

The Application of Service Orientation on a Mobile AR Platform — A Museum Scenario

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Abstract—Mobile augmented reality has become an influential tool for digital content representation in terms of enhancing users' experience and improving the adaptability and usability of augmented reality applications. In our research, we have developed a service oriented mobile AR architecture for multiple applications, such as a museum interactive or web app. Our solution enhances closed platform mobile AR applications to create more flexible mobile AR clients that efficiently support content acquisition and utilization of third party digital media contents on a real scene. Our example web service framework on a mobile AR client exploits specific museum (e.g. Victoria and Albert Museum) or third party APIs (e.g. Google Maps) to aggregate data from participating web service providers. A typical media API content request is sent to a content provider to obtain a targeted cultural object's associated media contents such as 3D models, images, text, videos and metadata. Acquired contents are then visualized in both VR and AR environments and consumed by mobile users. Other examples of supporting modules include photogrammetry based 3D reconstructions based on available commercial or open source web services and personalization that allow a user to request rich media, e.g. 3D models, and associated metadata, of a targeted cultural object for exploiting in a 'saved museum exhibition'.

Index Terms—mobile augmented reality; service oriented mobile AR architecture; content acquisition and utilization; web service framework

I. INTRODUCTION

Augmented Reality (AR) has been applied as a content representation tool in many different applications [1],[2],[12] and particularly complements other technologies museum interactives [13],[14],[15]. Mobile AR influences mobile users by providing a new way of visualizing computer-generated media contents and improving users' perception in interacting with those contents in real environments [3],[4]. Most mobile AR applications are currently implemented on closed platforms that can only offer pre-designed contents to users, e.g. Aurasma [5]. The AR contents are limited and the creation process must be completed in advance and then installed into the system. Implementing a Service-oriented Architecture on a mobile AR platform provides the ability to enhance the adaptability and usability of an AR application by supporting associated content acquisition through the APIs of multiple potential service providers [6],[7]. Acquired contents could then be consumed in conjunction with a camera based view or AR environments. In this paper, we propose a Service-

Oriented Mobile Augmented Reality Architecture (SOMARA) that is beneficially applied to museum study scenarios, but could also be applied in other creative technology scenarios such as e-retail. The mobile AR application exploits potential web service APIs that are able to create connections and send requests to participating museum service providers or online museum collections. The architecture also includes a content personalization feature and illustrates how the system could connect to a photogrammetry service (e.g. based on open source photogrammetry applications) that empower the mobile AR application to provide effective contents for a user's application scenario, for example, a digital 'show and tell'.

The system design and mobile client target a broad range of museum studies and exhibition scenarios. For defined cultural exhibition scenarios, specific cultural media contents are prepared and installed into the back end system in advance and then accessed via an open API, and these contents can also be aggregated with third party APIs containing associated or related cultural media contents and metadata. Users are able to use mobile devices such as an iPad to view related contents of a targeted cultural object on an AR scene and create personal AR environments as well as sending a request for image-based reconstruction services.

II. SERVICE-ORIENTED ARCHITECTURE ON MOBILE AR SYSTEM

General mobile AR applications basically perform AR tasks such as tracking, rendering and visualization. Increasing the functionality and ability of mobile AR systems, currently based on closed platforms, can be done by implementing service orientation into the system. The designed service orientation for supporting the open mobile AR system consists of a web service framework that exploits service APIs from potential providers and a SOMARA composed of a client-server architecture and supporting modules that enhance the usability and adaptability of a mobile AR application. The following are the main components that support an effective service orientation on mobile AR system.

A. Mobile AR Client

A mobile AR Client is an AR application on a mobile platform that implements a web service framework as a back-end system. The mobile AR client performs AR tasks as well as supporting tasks in order to track and visualize related digital media contents superimposed on top of a real scene. The mobile AR client requires a mobile interface that works as

a front-end system in order to support mobile users. Interaction between a user and the AR application can be done through the mobile interface. In the museum study scenarios, the mobile AR client could be an application on a bigger screen mobile device such as iPad in order to visualize various types of interactive contents aggregated from open service providers on the screen and also enable mobile users to beneficially view, interact and perform supporting tasks.

