The Application of Augmented Reality for Reanimating Cultural Heritage

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Abstract. This paper presents the design of a service-oriented architecture to support dynamic cultural content acquisition on a mobile augmented reality system for reanimating cultural heritage. The reanimating cultural heritage system provides several domain interfaces (Web, Web3D, Mobile and Augmented Reality) for presenting cultural objects accessed from an aggregated RCH data repository via web services. This paper largely focuses on the augmented reality system, but discusses the Web, Web3D and Mobile domains to set the paper in context. The mobile augmented reality system performs multiple objects tracking to augment digital media contents on real world cultural object scenes. The proposed mobile augmented reality system is composed of a mobile interface (smartphone, tablet), middleware including the augmented reality SDK and supporting software modules for the augmented reality application, and a web service framework.

Keywords: service-oriented architecture, multiple object tracking, web service framework, augmented reality.

1 Introduction

Reanimating Cultural Heritage: Reanimating cultural heritage is a Beyond Text Large Project [1][2][3] funded by the UK Arts and Humanities Research Council. The resource can be viewed live at www.sierraleoneheritage.org and it currently holds some 3,000 plus digital cultural objects. The project's full title is 'Reanimating Cultural Heritage: Digital Repatriation, Knowledge Networks and Civil Society Strengthening in Post-Conflict Sierra Leone'. The Reanimating Cultural Heritage (RCH) project is a "multidisciplinary project concerned with innovating digital curatorship in relation to Sierra Leonean collections dispersed in the global museumscape" [1]. The project is mainly concerned with establishing a digital repository and primary web interface that allows Sierra Leonean diaspora to access their heritage (cultural objects) digitally while also allowing the diaspora to contribute, through a social media context, their knowledge [3]. illustrates the Home page (with a two randomly selected media objects: in this case a video illustrating aluminium pot making, and a cultural object displayed in the 'From the collection' interface) and shows the Browse

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interface for the digital resource, which lists all the participating museums' collections in a gallery interface.

If the user clicks on an object in the Browse gallery interface they are taken to that objects results page, also they can do a Quick search for an object or select a more comprehensive search from the home page 'Search collections' tab, ether way the eventually arrive at the cultural object's results page.

Fig. 1. Home page

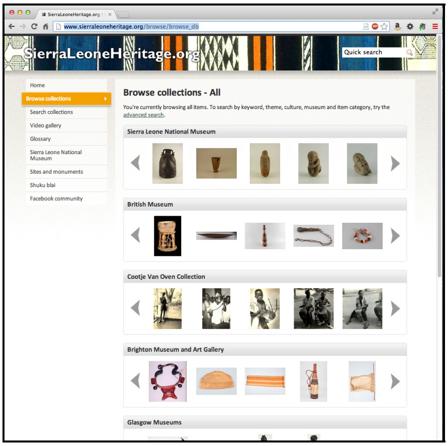

Fig. 2. Browse page

Fig. 3. Result page showing a Test 2D Image of a Wicker Basketillustrates the standard web view displaying a Test 3D Wicker Basket. Note the Facebook social media interface, which allows the diaspora to input their knowledge to the collections, and the ability to display related objects in a 'Related Objects' gallery [3]. While the current live version of the RCH resource does not support 3D media objects it is relatively easy to add this functionality using an abstraction of WebGL, such as X3DOM. To illustrate this we have inserted a temporary test object (Test 3D Wicker Basket Object) into the database and included a 3D interface utilizing X3DOM, see.

In addition to the 2D and 3D interface we have developed a mobile version of the RCH resource, see. Further, by clicking on the AR tab (see) when browsing on a mobile (tablet or smartphone) device, it is possible to switch to an augmented reality view whereby the cultural object of interest can be used to trigger access to media contents, such as the description, metadata, videos, images, etc., or if a 3D object exists, this can also be displayed along with other media contents. This is discussed further in Section 5.

