The integration of an augmented reality module within the Way- Cyberparks App.

The case study of Valletta city.

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Abstract – *Latest improvements on mobile devices capabilities are changing the way people interact with their surroundings. Nowadays, devices are able to sense the environment and user's location, enabling the user to experience improved digital services. This is a key aspect of public spaces enhancement, which plays a pivotal role for the improvement of public spaces; a key to make public locations more accessible, interactive and enjoyable. One of the most powerful technologies enabling this innovative set of services is known as Augmented Reality (AR). More in depth, AR allows users to visualise in real time virtual information about the physical objects of the real world, directly on the display of their own devices. AR provides innovative way-finding widgets and context-awareness services. Along with the aims of the COST Action Cyberparks, our aim is to improve the App delivered during the first stages of the project (Way-Cyberparks) with AR functionalities, by developing a location-based AR module tailored to be integrated within Way-Cyberparks. The AR section will link virtual geo-tagged annotations as an interface to (geo) spatial and attribute data, allowing users to quick access digital sensory inputs. The overarching idea is to populate the App with virtual signage fostering the fruition of public spaces by allowing users to experience new ways of moving within specific places. Thanks to that, on one hand, the App works as an interactive path-finder tool, heading visitors towards the most interesting locations or landmarks within a specific area (Points of Interest or POIs). On the other, users are enabled to create their own contents and upload them into the network of available POIs, enabling a true participative community. The city of Valletta has been chosen as first case study; here the AR module will be tested to identify historical locations and heritage buildings, acting as contextual objects for the Way- Cyberparks App.*

Keywords— Cyberparks, Augmented Reality; Smart Tourism; Way-finding; Context Awareness; Tracking

I. INTRODUCTION

Location-based Augmented Reality (AR) is becoming one of the most powerful cutting edge technologies for tourism. Among other features, AR has the capability of changing users' sight of the environment and this is the main reason of its increased usage by the users. Furthermore, the potential of mobile devices is growing with impressive speed, changing the way in which tourists gather and access information, especially in outdoor environments [1]. The worldwide adoption of mobile devices by the users has replaced traditional orientation, guides and way-finding maps. This is mainly because built-in cameras, global positioning system (GPS) sensors and Internet connection open the way towards a new manner of experiencing public spaces, thanks to contextual information. With context-awareness services tourists have access to interactive experiences and, even if with little knowledge of a certain area, they can naturally experience unfamiliar places. The trend of AR apps is growing, even if some aspects prevent them from becoming the main medium to explore outdoor spaces. Of course, maps are a good solution to find places and interesting areas in outdoor spaces. However, even if well-established solutions, they are not optimally designed for urban exploration and provide limited capabilities to access data; moreover, and more important, they oblige the user to look away from the reality. For urban environments, available 3D maps have the limitation that the camera view of the object is often occluded by nearby structures, which is especially problematic in densely built-up areas [2]. In contrast, AR represents a natural choice for exploring location-based information of real world objects, mainly because information can be superimposed onto the display, with the same point of view of the user. If one is equipped with an AR-enabled mobile device, simply by framing one's surroundings into its direction, one can easily access additional information about a Point of Interest (POI) in an urban environment. A good "vademecum" of the the challenges that developers have to take into account when designing AR browsers for outdoor environments are listed below [3];

a) many objects can be augmented with information;
b) each object can be a source of a substantial amount of information;
c) contents might be visually heterogeneous and dynamic;
d) tourists are walking through unknown places that might impede a natural way-finding;
e) tourists have information needs which differ from those of urban residents.

In recent years, many AR systems have emerged. However, most of these systems are designed for small indoor environments, since many limitations like brightness variation, occlusion, 3D registration, can be managed in a simpler way [4]. The development of AR applications for outdoor scenario implies the use of built-in sensors, handy and widespread for the most of devices, but error-prone in terms of accuracy.

In this light, and along with the scopes of the COST Action Cyberparks, our aim is to improve the App delivered during the first stages of the project (Way-Cyberparks) with AR functionalities, by developing a location-based AR module tailored to be integrated within Way-Cyberparks.