B. Web Service Framework

Web service framework is one of the components in the service orientation that pursues interoperability tasks between the mobile AR client and open service providers. The web service framework is a back-end system that simultaneously works with the AR application in order to sent requests to participating providers and receive responses. Web service framework requires service APIs of the providers that could be in SOAP or RESTful format. The APIs show how the web service framework can request a service by sending parameters through the link via mobile or wireless connection.

C. Service Providers

The open mobile AR client requires potential service or content providers. Participating content providers supply APIs for any applications that require integration of open contents from potential service or data providers. Acquired interactive media contents from different sources are aggregated and visualized on the mobile device. Example cultural object service providers include the Victoria and Albert Musiem [16] who provides a RESTful API of their collections and the British Museum who provides a semantic interface through SPARQL [17], in contrast to the Reanimating Cultural Heritage (RCH) aggregated repository on the small scale [11] or Europeana [18] on the large scale. RCH and Europeana are also offering API access, however once participating museums offer their own APIs, such aggregated repositories may be largely redundant because they offer only a limited subset of the original museums' cultural data.

D. Service Oriented Mobile AR Architecture (SOMARA)

SOMARA consists of a mobile AR client, web service framework and service providers (see details above). The architecture combines all functions including the mobile interface, AR application, AR SDK, web service framework and open providers in order to accomplish typical AR tasks and accumulation of associated media contents that could be consumed and published by mobile users. Fig.1 illustrates SOMARA designed for supporting AR tasks as well as interoperability tasks between the mobile AR client and web service providers.

In this paper, we illustrate how SOMARA is applied to museum interactive application scenarios that are focused on cultural artefact learning using a mobile AR system as well as a web-based platform. Therefore, mobile users are able to achieve museum learning in many situations where our novel web service-based mobile AR application can also support third party content consumption and acquisition, which is able to better exploit the usability and efficiency of an open mobile AR platform.