The RCH resource has been developed using a model, view controller design pattern, which enables us to connect different views (web, mobile, 3D, AR interfaces) to the same data repository. Connection to the data repository is achieved via a set of web services discussed in section 2.

The main focus of this paper is to discuss the application of augmented reality for Reanimating Cultural Heritage utilising a new service-oriented architecture

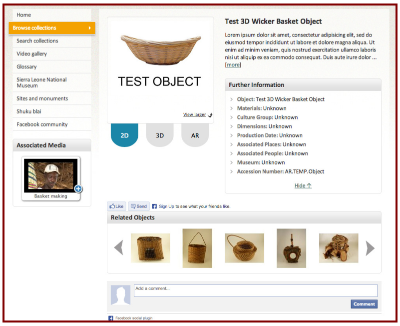

Fig. 3. Result page showing a Test 2D Image of a Wicker Basket

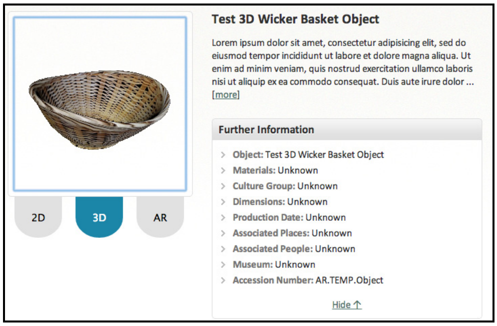

Fig. 4. 3D Model of the Test Wicker Basket

(web services) for accessing media contents and the ability to track multiple objects to trigger data access from the RCH database (via a web service) within the AR scene. This architecture also offers us advantages in creating a better personalisation approach. For example, in scenarios where a user can take images of a museum's object and submit these to a photogrammetry web service to generate a 3D model. That 3D model can then be displayed in the user's home environment along with download data from the RCH repository's result page for that object to re-create an AR based museum experience.

Augmented Reality and Mobile Services: Augmented reality (AR) has become a widely beneficial technique for users' to experience a different of perception of cultural objects represented with computer-generated media contents such as 3D models, labels, text, images, videos, etc. on real environments [4][5]. One of the current challenges for AR technology is to implement effective AR on mobile platforms. Mobile AR has become a most recent development in location based services and interactive graphic applications that allow users to experience visualization and interaction with 3D models or media contents on mobile devices. Currently, mobile AR has also been implemented efficiently in various innovative applications such as gaming, shopping guides, advertising, edutainment, travel guides, museum guides and medical visualization [6]. Adapting the visualization (e.g. better integration with different view domains), tracking (better multiple object tracking), recognition, interaction (user stories), displays and user interface techniques with real world scenes and virtual environments can greatly enhance these varied applications [7][8].

Most mobile indoor AR applications nowadays are based on stand-alone or closed platforms and provide users with limited amounts of data or contents on top of real world scenes. In addition, there is no communication channel for the AR application in order to download or obtain dynamic contents from other third party data sources in real-time [9]. Another limitation for mobile graphic applications, and application in general, that require virtual models is that the models have to be created and designed on desktop computers and then transferred to mobile devices for running or rendering in games or interactive media. Although new generation mobile devices can generate good performance 3D graphics contents, some complicated rendering tasks still require more processing power such as digital cultural heritage scenes, 3D virtual cities

