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Reanimating Cultural Heritage through Digital Technologies

by
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A thesis submitted in fulfilment of
the requirements for the degree of
Doctor of Philosophy
at the University of Sussex

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Declaration

The work described in this thesis, carried out in the Interactive Systems: Computer Graphics Centre, is that of the author and has not been submitted in any form for any other degree at this or any other university.

Signed:
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To,

My parents

Xuyou Zhang and Wenxiu Wei.

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Reanimating Cultural Heritage through Digital Technologies

ABSTRACT

Digital technologies are becoming extremely important for web-based cultural heritage applications. This thesis presents novel digital technology solutions to ‘access and interact’ with digital heritage objects and collections. These innovative solutions utilize service orientation (web services), workflows, and social networking and Web 2.0 mashup technologies to innovate the creation, interpretation and use of collections dispersed in a global museumscape, where community participation is achieved through social networking.

These solutions are embedded in a novel concept called Digital Library Services for Playing with Shared Heritage (DISPLAYS). DISPLAYS is concerned with creating tools and services to implement a digital library system, which allows the heritage community and museum professionals alike to create, interpret and use digital heritage content in visualization and interaction environments using web technologies based on social networking. In particular, this thesis presents a specific implementation of DISPLAYS called the Reanimating Cultural Heritage system, which is modelled on the five main functionalities or services defined in the DISPLAYS architecture, content creation, archival, exposition, presentation and interaction, for handling digital heritage objects.

The main focus of this thesis is the design of the Reanimating Cultural Heritage system’s social networking functionality that provides an innovative solution for integrating community access and interaction with the Sierra Leone digital heritage repository composed of collections from the British Museum, Glasgow Museums and Brighton Museum and Art Gallery. The novel use of Web 2.0 mashups in this digital heritage repository also allows the seamless integration of these museum collections to be merged with user or community generated content, while preserving the quality of museum collections data.

Finally, this thesis tests and evaluates the usability of the Reanimating Cultural Heritage social networking system, in particular the suitability of the digital technology solution deployed. Testing is performed with a user group composed of several users, and the results obtained are presented.

List of Publications

Conference Proceedings

2009

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Glossary

3D-COFORM	Tools and Expertise for 3D Collection Formation
3D-MURALE	3D Measurement and Virtual Reconstruction of Ancient Lost Worlds of Europe
ACMA	ARCO Content Management Application
AGAMEMNON	Pictures from the Past: A Wireless Network of Magic Digital Cameras and Palmtops for Archaeological Travels Through the Time
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
AR	Augmented Reality
ARCHEOGUIDE	Augmented Reality-based Cultural Heritage On-site Guide
ARCO	Augmented Representation of Cultural Objects
AS	Archival Services
AS3	Action Script 3
ASP	Active Server Pages
CGI	Common Gateway Interface
COLLADA	COLLABorative Design Activity
CONNECT	Design the classroom of tomorrow by using advanced technologies to connect formal and informal learning environments
CORBA	Common Object Request Broker Architecture
CRUD	Create, Retrieve, Update and Delete
CS	Content Services
CSS	Cascading Style Sheets
DCOM	Distributed Component Object Model
DHR	Digital Heritage Resource
DISPLAYS	Digital Library Services for Playing with Shared Heritage
DOF	Degrees Of Freedom
DR	Digital Repository
EPOCH	European Network of Excellence in Open Cultural Heritage
ES	Exposition Services
FLAR	Flash Augmented Reality
GUI	Graphical User Interface
HIT	Human Interface Technology
HMD	Head Mounted Display

HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technologies
IS	Interaction Services
ITACITUS	Intelligent Tourism and Cultural Information through Ubiquitous Services
JSON	JavaScript Object Notation
JSP	Java Server Pages
LOCKSS	Lots of Copies Keep Stuff Safe
MPEG	Moving Picture Experts Group
PHP	Hypertext Preprocessor
PS	Presentation Services
RCH	Reanimating Cultural Heritage
REST	Representational State Transfer
RIA	Rich Internet Application
RSS	Really Simple Syndication
SOA	Service-oriented architecture
SOAP	Simple Object Access Protocol
TOURBOT	Interactive Museum Tele-presence through Robotic Avatars
UDDI	Universal Description, Discovery and Integration
VR	Virtual Reality
VRML	Virtual Reality Modelling Language
WF	Windows Workflow Foundation
WSDL	Web Services Description Language
XDE	XML Data Exchange
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language Transformations
X-VRML	A high-level XML-based language for building parameterised 3D models and virtual scenes

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CHAPTER I

1 Introduction

Museum consortia and education institutions are leading international efforts to provide tools for digitizing, archiving, searching, retrieving and exhibiting cultural heritage in all kinds of ways. Digital devices and tools such as camera, laser, photogrammetry and 3D modelling tools (e.g. 3ds Max and Maya) are provided for museums' and institutions' developers to digitalize cultural heritage objects and reconstruct sites and monuments. Database technologies are applied in most museum cultural heritage projects to enable museums and visitors to archive, search and retrieve cultural heritage information. Modern visualization technologies such as 3D, virtual reality (VR), augmented reality (AR), together with appropriate interaction technologies, are becoming the main interest for communities for exhibitions of archaeological/cultural heritage content.

In Cultural Heritage, innovative modern visualization technologies, such as virtual and augmented reality and computer animation, can bring a new dimension to understanding museum collections. For example, 3D cultural heritage content can be integrated into a museum's web site for enhancing the experience of visitor's learning on the cultural heritage by interacting with 3D exhibitions. Furthermore, virtual reality interfaces together with the use of interaction technologies, which require the presence of special materials such as special screens or input devices (e.g. the Gamepad, Spacemouse, Blackbox and Kromstaff Replica Interface [1]), or special equipment (e.g. head mounted displays (HMDs) [2] and full body motion capture suits (i.e. a new interaction technology) [3]), enable visitors to navigate through the virtual heritage world, and interact with virtual objects and environments in interesting ways.

However, in most cultural heritage projects developed by consortia, museums are the sole content providers and visitors are just consumers of that content. In those projects, museums provide digital heritage contents from their own database repositories, and visitors just visit those cultural heritage exhibitions provided by museums in different interesting ways, such as 3D, VR, AR and advanced interaction methods that have been

described above. Web 2.0 marks an innovative step change in technology that allows users to integrate their own new content from other data sources, label data sources by using tags (keywords), share the knowledge through networks and make comments, and so on – user generated content can now be merged with museum collections. Thus, Web 2.0 technologies can mean that cultural heritage site content providers are not just museums, and visitors are not just content consumers.

1.1 Web 2.0 in Cultural Heritage

Although most cultural heritage projects are not involved with Web 2.0 services, there are still some cultural heritage projects that use Web 2.0 technologies, transforming the methods to access cultural heritage content. For example, some of them utilize Web 2.0 mashups that allows users to integrate digital heritage contents from different data repositories, such as Flickr and YouTube, or social tagging that allows users to label data sources using keywords (tags), or social networking which allows users to share their cultural heritage knowledge through networks [4].

However, most ‘Museum 2.0’ [5] examples only give users the tools to visit the exposition that had been made for them, and some members are still the main content providers. This is different from a full Web 2.0 approach in that users act as the main content creator based on Web 2.0 technologies.

There are still a few ‘Museum 2.0’ examples that allow users to be the main content creators based on Web 2.0 services. However, they just develop applications to allow users to update wiki, chat with other visitors, or make comments, and so on. There is a need for visitors to be really content creators, personalizing their own virtual exhibitions based on both user-generated digital heritage content and museums’ digital heritage collections.

From a museum’s perspective, their virtual exhibitions would only access their own digital heritage. However, a museum’s exhibition generally does not access user-generated digital heritage content and generate community contributed cultural heritage exhibitions. Furthermore, it demands large museum resources to moderate and organize such user-generated digital heritage resources that can be integrated effectively with their own digital heritage collections. This implies that there is a need to create a self-maintaining user-

generated digital heritage collection that can be mashed with regulated museum digital heritage content, while such digital heritage content is distinguishable as it would not necessarily have the museum ‘stamp of approval’.

Furthermore, if a museum happens to be interested in a particular user-generated digital heritage collection found through all kinds of search facilities such as Flickr or YouTube, they may wish to ‘copy’ specific digital heritage objects from social data repositories and add them permanently to their own digital heritage collection; this would preserve them for a further particular virtual exhibition.

This thesis is particularly concerned with how Web 2.0 technologies can be integrated with other digital technologies such as 3D visualization and interaction, and then all these digital technologies can be used in cultural heritage fields. This thesis demonstrates the functionality of Web 2.0 mashups with 3D to allow visitors to capture community contributed heritage knowledge. This would enable them to select user-generated digital heritage content from social data repositories and digital heritage objects from actual museums, and create and publish their own virtual exhibitions.

This thesis also introduces other Web 2.0 functionalities such as Facebook, which allows communities to access and interact with digital heritage objects and collections and contribute their knowledge. For example, Facebook news functionality allows users to see Facebook heritage community news (messages) in the home page of a digital heritage web site. Facebook comments functionality allows visitors to write comments on every digital heritage object in museum heritage collections – in effect adding community knowledge to a museum objects in a through a social network that the museum doesn’t have to moderate or maintain. Facebook Comments Publishing functionality enables Facebook users to publish their comments along with the thumbnail of the associated digital heritage object onto a Facebook fan page wall thus allowing a discussion forum on that object, i.e. object knowledge creation.

This thesis presents a digital heritage system called DISPLAYS [6], which is a concept for creating, interpreting, using and exploring digital artefacts and playing with shared heritage through content creation, archival, exposition and presentation and interaction services,

based on service oriented architecture. Based on the DISPLAYS concept, this thesis represents an approach for creating a multimedia based digital heritage repository called ‘Reanimating Cultural Heritage [7]’, which uses Web 2.0 technologies integrated with other digital technologies, such as 3D visualization and interaction, to reanimate cultural heritage objects in a digital space through images, videos and other media, e.g. 3D within a virtual exhibition environment.

1.2 Contributions

This thesis proposes that the use of Web 2.0 technologies can play an important role in cultural heritage fields to enable users to participate in sharing their own cultural heritage knowledge, creating and publishing user-generated digital heritage exhibitions. Museums and education institutions can benefit from such technologies for capturing user-generated digital heritage knowledge and enabling users, as main content creators, to personalize their own digital heritage exhibitions. This thesis brings museum professionals to a closer understanding of how Web 2.0 technologies can be integrated with other digital technologies, and this approach can be fully used in cultural heritage fields. In detail, the main contributions from this thesis include:

1.2.1 Mashing up a 3D Digital Heritage Scrapbook

The author of this thesis has created an innovative Web 2.0 application which mashes up a digital heritage 3D scrapbook integrating digital heritage content from any museum collection (e.g. the ‘reanimating cultural heritage’ repository: British Museum, Glasgow Museums and Brighton Museums and Art Gallery – this is the ARCO [8] radio button in Figure 6.7 with different social data repositories, such as Bing, Flickr, Yahoo and YouTube through their appropriate web services (APIs), in a novel visualization and interaction environment. This will enable users to select museum and community contributed digital heritage content and then build their own virtual exhibitions. In this digital heritage 3D scrapbook application, users are able to search digital heritage content from various social networking repositories; they are able to select a different 3D environment (scenes) to mashup a digital heritage scrapbook. After a user has selected a 3D scene, they are able to drag and drop selected images, or videos, of digital heritage content from an image or video

gallery into the virtual environment and create their own virtual exhibitions. Users are also able to interact with digital heritage content in a 3D environment. After creating a digital heritage 3D scrapbook, users are able to publish their own virtual exhibitions (the 3D scrap book) onto a server for inclusion in a further cultural heritage site virtual exhibition (i.e. collections of the user generated 3D scrap books can be exhibited online). To sum up, the author developed a digital heritage multimedia application integrating Web 2.0 technologies with other digital technologies, such as 3D visualization and interaction, to allow visitors to select both user-generated digital heritage content and actual museums' digital heritage content, build and publish their own virtual heritage exhibitions.

1.2.2 Facebook Cultural Heritage Community News

The author created a Facebook cultural heritage community news functionality that benefits museums by enabling them to notify the cultural heritage community news (messages) in the home page of a cultural heritage web site. A Facebook cultural heritage community can be built using a Facebook page, where any participant can contribute their cultural heritage knowledge by posting messages on the Facebook Wall. The Facebook graph API is utilized to retrieve the Facebook page Wall messages and format the top Wall news (messages) in HTML, and then integrate them as a feed into the cultural heritage web site. The significance of this approach is that Facebook comments can also be fed to the Facebook Wall, see next section, where comments (i.e. community knowledge about museum collections) and objects are aggregated and shared, and the latest news or discussion topic is fed as community news to the digital heritage repository homepage – an innovative example of social networking integrated into the museum collection is thus illustrated.

1.2.3 Facebook Comments for Digital Heritage Objects

The author created the Facebook comments functionality for digital heritage objects. In this functionality, a Facebook comments box is utilized for each digital heritage object in a museum digital heritage collection to allow users to write comments on every digital heritage object. A Facebook comments box enables users (including Facebook users and non-Facebook users) to write comments on a digital heritage object. The main issue of implementing a Facebook comments box for every digital heritage object is that the unique

ID of each digital heritage object should be found to be the XID of the associated comments box. In this thesis, the author uses the Reanimating Cultural Heritage project as an example of a cultural heritage field to demonstrate how the unique ID of each digital heritage object in a museum collection can be found and acted as the valid XID of the associated comments box, and then implement Facebook comments boxes for every digital heritage object. As mentioned above, these comments are then published to the Facebook Wall.

1.2.4 Facebook Comments Publishing

The author created the Facebook Comments Publishing functionality. In this functionality, Facebook users are able to publish their comments from the Facebook Comments box, together with the thumbnail of the associated digital heritage object, onto the Facebook page wall. This functionality utilizes JavaScript, PHP and AJAX technologies to catch the messages the user has posted on the Facebook Comments box, and the thumbnail of the associated digital heritage object, and then publish them onto the wall of the Facebook page of the Reanimating Cultural Heritage repository through Facebook APIs. This functionality also affects the Facebook news column of the Reanimating Cultural Heritage home page, as described above. Visitors are able to see the comments that have been made by the other users, together with the thumbnail of the associated digital heritage object in the Reanimating Cultural Heritage home page. It is then a short step to link back to the object from a URL tagged to the object thumbnail.

1.2.5 Contribution Summary

The author's contributions to knowledge in the context of 'reanimating cultural heritage' (RCH) through the application of innovation digital technology solutions are:

- Contribution to the overall design of the DISPLAYS conceptual framework [6, 9, 10, 11, 12, 13, 14] and the subsequent implementation of an architecture that validates several of the DISPLAYS concepts in the RCH [7, 15, 16, 17] project;
- Contribution to the design and implementation of the ARCO based Reanimating Cultural Heritage prototype architecture, based on a combination of HTML,

JavaScript, X-VRML technologies. For example, integrating HTML and JavaScript code into X-VRML code;

- Contribution to the design and implementation of the RCHLite system architecture, based on HTML, JavaScript, XML, and XSLT technologies;
- Integration of the Web 2.0 functionalities described above into the Reanimating Cultural Heritage system. For example, the integration of the 3D Scrapbook, Facebook News, Facebook Comments and Facebook Comments Publishing functionalities into the Reanimating Cultural Heritage system [7, 15, 16].

1.3 Organization of Thesis

This chapter was an introduction to the theme of this research. It provided a description of the problems in cultural heritage fields and suggested solutions to solve the problems raised. Particularly, this chapter discussed the needs of museums and education institutions using Web 2.0 technologies, and provided an introductory discussion on those technologies. Finally, this chapter outlined the author's research contributions.

Chapter 2 firstly presents and reviews the work done by several digital heritage projects. It then introduces the background of Web 2.0 and Web 2.0 technologies, and demonstrates how Web 2.0 technologies can be utilized in cultural heritage fields; then several existing novel examples of Web 2.0 mashups are reviewed in this chapter. Finally, this chapter presents and discusses the work done by several digital heritage projects using Web 2.0 technologies.

Chapter 3 presents a digital heritage system called DISPLAYS for creating, interpreting, using and exploring digital artefacts, and playing with shared heritage through content creation, archival, exposition and presentation, and interaction services based on service oriented architecture. This chapter demonstrates a digital heritage system concept that uses a service-oriented approach and workflow management service. In the service oriented system architecture of DISPLAYS, different user tools and services are implemented for different application layers, for example, the application layer has a digital content creation service, archival service, exposition service, visualization and interaction service.

Chapter 4 presents a digital heritage project called ‘Reanimating Cultural Heritage’, which was implemented based on the DISPLAYS concept for reanimating cultural heritage objects in a digital space through images, videos, texts and other media such as 3D, within a virtual exhibition environment and then give them a new life. The RCH project focuses on integrating museum database repository such as ARCO (which stores museum digital heritage collections) with social networking repositories (which deposit user generated digital heritage collections). This allows museums to integrate their own digital heritage collections with community heritage knowledge in interesting visualization and interactive ways, enabling the end user communities to build their own digital heritage exhibitions.

Chapter 5 introduces digital technology solutions for reanimating cultural heritage. This chapter demonstrates digital technologies such as Web 2.0 mashups, social networking and 3D visualization and interaction, etc. These are potential solutions to enable communities to select user generated digital heritage content from social networking data repositories and create their own virtual exhibitions in a very interesting visualization and interactive environment.

Chapter 6 presents the design and implementation of a social networking system using Web 2.0 technologies, integrated with other digital technology solutions for cultural heritage fields, and particularly for the RCH project. This chapter demonstrates a Web 2.0 mashup solution for implementing a 3D scrapbook application to enable users to create and publish their own virtual exhibitions based on both user generated digital heritage content and actual museums’ digital heritage content. This chapter also demonstrates a Facebook application for RCH to enable communities to access and interact with digital heritage objects and collections from museums. For example, this Facebook application allows users to make comments on digital heritage objects and enables Facebook users to publish their comments along with the thumbnail of the associated digital heritage object onto the Facebook fan page (community) wall; it also allows visitors to see the community discussions on the home page of the project web site. Finally, this Reanimating Cultural Heritage social networking system is evaluated.

Chapter 7 concludes this research. This chapter includes an outline of the outcomes and contributions. Some ideas for future work are also described.

CHAPTER II

2 Literature Review

This chapter provides a review of the significant projects in digital heritage using modern 3D visualization and interaction technologies, and discusses the problems they attempt to address, technologies employed in order to address the problems, and the benefits and limitations for museums. This chapter then introduces Web 2.0 technologies such as social networking and Web 2.0 mashups, and demonstrates how Web 2.0 technologies can be utilized in digital heritage projects. Finally a selection of digital heritage projects that use Web 2.0 technologies are reviewed and discussed.

2.1 Projects in the Digital Heritage

Several ICT project consortia have worked in the digital cultural heritage area to address issues and problems that the institutions face. In the following paragraphs, examples of digital heritage projects using modern 3D visualization and interaction technologies are selected and discussed.

2.1.1 3D-MURALE

The first project is the 3D-MURALE (started November 2000, completed October 2003). This project produced new multimedia technologies for recording, cataloguing, conserving, restoring and presenting the archaeological findings based on the archaeological site at Sagalassos, which is one of the largest archaeological projects in the Mediterranean [18]. The project has developed a set of multimedia tools such as Recording tools, Recording Post processing tools, Reconstruct tools, Encoding tools, Visualise tools, and Database Indexing and Search tools, for measuring and building 3D representations of landscapes, buildings, statues of the archaeological site from photographs, pottery, stratigraphy, terrain geometry, etc. Furthermore, a multimedia database has been created for querying, storing and retrieving the texts, 2D images, the digital archaeological artefacts, buildings, and their reconstructions. Additionally, the tools have been implemented to allow the museum

content to be remotely visualised by archaeologists and members of the public over the Internet [19].

Figure 2.1 shows the virtual tours through signposts and the virtual guide in the 3D-MURALE system. An advantage of the 3D-MURALE project is that the MURALE visualization tool focuses on two types of users: one is an archaeologist who would focus on a very accurate visualization of the stratigraphic layers and the finds; the other is a normal visitor who would like to see a complete reconstruction of the site such as buildings or objects in former times. The disadvantages of the 3D-MURALE are that the user interaction part of the system is limited, and visitors can only navigate the 3D environment. This digital heritage system is not involved with Web 2.0 technologies, visitors are consumers rather than creators of the content in the archaeological site. Visitors cannot access further archaeological information from social networks, and users cannot drag and drop the archaeological content from social networks and museum's collections into a 3D environment to build their own virtual exhibitions.



Figure 2.1: Virtual navigation through signposts (top) and virtual guide (bottom) in the 3D-MURALE system [20]

2.1.2 3D-COFORM

The second project is 3D-COFORM (started December 2008). The project aims to create 3D digital documentation as a practical, affordable and effective tool for the documentation of tangible cultural heritage in cultural heritage organizations. 3D-COFORM improves the state-of-the-art in 3D documentation and data manipulation, for example, managing the artefacts captured, integrating metadata information with the 3D artefacts, investigating how to document digital artefacts efficiently and accurately, etc. Furthermore, 3D-COFORM addresses the practical aspects of achieving the results that can be applied in computing science research, and combines technical research in computer science with practical strategic planning and research in the business impact; this helps to accelerate the sustainable deployment of these 3D digital technologies to good effect in the real world [21].

Figure 2.2 shows the Multiview Dome Tool in the 3D-COFORM which supports the acquisition of cultural heritage objects with complicated surface materials. The advantage of the 3D-COFORM project is that the system developed advanced 3D digitisation technologies, and some new technologies such as portable dome and bidirectional texture functions, to process mass digitisation of 3D assets at a low cost. The disadvantages of 3D-COFORM are that the user interaction on the public domain is limited, and, additionally, there are no Web 2.0 technologies involved. Visitors just consume the content of the archaeological site, cannot access further information for 3D artefacts from social networks, while users cannot drag and drop digital heritage content from social networks and museum's collections into a 3D environment and create their own virtual exhibitions.

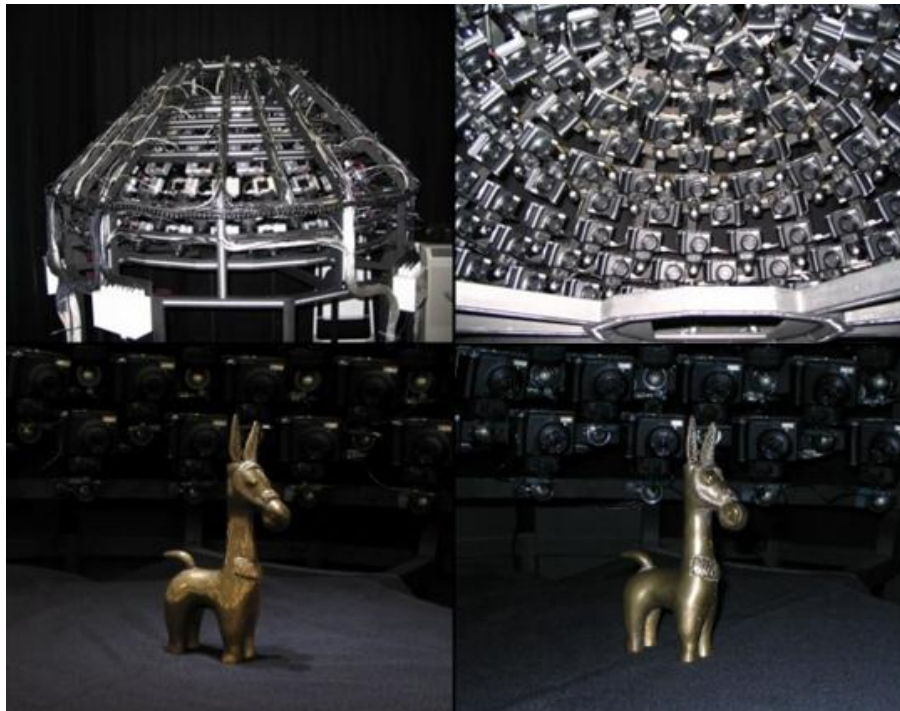


Figure 2.2: A precise 3D geometry of the object's shape and the representation of the object's surface materials in the form of a bidirectional texture function [22]

2.1.3 EPOCH

The third project is EPOCH (started 2004, completed 2008). The project aims to provide an organisational framework for improving the quality and effectiveness of the user interface between the information and communication technology and the cultural heritage that is presented in museums, sites and monuments [23]. In order to achieve the objectives, this project encompasses all the kinds of workflows of information, such as field recording and data capture, data organization, management and preservation, reconstruction and visualization, heritage education and communication, and dissemination, etc. [24]. Figure 2.3 shows the ARC 3D Webservice tool in EPOCH that allows users to reconstruct the cultural heritage model.