The AR section links virtual geo-tagged annotations as an interface to (geo) spatial and attribute data, allowing users to quickly access digital sensory inputs. By populating the platform, the app has become the container of virtual signage, fostering the fruition of public spaces, by allowing users to experience new ways of moving within specific places. Thanks to that, on one hand, the App works as an interactive path-finder tool, heading visitors towards the most interesting locations or landmarks within a specific area (POIs). On the other, users are enabled to create their own contents and upload them into the network of available POIs, enabling a true participative community. The city of Valletta has been chosen as first case study; here the AR module will be tested to identify historical locations and heritage buildings, acting as contextual objects for the Way-Cyberparks. AR and mobile technologies would represent the milestone for the outdoor learning experience for Cyberparks.

The aim of this paper is to describe the pipeline of work used for the development of a learning experience to be experienced in an outdoor environment. This implies the need to consider several aspects, mainly focused on the optimisation of the showed content. Numerous tests have been performed in order to optimise the contents (meaning file format, aspect ratio, gestures etc.) and the user interaction with them. The design of this experience has been conducted in a close cooperation developers and designers, to enhance the usability of the app.

II. RELATED WORKS AND PROJECTS

A. Research and projects

AR is able to attract a growing number of visitors, since it offers an innovative concept for exploring outdoor areas; it is also an affordable and simple solution for insiders (e.g. guides, administrators, etc.) who can enable new solutions, offering new information and management methodologies to simplify access to public areas, expanding the range of promotion and dissemination services. Starting from the territory, AR can take the user into other domains, evaluating the entirety of the cultural heritage (CH), encouraging a deeper exploration of diffused heritage goods [5]. From the e-learning standing point, Mobile Augmented Reality (MAR) has proved to be a winning solution [6]. However, some technological and anthropological issues still exist, preventing MAR from becoming a broadly used tool for open spaces. External variables that influence user acceptance include enjoyment, personal innovativeness, perceived benefits, costs and information quality [7].

In the following, a brief state of the art review is reported. Current issues and benefits of using AR for tourism purposes, highlighting the benefits offered to the tourists, are widely discussed in [8]. Authors state that the core idea behind the use of AR for tourism is the enhancement of users' perception of reality and of the surrounding environment. Tourists in fact are exposed to unfamiliar environments where the fast retrieval of information is fundamental for our decision-making. Access to relevant contents through location-based

services not only facilitates this process, but also changes the way we perceive destinations, creating more memorable and unique experiences. Recently, a lot of attention was directed towards AR interfaces as a suitable visualisation paradigm, especially within the domain of travel and tourism. AR browsers deliver (geo) spatial and attribute information about physical objects through spatially registered virtual annotations. Such interfaces reduce the need to translate abstract information (for example, encoded in maps), or oblige switching views between information and physical space. This happens with guidebooks or list-based mobile interfaces. This scenario is particularly beneficial for time-pressured visitors to unfamiliar locations. In [9], interesting consideration has been done, with respect to the criteria that should be used when developing an AR service for tourism. Four features should be followed:

a) Readability: labels should be readable at all times and should not overlap;
b) Unambiguous association: labels should clearly refer to their target objects;
c) Aesthetics: labels should be placed in a way that prevents visual clutter;
d) Frame-coherency: the system should provide a seamless transition of content among frames.

Many examples and available applications still exist. In the following, a brief explanation of existing applications for many domains, based on location tracking is reported, with particular focus on tourism.

B. AR for tourism and cities.

The use of AR solution is spreading between countless fields of application. Its intuitiveness and ease of use make it suitable, among others, for Medicine, Maintenance, Learning, Cultural Heritage and Tourism. The latter can particularly benefit from MAR, as demonstrated by the existing commercial solutions, reported in the following:

CorfuAR[2]: is a tourist city guide using the strengths of the AR technology, by placing digital information about surroundings upon the screen of the device. The experience of visiting Corfu is enhanced with virtual information about sights, museums, monuments, religious sites, nature and many more.