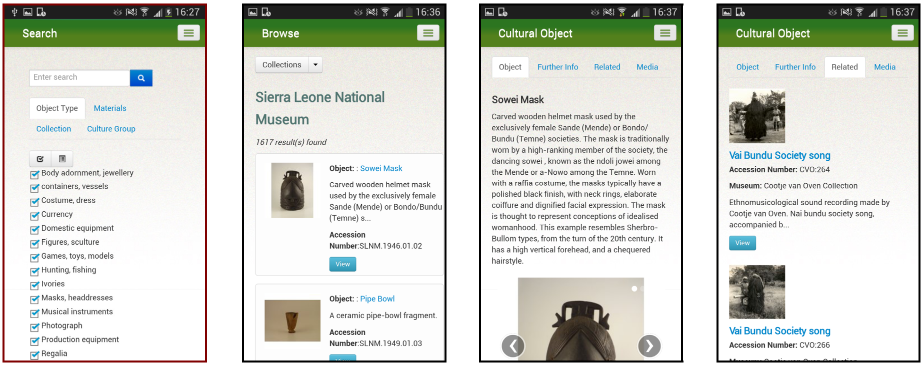

Fig. 5. Example screen shots from the RCH mobile interface showing the Search, Browse and a Cultural Object result along with information Related to that Cultural Object

or complicated 3D models. Therefore, processing image-based reconstruction or 3D photogrammetry tasks by multiple image matching and 3D model building cannot be completely done on mobile devices because of the limited resources.

Nowadays, there are some tools that enable mobile users to create and publish their own AR contents for indoor and outdoor environments such as Junaio, Layar and Aurasma. These applications enable mobile users to create AR environments and save them into their channels on the cloud server. Moreover, the channels can be accessed through an application programming interface (API) on mobile applications, which some application also support it such as Junaio. This technique is useful because it allows general mobile users who don't want to or who can't develop mobile AR applications to have their own AR environments. However, these AR applications still have some restrictions because they are implemented on closed platforms such that a user's AR environment can only be retrieved via the commercial application, i.e. you cannot reuse a Junaio environment in an Aurasma environment. Moreover, most commercial mobile indoor AR applications provide users with limited amounts of data or contents for augmenting real world scenes. There is no communication channel for current AR applications (e.g. Junaio, Layar, Aurasma or specific research application like an AR game, etc.) that allows them to download or obtain dynamic contents from other third party data sources in real-time.

This paper offers a solution that proposes a service oriented architecture for mobile AR system that exploits an AR SDK, multiple object tracking, AR supporting application and web service framework to perform basic AR tasks and dynamic content acquisition by accessing the photogrammetry service or open content providers over mobile/wireless network. In addition, there are some beneficial AR supporting modules that enable mobile users to utilize and manipulate acquired AR media contents on AR preference environments. We then look at the service-orientation of the mobile augmented realty part of the architecture.

2 Architectural Requirements

Several key architectural requirements are proposed to enable construction of the novel service orientation on mobile AR platform including:

Service Orientation on a Mobile AR Platform: The service-oriented architecture (SOA) entirely supports a client-server scheme over mobile/wireless network. To obtain more associated valuable contents and significantly increase the usability and functionality of the proposed mobile AR application, service orientation will be applied on the mobile AR platform, which basically integrates a web service framework into a mobile AR client [12][13]. This feature could be extensively implemented in indoor or outdoor AR scenarios, which AR browser is an application on web service framework to show media contents on real environment. Examples of web services, which developers can easily access to generate platform independent digital contents including: Web Map Services, mash-up services, geospatial and social network data, 3D models, and the Reanimating Cultural Heritage data, etc. The designed mobile AR client should offer advantages from being deployed on a service oriented architecture, which mainly provides third party open services from digital content providers that are currently available to clients on any platform [10][11].

Multiple Object Tracking: One of the basic AR tasks is object tracking used to track and recognize targeted reference objects. Associated contents can then be revealed on the real scene. In the mobile AR client, the tracking module is designed to perform markerless tracking, which require 3D object tracking so that the system can recognize more than one reference object in parallel. Moreover, the system can augment various contents of one reference object at the same time — this will lead to a richer AR environment in terms of media objects associated with the reference objects. That is, multiple objects tracking greatly enhances the interpretation of mobile AR scenarios and their environments where mobile users can obviously view the variety of media contents from multiple reference objects on the screen at the same time. Mobile AR applications can also offer some features for the users to manage and utilize those revealed contents, e.g. saving an AR scenario for future use.