The advantage of the EPOCH project is that this system provides tools such as MeshLab, ARC 3D WebService and Interpretation Management to allow users to digitalize, manage, preserve, reconstruct and visualize cultural heritage artefacts easily. The disadvantages of EPOCH is that the system misses tools in the production pipeline of cultural communication, and additionally the system lacks Web 2.0 technologies that enable users to be not only content consumers but also content creators in archaeological sites. Users

cannot access further heritage information from social networks for better heritage education and communication, and they cannot select digital heritage content from user generated content collections and museum's collections and preserve them in a 3D environment.

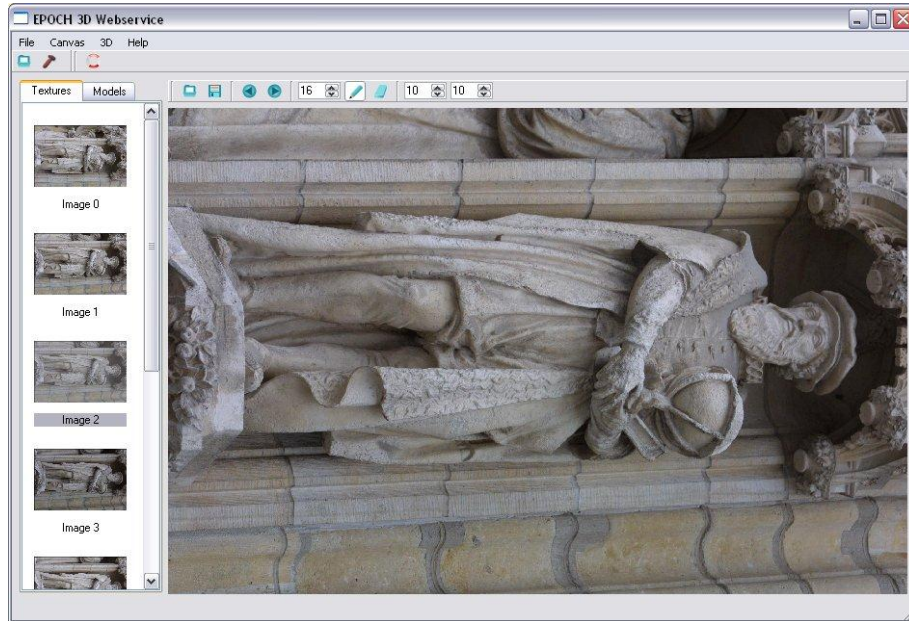


Figure 2.3: The Model Reconstruction Tool in the EPOCH project [25]

2.1.4 ARCHEOGUIDE

ARCHEOGUIDE (started January 2000, completed June 2002): this project developed a novel system to help visitors and scientists to have a better visiting and learning experience of the past glory of cultural heritage sites, by providing an interactive personalized AR guide [26] and reconstructions for the visualization of cultural heritage sites.

The archaeological site of Olympia, Greece, was used as a test case for the feasibility of the system. The system architecture comprises three modules which are the site information server, the mobile units, and the communication infrastructure. The site information server is a central PC consisting of a multimedia database that is utilized to archive digitalized cultural heritage artefacts, images, videos, audio and textual metadata information about the sites and monuments. A group of mobile units are formed into the client that is a wearable computer equipped with a special augmented reality Head-Mounted Display (HMD), a PC

camera, speakers, sufficient hard disk space, processing power and wireless connection to the system server [26].

The system provides users with an AR tour when they arrive at the site. The users are able to create their profiles to score their interests, the detail, the background and age, etc., at the beginning of the tour. Based on the profile information, the objects that constitute the tour, such as audio, image and VRML objects, can be ordered by the user [27]. Figure 2.4 shows the real time augmented reality presentation in the ARCHEOGUIDE system. In this diagram, users can view augmented reality of reconstructed monuments, for example, the temple integrated with the real environment.

The main advantage of the ARCHEOGUIDE is that the system provides users with real time AR views of reconstructed sites and monuments. The disadvantages of the ARCHEOGUIDE are that the effective use of the system depends on environment change when it is used in an outdoor environment, and the equipment for the system might be damaged in the outdoor environment. Additionally the system lacks the use of technologies to allow users to access and interact with the information of monuments such as text, images and videos from social networks, and users cannot put images and videos of digital heritage content from social network repositories and museum's digital heritage collections into a 3D environment and create their own virtual exhibitions.



Figure 2.4: Real Time Augmented Reality in the ARCHEOGUIDE system [28]

2.1.5 ITACITUS

ITACITUS (started September 2006, completed July 2009): this project aims to explore new ways of using AR to provide the mobile user with the most complete experience at cultural heritage sites. The AR application enables users to explore the information of cultural heritage sites by using a mobile computer. The user can immediately obtain further information such as virtual objects and on-site information in front of a place of interest when AR overlays the screen of the mobile computer. This effect allows users to navigate the real world on the mobile computer's screen, enhanced with further information such as virtual artefacts or information; the user can also possibly interact with the virtual objects by touching the screen or shaking the mobile computer [29]. Figure 2.5 shows an AR overlaying on a mobile screen in the ITACITUS system.

The main advantage of ITACITUS is that the system enables users to explore further digital information about the site as an AR overlay on a mobile computer screen in a direct way. The disadvantages of ITACITUS are that the AR effect relies on realistic lighting conditions: bad lighting conditions may ruin the AR effect. Additionally the system lacks the use of Web 2.0 technologies to enable users to access and interact with further digital information from social networks, and users cannot select digital heritage content from different user-generated collections and actual museum's collections and preserve them into a 3D world.



Figure 2.5: An Augmented Reality overlay on a mobile screen in the ITACITUS system [30]

2.1.6 AGAMEMNON

AGAMEMNON (started January 2004, completed June 2006): this project aims to explore an intuitive and innovative way of using third-generation cellular phones with an imaging and multimedia capability to provide users with a dynamic e-guide presenting them with their preferred historical and cultural information when they visit an archaeological site. The system allows visitors to establish their profiles in terms of their interests and the level of information that they want to acquire from artefacts, for example, a visitor may be very interested in historical details, while another may prefer to acquire detailed information about architectural aspects. Furthermore, the system will personalise the proposed route based on the visitor's interests and the available visit time to include the most interesting places for them. Additionally, the system introduces a new way to determine a visitor's attention by recognizing the monument from the image the visitor has sent, and provide back to the visitor the associated information such as 3D reconstruction and metadata information [31].

In addition, the AGAMEMNON system has more potential functionality to provide for an archaeological site. Firstly, it will allow visitors to interact with cultural heritage artefacts; for example, the visitors can interact with 3D heritage artefacts using different interaction technologies. Secondly, the system will allow visitors to create their own personalized visit routes. Finally, the system site manager will be able to better understand the behaviours and expectations of visitors by using image-based monitoring technologies [31]. Figure 2.6 shows the 3G-cellular phones or PDA mobile devices with imaging and multimedia capability in the AGAMEMNON system.

The disadvantages of AGAMEMNON are that the system functionality is restricted to the 3G-cellular phones' capabilities of processing power, network coverage and memory. Additionally the system lacks Web 2.0 functionality to allow users to explore and interact with multimedia from social networks, and users cannot drag and drop images and videos of cultural heritage artefacts from different user generated content repositories and actual museum's digital heritage resources, into a 3D environment and then save them for further exhibition.



Figure 2.6: A 3G-cellular phone shows the dynamic image and cultural information of a monument when the user visits an archaeological site [32]

2.1.7 CONNECT

CONNECT (started February 2004, completed July 2006): this project aims to develop an innovative framework to combine science teaching in schools with science learning in science centres or museum education. The project creates a network of museums, science centres and schools across Europe, to develop learning environments for students and teachers' playful learning. For example, it allows students to interact with instructional materials physically through 'hands on' experimentation, or intellectually through 'minds on' reflection. The CONNECT system provides users with an extremely interactive environment, the Virtual Science Thematic Park, by utilizing advanced information and communication technologies. The Virtual Science Thematic Park allows users to access education and scientific resources for educational purposes. For example, there is an educational scenario called field trips which allow users to virtually and conventionally visit science museums and parks, which tangentially learns the curriculum and visits curricular activities [33]. Figure 2.7 shows the interaction with objects in the Virtual Science Thematic Park of the CONNECT system.

The main advantage of CONNECT is that the system enables users to access the Virtual Science Thematic Park, visit the exhibitions and interact with virtual objects for playful formal and informal scientific learning. The disadvantages of CONNECT are that the remote AR visit of virtual exhibitions relies on broadband connections: bad broadband connections may ruin the remote AR visit. Additionally the system lacks Web 2.0 functionality to enable users to access and interact with further information from social networking, and contribute their knowledge for user communities. Furthermore, users cannot drag and drop images and videos of digital objects from social networking and actual science museum's digital collections into a 3D world to create their own virtual exhibitions for better scientific learning, and users cannot save the 3D exhibition they have created for further exhibition.

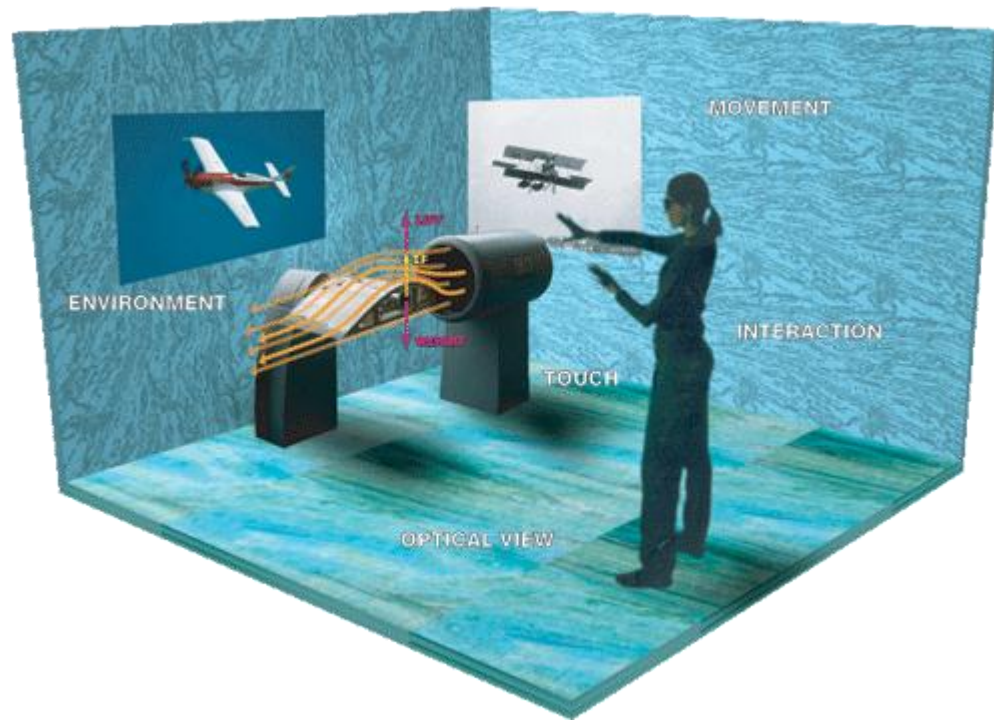


Figure 2.7: The interaction with objects in the Virtual Science Thematic Park of the CONNECT system [34]

2.1.8 TOURBOT

TOURBOT (started January 2000, completed December 2001): this project aims to find a new interactive way to provide access and personalised guides to museums' exhibitions and cultural heritage artefacts over the Web [35]. Several other digital heritage projects, such as ARCHEOGUIDE, ITACITUS, AGAMEMNON, and CONNECT, which have been described in this section, utilized virtual reality, augmented reality interaction technologies to provide online or onsite solutions, while the consortium seems to think this type of interaction technology is not enough for visitors use to interact with museum artefacts over the Internet.

The TOURBOT project developed an interactive tour-guide robotic system with advanced navigation capabilities to allow people to interact with museums' exhibitions and cultural heritage artefacts over the Internet. The system enables the user to interact with the robot through a multimedia web interface and to specify target exhibits. The robot is equipped with a camera that is used to provide real time streaming to the part of the exhibition the user wishes. Additionally, the multimedia web interface provides the user with personalised

access to exhibitions with a great deal of additional information [36]. Figure 2.8 shows a robot in the Deutsches Museum in Bonn.

The disadvantages of the TOURBOT are that the remote navigation to a museum gallery from a robot may cause problems when the robot is open to the public. Additionally, the multimedia web interface in the TOURBOT system is not involved with Web 2.0 technologies so visitors cannot access and interact with additional information from social networks. Furthermore, in the multimedia web interface, users cannot drag and drop images and videos of artefacts from different user-generated content repositories and actual museum's content collections into a virtual environment to create their own museum exhibitions and then preserve their own defined exhibitions for further exhibitions.



Figure 2.8: The Robot RHINO in the Deutsches Museum, Bonn [35]

2.1.9 ARCO

ARCO (started October 2001, completed October 2004): this project aims to develop an innovative system for creating virtual representations of museum objects utilizing image-based modelling technologies. The system is specially designed for museums to allow them to build their own virtual exhibitions including 3D virtual galleries. The ARCO system provides augmented and virtual reality interfaces to visualize the virtual representations of museum artefacts using X-VRML visualization technology. X-VRML is a high-level XML-based language designed to enable dynamic modelling of virtual reality [37]. The

ARCO system creates tools for content creation, content management, exhibition and interactions. Several museums, such as the Victoria and Albert (V&A) museum and the Fishbourne Roman Palace, are used as test cases for ARCO [38]. Figure 2.9 shows the ARCO virtual reality interface for remote web browsing.

The main contribution of the ARCO project is that it provides an integrated database-driven software architecture for museums to digitalize, archive, retrieve, exhibit and interact with cultural heritage artefacts. The disadvantage of ARCO is that the system lacks Web 2.0 functionality to allow users to access and interact with community contributed digital heritage objects and collections. Furthermore, users cannot select images and videos of digital heritage objects from different social networking repositories and actual museum's digital heritage resources and preserve them into a 3D world, nor can they publish their own created exhibitions into a server for a further exhibition.

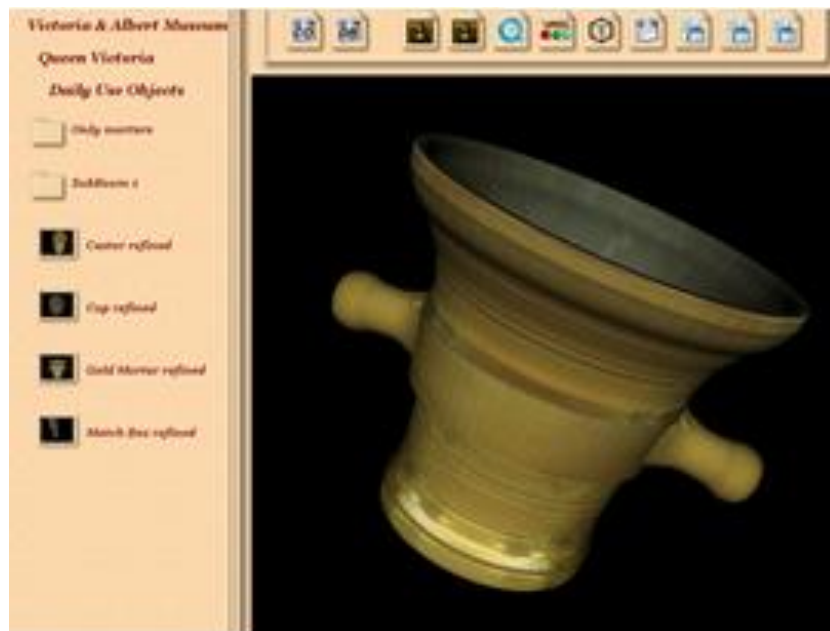


Figure 2.9: Virtual Reality Interface for remote web browsing in the ARCO system [39]

2.2 Web 2.0 Services

In recent years, more and more users have become involved in a variety of Web 2.0 environments, such as Facebook, Flickr, YouTube, Wikipedia, Del.icio.us, etc. Through Web 2.0 services, users can integrate new content from the other data sources, label data sources by means of tags, share knowledge and make comments, and so on [40].

Web has two generations: Web 1.0 and Web 2.0. Since the days of the dot-com crash, Web is changing and growing. In 2004, Dale Dougherty of the O'Reilly Media Company coined Web 2.0, which was upgraded from Web 1.0 [41]. The key difference between Web 1.0 and Web 2.0 is that contents in Web 1.0 are from offered sources only; users are not creating content but simply consuming content (e.g. you can only access Yahoo Weather or Google Sports, etc.) as with the research reviewed above. In Web 2.0, however, the contents could be from different sources and any user could be a content creator [42]. Web 1.0 companies built products, and services controlled data, which was isolated from the other data from other sources (e.g. there is no way to integrate travel information with a local weather forecast, or merge information about restaurants with a Google map of that area). Web 2.0 updated business models from Web 1.0 and represented a way to get different data across different services through opening up the customer data that the products and services controlled in Web 1.0 [41].

There are a number of useful web-based services offered by Web 2.0. These services are commonly used as existing data sources integrated in web-based applications. These include social networking, Wikis, Blogs, Tagging (Folksonomy) and social bookmarking [43].

2.2.1 Wikis

Wikis are web sites that can be easily edited by users who are allowed access. This functionality makes wikis a tool for collaboration over the Internet. Wiki was developed by Ward Cunningham in 1994. Users can visit, read, edit and update the structure and content of the wiki page. Wikipedia (<http://en.wikipedia.org/>) is a popular online wiki site that is a collaborative tool to facilitate the production by group works. Anybody who visits Wikipedia can edit and update the content of the site if they wish [44].

Wikis have two types of writing mode: the first is called 'document mode'. In document mode, contributors create and leave their documents to the wiki document unsigned. After that, many other authors edit and update the content of that document, and then gradually the content of the document becomes shared knowledge. Another wiki writing mode is called 'thread mode'. In this mode, contributors post signed messages to discuss in the wiki

environment, and eventually a group of threaded messages emerges and becomes shared knowledge [45].

Wikis have two states; are read and edit. Read state means the wiki page is like a normal web page on which people can read the content: Wikis are in read state by default. The wiki edit state is for users to edit the page. Wiki web sites have an edit button that allows users to click and access a free online editing tool to edit the contents of the web page in question [46].

Wikis normally have a 'history' feature that enables users to examine previous versions of the document, and a 'rollback' function that enables users to restore the previous versions of the document. These functions make wikis easy and extremely flexible to use for group working in an online environment [45]. The key advantage of wikis is that they are easy to use, anyone can edit them and people can work on the same document in a collaborative environment. The key disadvantage of wikis is that it may be too open for some applications, such as confidential documentation, because anyone is able to edit the content [47].

2.2.2 Blogs

A blog was coined by Jorn Barger in 1997. Blogs are websites where entries of different types of content, such as brief paragraphs of opinion, information, personal diary and links, together called 'posts', are commonly displayed chronologically with the most recent first, in the style of online journals. Users who maintain blogs are named 'bloggers', the action of posting contents to a blog is called 'blogging', and a collection of blogs and their interconnections are formed into 'blogosphere'. Most blogs also enable users to add comments below the entry of a blog [48].

Yochai Benkler, a Yale University law professor, called the process of posting and commenting contributions to blogs as a 'weighted conversation' between the main author and a group of comment contributors. Most blog platforms enable the administrator to invite and add other users as authors, which allows individuals to access and write contents to their web pages [48].

Blogs use tags for posts, for example, each post normally has one or two keywords as tags, which enables the categorization of the subject of the posts within the blog system. When new data is entered into the blog, the old post can be filed into a standard theme-based menu system. The user can click on the description or tag of a post to see a list of other posts that have been written by the same author, and use the same tag within the blogging system [45].

Blog linking is also a useful tool for blogging that helps users to retrieve and reference information on different blogs within the blogging system. For example, the user can link to other users' blogs and put their opinions on it, the user can even correct the other user's view when he is wrong in the first place. The user can also reference the other person's work when extracting some parts from it. Some of this blog linking has inherent problems. For example, the 'permalink' is a URL that is generated by the blogging system and points to a specific blog or post. A permalink remains unchanged indefinitely: even if the content is moved from the database, the permalink stays the same. Furthermore, if the post is renamed or the content is changed, the permalink will still stay unchanged. In the blogging system, there is no version control, which is a disadvantage of blogs compared with wikis (i.e. wikis commonly have the 'history' and 'rollback' functions that can examine and restore previous versions). Using a permalink, therefore, cannot guarantee the content of the post is the correct one the user wants [45].

Blogs have another function that is 'syndication'. Blog syndication makes information of the blog entries, such as the headline, available to other blogs, RSS feed and so on. The content of the blog is then aggregated into the blog feeds and the blog feed readers and aggregators can then make use of these blog feeds [45].

The key advantages of a blog are it allows users to share their knowledge with other people, to make friends with other users online, and it can be used as a diary to record the things around the user. The key disadvantage of a blog is that it is hard to maintain [49].

2.2.3 Tagging and Social Bookmarking

Tags are keywords that are attached to a digital object such as a web site, image or video to describe the content of it. For example, ‘del.icio.us’, which is one of the first large-scale tagging applications, launched the ‘social bookmarking’ phenomenon [50].

Social bookmarking is a method for users to share, organize, search and manage bookmarks that reference web resources. So the difference between social bookmarking and file sharing is that social bookmarking shares merely bookmarks that reference the resources, not the resources themselves [50]. Social bookmarking systems allow users to create ‘bookmarks’ or ‘favourites’ that are shared with other users of the system. These bookmarks can also be tagged with keywords, which is called ‘social tagging’ or ‘folksonomy’.

Social tagging has been widely used over the web. For example, third party services such as Flickr and YouTube allow all kinds of digital content to be socially tagged. The BBC’s Shared Tags project [51] is an experimental online social tagging service that enables members to tag BBC News content online. There is another typical social tagging example in academic fields, created by Richard Cameron, called CiteULike [52]; this is a service for academics to archive, manage and share their academic papers. CiteULike can automatically extract the citation details of an academic paper when the user adds the paper into the system [45].

2.2.4 Social Networking

The Internet has produced different kinds of information sharing systems, including the World Wide Web. Recently, online social networking has become more and more popular, and social networking sites are now among the most popular sites on the web. The number of users participating in social networking has increased dramatically in recent years. Social networking sites such as Orkut, MySpace and Facebook [53] allow millions of users to create their profiles, and share their interests and content, with other users such as friends, colleagues and strangers on the network. For example, MySpace is a popular social networking site; this site had over 190 million users in 2007. Orkut has over 62 million users [54]. Facebook has become the world’s most popular social networking site in recent

years, and this site had reached over 350 million users worldwide towards the end of 2009 [55].

The web mainly focuses on content, but online social networking is largely organized around users. For example, users could join a network through a social networking site; they can publish their profile or any other content such as images, videos and so on. They also can create links to any other people with whom they associate, such as those with similar content, similar interests, etc. Social networking provides a powerful means of maintaining social relationships, for finding contacts with similar interests, and for sharing and organizing content that has been contributed by other people [56].

Social networking has existed since the Internet emerges, but the concept of social networking is difficult to define. In 1996, Wellman stated that social networks are relations among people who are important or relevant in some way [54]. To date, online social networking sites have developed rapidly, and some social networks have become more and more popular, e.g. Flickr, YouTube, Orkut and Facebook, etc. Online social networking sites are often organised by individual corporations such as Yahoo and Google. Users, Links and Groups are often the main topics in social networking sites.

Users: Social networking is largely organized around users. To participate in a social networking site, users first need to register with the site. During the registration, users need to fill in personal information (e.g. date of birth, place of living, or interests, etc.), and this information may appear in a users' profile. Some social networking sites may allow users to browse some public information without signing up or signing in [54].

Links: Social networking mainly includes user accounts and links between users. Through the links, users can communicate with other users; they can share interests or they may be interested in each other's contributed content. The function and purpose of user links in social networking is similar to the purpose of hyperlinks and bookmarks in the Web. A user could visit the other user's account and look at this user's links along with his profile. In this way, users could explore the social network by following user links, browsing the user profile information and contributed content. For example, Facebook is a social networking site that allows users to access the other users' accounts, follow the users' links, browse the

other users' profiles (i.e. users can only view the profile information that is set to be visible by the owner), and so on [54].

