families with children. Among the set of themes, the “Biosensors” is potentially more appealing for experts and students. The remaining themes combine scientific and informative content with diverse playful experiences to please all the audiences.

Characteristics of tours. Considering the duration of the tours: based on information provided by the specialists that are in charge of the guided visits to the garden, and after performing some experimental walks in situ, we opted by tours for about a period of one hour and a half. Obviously, this is an estimate to the visitor, since with the app s/he can make the visit at her/his own pace, enjoying the garden as much as s/he wants and profit from the resting areas (e.g., the benches or the cafeteria).

The garden has only a gate open to the general public, therefore, the topology of the routes is circular, that is the ending point coincides with the starting point. The routes are free of locals with difficult access (considering both accessibility and safety) and should include the cafeteria. We also test the GPS signal strength to choose routes with an adequate signal.

Points of interest. The tour “Trees you must see” is, naturally, the one with more potential candidates to include. The PoIs were selected considering the following criteria: a) *characteristics of the specimen* - we considered the healthy look, the aesthetic value, the natural physiognomy (i.e., without pruning that might have significantly changed the natural form of the species); b) *relevance* - scientific, cultural and historical relevance of the species, age, rarity, species of main collections, as well as the specimens that better capture the interest of the public; and c) *diversity* - species from different taxonomic groups, and species from different geographical origins, although, tropical or subtropical species were preferred considering the “tropical” nature of this botanical garden. In this tour, the process

to choose the PoIs was two-phase. First, we applied those criteria and obtained an initial list, then, we refined this list considering the recommended duration of the tour and equalizing the number of PoIs along the route; by the end, 20 representative PoIs had been chosen.

The choice of the PoIs for the tour "Garden with history" had a distinct rational, as the number of potential items to include is by far smaller than the number of trees in the garden. The curators listed 36 potential items to include, comprising historical buildings and statuary of the garden and also a set of trees with remarkable stories. To make this list more manageable and comprehensive to visitors, it was organized by subthemes coherent to the long history of the garden and of its implantation area. Therefore: a) in the subtheme "18th and 19th centuries", the visitor can travel back, before the creation of the garden, and discover statues and a palace dating from these centuries; b) the subtheme "20th century" presents the buildings of this century, mostly, built during the installation of a Colonial Garden, reflecting the strong connection to Africa and other former colonies; c) the subtheme "National World Exhibition" shows the material traces of the colonial section of the National World Exhibition of 1940; and d) the subtheme "Trees with history" includes a group of trees with remarkable stories, some were planted by notable persons, while others are somehow associated with mythological or religious stories.

The PoIs of the tour "Birds" correspond to stopping stations (observation areas). They were selected considering the easy access and identification of the PoI by the visitor, as well as the differences in vegetation types so we could maximize the probability of encountering different bird species. For example, we selected one PoI near a lake, another in an area with well-developed vegetation, and another in an open space with higher visibility. When selecting the bird species for the app, we focused on showing the great diversity of species that occur in the garden, that goes from passerines to aquatic species. Although various species can be seen in different areas of the garden, we selected 6 to 10 species to be highlighted in each PoI, regarding the probability of being detected within the micro-habitat of that particular place.

For the tour "Biosensors", we selected 8 observation areas based on the presence of a larger number of distinct species (with different colors, distinct structures, and diverse forms of growth) on the tree trunks, and with different degrees of sensitivity to air pollution. These areas present 24 most common species: 14 species of mosses, 2 species of liverworts, and 8 species of lichens. Specialists prepared the species descriptions accompanied by an image (macro photography) and a pollution sensitivity scale.

4.3. Enabling technology

Augmented reality and multimedia experiences. Due to the richness of the collections, the themes and ideas to AR experiences that raised to our minds were countless. Then, the solution was to involve master students from Informatics in the development of these experiences, and this proved to be a good solution. First, it made possible to experience a set of solutions and to choose the best ones, second, to have different ways of approaching or/and implementing the same base idea, and finally, to raise students' awareness about the rich heritage of their own University. Multimedia contents were also available from the curators of the garden who capture surprising images and videos in their daily activities. However, to show to the visitor the life cycle of the trees, a weekly photo collection was planned for a year to capture the more significant stages of some iconic trees to create a time-lapse sequence. The final production of the AR experiences relied on free software tools that allowed the use of tracking techniques without impact to the garden, such as, natural markers, alignment assisted by an image (similar to the Instant Tracking used at Regaleira [2]), or based on the smartphones' inertial and magnetic sensors [20].