Middleware System and Web Service Provider: The middleware or the back-end system basically is the design of supporting functions working behind the mobile interface and AR SDK. The middleware and web service provider are generally designed to be versatile and open platform respectively so that they can be efficiently implemented in many mobile AR scenarios, which will want to obtain and utilize dynamic digital contents from the web service provider and allow mobile users to create their preferences on AR environments. The middleware system is generally composed of a web service framework and AR supporting modules that concurrently work with AR SDK in order to support the usability and adaptability of acquired AR contents. Moreover, some modules are designed to create connections and request for dynamic contents from the web service provider through a web service framework.

3 Service Oriented Mobile Augmented Reality Architecture

Service oriented mobile AR architecture (SOMARA) is mainly designed to support content and service acquisition on a mobile AR platform. SOMARA is composed of 3 components including:

Mobile Client: The mobile client mostly is an application on a mobile platform (currently iPhone and iPad) that exploits a web service framework and service interfaces from a web service provider into its framework. Thus, the mobile application becomes a component in the SOA. In SOMARA, the mobile client is developed on iOS and native development platform. The mobile AR client utilizes a high quality embedded camera and touch screen user interface to accomplish AR and additional supporting tasks. shows the structure of the mobile client and the components inside.

Mobile interface is a front-end component in the mobile client for mainly support interaction between mobile users and the AR application and AR environments as well as supporting interaction between mobile users and displaying contents via a touch screen. In the SOMARA, the mobile AR client is developed on a mobile platform basis, there is a touch screen user interface, which is focused on AR tasks and features for mobile users to view and interrelate with digital contents being visualized on the screen.

Augmented Reality SDK is open source software on native or hybrid platform designed for mobile AR application development. At the moment, there are existing AR SDKs available to potential AR application developers e.g. ARToolkit, Qualcomm and Metaio SDK. AR SDKs basically provide basic libraries to perform general AR tasks such as object tracking, rendering and visualization. In SOMARA, Metaio native SDK has been exploited in the mobile AR client and native framework. The Metaio native SDK will fully work with the AR application in order to track reference objects, create geometry, load AR contents and their features onto a real world scene depending on each reference object, environments and scenarios that the system is designed to be implemented on. Note we have adapted the tracking module to perform multiple object tracking.

Augmented Reality application is a component of the mobile AR client in the middleware layer designed to largely work with the Metaio native SDK to process some AR tasks, e.g. building geometries, visualizing contents, etc. Moreover, the AR application is also combined with the web service framework for efficiently requesting services and receiving responses, which are dynamic contents or final outcomes from the web service provider. In addition, some modules in the application will work with Global Positioning Systems (GPS) in order to process location base AR contents, personalization and outdoor AR tasks. The following sections explain each module in the application, which is designed to support the proposed features.

Web Service Framework: The web service framework implemented with web service APIs such as SOAP or REST is composed of client and server side service code. The web service framework simultaneously works with the AR application as a middleware layer for creating web service connections, sending requests and receiving responses between the mobile client and web service provider. In the web service framework, there is a XML Parser and XML serialization module to process XML data representing the final outcome of the web service provider. The outcome will then be transferred to the AR application. At the moment we are utilizing XMLHttpRrequest for server side response, but we plan to consider JSON as an alternative to XML for transferring data from the server.