Groups: A lot of social networking sites allow users to create or join groups with a special interest. After users join this special interest group, they can post messages or contribute content to the group. Some groups are restricted: joining this group, or posting messages or content to this group, is controlled by the administrator of this group. Most groups are open to allow any members to join and post messages or contribute content [54].

Online social networking is already playing an important role in some very popular web sites. As the technology develops, more applications that involve social networking will emerge, and social networking is going to play a more important role in future personal or commercial interaction and organization of web information and content [54]. Social networking provides a way for people to socialize and interact with each other across the Internet. It enables people to share interests and contribute digital content (e.g. photos, videos, music, etc.) with their friends, colleagues, family and or even strangers [56].

People can utilize social networking technologies to socialize with the other people on the web in many different ways. There is one kind of social networking that is typified by 'shared interest focus': Facebook, Orkut and MySpace are such social networking sites. These websites focus on sharing interests and communicating information between people. There is another kind of social networking typified by 'user generated digital content focus', and Flickr and YouTube are classic examples of this. These web sites focus on sharing digital content, for example, images (photos), videos, and so on.

In the existing digital heritage projects, there are some examples of using the 'shared interest' focused online social networks, such as MySpace, to allow users to share their interest and communicate information with each other. There are also some examples of using the 'user generated digital content' focused online social networks, such as Flickr and YouTube, to deposit digital heritage objects and collections generated from users. However, they just allow users to consume Web 2.0 social networking expositions that have already been built. Users cannot access and interact with digital heritage objects and collections, or contribute knowledge associated with these digital heritage objects, into the social

networking communities. Furthermore, in existing heritage projects, users cannot create their own virtual exhibitions based on user-generated digital heritage content. This will be discussed in more detail in Section 2.4.

2.2.4.1 Facebook – A Shared Interest Focus

Facebook is a popular online social networking community where users who are subscribed to Facebook can create or join many different types of groups and networks that focus on different types of shared or common interests. Members can create their own profiles that describe their own information and activities. Facebook members can be organized by many different kinds of groups, e.g. school, university, company, organization, etc., and users who join a Facebook group can communicate with other members within that group [57].

Like other social software tools such as MySpace, Friendster, and MeetUp, Facebook allows users to create their own profiles and make connections with other members; when users add other members as contacts, then those members are listed as ‘friends’. Other features, such as the ability to create and join groups of shared interest, and the ability to post photos and send messages, are also incorporated into Facebook.

Facebook, as an online social network, serves a number of purposes, for example, for ‘social searching’, finding out user information when users are offline, and for ‘social browsing’, developing new connections with new people. Facebook may also serve a surveillance purpose, which allows users to track the activities, comments and interests of their friends or the groups they joined. Facebook also enables a user who is not currently another member’s friend to view this member’s personal profile, and this function may be a way to increase the size of a member’s social circle [53].

Since Facebook introduced their first version of the Facebook API in 2006, hundreds of companies have utilized these APIs to dynamically connect with the information from Facebook. In 2007, Facebook announced Facebook Platform, and many developers started to build applications within Facebook. In 2008, Facebook launched Facebook Connect, which enables users to ‘connect’ their Facebook identities to any web site. This allows developers to implement applications using more Facebook Platform functionalities outside

of Facebook [58]. One of the most popular features of web sites using Facebook Connect is the Facebook Comments Box, which enables users to login to Facebook and comment with their Facebook accounts. The Facebook Comments Box is a great way to allow users to add social comments on web sites. For example, Facebook users can comment on your web site content by logging in to Facebook, posting their comments to their profiles and sharing with their friends. Non-Facebook users can also add their comments on web sites by filling in their name, email address and security check characters [59].

There are some online tutorials showing how to use Facebook Comments Box in your web site. For example, there is an online example which shows how to add Facebook Comment Box into the Travel to Less Social Website [60]. However, the Facebook Comments functionality has not been integrated into existing digital heritage systems to allow Facebook users, or non-Facebook users, to make comments on all the digital heritage objects and collections from museums. There are some online examples that show how to publish Facebook users' comments from a normal comments box onto the Facebook community. For example, there is an online tutorial that shows how to publish a message on the Facebook fan page [61]; however, they can only publish Facebook users' messages from a normal comments box, not from the Facebook Comments Box. Furthermore, those examples can only publish users' messages using one Facebook account and they cannot publish different Facebook users' comments onto the Facebook community. In addition, existing digital heritage systems lack the Facebook Comments Publishing functionality that allows Facebook users to publish their comments, along with the thumbnail of the associated digital heritage object, into the Facebook Community. This would allow users to contribute their heritage knowledge based on the museum digital heritage collections into the Facebook community. Other users in this community still can comment on previous published comments about the digital heritage object that are already displayed on the wall of the Facebook community in order to share their own heritage knowledge. Existing digital heritage systems also lack the Facebook news functionality that allows the display of the latest news of the Facebook community on the home page of the project web site; this would tell the administrator or visitors that someone has contributed their knowledge into the community.

There are other applications that use Facebook technologies. For example, there is a sample Facebook application with CodeIgniter that is implemented by connecting with a Facebook API [62]. Another Facebook demo application called Footprints is also implemented using a Facebook API [63].

2.2.4.2 YouTube and Flickr – A User Generated Digital Content Focus

Flickr (www.flickr.com) is a popular online photo-sharing and social networking site. In 2008, Flickr announced that it had hosted more than 200 million photos, which makes it one of the largest photo-sharing systems in the world [64]. Flickr users can upload photos into a Flickr repository, or tag photos in Flickr and share them with their friends or other people. Users could invite friends to join in the Flickr community, or users can add an existing Flickr user as their friend. Flickr allows users to add a title to, describe and tag their own images; it also enables users to organize their photos into photo sets. Flickr has two main differences compared to other photo-sharing sites, such as PhotoBucket, and social networking sites such as MySpace: firstly, Flickr images that are assigned as ‘public’ are viewable by anybody using pull technology. This technology opens some images of owners to everyone that some users find very useful because they could easily retrieve and find any images they desire from Flickr, while this activity is less intrusive to owners. Secondly, Flickr is mainly about images, unlike some sites that treat images as annexes to text [65].

As the practice of online public photo-sharing grows, a large amount of public photographs are available online. Online photo-sharing sites like Flickr hold billions of images which record the culture and environment. As a community-contributed media collection, Flickr could enhance and improve the ability to access user-generated multimedia resources and understand the knowledge of culture and environment [66].

YouTube (www.youtube.com) is a public video-sharing and social networking site where people can view and share videos with other people. Since February 2005, when the YouTube website was established, YouTube has provided a new generation of short video sharing service for people to watch online videos and add their comments. In recent years, among many networked video sharing applications, YouTube is the most successful on the

Internet with over 100 million videos being watched every day, and 65,000 video uploads every day [67].

YouTube allows users to easily share their videos and tag their uploaded videos with keywords which best describe their video content. These tags can be utilized by YouTube for searching and then providing a list of related videos for users. Social networking, plenty of tagging, and an abundance of user-generated video content make YouTube the largest video sharing web site [68].

One of key reasons for YouTube's success is that YouTube is using Adobe Flash technology to display all kinds of video content, such as video clips, music videos or movie videos. When users upload video content in different video formats such as WMV, MPEG, AVI and RMB, YouTube converts them into FLV format and then posts them on to the website. This is very convenient for users because they only need install Flash Player in their computer without downloading any other additional browser plug-ins [67].

Social networking sites like Facebook provide the 'shared interest' focus functionality to allow communities to communicate with each other; this research also needs community-contributed media collections for users to deposit shared Sierra Leone digital content for the RCH project. For this purpose, this research proposes to utilize YouTube and Flickr features – the sharing of user generated video content and image content – and integrate YouTube and Flickr repositories as parts of Web 2.0 mashups to access user-generated digital content. There are other applications using Flickr and YouTube technologies such as 'Jotle' which is a Web 2.0 mashups application integrating Flickr, YouTube and Google Maps [69].

2.3 Web 2.0 Mashups

2.3.1 Background

Mashups represent a new generation technology for creating novel web-based applications that aggregate or mashup open and subscribed data from different data sources, such as YouTube, Flickr, Yahoo, Facebook and other third party services, into one new unique application. As the name implies, a mashup usually combines and 'mashes' different

elements from different companies' services, and then displays these data in a meaningful way that can enable users to easily identify useful information [70]. Mashups usually integrate content from third parties like Yahoo, Flickr, and YouTube through third party web services. Those third-party companies, such as Amazon, Flickr, Google, Yahoo, and YouTube, have published Application Programming Interfaces (APIs) through a web service based on web standards that allows users to utilize their complicated functionalities [41].

The paragraph above has explained what mashups are: the following paragraphs will discuss the history of how mashups evolved in web technologies and which technologies are used to create mashups.

The term mashup comes originally from the music industry, where artists remix two or more music recordings into one new entity. A typical example is the Grey album, which mixes and 'mashes' The Beatles' White album and Jay-Z's black album. Wikipedia defines mashup as a web-based application that combines content from more than one data source [71].

The history of mashups is difficult to explain without tracking the history of the web, because mashups were born as web technologies developed. From a technical perspective, the web can be defined as products, services or business models that are implemented through the Internet platform. Web 2.0 updated business models from Web 1.0, and represented a way of getting different data across different services through opening up the customer data that the products and services controlled in Web 1.0 [42]. A popular innovation in Web 2.0 is 'mashups', which enable the retrieval and control of data from different data sources using the open APIs provided by different service providers such as Yahoo, YouTube and Flickr. For example, on a restaurant web site (where all the information is presented such as the history of the restaurant), all kinds of restaurant services are stored in a content management system that is also linked with a Google map web site to visualize the location.

Since Web 2.0 was founded, there has been a significant shift in Internet traffic because the number of people using Web 2.0 web sites is increasing. Yahoo's Tom Coates instituted a

phrase, ‘a web of data’, which describes the web as changing from many websites providing isolated content to websites that link to many more interconnected websites; these in turn provide different shared and manipulated data that allows users to easily identify information. The Web 2.0 environment attracts developers to take this technology much further, developing new novel web-based applications by ‘mashing’ different data and functionalities from sets of content service providers to implement Web 2.0 mashups [72].

Mashups technologies are derived from the evolution of Internet technologies, especially the transition from Web 1.0 to Web 2.0. Web 2.0 makes the web dynamic, and the web content is no longer only a ‘static’ mark-up document (e.g. HTML document), but also contains more ‘dynamic’ data that can be consumed through web services such as REST, SOAP or ATOM, etc. [41]. Figure 2.10 shows the evolution of web technologies that serve as the foundation for developing mashups.

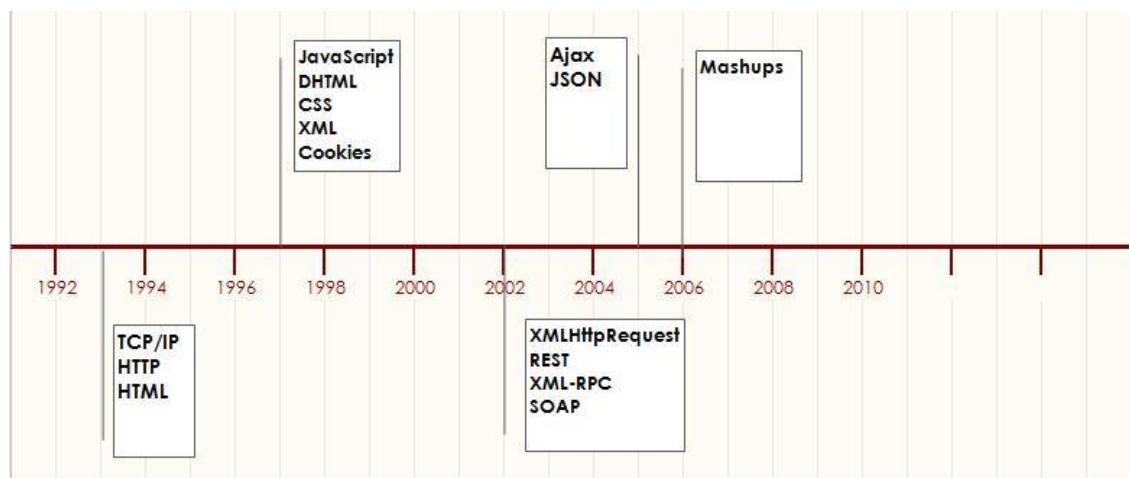


Figure 2.10: Mashups technologies timeline [41]

The timeline diagram above shows when particular mashups technologies were created and widely adopted by the overall community. These mashups technologies will be explained after they are further categorized into the different roles they play in the mashups development. Figure 2.11 shows the categorized mashups technologies relating to the roles they play in the implementation of mashups.

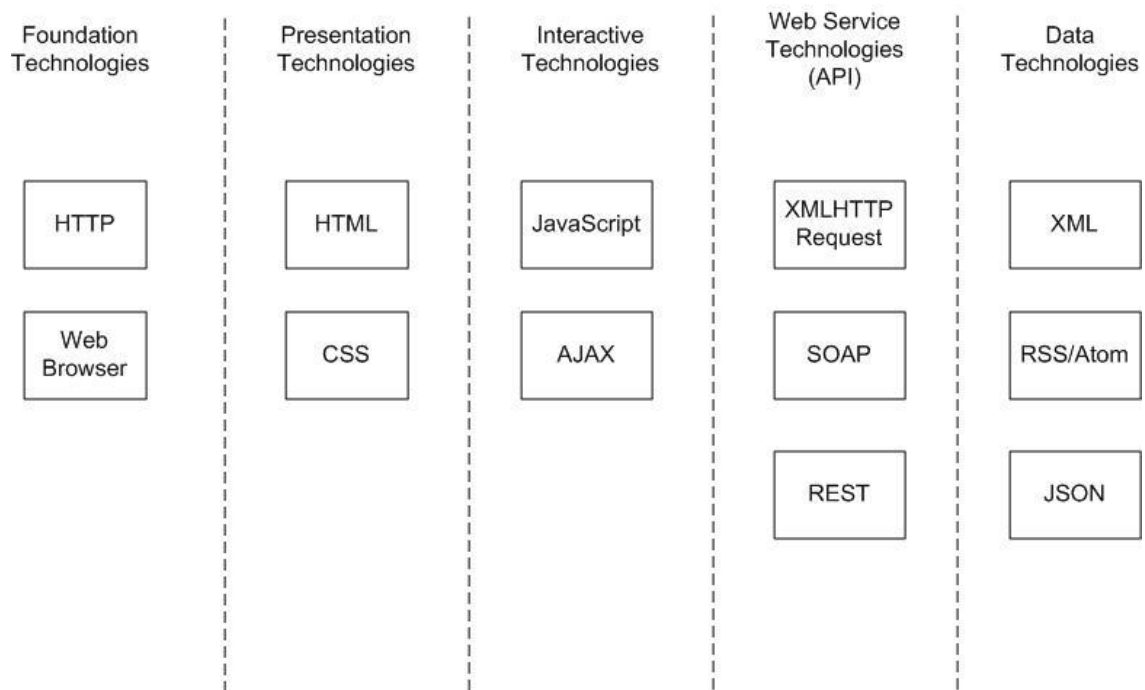


Figure 2.11: Categorized technologies relating to the roles they play in mashups [41]

When creating mashups, there are two foundation technologies – HTTP and web browser that provided for all the other technologies.

Hypertext Transfer Protocol (HTTP) is an application layer protocol that enables clients to navigate the web [73]. A client can submit an HTTP request for a web page to a remote server, and the server sends the content (web page) they request back to the client and enables the client to access that web page. Web browser is a software application for displaying, retrieving and interacting with information resources such as text, images and other content on the web [74]. The web browser could retrieve information resources from remote servers through the HTTP. There are a lot of web browsers that can be used, e.g. Internet explorer, Firefox, Google Chrome, and so on.

Presentation technologies are used for rendering the look and feel of a user interface to make the interface attractive to users. HyperText Markup Language (HTML) is the predominant mark-up language for creating web page structures. It describes a means of creating the structure of text based documents through denoting text such as headings, paragraphs, links, lists and others [75]. Cascading Style Sheets (CSS) is a language for users to describe the presentation style, such as the look and formatting of a document

written in a mark-up language like HTML, by defining style rules to specify how mark-up should look [76]. HTML and CSS are usually both utilized for the presentation of a web interface.

The interactive technologies are used for creating the dynamic behaviour of a web site, for example, showing or hiding web content, dragging and dropping the content, the animation of the content, and so on. JavaScript is an object-oriented scripting language used for web browsers to provide interactivity and dynamism to websites. JavaScript (originally called LiveScript) was originally created by the Netscape Communications Corporation in 1995; Microsoft used JavaScript in its browser Internet Explorer in late 1996 [77]. JavaScript was designed to have a similar look to Java, not related to the Java programming language and be easier for non-programmers to work with.

Asynchronous JavaScript and XML (Ajax) is a group of web development techniques like Document Object Model (DOM) [78], JavaScript and XML, for creating interactive web applications on the client side. Ajax was coined by Adaptive Path's Jesse James Garrett in 2005 [79]. With Ajax technology, web applications could load data from the server asynchronously in the background without interfering with normal page loading, and without requiring the entire web page be reloaded each time when users request a change [41].

Mashups use web service technologies to access third-party repositories and use their functionalities. When companies want to create APIs for users to access their products and use their services on the web, web services are the means to do the job. Developers could utilize existing companies' web services to create rich Internet applications (RIAs) [79]. APIs are interfaces implemented by software programs to provide applications for accessing external services or databases. Web services APIs are now exposed by some companies as a way of sharing their functionalities and services on the Web [80]. Many Web 2.0 companies such as Amazon, Yahoo, YouTube and Flickr, provide APIs to encourage people to use their services and data in the implementation of mashups.

XMLHttpRequest is a DOM API that can be used in JavaScript, sending data to or from a web server by utilizing an HTTP or HTTPS. There are many web services available to call

on for creating the API – XMLHttpRequest. XMLHttpRequest is an important part of Ajax technology and used for many dynamic web applications [41].

Simple Object Access Protocol (SOAP) is a web service protocol for exchanging structured XML-based information over computer networks. SOAP forms the foundation layer of web services, and provides a message framework on which web services can build [81].

Representational State Transfer (REST) refers to a style of web service using HTTP URLs for function calls. REST was originally proposed by Roy Fielding in his doctoral dissertation in 2000. RESTful web services are simple web services implemented by using HTTP and REST. Every operation in RESTful web services uses one unique URL, so the server will immediately know how to perform the operation when it receives a request call from a client. This web service could be used in a program or directly in a Web browser, and the results of some particular operations in web services can be cached locally in a web browser in some cases, which makes requests for the same operation faster by loading content from the cache of the web browsers rather than loading from the server [82].

Compared to REST-based web services, SOAP requests must be deciphered when they are sent and received by the server and the server then decides which operation to perform and how to perform that operation; SOAP does not provide a solution to cache the results of operations. For these reasons, RESTful web services could make requests faster when SOAP and REST-based web services are both used in a program [83].

How data goes through mashups? There is an important data format used in mashups to send, receive and cache data. Extensible Markup Language (XML) is an important data technology used in mashups. XML is widely used for representing the data using elements to provide structure; for example, it can be used in web services [84]. HTML represents data in the same way. The key difference between XML and HTML is that, with XML, you could create your own custom format by using your own method of representing data, while HTML is written in the form of an HTML element and just used for marking up web pages.

Really Simple Syndication (RSS) is a family of web-feed formats for publishing frequently updated content such as blog entries, news, audios, videos and podcasts. An RSS document

is usually called a ‘feed’, ‘web feed’ or ‘channel’, which contains full text and metadata from associated web sites. Web feeds benefit users who want to subscribe to frequent updates from some favourite websites, or to grab feeds from other sites into one web site [41]. The Atom Syndication Format is an XML language which is used for web feeds.

JavaScript Object Notation (JSON) is a lightweight data interchange format for representing data structures and objects. JSON format was originally specified by Douglas Crockford and usually used for transmitting structured data over a network [85].

JSON and XML formats are both used for asynchronously transmitting structured information between a client and a server. The key difference between JSON and XML is that JSON is much easier and shorter to configure. For example, in XML you could go 7000 lines for only 75% of data configuration. However, in JSON you could actually reduce to 1500 lines for data configuration. So JSON is far easier and more controllable [86].

2.3.2 Related Work

Mashups provide a platform for innovation where developers can demonstrate their creativity and create novel web-based applications in many ways by accessing data sources. The following paragraphs review the most novel, innovative and relevant mashup implementations.

Picnik [87] is a Flash based application allowing users to edit photos directly from their web browser. Picnik functionality has been added to Flickr so that users can edit a photo from Flickr by using the Picnik interface. Figure 2.12 shows the Picnik editing interface within Flickr. The main advantage of Picnik is that it has advanced editing features and capabilities, such as exclusive effects, Touch-Up Tools, FontShop fonts, Fancy Collage and Curves, etc. Picnik would be useful for editing digital heritage object images from digital heritage resources.

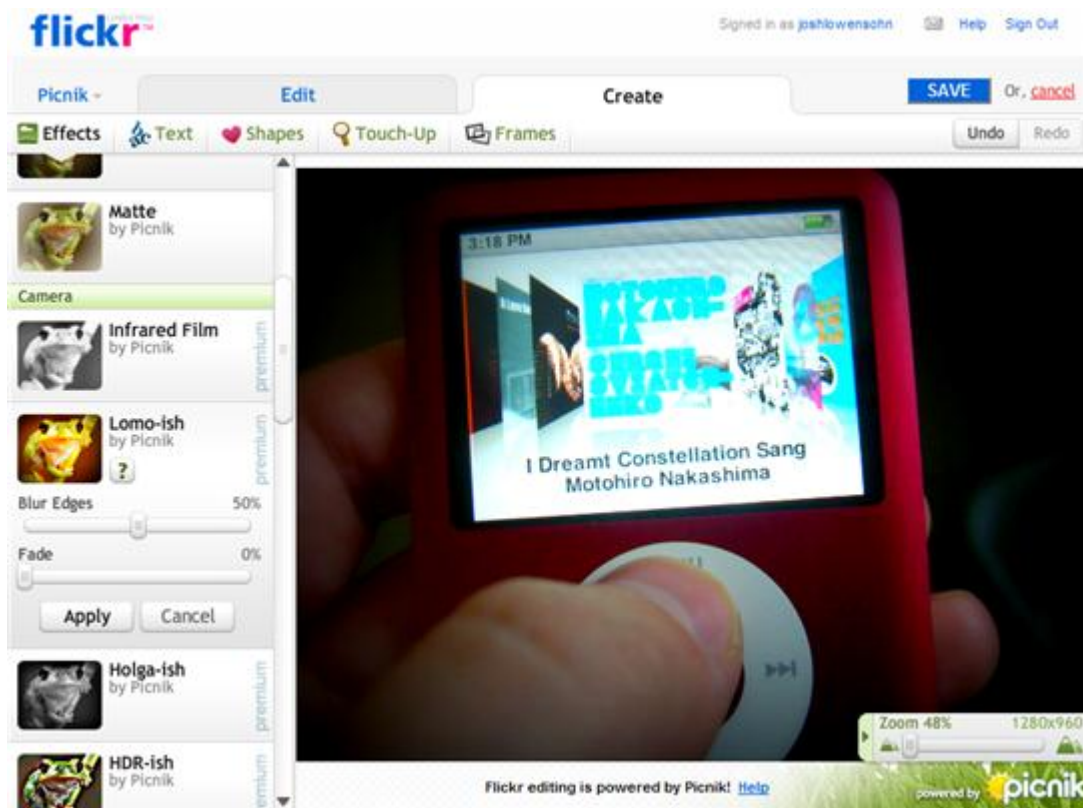


Figure 2.12: The Picnik editing interface within Flickr [88]

Housingmaps.com [89] is a mashup website that integrates Google maps and real-estate listings from Craigslist (a popular free online classified advertisements service [90]) to create a map marked with available housing listings. Mashups with maps is very popular in many web sites enabling users to identify a location. Figure 2.13 shows the web mashups integrating Google maps with available housing listings from Craigslist in Housingmaps.com. The main advantage of the Housingmaps.com mashup is that it combines available housing information with Google maps so that visitors can easily see both the location and house information of these available housing listings. The method of integrating Google maps with data from other sources in Housingmaps.com could be useful in the digital heritage area to allow users to easily find the location of digital heritage objects.