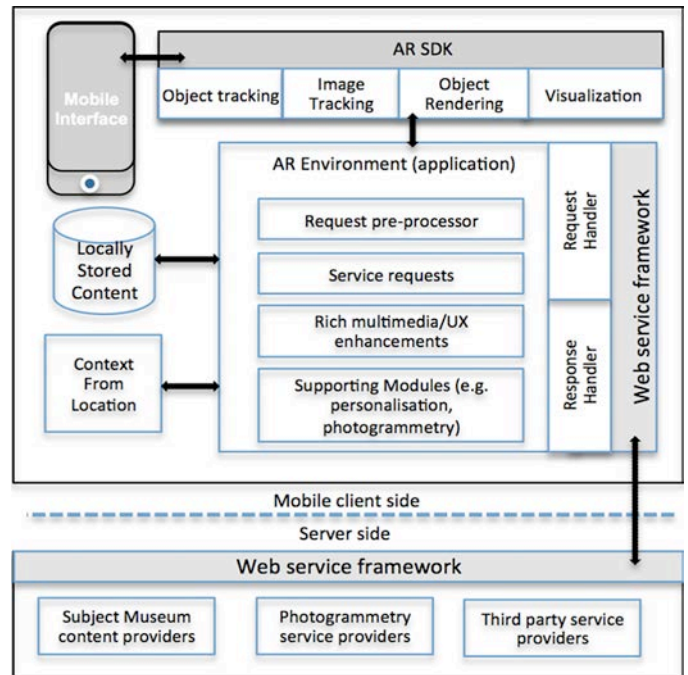


Fig. 1. Service Oriented Mobile Augmented Reality Architecture

III. MUSEUM ENVIRONMENT SCENARIOS

A. Museum Study

This scenario focuses on users while they are visiting a museum. In this case the selection of cultural media contents for augmenting the cultural object is affected by the context of location. Proximity of a physical exhibit can reduce the value of a 3D model on the display, which means maximum benefit will often be gained by presenting related media such as video, text, audio descriptions, etc. or indeed related cultural objects (in 3D format). In this way a supply of new cultural information at the point where the visitor is viewing the exhibit improves the visitor understanding and knowledge about the cultural object physically on display, when compared to the usual curator's small label next to the exhibit. Object based tracking incorporated in SOMARA can request associated media contents from other participating museums through the SOMARA web service framework embedded into the mobile AR application. In this scenario, the mobile AR application provides features that allow users to create personal AR exhibitions by saving preferred contents and user contributed data such as photographs of the exhibited cultural object or artefacts. These photographs can be passed to a web service based photogrammetry service for an image-based reconstruction of the exhibit. The photogrammetry output is a 3D model, that is returned to the mobile client where users can then use the acquired model in their AR environment along with other selected media contents from outside the museum.

Further, latest research is allowing preliminary 3D reconstructions of physical objects on a smart device, which for example, are integrated with RGB-D cameras [8]. Fig.2 shows screenshots of a sample AR environment in the museum study scenario where the mobile AR client can track a targeted object and related contents are then visualized in a

real scene. Mobile users can also request associated contents from the participating service providers e.g. through the RCH or V&A Museum API.



Fig. 2. The snapshots of a sample museum study scenario on an AR scene

B. Home-based Museum Study

This scenario is designed for visitors to the physical museum who wish to reflect on their experience or share it with others after the event. In this case a so called ‘magic book’ [9] interface is used in conjunction with our SOMARA application to present and interact with a rich aggregated multimedia experience populated by the museum’s virtual contents and augmented by user and third party contents. Incorporation of the users own multimedia and shared content adds to the personalization of the experience and increase opportunity for reflection. Growth in the use of social networks [10] and content sharing increases the potential for crowd sourcing contents, which in turn enriches the data source available for populating a user’s personalized AR environment/ presentation [11].

This scenario requires trigger images such as a leaflet that can be distributed at the museum or downloaded from the museum’s website. Users can also select, save and contribute preferred contents in order to create personal AR environments that can be presented again anytime and anywhere. To accomplish this, the mobile client still requires access to museums’ web services and third party APIs to retrieve digital contents from different content servers, etc.

Users who choose to share their personalized AR environments can further contribute to the wealth of crowd sourced media and metadata both through the aggregation of media and also through contributing to statistical analysis of preference or use of available resources which can help to reveal their potential value to other users.

A key feature of this scenario is that the user can associate their images (taken of the cultural object) with the museum ‘magic book’ to provide personalization, including a 3D reconstruction of the cultural object. Fig. 3 illustrates a sample AR scene of the home-based museum scenario where the system can track an image of a preferred cultural object and the associated contents of that image marker will be requested and visualized on the sample AR scene. The screenshots show the contents from the RCH API composed of text,

images and a 3D model of the trigger image so that museum study could be performed anywhere and anytime.