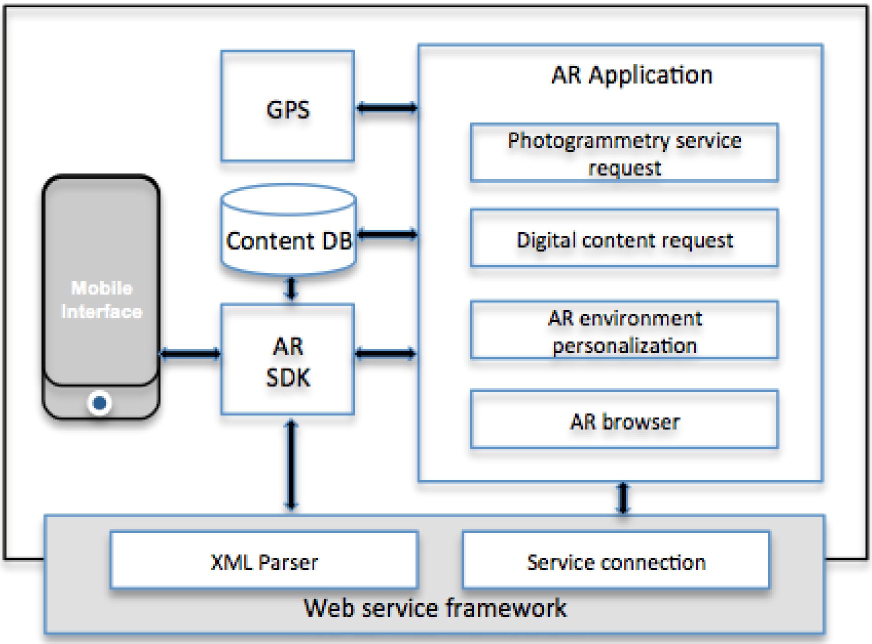

Fig. 6. Mobile augmented reality client

Web Service Provider: The web service provider on an open server side platform is composed of the web service framework and open digital content service providers, which are included into the web service provider. The web service framework offers service interfaces to the mobile AR client and the service connection module is used to communicate with integrated open service providers for processing and dynamic media contents. The web service provider in SOMARA designed to supply a digital content service, a photogrammetry service and other services, which could be third party content providers or any providers that their contents will be beneficially applied into the potential scenarios. Note the RCH Cultural Objects service.

Multiple Object Tracking: Typical AR applications are able to track and recognize only one object. In addition, the applications will present only single content on top of the real scene. In this architecture, the mobile AR client will perform multiple 3D object tracking and visualize associated contents such as 3D models, billboards, images, videos, etc. on reference objects at the same time. presents the process of multiple objects tracking and associated content configuration.

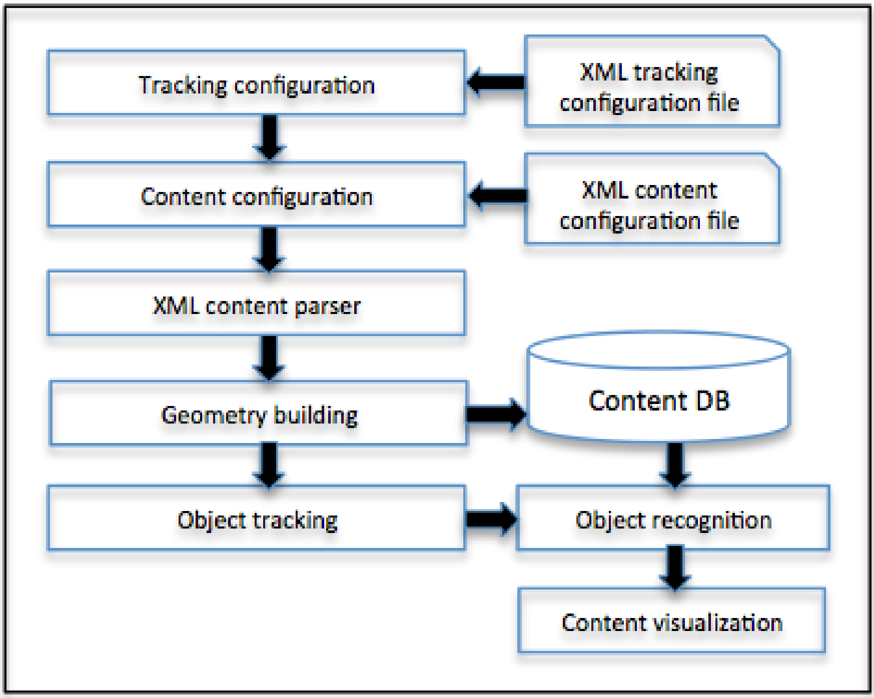

Fig. 7. Multiple objects tracking configuration

4 Augmented Reality Application

The AR application is a middleware system in the mobile client that contains important supporting modules for extensively work with the web service framework, AR SDK and mobile interface. The designed modules in the AR application are the photogrammetry, digital content (e.g. the RCH cultural objects), personalization and AR browser request services.