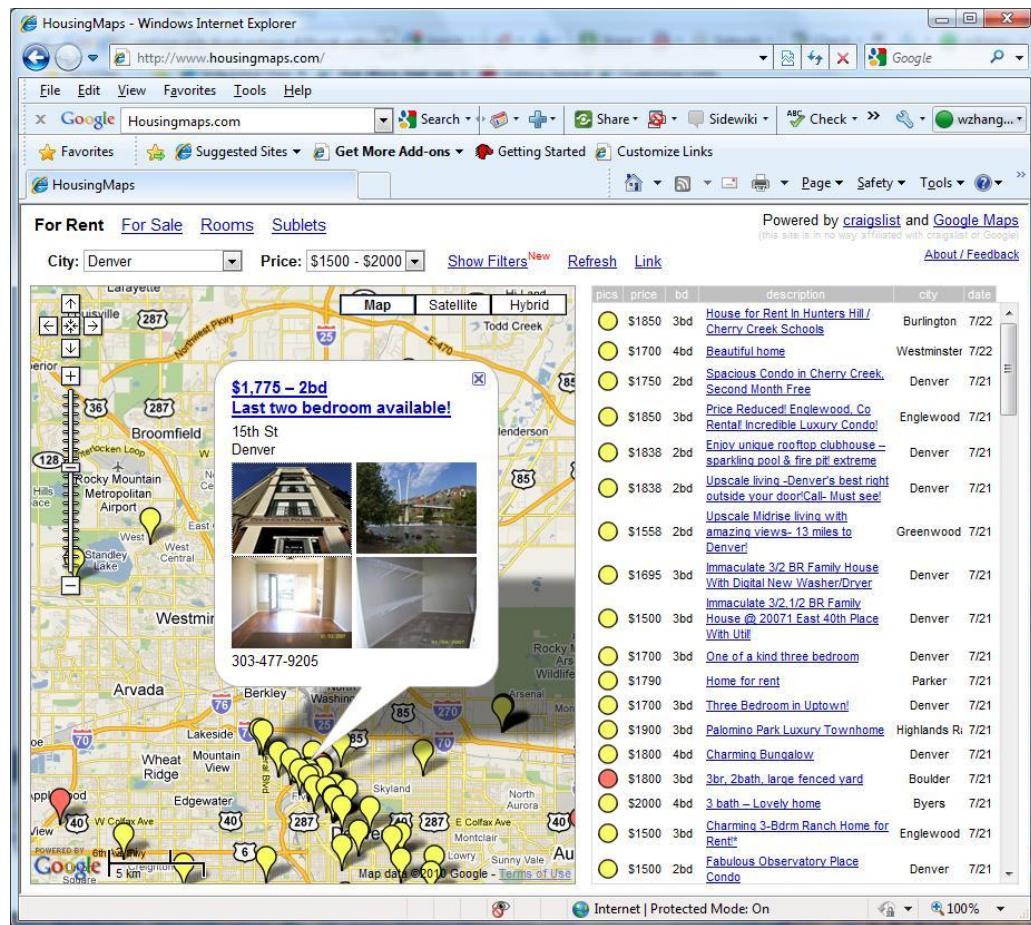


Figure 2.13: The mashups integrating Google maps and house listings from Craigslist in Housingmaps.com [89]

Flappr [91] is a mashup that is built on the Flickr APIs, and provides a complete new interface that could be used for consuming data from photo-sharing web sites. Flappr also provides impressive flash technology for viewing and browsing through large photo collections. Figure 2.14 shows the Flickr mashup in Flappr. The main advantage of Flappr is that it allows users to access large Flickr photo collections from a very impressive flash user interface. Flappr would be useful to access digital heritage photo collections from Flickr.

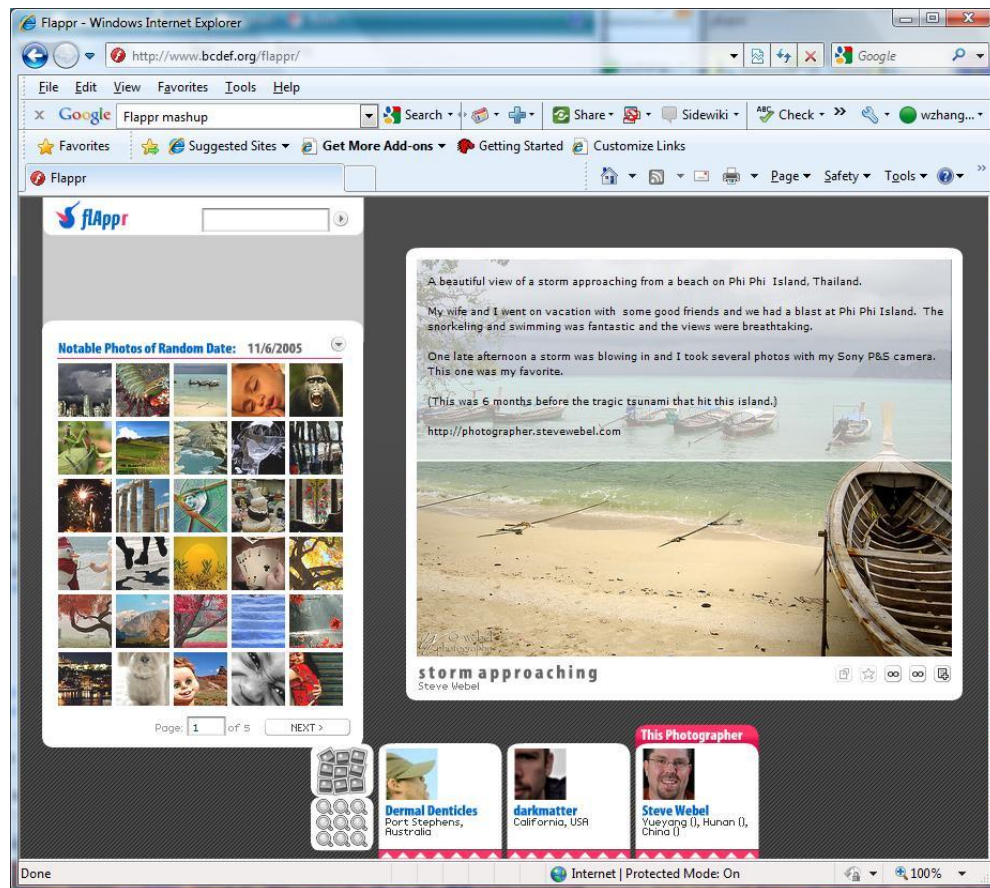


Figure 2.14: The Flickr mashup in Flappr [91]

vDiddy is a mashup web site from LoftLab that integrates YouTube videos, Yahoo videos and Grouper videos, etc., through YouTube, Grouper Video and Yahoo Video Search APIs. This mashup web site allows users to take a look at a daily buffet of videos from the most popular video web sites, such as YouTube, Yahoo Video and Grouper, etc. In addition, this web site allows users to play all the videos on the site itself [92]. Figure 2.15 shows the YouTube mashups in the vDiddy web site. The main advantage of vDiddy is that it enables users to take a glimpse into what is popular on these video web sites without going to the individual web sites. The disadvantage of vDiddy is that it only shows the several most popular videos from different video web sites, and users cannot search for videos from these popular video web sites.

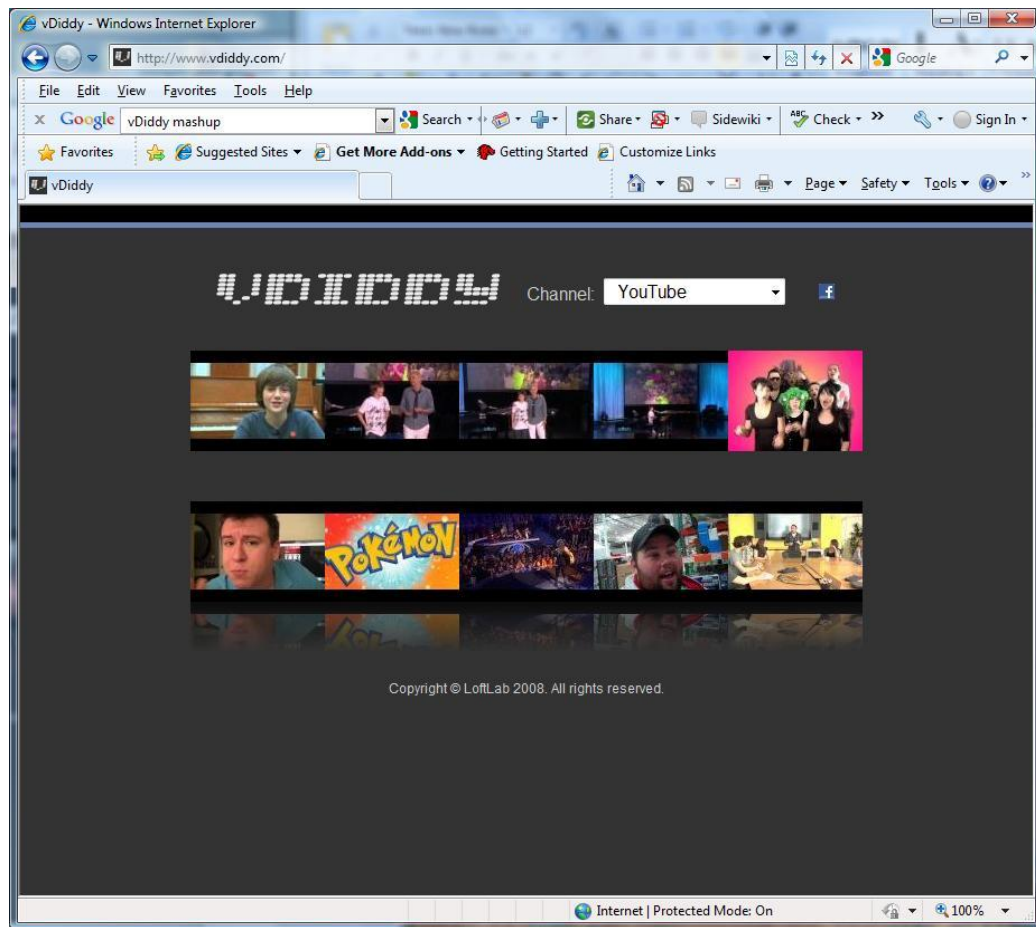


Figure 2.15: The YouTube mashup in vDiddy [93]

Wimbledon Live Press Room is a Facebook mashup application that integrates Wimbledon live player interviews with Facebook Live Stream Box to enable Facebook users to connect, share and post their updates in real time when they are watching the live interviews online [94]. Figure 2.16 shows the Wimbledon Live Press Room Facebook application that integrates Facebook functionality with Wimbledon live player interviews. The main advantage of this kind of Facebook mashup is that it enables visitors to participate in a conversation around the content in the web site. The disadvantage of this application is that visitors cannot interact with the content in the web site. For example, users cannot publish their messages together with the content, such as images and videos, on a wall of an online community, such as a Facebook page, to allow other Facebook users in this community or visitors to see their discussions.



Figure 2.16: Wimbledon Live Press Room Facebook mashups [95]

Flickrvision 3D is a new 3D version of the Flickr-Google Maps mashup interface. This interface displays recently uploaded Flickr images in a 3D Google Earth-looking globe. Flickrvision 3D uses 3D rendering technologies to allow users to circle a 3D Earth-looking globe to find out what other people are Flickrimg [96]. Figure 2.17 shows a Flickr image on a 3D Earth Globe in Flickrvision 3D. The main advantage of the Flickrvision 3D is that it enables users to see the most recently uploaded photos on a 3D spinning globe. The disadvantage of Flickrvision 3D is that users cannot search for photos from Flickr, and users cannot watch photos in a specific location.

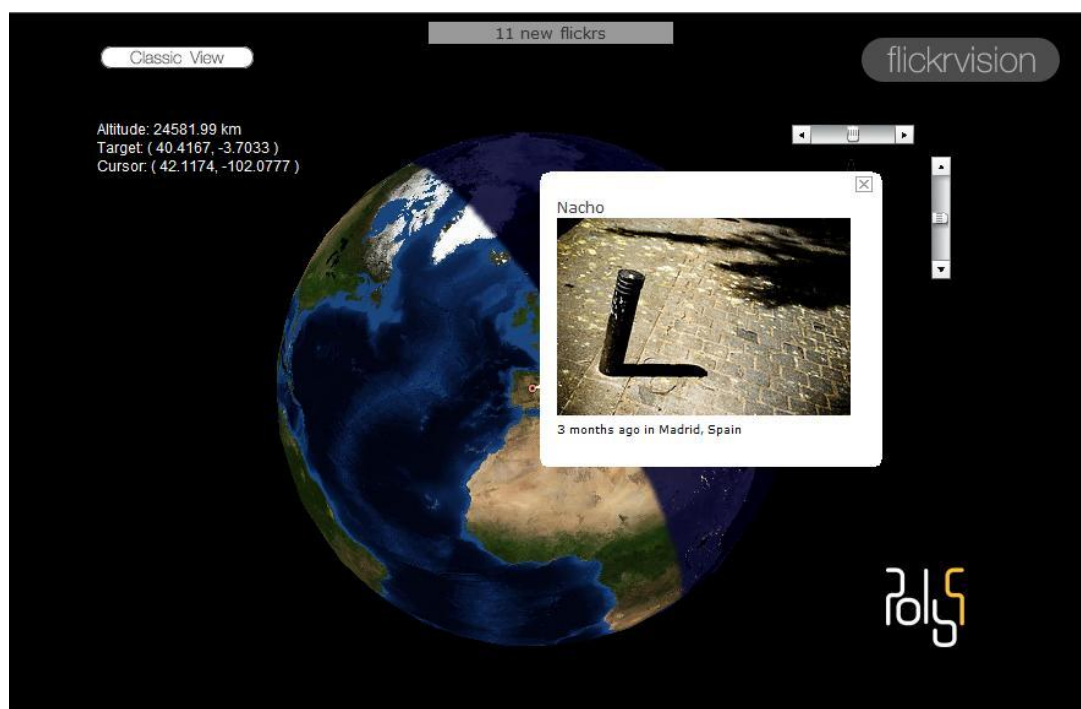


Figure 2.17: A Flickr image on a 3D Globe in Flickrvision 3D [97]

2.4 Digital Heritage Projects Using Web 2.0 Technologies

Most museums, cultural heritage sites and libraries are not involved in Web 2.0 technologies; they just act as content providers, and users are only consumers, although there are still some cultural heritage organizations that integrate Web 2.0 services in their web sites. The following paragraphs review the most novel and relevant cultural heritage projects that use Web 2.0 technologies.

Steve is a multi-institutional collaborative research project exploring the potential of subjects of artwork for user-generated descriptions to improve effective access to museum digital collections, and developing tools and technologies to facilitate engagement with museum cultural content [98]. Steve is an open collaboration using an experimental and research driven methodology. Users can access steve.museum and pool their raw data, resources and research results, while the social and folksonomy sides of Steve are more attractive for institutions. This project aims to develop open source software tools for tagging museum cultural collections and managing social tags. It also aims to engage with participants of the community to discuss methodologies in implementing social tagging for their own museum digital collections. This project researches how social tagging can best

serve museum communities and their own digital collections. Steve developed a set of open source social tagging tools to allow users to use and publish basic online collections with record tags. Figure 2.18 shows the steve.museum social tagging system [99].

The main advantage of the Steve project is that it helps museums to describe their digital heritage collections by applying keywords or tags to digital heritage objects. The disadvantages of the Steve project are that the system lacks inter-operability to enable tags to be shared across communities and annotation heritage systems. Additionally the system only gives users Web 2.0 tools such as social tagging tools. These tools allow users to use Web 2.0 expositions such as basic collections with record tags. The users are still not the main content creators in this Web 2.0 social tagging system.

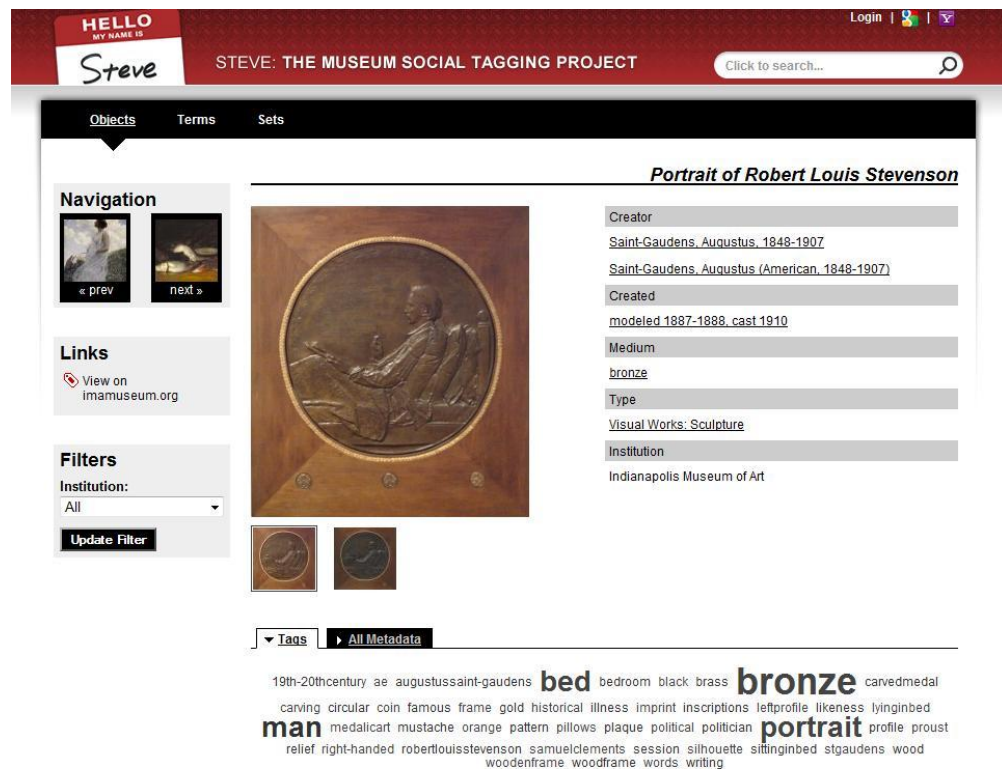


Figure 2.18: The steve.museum social tagging system [100]

The Brooklyn Museum Site (<http://www.brooklynmuseum.org/community/>) has a Community section that integrates Web 2.0 services such as Flickr, YouTube, Twitter, Blogs, Podcasts, etc. [101]. For example, it has a community photos section that displays Flickr photos that visitors added to the Brooklyn Museum Groups on the Flickr Community Podcasts section. This allows visitors to listen to the museum's podcasts directly from the

web page using the audio player, or download the podcasts into the local computer by clicking the ‘download’ button. The Community Twitter section displays visitors’ messages about the Brooklyn Museum at Twitter, see Figure 2.19, etc.

The main advantage of the Brooklyn Museum Web 2.0 site is that it displays Flickr photos and YouTube videos that users have added to the Brooklyn Museum groups on Flickr and YouTube. The disadvantage of the Brooklyn Museum Web 2.0 site is that it has only developed tools to display Web 2.0 expositions, such as the Flickr photos collection and YouTube video collection, that have already been received. Visitors are not the main content creator in this Web 2.0 site.

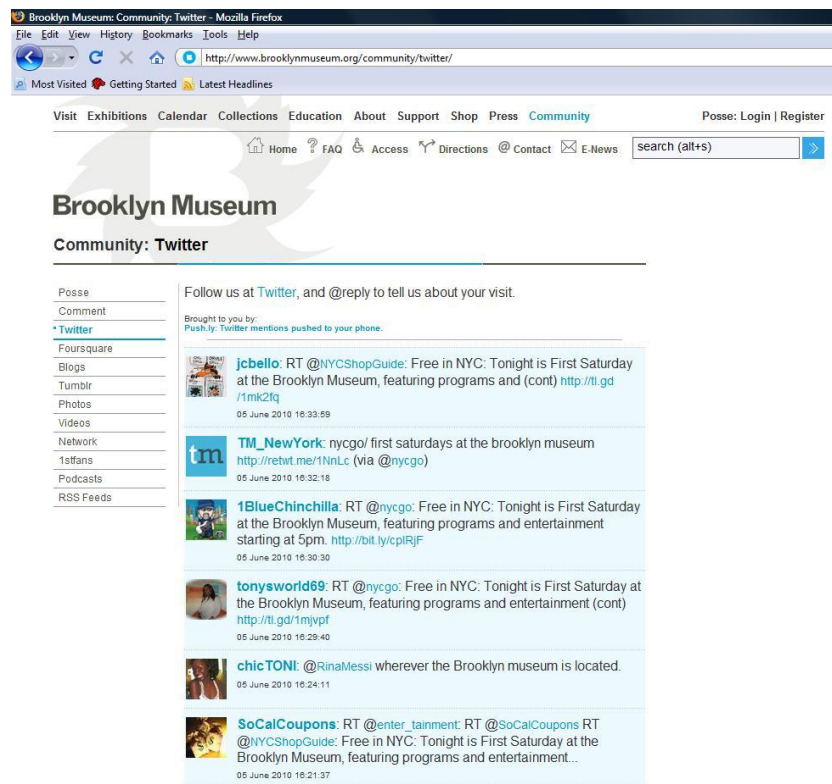


Figure 2.19: Brooklyn Museum Community Web 2.0 services [102]

Picture Australia is a project that aims to develop a service that enables users to search for information about Australian people and organizations, and capture associated resources such as works about the people. A person’s personal information could be provided by linking to photos, journal articles, newspapers, reference sources and oral history interviews. The service provides a search feature for looking at image collections from a number of Australasian galleries, museums and libraries [103].

People Australia also involves user participation; it is difficult to solve the conflicts between parties that have the same name whilst maintaining traditional library name authority files. However, Web 2.0 services can be used to solve this issue by providing models for utilizing the collective efforts of online communities. For example, all kinds of users who have knowledge about a subject, from subject experts to the general public, can contribute to the implementation of the service. In order to clarify ambiguities created by people who have the same or similar names, easy to use Web 2.0 interfaces will be created to support user contributions in its development [103].

Picture Australia also integrates the Flickr photo sharing service to allow users to contribute images to the Picture Australia service through Flickr. For example, Picture Australia creates sets of Flickr groups such as 'Our town'; users can add images to the groups and these images are then retrieved by the Picture Australia service [103].

The service aims to explore a model of collecting resources that includes providing services to support the creation and dissemination of knowledge sharing among users [103]. Figure 2.20 shows the Picture Australia project web site integrating Flickr and other Web 2.0 services. The main advantage of Picture Australia is that it utilizes Web 2.0 technologies to solve the conflicts between parties that have the same name in the traditional library name authority files by using the contributions of online communities. The disadvantage of Picture Australia is that the system has only developed Web 2.0 services to allow users to explore a model of collecting resources that are already in existence. Visitors are still not the main content creators in their Web 2.0 services.