Augmented Walks: visitors can view 3D reconstructions of monuments or buildings, on the screen of their devices or Head Mounted Devices (HMD) which capture through the camera the surroundings superimposing 3D virtual models of monuments.

Ename 974[3]: project for the study and promotion of the Belgian village called Oudenaarde, visualising 3D models of the monuments inside the archaeological site. Navigation is conducted through a predefined path close to the excavations, allowing one to view the virtual reconstructions superimposed on the real scene exactly on the foundations. In this way visitors are helped in both observation and understanding of the original structures.

[2] http://www.corfuar.com
[3] http://www.enamecharter.org/initiative_1.html

Archeoguide [10]: provides the user with the opportunity to observe in the real world 3D reconstructions of monuments, obtaining additional information during the visit of archaeological sites or places of interest. For example, several national parks in the US have added AR stations to view distant archaeological sites and other inaccessible places overlapping information and reconstructions on the real fossils.

PRISMA [8]: project still under development with the aim of enriching the real scene with interactive multimedia information and of increasing the user's tourist experience, who can retrieve this information from a user-friendly interface.

Fu-Jen University mobile campus touring system [11]: A prototype to increase tourism has been developed and reviewed by two focus groups on the campus of Fu-Jen Catholic University. AR provides hidden information of the campus in the area, providing students with immediate assistance in case of losing and also representing a mobile learning tool.

Lecce AR[4]: it is an interesting example of visualisation of 3D models during a visit for city environment. It allows adding to a real-world scene, seen from a mobile device's camera, with 3D models of cultural heritage sites as they looked in the past. 3D models are displayed when the user points the device's camera towards a planar target which can be a photograph or an image.

III. ENABLING TECHNOLOGIES

AR is a technology that enables the visualisation of digital contents above a screen, with the same point of view of the user. Hence, AR systems can be classified according to device /display typology (mobile, wearable, head mounted, haptic, etc.). Furthermore, to permit a device displaying a virtual object, as if it exists into a real environment, it must be able to sense the environment and track the viewer's movement and orientation. This procedure is called tracking. Even if the afore-mentioned technologies are well established, technical impediments exists, ranging from hardware capabilities to the availability of reliable connection infrastructure. 3D models are often huge and the displaying of multifaceted items represents a hard task. Finally, from the human point of view, the hampering lies in the interaction and human resistance to changes.

A. Tracking system

The number of tracking systems is growing (the more innovative are acoustic, inertial, edge modelling), but the widely adopted are positioning and optical based (respectively sensor- and vision-based). Especially used for outdoor tracking, sensor-based approach relies on global positioning system (GPS) receiver embedded into commercially available devices. Once the system gets the user coordinates, it is able to display POIs in a predefined location; the registration process is possible thanks to other sensors such as gyroscope, compass and accelerometer for a more accurate superimposition of contents or model. The

[4] http://vcg.isti.cnr.it/LecceAR/

estimation of user's position in indoor scenario is generally performed adopting vision-based approaches. Once the field of view of the camera coincides with that of the user (e.g. in video see-through) a pixel registration is implemented for a precise overlapping of contents. If just few years ago this process based on artefacts landmarks (e.g. QR code), nowadays the possibility to process images in real time is well established, implementing image matching algorithms (Liu, Yang, Sun, & Liu, 2008), to reach the so-called markerless AR. Robustness and responsiveness depend on the adopted platform and device capabilities, but results of vision-based approaches (hybrid and/or markerless) for general cases still represent the best in quality solution for AR.