Positioning systems. To calculate the position of the visitor in the map the phone's GPS is used, and the gyroscope, accelerometer and magnetic field sensors are used to calculate the user orientation and also used in the AR experiences.

Maps. To represent on a map of the Garden the tours' routes, several interactive map SDKs were analyzed, such as Google Maps and OSM. However, we decided to create our own map based on an existent topographic survey because some important paths of the Garden were not represented, or they were wrongly represented in shape or position. Based on this information, a new map was designed containing all the paths, buildings, lakes and other built objects that could serve as references for the visitor.

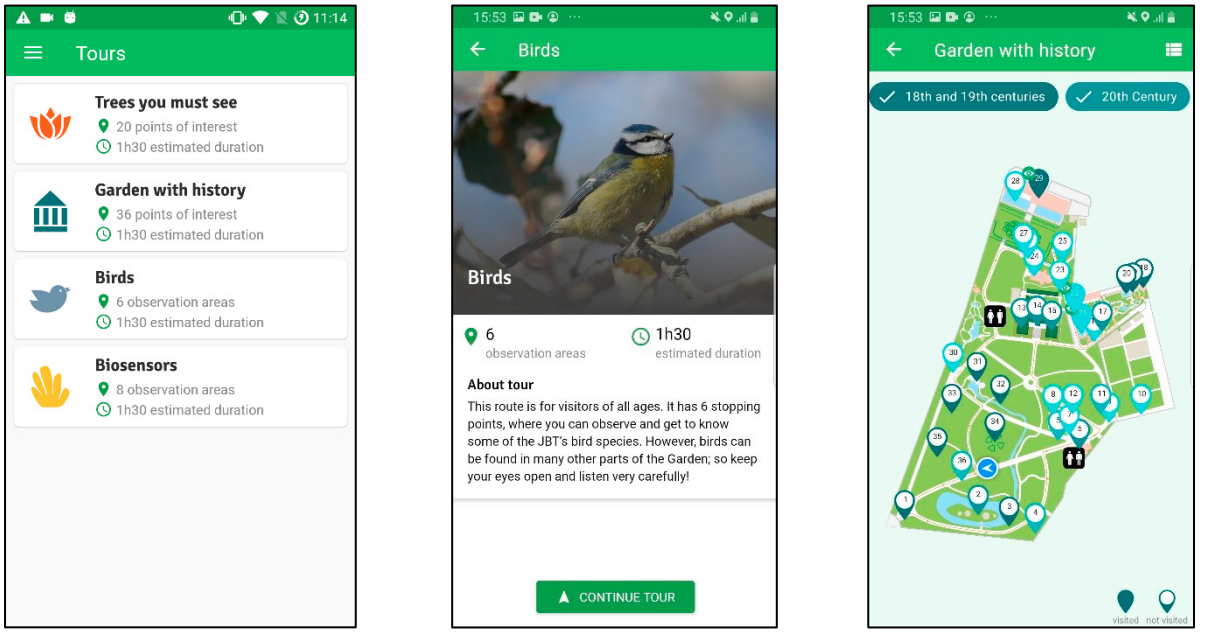
4.4. Other non-functional requirements

Data quality requirements. The experts mentioned in Section 4.2 were fundamental to satisfy data accuracy and completeness. They defined a comprehensive text structure common to all PoIs and provided the text and most of the multimedia contents, including photos, videos, and audio recordings (some media were obtained externally). The data were validated on numerous occasions, initially using text editors and multimedia players and afterwards using the developed mobile app. Later on, all paragraphs were translated to three additional languages, to address readability, based upon the nationalities of the most frequent visitors of the JBT.

Software quality requirements. To meet the expectations of the users and satisfy the reliability and usability requirements, we followed a User-Centered Design (UCD) approach [1]. The development of the JBT app comprised multiple iterations: the first ones evolved the design, creation, and validation of low and medium fidelity prototypes with domain experts and also with some participants in a national forum of science; and the last iterations included the implementation and tests of the app, including the validation with end-users in the garden, which was essential for refining the AR experiences. Concerning accessibility, the palette of colors used in the icons representing the tours is color blind friendly[††], addressing the special needs of some users.