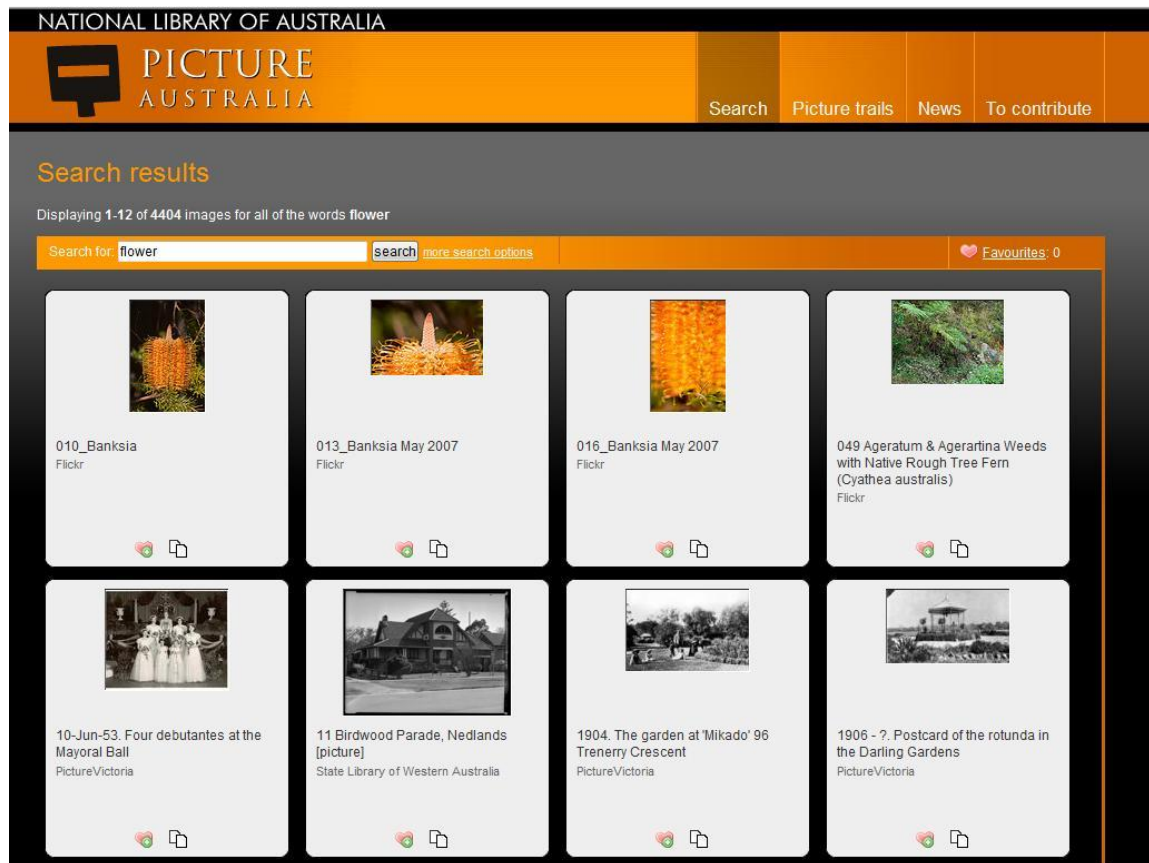


Figure 2.20: The Picture Australia web site integrating Flickr and other Web 2.0 services [104]

The Public Library of Charlotte and Mecklenburg County (<http://plcmc.org/>) in Charlotte, North Carolina, has a teen outreach programme that integrates a presence in Second Life with Teen Second Life, which is a virtual environment similar to Second Life but for people aged 13 to 17 [105]. This Web 2.0 integration allows participants to communicate with each other through text or voice and work together through their avatars. One of the reasons the Teen Second Life 3D environment was chosen to be integrated with a library service is that, according to a Pew Internet report in 2005 [106], there are a large number of teens (over 43,000) participating in Second Life, and it is a good idea to develop creative and interactive learners in their world. Another reason for integrating the Teen Second Life is because of its ability to collaborate with other participants in a 3D environment. This 3D collaboration environment is different from some other virtual environments because participants can share photos and documents without leaving the 3D world [107]. This project explores library services in a 3D virtual space to allow teens to interact with various concepts such as space and science in a 3D environment; it also brings the community together by inviting other organizations into this public library to contribute

their own knowledge. Figure 2.21 shows the Public Library of Charlotte and Mecklenburg County (PLCMC) in the Teen Second Life.

The main advantage of the Public Library of Charlotte and Mecklenburg County site is that it utilizes Web 2.0 technologies to integrate the Teen Second Life 3D environment with library services to allow teens to interact with all kinds of concepts in a virtual environment. The disadvantage of the Public Library of Charlotte and Mecklenburg County is that the system only allows users to explore the Web 2.0 expositions such as library services integrated in a 3D environment that have been already built. Users still cannot create their own content or exhibitions.

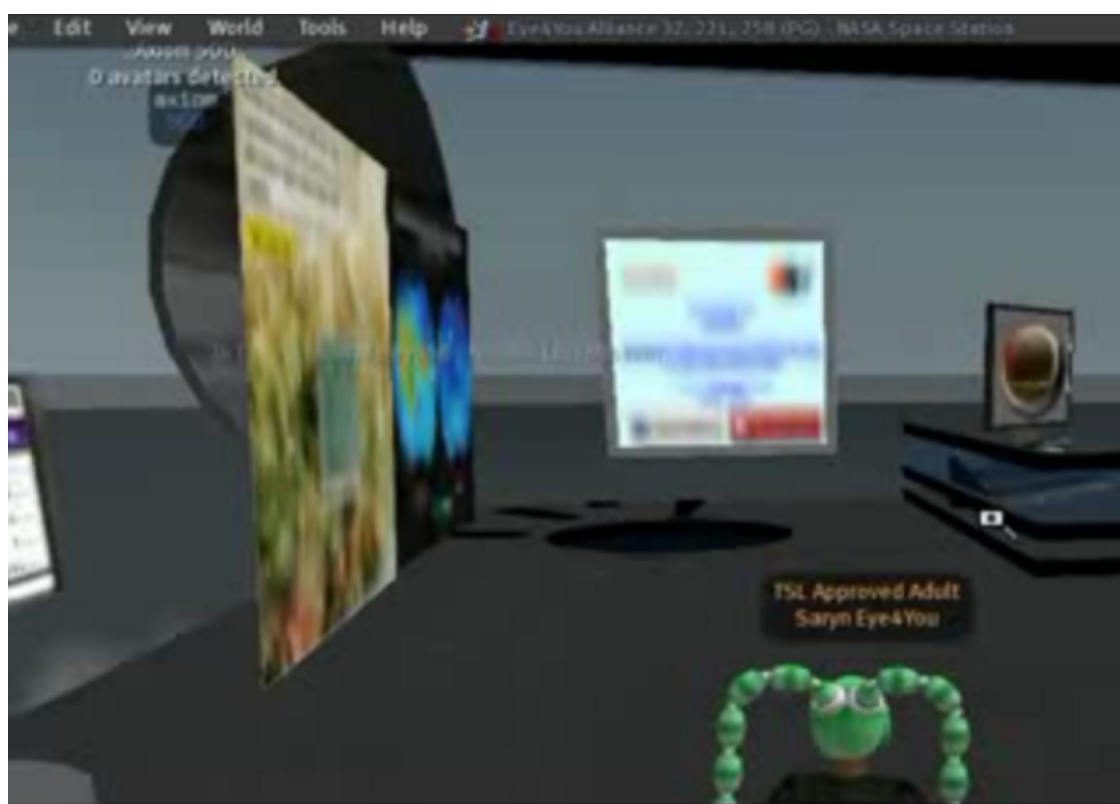


Figure 2.21: The PLCMC in the Teen Second Life [108]

Brooklyn College Library uses MySpace, which is one of the most popular social networks, to allow participants to post their personal profiles that contain their favourite photos, videos, books and movies. Participants can add other users as ‘friends’ and can then email, chat, and post messages to them. The librarian can also invite people, such as college students, faculty and graduates, to be the library’s friends and post their personal profiles. A Brooklyn College MySpace page was created by the Librarian Beth Evans in 2005. The

library listed about 2,350 friends who have set up MySpace profiles seven months after the Brooklyn College MySpace page was created [105]. Figure 2.22 shows the Brooklyn College MySpace page.

The main advantage of the Brooklyn College Library site is that it utilizes MySpace, which is a social networking web site, allowing users to post their photos, videos and movies, etc., to enable users to contribute their knowledge into Brooklyn College Library communities. The disadvantage of the Brooklyn College Library site is that users only visit the Web 2.0 exposition such as Brooklyn College MySpace page that has already been created. Visitors are not the main content creators in this Web 2.0 site.

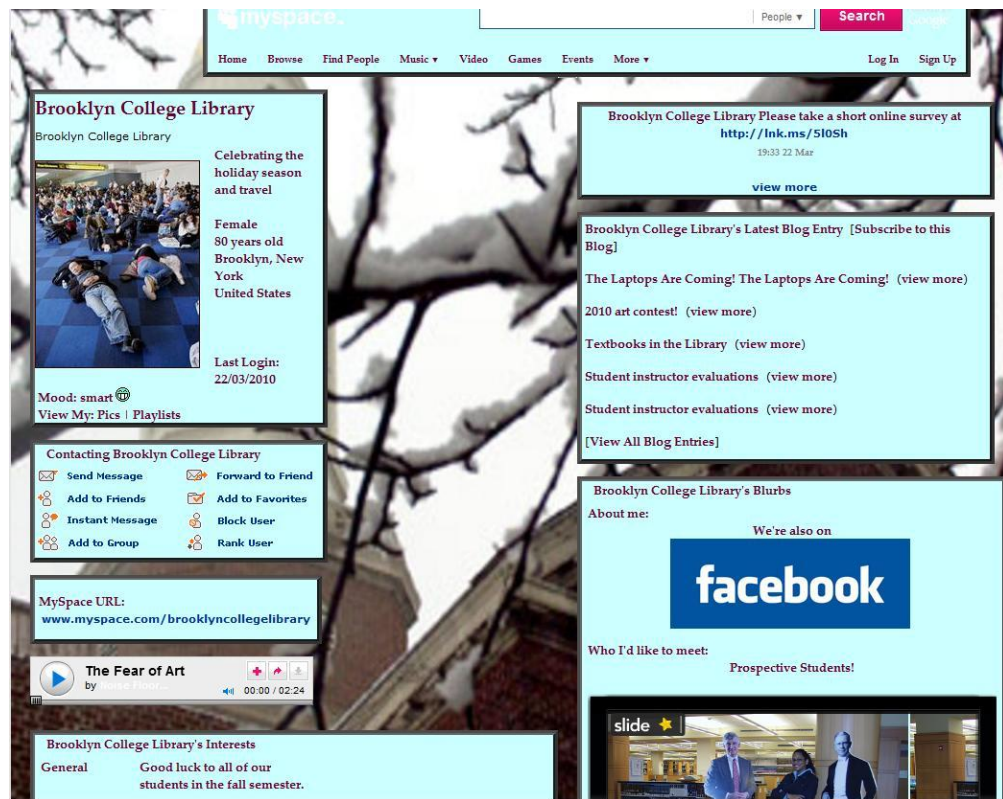


Figure 2.22: The Brooklyn College MySpace page [109]

M-Dvara 2.0 is a system that allows users to create, share and use cultural heritage contents, including mobile context-aware features. This system integrates Web 2.0 and Mobile 2.0 services that are then applied to the cultural heritage sector, allowing public users to be the main content providers [4]. M-Dvara 2.0 provides content based on user participation and collaboration, and has a content repository that contains user-generated textual and multimedia content. M-Dvara 2.0 aims to mashup several existing Web 2.0

services such as YouTube, Flickr and Blogger, etc. This project uses SOAP, Javascript and other web technologies to enable web sites to remix and aggregate existing Web 2.0 services [40]. In m-Dvara 2.0 system functionalities, Web 2.0 technologies are used in several aspects. For example, they use the Wiki and Blog functionalities to allow users to add new contents of cultural heritage into an open wiki such as Wikipedia or post their work onto their own blog. What is more, they utilize social network functionality to allow users to add friends, suggest their friend to notify their interests. Furthermore, they integrate a 3D museum that is already created such as Second Life with wiki, chat and comment together to allow users to update the wiki, chat with each other and make comments as they visit the 3D environment [40].

The main advantage of the m-Dvara 2.0 project is that the system utilizes Web 2.0 technologies to allow users to be not only visitors of Web 2.0 expositions but also to be the main content creators through a collaborative framework such as a 3D collaborative environment based on Web 2.0 services. However, the content creation functionality of visitors is still limited, and it only enables users to update the wiki, chat with other visitors or make comments during their visit to the 3D environment, such as the 3D museum in the Second Life.

2.5 Conclusion

The typical examples of projects in digital heritage show that, although most digital heritage projects are making efforts to develop novel 3D visualization and interaction services for exhibitions of cultural heritage content, they are not involved with Web 2.0 technologies. So, in most digital heritage projects, visitors are only content consumers and not the main content creators. In addition, their technologies cannot select images and videos of digital heritage objects from different user-generated content repositories, such as Bing, Flickr and YouTube and actual museum's digital heritage collections, and preserve them into a 3D world.

Novel examples of Web 2.0 mashups show that some Web 2.0 mashup technologies can be applied in the digital heritage area. However, these mashup technologies do not provide a full approach to enable communities to access and interact with the content in the web site,

or mashup images and videos from social networking repositories into a virtual environment and then create their own virtual exhibitions. From the typical examples of cultural heritage projects using Web 2.0 technologies, it is evident that Web 2.0 technologies are accessing and involving museum cultural heritage contents. At the same time, museums are evolving towards to user-generated digital heritage content.

However, most of these typical examples only give users the tools to visit an exposition, and some members still act as the content providers, which is different from a full Web 2.0 approach which is that the users act as the main content creators. The last example of digital heritage projects using Web 2.0 involved users as main content creators through a framework of collaboration and participation based on Web 2.0 services. However, the content creation functionality of visitors is limited, and they just allow users to update the wiki, chat or make comments in a collaborative environment. There is a need for users to capture community-contributed cultural heritage knowledge, and create and publish their own personal virtual exhibitions based on both community contributed digital heritage content and actual museums' digital heritage content.

This thesis explores digital technology solutions to implement a digital heritage multimedia system that integrates content creation, archive, exposition and presentation services to enable both museums and communities to create their own digital heritage exhibitions. This research mainly contributes to how Web 2.0 technologies are utilized and integrated with other digital technologies to enable communities to access and interact with digital heritage objects and collections, and allow communities to create their own virtual exhibitions based on both user generated digital heritage content and actual museums' digital heritage objects and collections.

CHAPTER III

3 The DISPLAYS Concept

3.1 Introduction

Currently, some museums provide a scheme that allows the public to access their museum web sites and record archaeological finds. However this scheme only performs simple access and records the heritage objects. It is not a real digital heritage library system that can allow the public to create, interpret and use their heritage objects in a digital heritage environment.

A digital heritage system is needed that allows people to create heritage objects by importing heritage object images, videos and metadata or creating 3D for heritage objects. It would also need to allow the interpretation of heritage objects by using web technologies to link object images, videos and metadata information together, and display them on the web page, then use those heritage objects in interesting visualization and interactive ways. If images and videos of similar heritage objects in social network repositories such as Flickr and YouTube can be found, those heritage artefacts can be used and shared in a visualization and interaction environment. For example, these heritage object images and videos could be dragged and dropped into a 3D virtual world, and people could play with those heritage objects in a virtual environment. Also more functionality could be provided on visualization and interactivity for people to use those heritage objects, for example, a 3D scrapbook functionality. People could use the scrapbook to save heritage artefacts in a virtual world they have created on their desktop computer. They could then play with those heritage artefacts in a 3D world in their own computer. What is more, they could publish their scrapbook into a server for further exhibition.

This chapter proposes an innovative digital library system called DISPLAYS. This system is composed of five main functionalities, content creation service, archival service, exposition service, presentation service and interaction service, which allow the general public to create, interpret and use their heritage artefacts to a professional standard. While this chapter discussed DISPLAYS in general, it will focus on the presentation (e.g. social

networking and Web 2.0 mashups) and interaction (2D and 3D interaction) services in this DISPLAYS concept as main contributions by the author to this concept.

The DISPLAYS (Digital Library Services for Playing with Shared Heritage) is an innovative conceptual framework around which several architectural components can be specified, designed and implemented [6, 9, 10, 11, 12, 13, 14]. Components for DISPLAYS can be implemented from existing digital heritage architectures, e.g. ARCO system components could be used to implement the archival, exposition and presentation services, see below for further discussion. The components of DISPLAYS that the author of this thesis worked on include archival services (e.g. ARCO functionalities in DISPLAYS and social networking), presentation services (e.g. Web 2.0 mashups) and interaction services (e.g. 2D Facebook interaction and 3D VRML interaction). Other people were responsible for the other components of DISPLAYS such as requirement engineering. As a complete implementation however, DISPLAYS does not exist; rather several components have been implemented (some by the author of this thesis, see Chapters 5 and 6), and a validation architecture; the ‘reanimating cultural heritage’ (RCH) digital repository has been implemented. Several prototypes of the ‘reanimating digital heritage’ digital repository have been implemented, and Chapter 4 discusses the version on which the innovative technology (e.g. integration of social networking through mashups and 3D scrap book) proposed in this thesis has been evaluated.

3.2 DISPLAYS Services Architecture

The aim of DISPLAYS concept is to implement a service-oriented approach to create a digital library system that focuses on how to allow museum professionals and community users to create, interpret, and use their digital heritage objects in interesting visualization and interactive virtual environments. This digital library system can allow the public to create, interpret, and use digital heritage objects (3D, videos and images) of physical archaeological objects. For example, videos and images from YouTube and Flickr using Web 2.0 technologies can be integrated with collections of museum digital objects to augment such collections in more interesting visualization and interactive ways.

This digital library system is named DISPLAYS, and is composed of digital content creation, archival, exposition and visualization and interaction services. The implementation of a DISPLAYS system can be described thus: users collect heritage object data from museums or third parties and transform all information about the heritage object, including collector name, object description, location, object images (or videos, 3D), into a database through DISPLAYS Archival Services. The database for archiving data information can store all kinds of data, for example, a 3D designer can store and access a 3D model and metadata associated with that 3D object. These objects, which are collected and associated with metadata, can be organized in a more interesting and understandable way, and can then be presented to users in a very interesting visual and interactive environment. In summary, a typical DISPLAYS system architecture can be divided into five parts: data (Content Services), information (Archival Services), knowledge (Exposition Services) and display (Presentation Services) and play (Interaction Services), see Figure 3.1.

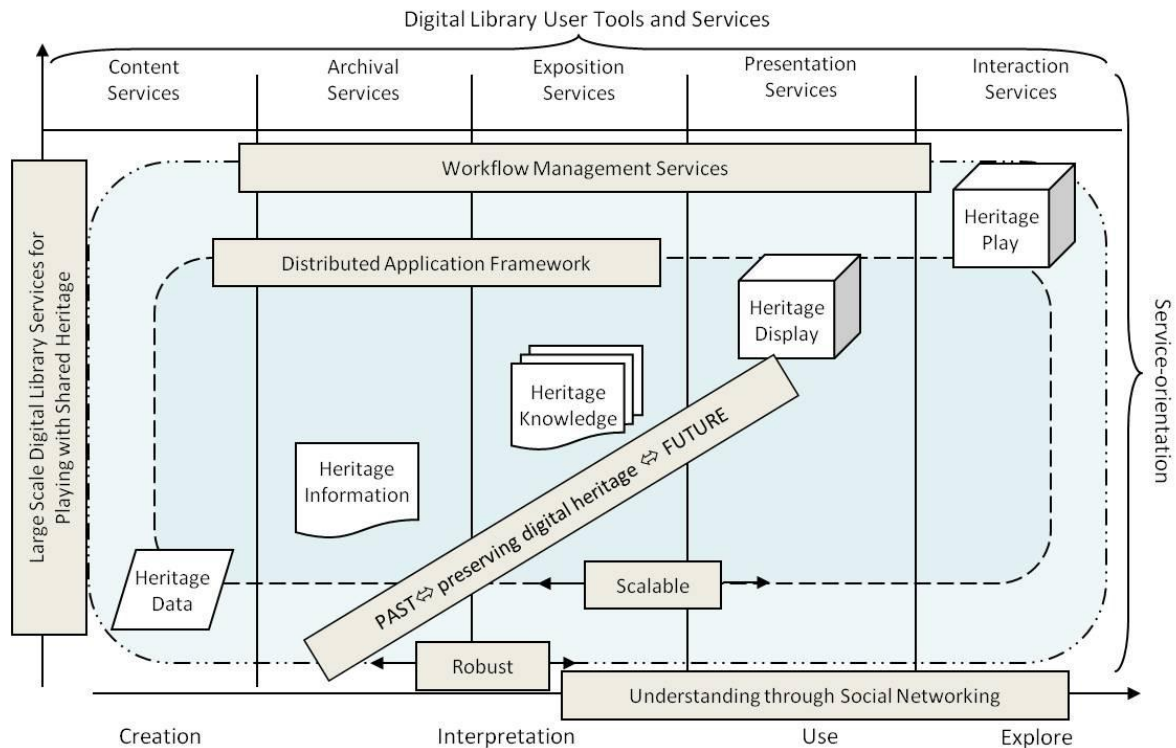


Figure 3.1: DISPLAYS system architecture [7]

The DISPLAYS system can be used to create very interesting and interactive museum exhibitions online. For example, users collect heritage data from museums or some third party repositories (e.g. YouTube and Flickr), then they begin to organize the data

information and create knowledge of heritage objects. These are then associated with XML metadata, which have name, description, location and images (videos, or 3D). Finally, the knowledge can be interpreted to a virtual exhibition through visualization and interaction services. General users can then explore these virtual exhibitions online to get more understanding and wisdom on cultural heritage.

The DISPLAYS process, is concerned with creating heritage *data* (digital objects), turning this data into *information* through appropriate archival methods (i.e. organising the data into meaningful collections), generating *knowledge* through exhibitions, *displaying* digital heritage through good presentation methods and allowing users to *play* with the digital heritage through appropriate interaction methods. These processes or services are all managed by the DISPLAYS workflow management service. This workflow management service implements tools to control the process of data that is imported and exported between users, services and application layer. In summary, the DISPLAYS system is composed of several services (as shown in Figure 3.1), which are:

1. Content Services (CS)
2. Archival Services (AS)
3. Exposition Services (ES)
4. Presentation Services (PS)
5. Interaction Services (IS)

These services are now described in more detail.

3.2.1 Content Services (CS)

The content service (CS) is the first functionality of the DISPLAYS system: it aims to efficiently create digital content such as images, videos, audios, documents and 3D graphics (3D scenes and objects). These contents can be created using cameras, image editing tools (e.g. Photoshop), MS Word, XML tools, 3ds Max, Blender and so on.

The CS can provide a collaborative environment where several digital content creators can collaborate on the modelling of digital contents from different domains for visualization and interaction. An example of a museum virtual exhibition could be this: if museums want

to build a web site with Web 3D embedded or a virtual museum gallery, they need digital contents such as 3D scenes, 3D objects or flash animations. This service can offer pre-designed virtual spaces, 3D or flash contents for the museums. These digital contents (3D scenes, 3D objects, and flash animations) can be developed to create their virtual exhibitions by using VR editor. For example, there is an open source VR editor application called NeuroVR [110], which can provide a 3D editing environment for users by using open source code from Blender [111]. Digital contents can also be used to develop a very interactive visualization and interaction virtual environment by using HTML, JavaScript, VRML, VRML script code. These technologies will be demonstrated in detail in the following chapter.

A scenario for content creation could exist where 3D modellers sometimes need to work together through a network. In this case, a collaborative framework needs to be designed for all 3D modellers to work on, and this framework could include a chatting tool (where modellers can chat with each other on the network). This collaborative framework could also provide a render farm that allows access to all the modellers; in fact DISPLAYS has implemented an innovative render grid as one of its components [13, 14]. Such a collaborative framework needs a method of exchanging data, and there is one tool called COLLADA which is an open digital-asset exchange schema [112] that is suitable for this task. COLLADA can be used for holding digital contents that have been created by modellers because it provides an XML database schema for these contents; these digital contents can also be exchanged with the other elements of DISPLAYS in COLLADA environments. There are many other digital content services that could be discussed, the above only serves to illustrate an example. The significant point to make is that any museum collection may need to use many different tools or services to generate their digital objects. As another example, one can envisage a specific collection of objects requiring 3D models, images, and scene to create a virtual 3D gallery as an exhibition. In such a case it is entirely possible to use 3ds max and Photoshop tools with data exchanged in a COLLADA format, and converted to XML for archival in a DISPLAYS system. However, it is not the focus of this thesis to develop solutions for CS.

3.2.2 Archival Services (AS)

The archival service (AS) is another important functionality of DISPLAYS. Several technological issues need to be addressed by a potential DISPLAYS archival service:

1. Archival format structure, e.g. XML, COLLADA, for storage, import and export
2. Archival operations or basic database operations, i.e. create, retrieve, update, delete (CRUD)
3. Database technology, e.g. XML, Oracle, MySQL, etc.
4. Social networks for storing user generated content, e.g. Facebook, Flickr, etc.
5. Heavy weight versus a lightweight approach depending on collections size
6. Data processing and search technologies, e.g. XSLT, XQuery, PHP, etc.
7. Sustainability and preservation technology, e.g. LOCKSS
8. An archival architecture

Archival Format:

The DISPLAYS system will have a lot of heritage objects with different digital formats, such as 3D objects (.wrl), flash animations (.swf), images (.jpg), videos (.avi) and documents (.xml or .txt), etc. As implied above, it may be feasible to use COLLADA itself as the XML structure for archival services, however this need not be so, one can also develop an XML structure for archival systems and readily translate from one XML structure to another using XSLT. Whatever archival format is used, these digital contents need an archiving system to store the data, which can then be retrieved from the archival system. This kind of archival system can be a database; for example, typical database systems, such as Oracle, Microsoft SQL Server, MySQL and PostgreSQL, etc., can store all kinds of data types, metadata, and multimedia content (images, videos and 3D). An example of an archival system for DISPLAYS could be the ARCO's Cultural Object Manager, which in fact uses Oracle as the underlying database. For small collections, the archival service could simply be performed with an Excel spreadsheet that holds all digital object information and exports to XML, using XSLT for further transformations (e.g. a particular XSLT could provide the exposition format)

Basic Archival Operations:

An archiving system needs to deal with at least the basic operations of create, retrieve, update and delete (CRUD) its data. For example, an archiving system often allows users to create data (e.g. uploading images or videos, adding descriptions) and store them into a database. A web-based digital heritage system normally has a search functionality that enables users to retrieve all heritage objects that match the participant's key word input. When the participant gets all the appropriate heritage objects, they can access the information about those objects, which includes metadata, images, videos or 3D by using data retrieval from the database. Furthermore, an archiving service often allows high-authority users (e.g. administrators) to update and delete data from the database of the system.