B. Technological challenges

Technological challenges encompass a different aspect that depends on devices and infrastructures. It is well known that, nowadays, a growing number of commercial mobile phones and tablet are available; this introduces the problem to make apps fitting for both kinds of devices. However, screen size and aspect ratio change from one another, forcing developers to consider this aspect from the very beginning of the design of the app. Furthermore, different devices mean different operative systems and platforms, widening the spectrum of solutions and making the cross-platform development difficult. Also computational capabilities cannot be managed in advance; since a real time rendering requires good hardware performances, planning applications for a wider range of user means finding a balance between complexity and efficiency. Internet availability is another obstacle for AR experiences, especially for outdoor settings. If the application needs to retrieve remotely stored contents, the user needs to rely on his own Internet provider. On the one hand, out-of-range areas prevent the use of the application; on the other hand, limited bandwidth could make difficult loading files.

C. Available tools

During the last year a growing number of Software Development Kit (SDK) have emerged, providing developers with tools and libraries. A comparison[5] of the most diffused SDK shows that iOS and Android solutions are the most compatible. It also interesting to note that the number of free tools is greater than the commercial ones, even if the latter have become well established. For the purpose of this work several platforms have been tested; below is a brief report of our research.

Mixare (Mix Augmented Reality Engine) is a free open source AR browser, which is intended to display contents of Wikipedia. However, it can be personalised with own contents from a remote GeoData Base (Geo DB).

DroidAr is a framework for AR, specifically designed for Android only. Location-based AR and marker-based AR are both possible.

Wikitude and **Layar** are the leading commercially available tools. They provide professional services and features that make the development more stable and efficient.

[5] http://socialcompare.com/en/comparison/augmented-reality-sdks

IV. THE PROJECT OF THE APPLICATION

This study explores how handheld digital devices like smart phones or tablets can provide instances of engagement in 'Smart City' learning within or in the vicinity of Valletta. The core objective of this work is the development of a learning experience, focused on the city of Valletta and exploiting the functionalities of AR browser, as explained in the previous sections. More in depth, we have dealt with the improvement and on the integration of contents within the existing WAY-CyberParks App.

A. Learning experience

This innovative technology-enhanced learning approach is being used to promote mobile learning about Maltese History and Botany. Using an interactions-based methodology, mobile learning activities were designed to be managed through the Android-based WAY-Cyberparks App (freely downloadable from Google Play). This App is being used, in the context of the Cyberparks COST Action 1306, to develop location sensitive mobile learning experiences. Besides the Navigation tracing and Geo-Activation functionalities, the App will provide further location-based AR services. Considering these functionalities, a number of GNSS-based learning activities were designed for identified locations in Valletta with the specific pedagogical objective of promoting different modes of Smart City Learning (Playful learning, Seamless learning, Geo-learning, Citizen enquiry and Crowd learning). The App will also be used to mediate, trace and record user-generated (learning) interactions as triggered by the prescribed App-based activities. GNSS-based learning activities were developed for two different sites in Valletta: the Argotti Botanical Garden in Floriana (just outside Valletta) and the Upper Barrakka in Valletta, a site providing picturesque views of the Grand Harbour and the surrounding Cottonera region.

B. Implementation

To implement these functionalities, it is necessary to identify the POIs within the area of influence of the learning experience. A web-service has been specifically designed by DeustoTech Mobility research Unit[6] (Figure 1) allowing a smart and agile addition of POIs. During this first stage, we produced a report describing the places, contents and contextual information of the City of Valletta, [12]. The stage of conceptual design served to identify domain, type of learning and outcomes. Also the interaction design was taken into account, with the objective of providing a mediated experience between the content and the real environment. Multimedia resources (e.g. commentary texts, digital images, video clips and audio tracks) were chosen and assigned to the pre-defined POI. The identification of technical requirements was compulsory for the integration within the WAY-Cyberparks app.

In Figure 2 the POIs selected for the case study of Valletta are illustrated.