5. The JBT mobile application

The JBT app is composed of four thematic tours as already mentioned (see Figure 1a), exists in four languages (English, French, Portuguese and Spanish) and was designed for Android and iOS.



(a) List of tours. (b) Description of a tour. (c) Map of a tour.

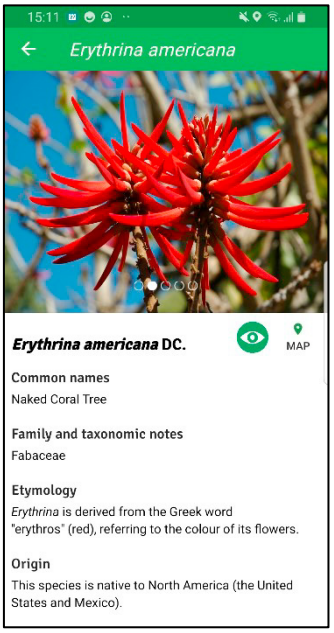
Fig. 1: Information about the tours.

Before designing the user interface, we made a User Environment Design diagram [6] to capture the appropriate structure of the application into focus areas that support the user's natural flow of work. We defined five focus areas:

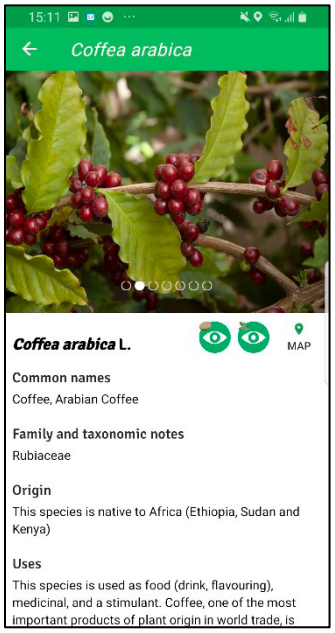
[††] https://davidmathlogic.com/colorblind

tour list, tour details, map, PoI list, and PoI description. Figures 1 and 2 show the five corresponding interface views of these focus areas. The tours list (Figure 1a) includes all features related with the tours in the app, namely the duration and number of PoIs. The user can choose one of the tours to access to its description entering in the Tour Details focus area (Figure 1b). From this point, if it is the first time to this tour, the visitor must download the contents, otherwise s/he continues to the next focus area, the Map (Figure 1c). At any time, the user may cancel the download and go back to the Tour details focus area, or it may go to the Tour list area directly. From the Map area and selecting the hamburger icon, the visitor could go to the PoI list (Figure 2a), or to the PoI details directly (Figure 2b and 2c), by tapping on one of the markers on the map.

(a) List of PoIs.



(b) Description of PoIs.



(c) Description of PoIs with two AR experiences.

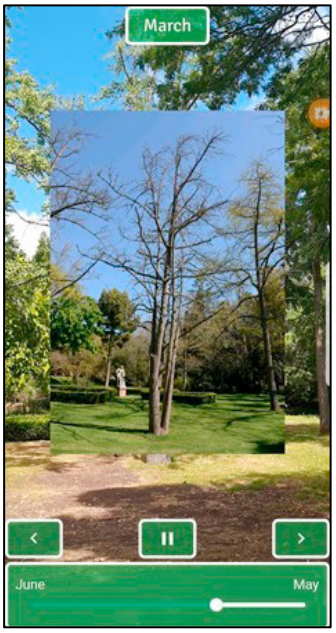
Fig. 2: Information about points of interest (PoIs).

The PoIs are represented on the map by icons visually similar to Google map markers, with a white circle and a number in the middle representing the order of the PoI in the corresponding tour. To allow the visitor to be aware of which PoIs has already been visited, the markers are represented without the white circle (Figure 1c). A blue circle with white outline represents the visitor's position and the orientation is represented by an arrow in the middle of the circle (Figure 1c). The color of the PoI markers is consistent with the color of the icon tour. To represent PoIs that have AR and multimedia experiences, a green icon could appear associated with the map PoI marker, or in the PoI list and description (Figure 2). Two icons means the PoI has two associated AR experiences (Figure 2c).