The AS will store and retrieve digital heritage objects through the network; it will therefore require a well-designed database with little or no maintenance so users can easily search, retrieve, and use the heritage objects that are archived in the archival system. The ARCO system, which is a digital heritage system for archiving digital heritage objects, has been successfully implemented [8], and as mentioned can be used for the AS to archive all the digital heritage objects required. The ARCO database is an already well-designed Oracle database that can provide data storage and data retrieval functionalities efficiently.

Database Technology:

As mentioned above, in the DISPLAYS architecture, ARCO functionalities can be used to implement DISPLAYS components. In this case, the ARCO Cultural Object Manager, see Chapter 4, can be used as an archival system to import digital heritage data information. This digital heritage data will include images and videos of digital heritage objects and associated metadata formatted for import (as an XML file) into the ARCO database. Before archiving digital heritage data into the ARCO system, raw data needs to be collected from different museums. When images, videos and metadata of digital heritage objects from museums have been collected, images, videos and metadata can then be organised as an XML file and uploaded into the ARCO system.

In an ARCO system, there are three main functional tools or services: cultural object manager, presentation manager and template manager. Image or video folders can be

directly assigned into the cultural object manager as multimedia content. As the ARCO system only accepts XML data, all the other data format documents need to be translated into XML format before archiving into ARCO. A museum collection is often exported as an EXCEL spreadsheet containing digital objects, e.g. metadata, and descriptive data that is associated with heritage images and videos. These data needs to be translated into XML documents, which in turn need to be archived into ARCO system.

Social Networks for Storing User Generated Content:

It is proposed to use social networking technologies to capture user-generated digital content, and then use Web mashup technology to give this digital content new life and send them into exhibition. Social networking repositories are another kind of AS for heritage data storage and retrieval. One of the advantages of this approach is that the museum leaves the social networking system to maintain its database servers, so that it does not need museums to build large resources for moderating and organizing user generated digital heritage resources. There are many different social network repositories which can be used to preserve user generated digital content, e.g. Flickr, YouTube and Facebook, etc.

Light Weight Implementation:

A lightweight digital heritage system could be created, as implied above, by simply archiving small collections in structured XML files and processing those XML files with XSLT technology into a visualisation of the objects. Chapter 4 discusses a prototype implementation of such a system, called RCHLite system, which aims to be implemented at low cost and with a more portable functionality. XML is an easily read language and it is also extremely portable, to the extent that it can be deployed on any network and platforms with the application in use [113]. All the data information, such as collector name, date, location, and object description, can be described as metadata and written into XML. The XML data preservation repository will include all the XML files and several folders for digital contents such as images, videos and 3D objects associated with those XML metadata.

Data Processing and Search Technologies:

XSLT [114] and XQuery [115] are two popular languages used to query XML data. The main advantage of using XSLT is that it provides an easy way to process XML data into HTML [116]. The main advantage of using XQuery is that it can query a lot of different data structures such as tree and graph structures [117]. Users can retrieve digital heritage objects and access information about these objects, such as object images or videos or 3D through querying XML metadata by using XQuery or XSLT.

XQuery is a query and functional programming language that queries XML data collections [118]. It provides the function to extract and manipulate XML data from XML data collections, such as XML documents, or data source that can be translated into XML, such as Microsoft office documents. XQuery can be used to get the data information from XML documents that have been created, and display that information, with associated images or videos, in the web presentation. It can also be used to perform a semantic search on the XML documents, and users can get a list of heritage objects when they input keywords of heritage artefacts such as name or description.

XSLT is an XML-based language that can translate XML document information into other formats. It is often used to translate XML data information into HTML or XHTML, and then display this information on a web page.

Sustainability and Preservation Technology:

An open source software called LOCKSS [119] has great potential to assist researchers to maintain their local archives of open access research. It is therefore proposed to use LOCKSS to back-up digital heritage resources. LOCKSS, developed by Stanford University, allows libraries to collect, preserve and provide their users with the ability to access contents that have been published on the web. Originally designed for academic journals, it can now be used for other materials in content management systems.

LOCKSS software will be installed in several PCs, and these PCs will be turned into digital preservation equipment that will be called a LOCKSS Box. These LOCKSS Boxes will be connected together to compose a LOCKSS Network. The LOCKSS Box performs several functions: firstly, it takes content from a web site, compares the content it has copied with the same content copied by the other LOCKSS Box, and then updates the back-up. It also

provides a browse function to allow museum communities to access web site or preserved contents. It provides a web interface to allow the administrator to target new materials to back up, monitor the state of backing up and control the access of backed up material [120].

An Archival Architecture:

Figure 3.2 shows the DISPLAYS AS architecture. This diagram shows three ways of archiving digital heritage data. The first way is using an ARCO system to archive digital heritage data; users can retrieve data from ARCO through a data query functionality (e.g. CRUD operations). The second way is developing a XML structure for data Storage to archive digital heritage data. As mentioned above, it should also be possible to use COLLADA itself as the XML structure for the archival service; adding an .xml extension to a COLLADA file in effect turns a COLLADA file into an XML store. Similarly, because the COLLADA XML file has structure, it could theoretically be used to contain an exposition—users can then retrieve data from the COLLADA XML Storage through XSLT and XQuery technologies. The third way is utilizing social network repositories such as Flickr, YouTube and Facebook for archival systems to preserve user generated content. Users can retrieve information from social networks through Web 2.0 technologies. This diagram also shows a user who is also the administrator who could back-up materials in the system using the LOCKSS software—although the LOCKSS may need to be modified in some way [121].

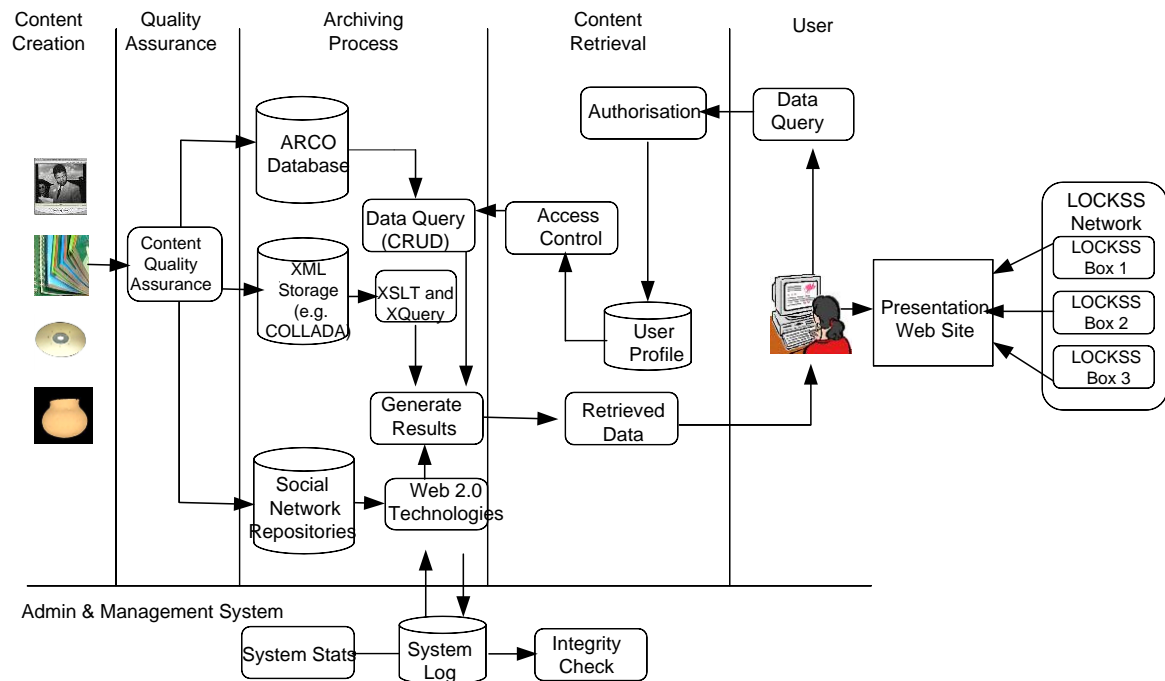


Figure 3.2: Archival Service Architecture

3.2.3 Exposition Services (ES)

ARCO has also implemented a successful exposition service (ES) for a virtual museum, thus it is feasible to use ARCO for a DISPLAYS ES. In an ARCO system, all the objects and information are well organized in the cultural object manager. In the presentation manager, the programmer can create structured exposition spaces; each space is associated with an X-VRML template (which is organised in the template manager) that gives the structure of the layout of heritage objects and metadata. These exposition spaces are stored in an ARCO presentation manager and can be published into a web-based exhibition through a local or remote web.

In a heritage lightweight system such as the RCHLite system, see Chapter 4, the Windows file manager system is used to archive a collection of structured XML files as an exposition. This exposition would include all the metadata of the heritage objects and several folders that contain images, videos and 3D objects associated with those metadata. The designer can create different XML exposition spaces; each space has an XSLT template that constructs how the heritage contents and XML metadata will be displayed in the museum's exhibition (e.g. as a virtual museum online). These exposition spaces (XML structures) are

contained in the server root (set of files and folders) whose content can be loaded into a web presentation using server side web technology such as PHP or client side technology such as JavaScript—each of these methods working with XSLT, where the XSLT processor is installed on the server side or is integrated in some web browsers. The XSLT processor performs the transformation and formatting of the XML data into XHTML format, and CSS is for style formatting of the XHTML.

3.2.4 Presentation Services (PS)

A presentation service (PS) can be used to display exposition data in very interesting and interactive ways. For example, Web 3D, virtual reality and web mashups can be utilized [122], and Web 2.0 technology effects can give users a very rich Internet application interface. In the ARCO project, several kinds of visualization technologies have been implemented; in the DISPLAYS concept more visualization functionalities are added to make the application interface more attractive and interactive.

Web 2.0 technologies will be used for application interface visualization effects. Web Mashup is one of the most important and fashionable technologies in Web 2.0. Web Mashup is a new exciting technology for building good web-based applications. It aggregates different data from different data sources such as YouTube, Flickr, Bing, and Yahoo third party services into a new rich meaningful application. Mashup technology will be described in more detail in Chapters 5 and 6. Other web technologies such as Shadowbox, Carousel, etc., can also be used for web presentation.

3.2.5 Interaction Services (IS)

Interaction technologies adopted in this research work to illustrate innovative ways for implementing interaction services (IS) include ‘drag and drop’, ‘VRML interaction’, ‘augmented reality’ and ‘multimodal interaction’, etc. In previous projects such as EPOCH, a multimodal interaction with an artefact was implemented to give users an interesting method of interacting with the heritage contents [123], this thesis continues this concept in an innovative way through the integration of social networking using mashups. For example, users can drag and drop images and videos from a gallery into a 3D environment. What is more, users can interact with 3D objects textured with images and videos in the 3D

environment by dragging, rotating, wheeling and clicking using VRML interaction. Further, users can interact with a 3D mashup using augmented reality or advanced input devices such as a black box [1]. These interaction technologies will be demonstrated in more detail in Chapters 5 and 6.

3.2.6 Heritage Workflow Management Services

The workflow management service is another important function of DISPLAYS. The DISPLAYS system will be built on a service-oriented infrastructure that allows the implementation of dynamic collaborative applications. Workflow management technologies will deliver data and information throughout the system. Data import and data export are the important functionalities of workflow. Effective workflow management will be important for both administrator and general users to transfer and access data and information efficiently.

Workflow management means trying to manage the process of data import and data export. For example, how data from different museums are imported and stored into the system, and how data from a database are retrieved and displayed in the visualization and interaction system for museum exhibition, are vital for the workflow. Effectively, workflow management will mostly deal with the data process between the applications layer and the infrastructure.

Workflow management controls the data flow between the application layer and the service oriented layer. During this data flow, many job processes are performed, for example, data retrieving, visualization and interaction, etc. Therefore heritage workflow manages import and export data of different sources that perform different kinds of jobs between the application layer and the service oriented layer. As heritage workflow can manage the distribution of the job process between the application layer and the infrastructure layer, it may involve controlling the job process of all kinds of performances such as object modelling, object retrieving and visualization and interaction and so on. Then job processes management between the application layer and the infrastructure layer will be very important for heritage workflows in the system. For example, the job process management

of data repositories such as importing, exporting, and retrieving data will be an important functionality for heritage workflow management.

How to use workflow management to manage the whole digital heritage system becomes a challenge due to the complexity of digital heritage system architecture and the data model. A workflow solution needs to be found to implement a workflow model that can improve and increase the digital heritage system's speed and efficiency. In the system, there will have all kinds of different use case scenarios to match different user requirements; these scenarios will need different components and sets of services to achieve different functionalities in a hosting environment. What is more, some system processes need to be operated properly in a particular hosting environment. For example, some processes can be operated manually by users (e.g. the administrator of a museum takes photos for a heritage object for digital image collections). Some processes could be operated automatically by machine (e.g. the ARCO system will automatically create thumbnails for original images).

Figure 3.3 shows an example of DISPLAYS Workflow Management Service architecture, and shows the implementation process of the digital heritage system. Workflow management should manage all the data flows during this process. For example, in the CS, the workflow manager should manage the data process from Object Acquisition to Object Transformation, and then to the Digitised 3D Object.

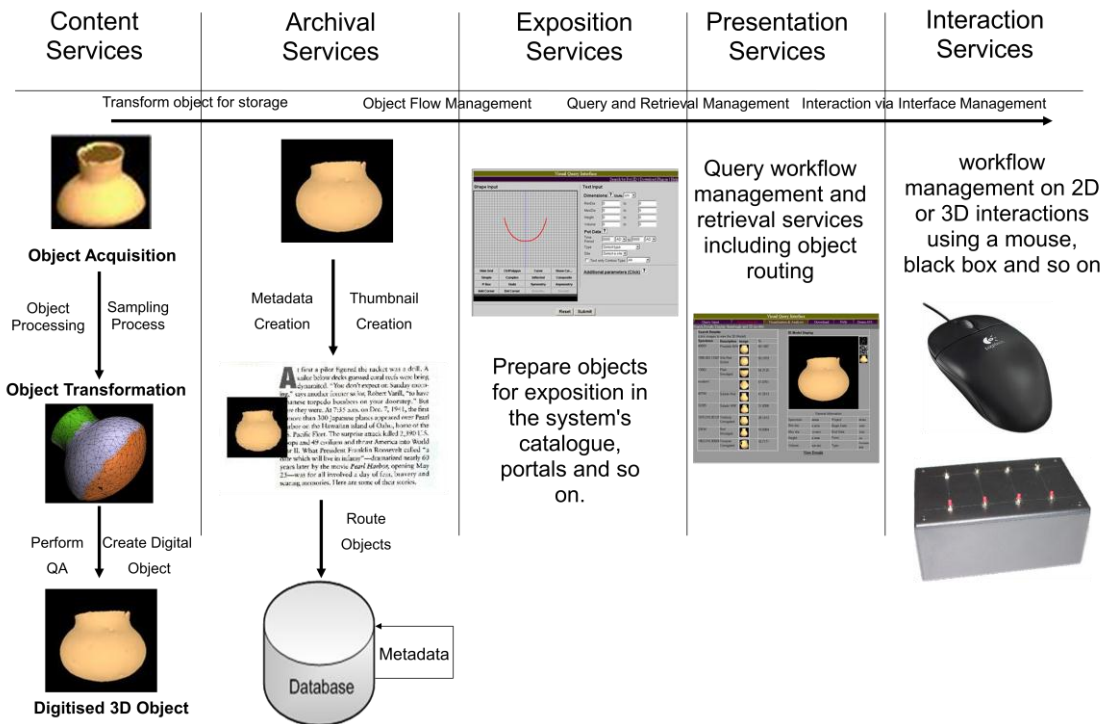


Figure 3.3: Workflow Management Service Architecture [124]

3.2.7 Service Oriented Architecture

The adoption of service orientation is an important concept for DISPLAYS. This is because DISPLAYS relies on social networking to implement a significant part of its functionality, that of allowing users to generate content and merge this content with museum's collections while actually keeping the management of that content separate.

Many technologies can be utilized to create service orientation, for example, a Web service is a very popular technology that is currently used in web-based applications. There are also other technologies available, for example, CORBA [125], or DCOM [126], and so on. To implement service orientation in a DISPLAYS type architecture, a software stack has to be designed for the DISPLAYS application. Conceptually, there are three layers for DISPLAYS. The DISPLAYS service oriented architecture layer is based between the application layer (creation, archival, exposition, presentation and interaction tools or services) and the underlying database or functionally technology that executes the services.

Render Grid Service Oriented Example:

DISPLAYS has implemented a render grid component for use in a collaborative modelling scenario, so Figure 3.4 illustrates the application layer accessing the render grid infrastructure layer through the service layer. The service orientation layer is the middle layer of DISPLAYS. Workflow management is inside the service orientation layer. Workflow manages the import and export of data between the application and infrastructure. Workflow management has a lot of open source tools to use for managing the data flow. For example, .Net Workflow Foundation (WF) [127] is a useful tool for workflow management. WSDL [128] is another open source tool for workflow management service. The application layer is on the top of the software stack, while at the bottom is the grid and P2P infrastructure layer.

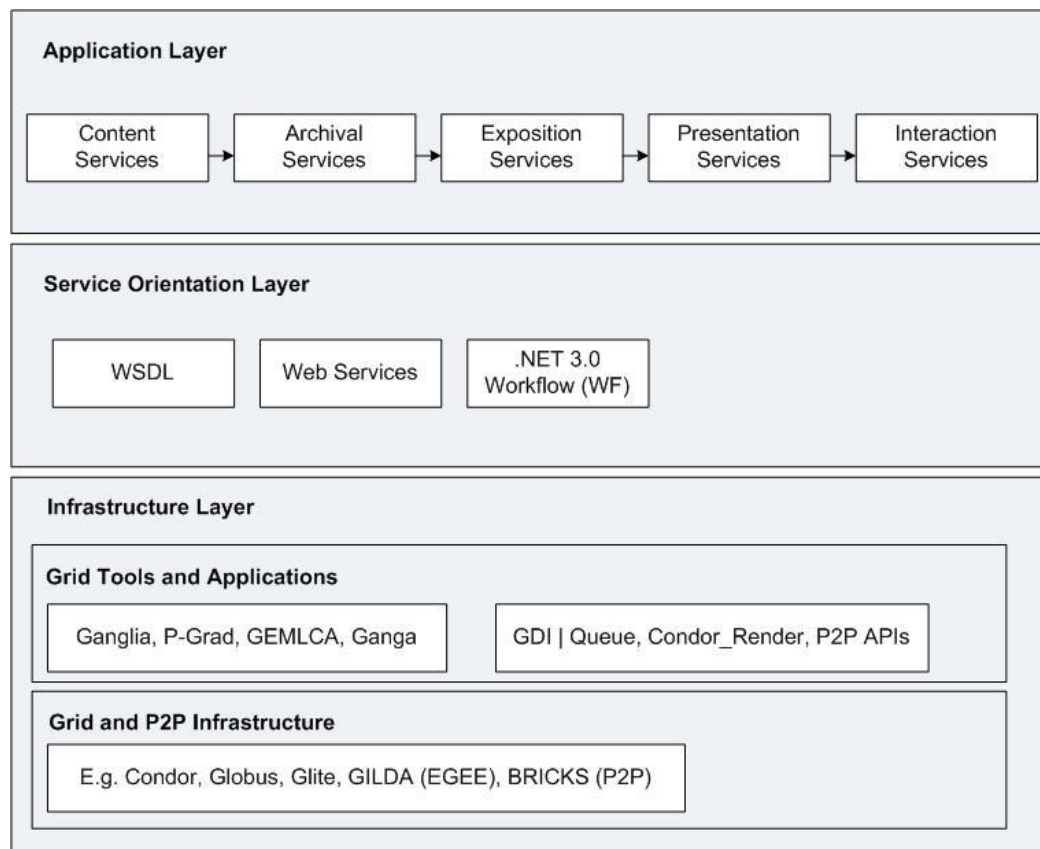


Figure 3.4: DISPLAYS application, service oriented architecture and infrastructure layers [6]

RCH Service Oriented Social Networking Example:

Currently, service orientation becomes an approach for developers to create dynamic collaborative applications. The RCH digital repository (based on the DISPLAYS concept), described in the next chapter, utilises service orientation through the integration of several

social networking technologies. The RCH system aggregates data information from different data sources such as ARCO, Flickr, and YouTube into one single application. Data from ARCO, which is a museum digital heritage object repository, can be aggregated with data from social networks, which are user-generated digital heritage object repositories, by using Web 2.0 mashups technology.

As a point of definition, this thesis refers to the aggregation of museum collections and user generated content as a digital repository (DR). This thesis further divides the concept of a DR into a collection of digital heritage resources (DHR), where an example of a DHR could be a museum collection(s), or user generated digital heritage content stored in some way, e.g. on a social network. In general, a DISPLAYS based DR may have several DHRs. For example, the RCH DR has two main DHRs: 1) the museum's collections stored and managed on an ARCO system, and 2) the user generated content stored and managed on the social network.

In reality, the RCH application layer accesses the DHRs through their respective interfaces (ARCO or the social network). Any DHR created is based on a set of DISPLAYS services such as CS, AS, ES, PS and IS, which are communicated with each other through digital heritage workflow management services. With any DHR, all its functionalities are implemented based on a service oriented approach. For example, a DHR can be implemented by retrieving data from several social networking repositories, such as Flickr, YouTube and Facebook, through appropriate web services, such as Flickr web service (API), YouTube web service (API) and Facebook web service (API) and integrated as a mashup with museum's collections.

The service orientation layer in a DHR includes several web services (mainly the REST web service). These web services are used to connect data repositories with the DHR application interface. For example, a Web 2.0 mashup (user interface) can retrieve data from Flickr, YouTube and other social networking repositories through Flickr, YouTube and other web services.

Figure 3.5 illustrates the RCH Service Oriented Architecture (SOA). In this diagram, the RCH application layer includes five DISPLAYS application services. The RCH SOA layer

includes several web services such as ARCO, Flickr, YouTube and Facebook. RCH Mashup Repositories include ARCO, Flickr, YouTube, Facebook, etc. The application services in the RCH application layer integrate data from RCH mashup repositories such as ARCO, Flickr and YouTube, through appropriate web services in the RCH SOA layer.