[6] http://mobility.deustotech.eu

Figure 1: The web services

Figure 2: The addition of Points of Interest into the web service

The second stage of the work consisted of the set up of the learning experience; images and content, related to the POI, were developed and inserted through the web service (Figure 2). Problems were mainly related to the size, format and typology of the images, so that several tests were conducted to achieve the best results in term of visualisation and responsivity of the app. After an initial phase of testing and adaptation of the contents, we implemented the learning experience storing the POIs and the related information, dividing them into sub-categories. The mobile app is based on a localisation engine to retrieve the user location, and an AR engine for the visualisation of contextual information. All the features available from the web service have been used for developing the location-based services (LBS) that will provide the participant with the learning experience

in Malta with context based information; Figure 3 shows the POIs chosen to be enriched with additional information. Since the position did not allow performing the app in the real scenario, we used a fake positioning service, in order to simulate the latitude and longitude coordinates of the site where the experience will be carried out. In Figure 4 a screen shot of the app running during the tests is shown.

In occasion of the *iCiTy Conference*, which took place in Malta as the mid-term conference of CyberParks project, people were asked to test the application in situ. Once the users arrived into the predefined area, augmented contents (i.e. audio track, archival images and so on) were shown in AR mode. The feedback from these panelists is positive, since they found the use of this type of experience very useful for outdoor scenario and to have deeper information of the surroundings. Some images of the test performed in La Valletta are reported in Figure 5.

Figure 3: Upper Barrakka and Senglea Point, POIs of the application

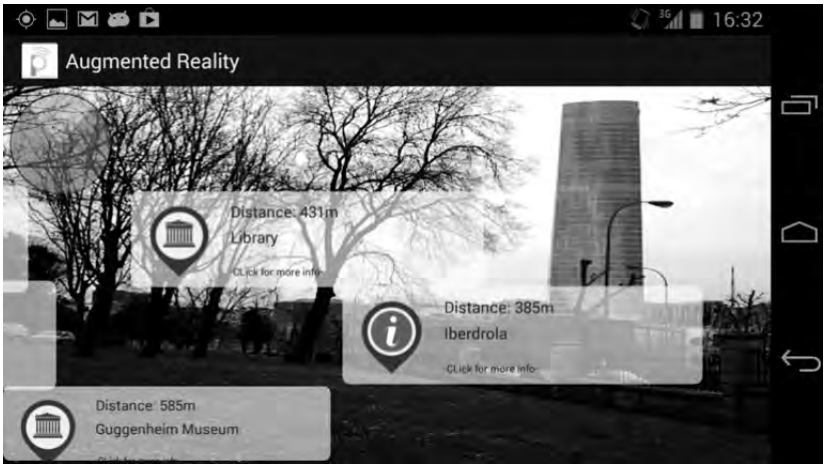

Figure 4: The mobile application running in outdoor scenario to test the functionalities.

Figure 5: The mobile tested by the users in the real environment.
On the left the Upper Barrakka site, on the right the garden of Argotti Villa.

II. DISCUSSION

During the development, several issues arose, with respect to the technical limitation that state of the art technologies highlight. Displaying and clicking POIs appearing in AR mode is strictly dependent on the platform and on the device, and making them work for all of them is a very time consuming task. File's size depends on a device's performances, and of course, on the available connection bandwidth. To overcome this problem, we stored all the contents into a separate folder, which can be downloaded in advance with a free Wi-Fi connection. Finally, POIs positioning depends on the GNSS receiver accuracy and, even if deviations of up to 7-8 m are possible, they are satisfactory for the purposes of the proposed learning experience.

Also a prospective outlook of state of the art technologies has been presented, which demonstrates how similar solutions are useful to trigger a more interactive experience for public areas, especially for tourism purposes.

III. CONCLUSION

In this paper we outlined best practices useful for the development of location-based AR applications. An interactive route guidance through AR as designed and implemented, ready to be run for the case study of the City of Valletta; the core idea is to populate the existing Way-CyberParks App with POIs. LBS serve as guide for the tourists towards the main attractions, scattered among public parks and historical areas. The database containing the POIs has been enriched with metadata, in order to categorise the various cultural goods. The recuperation of urban parks means, first of all, persuading people to visit them; by providing users with digital tools, making their visit more interesting, fun and simple, this objective should be pursued. With our solution tourists will discover the space more easily. The simplicity of the architecture further eases a constant updating by the public administrations.

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