Photogrammetry Service Request: The photogrammetry service enriches the functionality of the mobile AR client by enabling mobile users to request for image-based reconstruction services. The photogrammetry service request module handles connections between the AR application and a web service provider for requesting photogrammetry services and receiving responses (i.e. a 3D model of a cultural object). The AR application will capture photos of an intended object and then transfer them via the web service framework to the provider. When a final model is completely done, it will be sent back to the mobile client via the same web service. The final model will then be visualized and manipulated on the working scene. Note, this requires existing photogrammetry services, such as Autodesk 123D to adopt a web services approach.

Digital Content Request: The digital content request module is required when mobile users want to search for other relevant contents from the web service provider. Such digital contents are sent back to the mobile client to allow users to utilize them in the AR environment. These content providers could be the third party or existing open service providers that will be able to provide various kinds of digital contents so that mobile users can put them on their preferred environments, which can also be viewed on the AR browser in other conditions.

Augmented Reality Environment Personalization: The AR environment personalization enables mobile users to create their own interactive AR preferences on the working scene by selecting; manipulating and placing preferred contents and also locations of reference objects or real world scenes on AR environments. This module also allows mobile users to save created AR environments in the XML/JSON formats, including 3D contents provided by the museum or photogrammetry service.

Augmented Reality Browser: The AR browser presents AR preferences, which are saved in the user's profile in standard representation formats including XML and JSON. The AR browser will require object tracking and a GPS module in order to reveal a user's preferences on the AR browser. The browser extensively supports indoor and outdoor uses by tracking proposed objects or user's location so that the application can then provide a saved AR environment. illustrates the Test Wicker Basket Object with associated media contents in an AR scene using the iPhone 5 as the mobile AR interface. Here you can see a video showing how to make wicker baskets, the object label, a test description and a series of related objects.