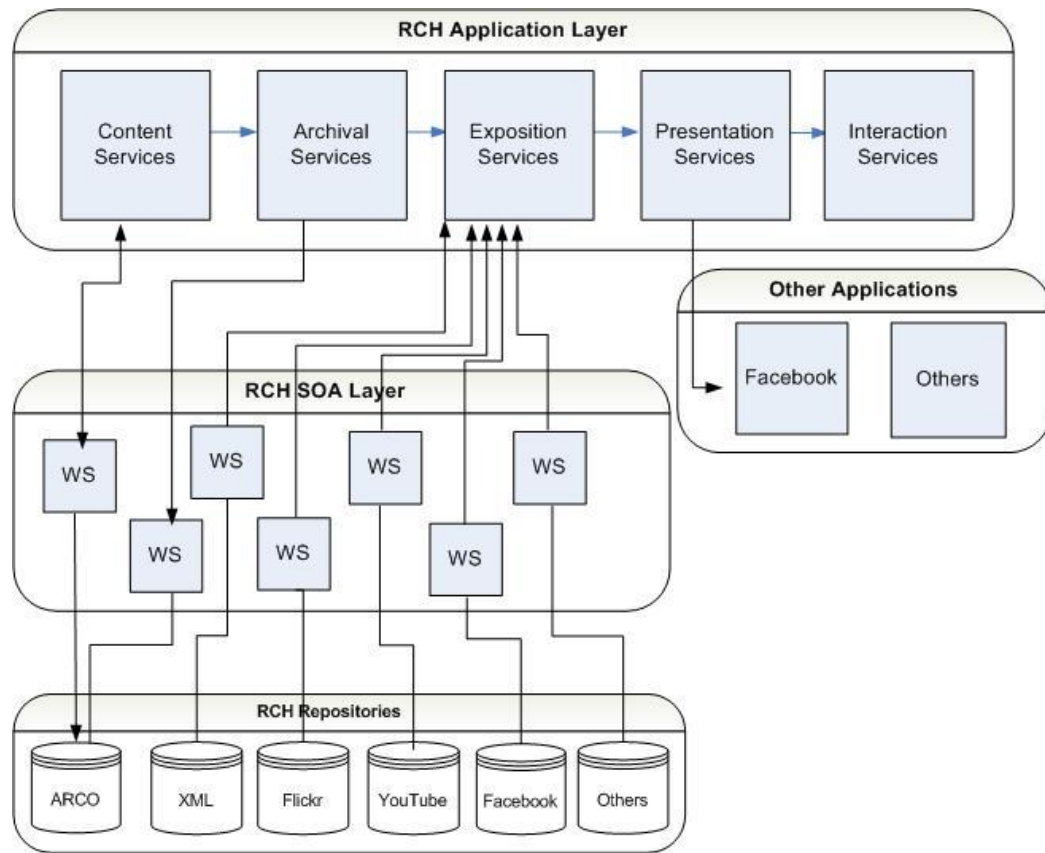


Figure 3.5: RCH Service Oriented architecture [7]

SOA can utilize many kinds of web services. These web services connect data repositories and application user interfaces. For example, the content creation workflow manager can use Adobe web services that can be connected through Adobe Creative Suite 4 (CS4) to access to Adobe CS4 applications for heritage contents creation, animation and so on. The archival and exposition workflow manager could utilize archival and exposition web services to achieve several functionalities such as creating, reading, updating and deleting heritage artefacts from the ARCO database.

Any DHR should have the five DISPLAYS services: CS (Content Services), AS (Archival Services), ES (Exposition Services), PS (Presentation Services) and IS (Interaction Services). CS is used to create digital heritage objects, such as metadata and associate

images or videos. In this RCH example, AS utilizes the ARCO Collection Manager to place metadata images into ARCO. ES utilizes the ARCO template manager and presentation manager to format heritage object metadata and associated images, videos or 3D by using X-VRML template, and then assigns those X-VRML templates into an appropriate presentation in the presentation manager. The PS shows the exhibitions on a web (local or remote). The IS shows any interactions between users and the exhibition interface. An example of interaction could be dragging and dropping digital heritage objects into a virtual world, or viewing a digital heritage object in augmented reality.

3.3 DISPLAYS Scenarios

A DISPLAYS scenario can be described from five main application viewpoints of the DISPLAYS digital library system, or even from a combination of the use of more than one service.

Scenario 1: Finding and Recording an Object

A tourist group are travelling to a heritage building at a Roman villa in Kent. One member finds a beautiful silver bottle. He writes down its location, the date, and the description of the bottle on a piece of paper. When he returns home, he turns on his computer and accesses the DISPLAYS AS on the DISPLAYS web site to import that heritage object – a silver bottle. The other members of that tourist group also found some heritage objects in the same place – around the heritage building. They used the same method of recording their heritage objects information that includes object name, location, description, object images, videos, etc., into the DISPLAYS AS.

Scenario 2: Metal Detecting

There is a metal detector society, which has special treatment when they archive their heritage objects. This is because they are working with their local archaeologist who is responsible for DISPLAYS museums. This special treatment is that when they login and access the AS, they can find other digital heritage objects from the same location as the objects they found. This functionality is only open to DISPLAYS museums' members: this access is denied to other people because the museums try to prevent heritage hunters

finding information about the heritage data in AS. A member of the ‘heritage detector society’ wants to look for all the heritage objects from a particular location – the heritage building in Kent. He finds the records from the tourist group, then uses the DISPLAYS PS and IS to find that particular geographical location.

The heritage detector society finds several more heritage objects in that particular location from his heritage detector. He starts recording all the data information which includes the geographical location, video, images and description. The data information that has been recorded will also be sent to a DISPLAYS administrator.

Scenario 3: Museum Curator

DISPLAYS museum people can search for all similar objects in AS when they find that a record inputted by a tourist looks special. One day, a DISPLAYS administrator opens his email and finds a new submission from the DISPLAYS AS; this new email said a user, John, has recorded a heritage object. The object description is called, a silver bottle; location found: a heritage building in Kent; a photograph of that bottle, and so on. This administrator finds this silver bottle very special and then searches for the silver bottle object in AS. He finds several similar objects and a lot of them are from the same location. Now he is interested in this particular location.

Scenario 4: Archaeology

As the DISPLAYS AS can perform a semantic search that can be by location, object name or keyword description, the administrator searched that particular location; he found a lot of interesting finds that are recorded from tourists or local people. He reported this information to the DISPLAYS museums. The museum people found that the location and resources indicate that this location has not been archaeologically excavated. The museums then tell the archaeological staff to explore that area and they may find a large amount of heritage buried under the ground.

Scenario 5: Museums

The DISPLAYS museums want to show a virtual museum exposition of all the heritage objects that are recorded from that particular location in AS. The museum people go to the

DISPLAYS AS and search for all the heritage objects by that location. They get all the photograph of those heritage objects and when the image is clicked, get all the metadata information of the object that includes a description of the object, images, videos, 3D and so on. Now the museum people want to use this metadata information to implement a virtual museum exposition. The museum people also looked at the heritage objects found by the ‘heritage detector society’ for another virtual museum exposition. The ‘heritage detector society’ people want to make a 3D view for those heritage objects they detected. They found a university research group that is good at 3D modelling and collaborated with this research group. This research group becomes the DISPLAYS CS that provides 3D digital content for DISPLAYS.

DISPLAYS will use the ARCO exposition service as the DISPLAYS ES. In this way, the DISPLAYS ES will have access to a technology called X-VRML [37] to organize the digital contents with metadata information into virtual exhibition spaces through the X-VRML template, and assign media objects into exhibition spaces by uploading a media objects folder. Users can then see the appropriate DISPLAYS visualization and interaction on the web.

The DISPLAYS PS and IS can be easily invoked after all the digital contents and information have been assigned into the DISPLAYS ES. The DISPLAYS PS and IS will publish all the results that are assigned in the ES into a local web or a remote web. They will then apply for appropriate visualization, such as 3D visualization and Web 2.0 visualization (e.g. Carousel and Shadowbox), and appropriate interaction such as drag and drop, VRML interaction or multimodal interface.

3.4 DISPLAYS Presentation and Interaction

3.4.1 E-heritage and E-learning Application

Figure 3.6 shows an example DISPLAYS e-heritage and e-learning applications that present content, archival, exposition and presentation architecture deploying the grid render farm where the author of this thesis contributed to the implementation of the ARCO based archival and exposition services, further implemented the social networking solution based on the Google, Flickr and YouTube web services [7].

DISPLAYS PS and IS are the last part of the functionalities in DISPLAYS. In this e-heritage and e-learning application, the presentation service shows the PS and IS of the DISPLAYS concept. Firstly, the CS creates virtual heritage artefacts, and then those artefacts are archived into a database. This database can be an Oracle, MySQL or ARCO database. The database is connected with an archiving system through web services such as Oracle-MySQL-ARCO web services. After that, all the heritage artefacts and data information are retrieved and assigned into DISPLAYS ES. The heritage contents are then published into the local or remote web through PS and IS.

In this application, ARCO is used as the AS and ES. Social network repositories such as Flickr, YouTube, Bing, and Yahoo can be used as other data sources. Users can now retrieve data into presentation from different data sources (e.g. Flickr, YouTube) through appropriate third party web services such as Flickr web service (API) and YouTube web service (API).

In the presentation of DISPLAYS e-heritage and e-learning applications, ARCO heritage artefacts and associated metadata information will be displayed. Heritage object images and videos that have been retrieved from the social network repositories such as Flickr and YouTube, will also be displayed in the presentation as a heritage mashup [7].

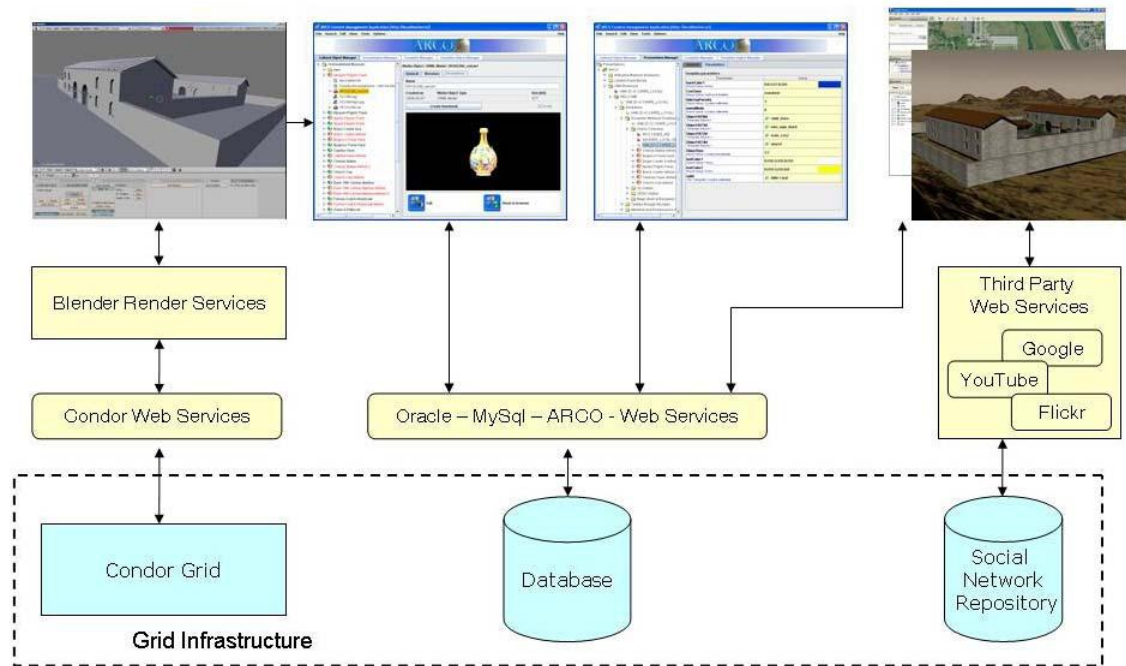


Figure 3.6: Content creation, archival, exposition and presentation architecture [13]

3.4.2 DISPLAYS Presentation

Presentation includes Internet-based visualization and platform-based visualization. Internet-based visualization is viewing videos, images or 3D contents in a local or remote web. Platform-based visualization is visualizing videos, images or 3D in a portable device such as a PDA and mobile phones.

DISPLAYS presentation belongs to Internet-based visualization because DISPLAYS is a web-based application system. Visualizing multimedia based heritage artefacts is the main task of DISPLAYS PS. How to implement a good visualization for videos, images or 3D of heritage artefacts is the challenge of DISPLAYS visualization. Web 2.0 technologies are utilized to develop web-based visualization for heritage artefacts.

Today, Web 2.0 technologies are popularly applied in web based applications. Web 2.0 technologies normally perform interactive information sharing, user interface design and collaboration on the web [45]. Social networking and mashups technologies are utilized for DISPLAYS web presentation. In addition, Yahoo Carousel and Shadowbox web technologies are used for better visualization. Social networking provides a convenient way for people or groups to socialize and interact with each other on the World Wide Web.

Mashups represent a new technology for web-based applications. It aggregates data from different third party data sources, such as Flickr or YouTube, into a meaningful rich application. Mashups and social networking will be demonstrated in more detail in the following chapters.

3.4.3 DISPLAYS Interaction

3D Interaction includes multimodal interface interaction, AR interaction, drag and drop interaction, VRML interaction, touch screen, etc. DISPLAYS interaction will be based on DISPLAYS presentation, i.e. an interaction occurs with a particular presentation. The end users will use a DISPLAYS IS to interact with the PS (e.g. an interface) of DISPLAYS. For example, users can use 3D interaction to interact with heritage mashups in a virtual environment. Specifically, see Chapters 5 and 6, when users access a particular (3D Scrap book) heritage mashups interface of DISPLAYS, they can drag and drop heritage images or videos onto the surface of a 3D scene or a 3D object; users can also drag and drop 3D objects into the 3D scene. After the dragging and dropping interaction, users can undertake a VRML interaction by clicking the surface of 3D objects or 3D scenes; an image can then be presented or a video can be played in a pop-up window. What is more, users can also use VRML interaction to rotate or move a 3D object in a virtual scene.

Multimodal interface interaction is another 3D interaction that uses a multimodal interface to interact with 3D objects or 3D scenes. In a previous project called EPOCH, a multimodal interface was implemented with an artefact to interact with heritage objects [123]. The multimodal interfaces such as black box or space mouse can also be used to interact with a heritage artefact in a virtual environment.

Augmented Reality (AR) interaction is another interaction service that can be implemented quite readily using AR Toolkit [129] or FLAR Toolkit [130] to interact with heritage artefacts. Normally users need to use a camera to have AR interaction with heritage objects. The AR Toolkit is a kind of computer vision tracking library for creating an AR application [131]. FLAR Toolkit is a kind of AR Toolkit using Action Script 3 port for flash animation [132]. FLAR Toolkit is a new technology for AR interaction: users can interact with objects in augmented reality with flash animation.

3.5 Conclusion

In conclusion, this chapter has demonstrated a digital library system called DISPLAYS for creating, interpreting, using and exploring digital artefacts, and playing with shared heritage through content, archival, exposition and presentation and interaction services, based on service oriented architecture. The DISPLAYS concept is to build such a digital library system using a service oriented approach and workflow management service. A DISPLAYS implementer aims to implement different user tools and services for different application layers; for example, a content service, archival service, exposition service, presentation and interaction service are all implemented in the application layers. The workflow management service is implemented to control the data flow of the DISPLAYS system, e.g. data import and data export of the system.

A service oriented approach is used in a DISPLAYS digital heritage system, so the application layers can connect with data repositories through appropriate web services, e.g. archival and exposition services connect with an ARCO database through the ARCO web service. Presentation and interaction services (e.g. Web 2.0 mashups) connect with social networking repositories through appropriate third party web services (APIs) such as Flickr web service (API) and YouTube web service (API). Grid/P2P technologies will be used for large scale computer graphics animations in the DCC application layer, e.g. users use Blender 3D, a render farm management tool, and Condor Grid to achieve virtual reconstruction, job submission and rendering. Based on the DISPLAYS concept, a digital heritage system called ‘Reanimating Cultural Heritage’ is implemented by the DISPLAYS group. The next chapter will demonstrate this Reanimating Cultural Heritage project.

CHAPTER IV

4 Reanimating Cultural Heritage (RCH)

4.1 Introduction

The last chapter demonstrated a digital heritage system concept called DISPLAYS that includes content creation, archival, exposition, presentation and interaction services. Based on this DISPLAYS concept, a new digital heritage system called ‘Reanimating Cultural Heritage’ has been implemented. RCH is an underlying architecture of DISPLAYS. For example, in the same way as DISPLAYS, RCH has five services in the application layer: content services, archival services, exposition services, presentation services and interaction services, and these services and data processes in RCH are all managed by workflow management services. The implementation of RCH validates several of the DISPLAYS concepts. For example, social networking, Web 2.0 mashups and 3D elements in the DISPLAYS concepts are utilized and implemented into RCH applications to allow users to access user generated digital content and create their own virtual exhibitions. The author’s contribution to this digital heritage system was to design and implement an innovative social networking system to allow users to access and interact with digital heritage objects and collections from the Sierra Leone digital heritage repository. Specifically, in this social networking system, a novel Web 2.0 mashup application was implemented to allow communities to create and publish their own virtual heritage exhibitions based on user-generated digital heritage content.

RCH is an AHRC funded project. This project aims to innovate ‘digital curatorship’ in relation to Sierra Leonean digital collections dispersed in a global museumscape. It considers how digital heritage objects can be reanimated in a digital environment together with associated images, videos, sounds, texts and other media, such as 3D, within a virtual exhibition space, and then gives them a new life.

Reanimating Cultural Heritage is based on the digital heritage collections in relation to Sierra Leone. This project is in partnership with the British Museum, Brighton Museum & Art Gallery, and Glasgow Museums, which will provide all the metadata of heritage

artefacts related to Sierra Leone and associated images, videos, texts and other media. For this RCH project, a digital heritage resource will be created that utilizes social networking technologies with a system called ARCO (as reviewed in Section 2.1.9, used to manage the museum's collections) to allow both museums and communities to create their exhibitions online.

This chapter presents an approach for creating a digital heritage resource that utilizes workflows, web services, social networking, and Web 2.0 mashup technologies to reanimate a museum's digital heritage objects in a digital space through different kinds of media such as images, videos, sounds, texts and 3D, and then allow museums and communities to build digital heritage exhibitions online. This chapter focuses on how this digital heritage resource can effectively integrate user-generated heritage content (e.g. heritage objects from social networking repositories) with museum collections (e.g. ARCO digital collections) online, reconnecting digital heritage objects in collections dispersed in communities such as third party repositories (e.g. Flickr and YouTube). It demonstrates a novel digital heritage system using a variety of digital technologies, such as social networking, Web 2.0 mashups, 3D visualization and interaction technologies, to allow communities to access and interact with museum digital heritage objects and collections and contribute their knowledge. It will also demonstrate how this would enable communities to create and publish their own virtual exhibitions based on user-generated digital heritage content.

4.2 RCH Requirements Gathering

4.2.1 RCH Hardware and Software Requirements

It is proposed that the ARCO system is used and integrated with social networking, Web 2.0 mashups and other Web 2.0 technologies, to create an effective RCH digital repository holding Sierra Leone digital objects from the participating museums, and user generated content from Sierra Leone diaspora. The general hardware components of the RCH digital repository are based on:

1. RCH Digital Repository (DR)

- Museum's **Digital Heritage Resource (DHR)**

- ARCO database server – which contains all the digital heritage objects
 - Web Server – utilising Apache Tomcat for web applications
 - Social Network **Digital Heritage Resource (DHR)**
 - YouTube Server
 - Flickr Server
 - Facebook Server
2. Poznan Backup **Digital Repository**
- Copy of Museums **Digital Heritage Resource**
 - Combined ARCO database and web server

The ARCO database (and backup) server will act as a database repository to contain 1,500 digital objects from the museums' Sierra Leone collections. New digital objects can also be discovered and contributed through social networks. These social networks reside on appropriate public repositories. Figure 4.1 shows this digital repository architecture. In this diagram, ARCO and social network digital heritage resources can be integrated into the RCH digital heritage resource by using Web 2.0 technologies (e.g. Web 2.0 mashups), and connected to data repositories (e.g. ARCO or third party repositories) through appropriate web services (ARCO web service or REST web service). Note, the backup servers have been excluded for clarity.

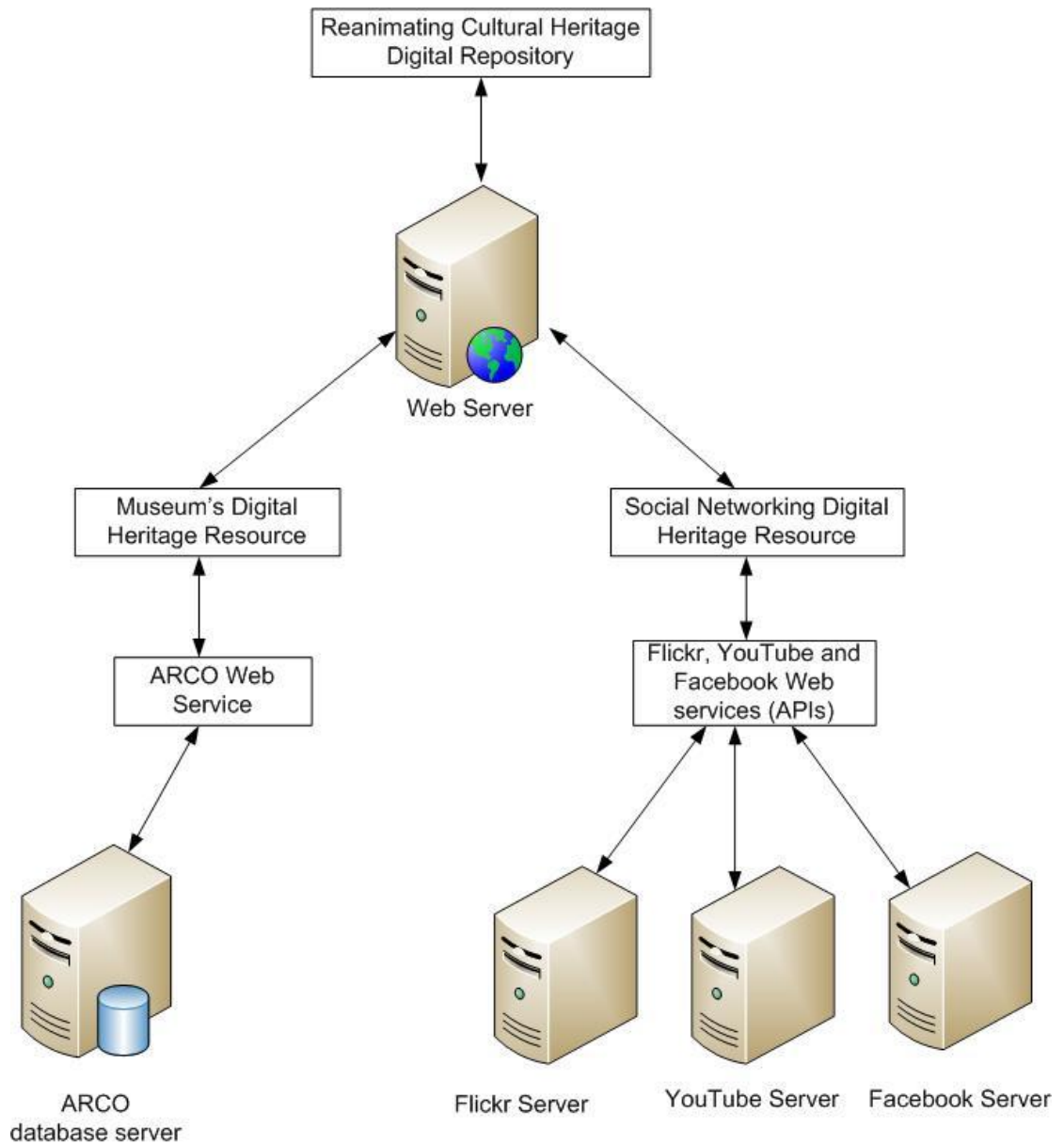


Figure 4.1: The reanimating cultural heritage (RCH) digital repository (DR) showing the two digital heritage resources (DHR) combined into one presentation service (PS) on the Web, based on the DISPLAYS concept

The software components will include ARCO system software components, other open source or commercial software, and libraries.

This digital heritage resource will be built on the ARCO system. As such, the ARCO Centre will expect to be able to benefit from giving the ARCO system to the partner museums for utilizing (e.g. used as the backbone for the digital heritage resource).