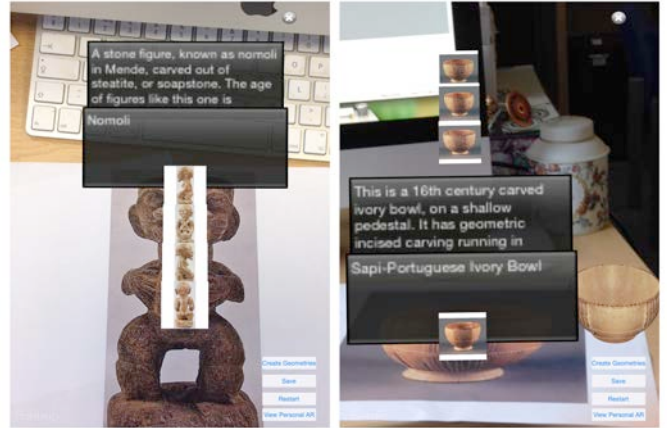


Fig. 3. The snapshots of a sample home-based museum study

C. Online-based Study

This scenario supports mobile users who don’t visit the actual museum, but visualize cultural exhibits including 3D models of cultural objects at home or school, etc. In this case SOMARA provides a self contained virtual museum experience rich in multimedia and information sources that is populated using the same aggregated sourcing of content where content selection is influenced not only by user selection but also by other contextual information such as location. For example multiple devices in close proximity operated by school children accessing the same AR environment could form the trigger to present an exhibition exploiting gamification or to stimulate discussion and classroom activities. A typical example that illustrates this scenario is our RCH website, which handles 3D model presentation itself and AR visualization on a mobile device. Users are able to view 3D models of each cultural artefact on the website using X3DOM and are also able to launch an AR application. Our current version illustrates how a user can access Sierra Leone digital cultural objects from several participating museums including the British Museum, British Library, Sierra Leone National Museum, and others, see Figure 4. The SOMARA mobile app (mobile AR application) links seamlessly with this scenario to visualize the same media, including 3D, contents on an AR scene by tracking a trigger image of a cultural object.

Fig. 4 presents an example of RCH’s online museum study web page where mobile users are able to view cultural objects and their related contents from the aggregated repository. Associated contents of a targeted object can be requested from participating museums through their APIs.

D. Generating Curatorial Contents

It is also possible to utilize an API connection to a museum’s digital object repository (the back end database) and exploit the smart devices’ camera technology and other resources to generate new digital contents during, for example, any restoration activity being performed by the curator. Here,

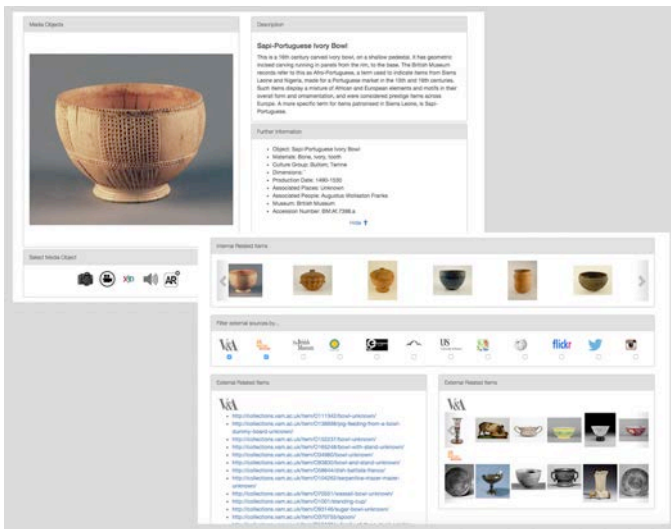


Fig. 4. The RCH online museum study page

the curator can use SOMARA's image gathering utility, add text and audio notes, etc. and use the images to build 3D reconstructions that can be aggregated with the cultural objects database entry for repurposing – in essence the curator is using the same facilities as the visitor, but providing expert input.

IV. PERSONALIZED MOBILE AR ENVIRONMENTS

Personalization is one of the value added features that the mobile AR client has offered to mobile users in order to improve the capability of mobile AR systems and content utilization in web service framework. Acquired contents on a real scene could be effectively exploited by allowing the users to create personal AR environments that they can save and take away for reviewing in other situation. In museum study environments, mobile users can perform for example on an active screen.

V. PHOTOGRAMMETRY SERVICES

Image-based reconstruction exploiting a photogrammetry service is a technique that allow users to acquire a 3D model of a cultural object by taking overlapping photographs of that object and upload the photographs to the application server. The SOMARA mobile application combines this feature into the service request module so that the content acquisition process could be done not only by sending a request to the potential content providers, but also by integrating the availability of any available photogrammetry services. This process requires APIs of the service providers in order to implement into the web service client framework, however it is possible to build a photogrammetry service from open source photogrammetry softwares.

VI. CONCLUSIONS

We have proposed a service-oriented mobile AR architecture and value added modules in order to improve the functionality and adaptability of general mobile AR systems by aggregating associated media contents of a targeted object

and visualize those acquired contents superimposed on top of the object in an AR environment. The designed SOMARA is versatile and its application can be also usefully applied in many different scenarios such as e-retail and AR learning. Content utilization and acquisition is the main feature that the SOMARA offers to mobile AR applications so that a web service framework on a mobile AR client and the APIs of participating third party services will be used to create connections and collaboration between a novel mobile AR client and potential service providers.

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