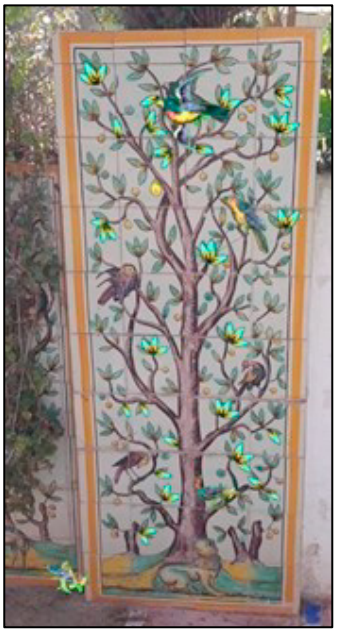
As in the "Biosensors" tour, the PoI icon in the "Birds" represents an observation area, where the visitor can observe and get to know some of the JBT 's bird species. However, birds can be found in many other parts of the Garden. For each PoI the visitor can access the list of the birds' species that could be seen in that area, obtain detailed information about each one and access to the existing AR experiences. In the "Garden with history" tour, it was decided to organize the PoI in several subthemes according to the various historical periods of the Garden. To accommodate subthemes, the map view has a list of button filters to select the PoI of the corresponding historical period (Figure 1c).

A set of AR and multimedia core experiences were defined according to the characteristics of each tour and in coordination with the experts who developed its contents. The purpose was to create experiences that give the user information which is not directly visible, or draw attention to elements that exist in the garden, providing in either case a pleasant experience. In the "Trees you must see" tour, a set of trees whose appearance varies significantly throughout the year was selected. In these PoI a sequence of images, one per month, shows the evolution of the tree

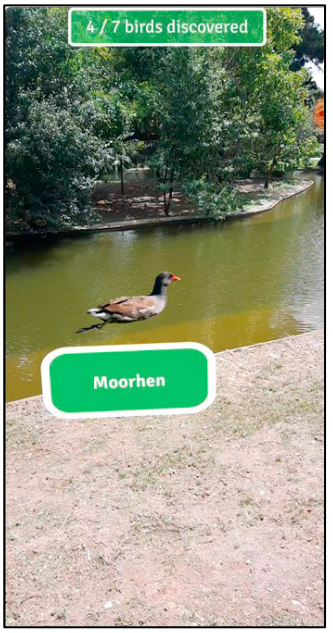
over the year (Figure 3a). For the "Garden with history" tour, the tiles in the Garden were used to trigger the beginning of ludic videos inspired by these tiles (Figure 3b). The experience conceived for the "Birds" tour displays virtual images of birds that, through touch, emit the respective sound (Figure 3c). Besides core experiences, multimedia content is associated with some PoI to add more information, for example, videos that explain the processing of coffee beans or show the living nature in the garden, such as a squirrel walk or woodpeckers in the nest.



(a) Time-lapse.



(b) Tile augmented with virtual elements.



(c) Virtual bird in the scenario.

Fig. 3: Augmented reality experiences.

Finally, the app also collects authorized demographic data of the visitors and specific data associated with the routes they follow. It allows the understanding about who uses the routes on offer and, above all, who does not use them, in order to promote the informed development of new contents or the innovation of current ones.

Despite the JBT app is available for almost a year, the number of answers we have is not significant and the results could be biased. Indeed, due to the pandemic context, the number of visitors of the garden have decreased greatly.

In addition, the pandemic also has impact on tourism and school activities, two activities responsible for many usual visitors of the garden. During this year, the majority of visitors were nationals, with predominant age groups between 20 and 40 years old (49.8%), working on science or technology areas (56.8%), with the majority having a higher education qualification (79.3%). The most chosen route was "Trees you must see".

6. Conclusions

This paper proposes contributions for the requirement analysis of mobile applications for Botanical Gardens. These gardens present specific challenges due to their thematic richness including flora and fauna as well as other perspectives such as history. In addition, they share some characteristics with museums, being, however, an outside space where we need to be aware of the safety both visitors and collections and the constant change of the nature (e.g., the trees grow, the color of the leaves changes, the birds fly). Leaving out the functional requirements, we focus on the definition of tours, considering their contents and the enabling technology, in particular AR and multimedia experiences, unavoidable to provide visitors with a richer and more interactive experience. We have applied these contributions to the development process of the JBT app, which is already available to visitors. Besides the analysis of the authorized data collected by the app, we are conducting user studies in loco, which are delayed due to the present

pandemic limitations. After having a significant number of participants, we will analyze the results to identify the adaptations needed to improve the engagement of visitors and conceive and develop new contents and experiences.

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