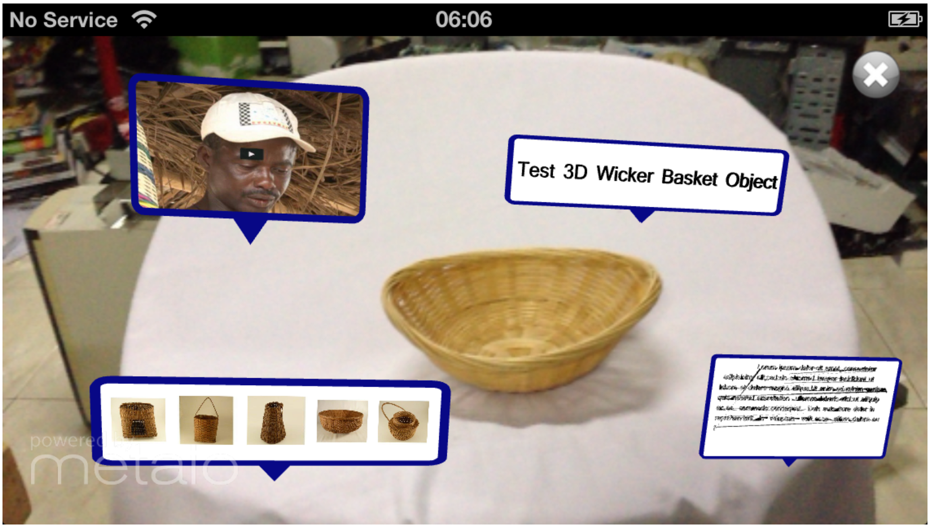

Fig. 8. iPhone 5 AR presentation of a Test Wicker Basket Object

5 Conclusions

The SOA for multiple objects tracking AR system supports dynamic content acquisition over a wireless or mobile network. The mobile client is composed of featured modules to access open services through a web service framework. Planned services include a photogrammetry service based on existing services, such as Autodesk 123D, that enables mobile users to obtain virtual models from image-based reconstruction so that the users are able to design what they want to visualize on the screen. Another aim of this architecture is to support open content utilization so that acquired contents can be freely selected and placed on AR environments together with other perspective contents, e.g. location, geographic or social media data. User preference AR environments can then be view in other situation by augmenting reference 3D objects, markers or markerless such as 2D images. The system is illustrated using a Reanimating Cultural heritage web services that access digital cultural objects from the RCH repository — note we use a Test Wicker Basket Object and associated 3D to illustrate. It is instructive to note that even large collections of cultural 3D objects are not yet mainstream in museum interactive environments, and the use of AR in this context is also rare. We feel that exploring the notion of what is effectively 'user generated 3D contents' in this context is worthy of further exploration.

Future Work. Future work will include the notion of 'crowd sourcing' the generation of high quality 3D to associate with a digital heritage repository, such as RCH, so that eventually over time all objects on display in a museum's gallery (virtual museum) could potentially have a 3D presentation online gathered through an AR application such as discussed in this paper. This will, however, require a 'mind shift' from a museum's perspective; they tend not to allow visitors to take photographs in the museum!

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References

1. AHRC Beyond Text RCH project, http://projects.beyondtext.ac.uk/reanimatingculturalheritage/index.php (last visited February 7, 2013)
2. Zhang, W., Patoli, M.Z., Gkion, M., Al-Barakati, A., Newbury, P., White, M.: Reanimating Cultural Heritage through Service Orientation, Workflows, Social Networking and Mashups. In: International Conference on CyberWorlds, pp. 177–184 (2009)
3. White, M., Patoli, Z., Pascu, T.: Knowledge Networking through Social Media for a Digital Heritage Resource. In: Digital Heriatge 2013, Marseille (October 2013)

4. Genc, Y., et al.: Marker-less tracking for AR: a learning-based approach. In: Proceedings International Symposium on Mixed and Augmented Reality, pp. 295–304. IEEE Comput. Soc. (2002)
5. Damiani, E., et al.: Augmented reality technologies, systems and applications. Multimedia Tools and Applications 51(1), 341–377 (2011)
6. Papagiannakis, G., Singh, G., Magnenat-Thalmann, N.: A survey of mobile and wireless technologies for augmented reality systems. Comput. Animat. Virtual Worlds 19(1), 3–22 (2008)
7. Zhou, F.Z.F., Duh, H.B.-L., Billinghurst, M.: Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. In: 2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality (2008)
8. Perey, C., Engelke, T., Reed, C.: Current Status of Standards for Augmented Reality, pp. 21–38. Springer, New York (2011)
9. Luo, X.L.X.: From Augmented Reality to Augmented Computing: A Look at Cloud-Mobile Convergence. In: 2009 International Symposium on Ubiquitous Virtual Reality (2009)
10. Lee, R., et al.: Interoperable augmented web browsing for exploring virtual media in real space. In: Wilde, E., et al. (eds.) Proceedings of the 2nd International Workshop on Location and the Web LOCWEB 2009, pp. 1–4 (2009)
11. Selonen, P., et al.: Mixed reality web service platform. Multimedia Systems 18(3), 215–230 (2012)
12. Belimpasakis, P., Selonen, P., You, Y.: A Web Service Platform for Building Interoperable Augmented Reality Solutions. In: International Augmented Reality Workshop, pp. 1–6 (2010)
13. Wang, R.W.R., Wang, X.W.X.: Applying Service-Oriented Architecture into an Augmented Reality E-business System. In: 2008 IEEE International Conference on e-Business Engineering (2008)