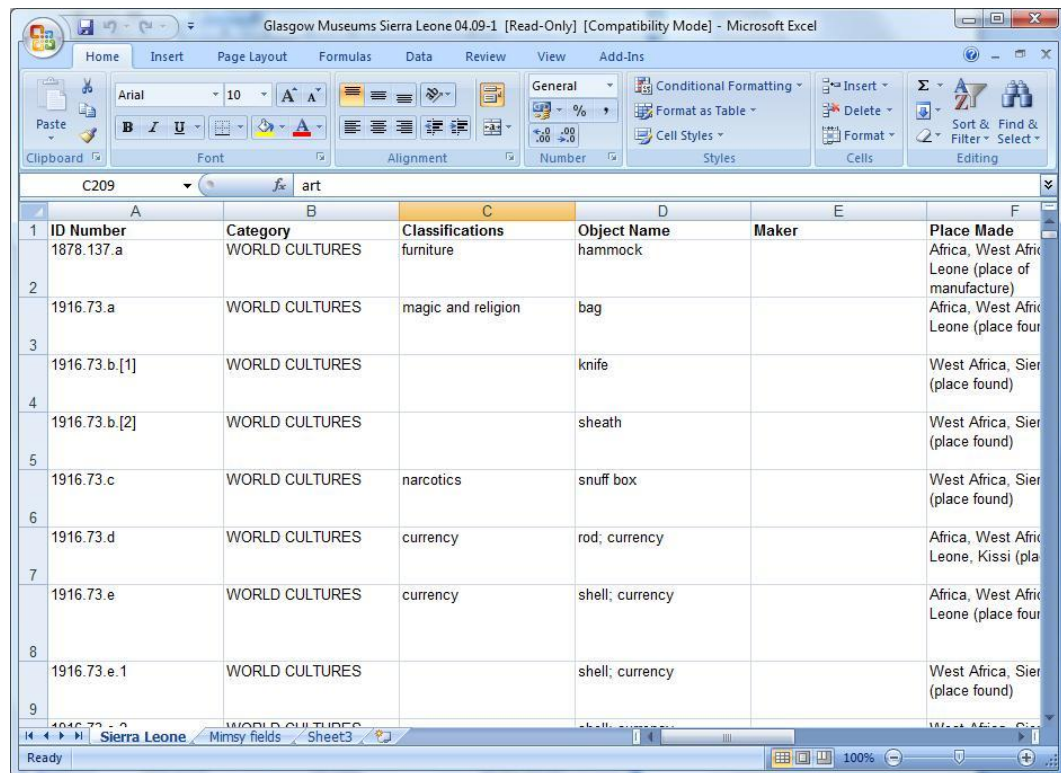
Other open source software or libraries will be deployed for the digital heritage resource; for example, Web 2.0 open source tools (e.g. image galleries, image Carousel and Shadowbox). Some commercial software will be used for the project (e.g. 3ds Max software for 3D modelling and reconstruction for 3D objects and virtual environment).

4.2.2 RCH Metadata Requirements

The RCH digital repository needs to collect metadata from different museums which include the British Museum, Glasgow Museums, and Brighton Museum & Art Gallery. All the metadata of heritage artefacts in relation to Sierra Leone heritage collections and associated images, videos, sounds, texts and other media are provided by those three museums. The museums provide Excel spread sheets that contain all the metadata of Sierra Leone heritage objects exported from their respective museums database systems, and CDs that contain all the associated images for their Sierra Leone heritage artefacts. Figure 4.2 shows the Excel Sierra Leone objects metadata list from the British Museum; Figure 4.3 shows the Excel Sierra Leone objects metadata list from the Glasgow Museums.

British Museum object list [Compatibility Mode] - Microsoft Excel								
W9								
REGISTRATION NUMBER								
	Prefix	Year	Collection	Object Number	Object Range	Part Number	Part Range	
2	Af	1851	810	4				Object Name
3	Af	1856	623	163				canoe; model; shield
4	Af	1856	623	164				spoon
5	Af	1856	623	164				spoon
6	Af	1867	325	1		a		cup; bowl
7	Af	1867	325	1		b		lid; cover
8	Af	1886	1126	1				mask
9	Af	1886	1126	2				armlet
10	Af	1886	1126	3				armlet
11	Af	1886	1126	4				figure
12	Af	1893	1114	1				figure
13	Af	1893	1114	2				figure
14	Af	1897	713	1				figure
15	Af	1901	419	1		a		neck-ornament; charm
16	Af	1901	419	1		b	c	bracelet; charm
17	Af	1901	419	2		a	d	hair-ornament
18	Af	1901	419	3		a	b	charm; neck-ornament
19	Af	1901	419	4				screwdriver; arms equipment
20	Af	1901	419	5				currency
21	Af	1901	419	6				buff coat

Figure 4.2: British Museum Sierra Leone objects list



	A	B	C	D	E	F
1	ID Number	Category	Classifications	Object Name	Maker	Place Made
2	1878.137.a	WORLD CULTURES	furniture	hammock		Africa, West Africa, Leone (place of manufacture)
3	1916.73.a	WORLD CULTURES	magic and religion	bag		Africa, West Africa, Leone (place found)
4	1916.73.b.[1]	WORLD CULTURES		knife		West Africa, Sierra Leone (place found)
5	1916.73.b.[2]	WORLD CULTURES		sheath		West Africa, Sierra Leone (place found)
6	1916.73.c	WORLD CULTURES	narcotics	snuff box		West Africa, Sierra Leone (place found)
7	1916.73.d	WORLD CULTURES	currency	rod; currency		Africa, West Africa, Leone, Kissi (place found)
8	1916.73.e	WORLD CULTURES	currency	shell; currency		Africa, West Africa, Leone (place found)
9	1916.73.e.1	WORLD CULTURES		shell; currency		West Africa, Sierra Leone (place found)

Figure 4.3: Glasgow Museums Sierra Leone objects list

The data within these spreadsheets has to be processed to create the RCH digital repository, in this case it will need exporting as an XML file for import to the ARCO database.

4.2.3 RCH Aims and Objectives

The RCH project has several aims and objectives that need to be observed in the design of the digital repository, the following aims and objects (1 to 7) are paraphrased from the project documentation:

1. “To study the relationship between material culture, sensory experience and knowledge/memory transmission in Sierra Leone, and to investigate how conflict and other factors impact on this;
2. To examine current innovation in digital libraries, for example, to look through new media in exhibitions, ‘virtual repatriation’ contexts, and knowledge networking;
3. To investigate how the ‘remediation’ of cultural heritage artefacts in digital spaces

can reanimate ethnographic collections and associated knowledge;

4. To examine how digital heritage resources can be implemented to reactivate the ‘work of memory’ in post-conflict Sierra Leone;
5. To develop a digital heritage resource that enables the performance of the virtual exhibitions of dispersed Sierra Leonean digital heritage collections, and utilizes social networking technologies to facilitate the generation of disparate knowledge networks around objects and the remote uploading and organisation of digital media by different kinds of user groups;
6. To lead and assess the potential of the digital heritage resource as a tool of civil society strengthening in Sierra Leone through participating in other projects developed and implemented by local partners (including training and capacity building of local partners in addition to wider communities and so on);
7. To build a framework for the on-going and sustainable development of the digital heritage resource, for example, for expanding to incorporate additional Sierra Leonean collections, and the generation of future research work and community development initiatives based on the digital heritage resource” [133].

These are the aims and objectives of RCH in general. In the context of the RCH digital repository this chapter presents the development of an innovative social networking digital heritage resource [7] to allow communities to access and interact with the Sierra Leone digital heritage objects and collections and contribute their knowledge. It will also allow communities to create and publish their own virtual exhibitions based on user-generated digital heritage objects related to the Sierra Leone cultural heritage.

4.2.4 RCH User Requirements

In the RCH system, the ARCO digital heritage resource has developed very quickly because the ARCO system is a commercial system that is already licensed for use. This project will not only use ARCO for museums’ digital heritage exhibitions, but also create more functionality for communities’ digital heritage exhibitions. This specification, therefore, will involve mapping appropriate function requirements onto the ARCO system,

and building more new functionalities (e.g. social networking digital heritage resource) that will be integrated into the ARCO system.

A number of user case scenarios are needed to describe the functional requirements of the proposed application. According to the RCH aims and objectives, several user case scenarios have been developed to outline how the digital heritage resource may be used. The following use cases have been adapted from the RCH use case document originally developed by Johanna Zetterstrom-Sharp:

“User case 1 – User Addition of Content through Social Networks

- Mark, who is a university student from the USA, has a selection of photographs taken of Freetown in 2009 when he was travelling there. He saw a selection of photos of Freetown taken by a group of British anthropologists in 1926 on the Sierra Leone heritage web site. He was shocked by the big changes in architecture that had taken place in Freetown. He thinks other people may be interested in the photos of Freetown he has taken, and his sharing may encourage others to share their own photos taken of Freetown. He knows Flickr is a photo sharing web site and has used it to share photos of his holidays with his friends.
- Ishmael is a primary school teacher in Bo who has just finished a school project about storytelling, and cooperates with an NGO that provides digital recording equipment to schools and invites teachers to use it through workshops. In this project, children in school are divided into groups and make up their own story, or use a story they remember, and then the performance around children is built for a video. John wants to share this video on the web, but the school is not yet connected to the Internet. He knows the local library has the Internet and was shown how to upload the children's videos onto the Sierra Leone heritage web site via YouTube. So he copies the videos onto a disk, goes to the town and uploads them onto the site.

User case 2 – Searching the Digital Repository

- Kenai is a college student in Freetown, and he is particularly interested in Lomba wood carvings. He has visited the National Museum of Sierra Leone in order to find some Lomba wood carvings and compare them. However, there is only one example

of Lomba wood carvings in the Sierra Leone museum. His friend told him the British Museum has a number of examples of Lomba wood carvings and that photos of those examples can be found at the Sierra Leone heritage web site. He opens the web browser, enters the site and sees a 'search function' on the top of the website. He performs a search for Lomba wood carving and finds a couple of examples brought from the British Museum, and some further examples from the Glasgow Museum. In addition, an audio clip is brought up showing an elder talking about the carving of these items that was uploaded by a small film school. Kenai did his research on Lomba wood carvings and discovered that there are a lot of different types of wood that are used in these carvings, and that these wood carvings hold different kinds of meanings according to time and situation. Kenai notices that the different wood type name for each carving is treated as a 'tag', and his favourites are Lomba wood carvings made from the trunk of the cotton tree. He wants to save his search for the next visit, creates a user name and password, and picks out the relative objects and video clips and saves them on the browser.

Use case 3 – Upload through the Social Network

- John is doing field work in Sierra Leone and does his research on oral histories in Freetown. He has heard some stories about the process of wood carving and the carvers themselves. He visited some artists in Freetown and did video interviews with them on how to make wood carvings. He accesses the Sierra Leone heritage web site, logs in and uploads his videos through YouTube. Whilst he also searches through all the other data that has been tagged with 'wood carving', he notices a number of wood carvings have already been tagged by their wood type (e.g. Lomba wood carvings are tagged by Kenai). He also tags his own videos accordingly.

User case 4 – Pathways

- Kenai (above) is about to finish his thesis and he has already collected a large number of data about wood carvings that he thinks might be interesting for others. He also thinks that the interpretation of Lomba wood carvings available to the public on the web site needs to be updated. He logs in to the Sierra Leone Heritage web site and re-

searches ‘wood carvings’; he found that the number of objects of wood carvings has increased and that other people (John) have tagged new objects of wood carvings. He selects a number of objects including museum objects, photographs and videos related to Lomba wood carving. Then he saved his search and named it ‘Lomba wood carving and wood types’. Additionally, he adds his own textural interpretation on the collection of objects and re-saves it. This ‘pathway’ can then be accessible to the public through the creation of a scrap book.

User case 5 – Downloadable Material

- Ishmael (above) is continuing his school project on storytelling. The making of his videos was very successful and these videos are much enjoyed by children. He learned that there are similar training projects in other village schools surrounding his area from the Sierra Leone heritage online resources. He feels that it would be very useful for children to see the results from other similar projects. However, his school does not have funds for him to take children to visit other schools. He goes to the town to use the Internet at the library and searches ‘school videos’ in the Sierra Leone heritage web site. There are a couple of videos brought up: he logs in and saves them into the web browser. From the search results, he notices that all the videos have been ‘tagged’, for example, the videos from his own school have been tagged as ‘wood carving’. He follows the ‘wood carving’ tag and finds some images of objects related to wood carvings from the Sierra Leone National Museum and the British Museum, and a number of videos about wood carvings uploaded by other users (e.g. Emily). He selected these objects and clicked on the ‘download’ tab to download them into a disk. He takes these images and videos of objects into his school and shows them to the children.

User case 6 – Object ‘Comments’

- Hannah, a girl living in Kanema, often goes to Internet cafes and emails her brother in Makeni through the Internet. She moved to Kanema after the civil war when her hometown in Kono was destroyed and wonders whether there is any information about her hometown on the web. She searches for ‘Village in Kono’ on Google.

Google brings her a selection of images and videos of objects held at the Sierra Leone heritage web site. One particular photograph showing a boy in a cassava field reminds her of her brother's story. She writes her comments about that memory in the comments box. There is also a video of someone using a Sodingbai trap to catch a squirrel that attracts her, and she makes comments on that video about how her father used to do the same thing when she was a child. These comments remain with the object when another user comes across this object the next time" [134].

4.3 RCH Features

Based on user requirement and studying what other museums are doing in this area, the RCH project has created a feature list for the system. Figure 4.4 shows the proposed RCH system based on features.

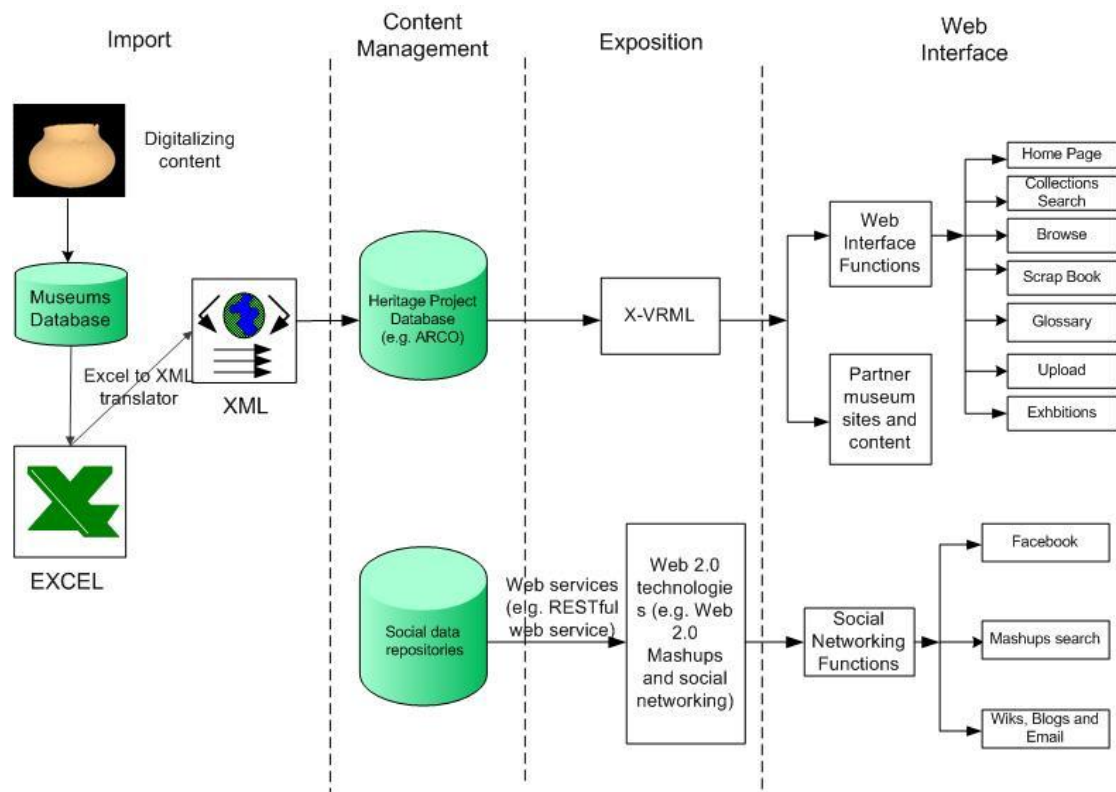


Figure 4.4: The proposed RCH system based on Features

The RCH features will include five main areas: content management, social networking functions, web interface functions, import and export, and partner museum sites and content. These features for the RCH digital repository are still under development, the

following represents the feature list at the time of writing this thesis, adapted from the project documentation:

1. **“Content Management Tools:**

- Using ACMA (ARCO Content Management Application) to access the cultural object manager, the presentation manager and the template manager for achieving, exposition and presentation services.

2. **Social Network Functions:**

- Facebook: A popular social networking web site that people can access and then connect and communicate with each other. This community access (shared interest) interface allows a user to create, read, update and delete objects for discussion, allows users to add basic comments to an object. For example, a user can insert an image from a local disk or from a Flickr repository, users can write comments to their pictures or other people’s pictures, and all users from the communities (groups) can see those comments, and so on. This Facebook functionality will be described in detail in Chapter 6.
- Mashups Search: This functionality is also used in the scrapbook function. Users can use this mashup search to retrieve images and videos of digital heritage objects from different social network repositories such as Bing, Flickr, Yahoo and YouTube through their appropriate web APIs.
- Wiki and blog: In wiki and blog, users can add their own descriptions, or knowledge, to the digital collections, or give some suggestions to the digital heritage resource, or read the museums curators’ blogs with more controlled and focused discussions and sharing of knowledge.
- Email can be used for contacting the RCH people.

3. **Web Interface Functions:** see Figure 4.7.

- Home: the Home Page.

- Collections and Collections Search: this is a sophisticated search function using an extensive X-VRML template to allow searching the heritage objects across the ARCO database. This search function includes word search, search by object category, theme culture and related media; all the above search functions are to search the ARCO database metadata. The search function will be the same as the <http://alaska.si.edu/search.asp> search, but using the ARCO X-VRML template.
- Browse: the browse function also uses an X-VRML template to allow the user to browse all the database objects organised by museum collections. So, in this case, the British Museum, Glasgow Museums, and the Brighton Museum and Art Gallery Sierra Leonean objects would be displayed the same way as www.alaska.si.edu/browse.asp browse their collections, but with the RCH DR brand and dynamic update using X-VRML templates.
- Glossary: a simple HTML list of glossary terms.
- Scrap Book: a heritage scrapbook is a novel functionality that will be implemented with the social networking and 3D virtual environment embedded in the RCH DR using the mashup approach. In this functionality, users can make their own 3D scrapbook by dragging and dropping images and videos from social networks such as Flickr and YouTube into a 3D environment, and then users can save their scrapbook that has been scrapped into their desktop computer. If he would like, he can then publish the 3D scrapbook into further exhibitions.
- Exhibitions: this is the core functionality that is inherent in the ARCO system. Using the ARCO presentation manager, a museum curator can create dynamic presentations for displaying on the web. Think of each exhibition as a micro web site whose digital heritage content (digital cultural objects, images, video, text, metadata, etc.) is dynamically updated. The exhibitions include museum exhibitions (a museum creates the exhibition of digital heritage collections) and user-generated exhibitions (a user created his own exhibition in the scrapbook function, then that exhibition is uploaded into web presentation).

- Upload: the name of this function may change, but basically this is really just a method for a user to contact the curator to ask for their cultural object to be integrated (uploaded) into a RCH DR collection. The curator has to be able to moderate such requests.

4. Import and Export:

- Import: the ARCO database has to be able to import Sierra Leone digital heritage objects from their partner museum, and there are in total about 1,700 digital heritage objects from the three British participating museums (British Museum, Glasgow Museums and Brighton Museum & Art Gallery). This process involved converting the British Museum metadata format and Glasgow Museums and Brighton Museum & Art Gallery MIMSY format into an XML format suitable for importing into the ARCO database. This is discussed in more detail in Section 4.4.2.
- Export: similarly data, collections and exhibitions will need exporting or migrating to other museum standards, e.g. using an X-VRML template to allow the export of data, collections and exhibitions into both XML and XHTML format. This is discussed in more detail in Section 4.4.1.

5. Partner Museum Sites and Content

- Site and Monuments: this is effectively a separate micro-site, which could be hosted anywhere but the ARCO web server is chosen to host it.
- Sierra Leone National Museum: in the context of post-conflict Sierra Leone, the museum does not currently have a web site, but when this is created a user will be able to access it from this link.
- Cultural Expressions: this will link to a separate cultural expressions micro-site, which will provide a collection of video clips presenting Sierra Leone cultures, so users will be able to access this to know about the cultures of Sierra Leone from this link” [135].

This thesis presents in more detail the innovative social network functions and 3D scrap book features.

4.4 RCH Digital Repository

4.4.1 RCH based on ARCO and X-VRML

The work in this section is based on work the author and colleagues published in the Cyberworlds conference [7], but also includes additional content to that paper not yet published. It is necessary to re-state the work published in that conference [7] in order to lay the ground work for the additional work discussed, and to set the scene for new innovations – the integration of RCH within X-VRML templates. An early version of a paper that also details this additional work is available titled “Reanimating Cultural heritage through Service Orientation, Workflows, Social Networking and Mashups” [136] as an unpublished work – the author does of course intend to publish this work at a later date along with other developments beyond the scope of this thesis.

In previous chapters, the Augmented Representation of Cultural Objects (ARCO) project has been discussed. ARCO provides a very effective way to enable museums to create virtual exhibitions or virtual museums online [137]. The ARCO system is mainly intended for use by museums, and the system will be installed in a local museum along with its components, e.g. the ARCO database server along with its virtual museum web server that can be integrated in some way with a museum web site. Museum officers are given permission to use a tool to access all the parts of ARCO system, e.g. there is a tool called ACMA (ARCO Content Management Application) that contains the cultural object manager (for managing the museum’s digital heritage collections), the presentation manager (for building virtual museums exhibitions), and the template manager (for implementing the web layout (look and feel) of the virtual museum).

There are some important components or tools which are needed to manage ARCO exhibitions. For example, Figure 4.5 shows the ACMA tool and a zoom in on the tabs that are used to access the ARCO system, e.g. the entire manager functions (cultural object manager, presentation manager and template manager).

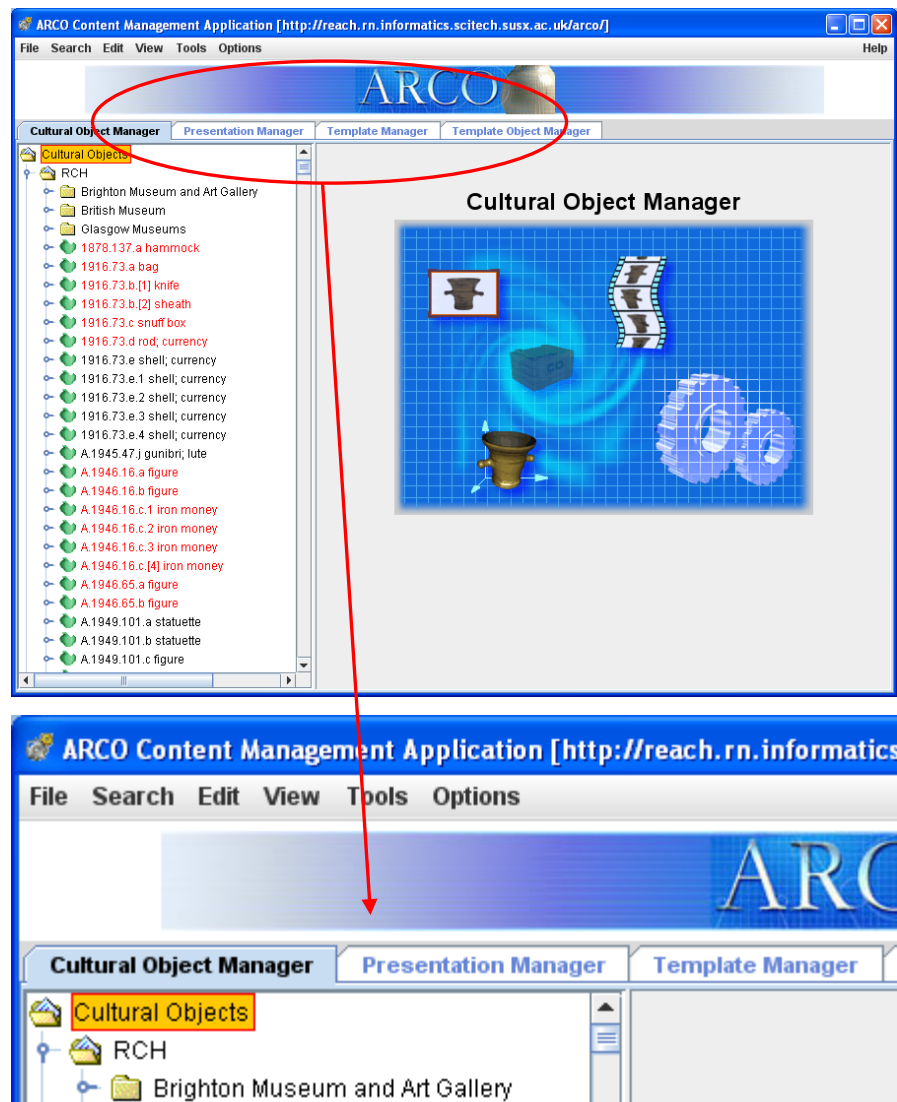


Figure 4.5: ACMA Interface and zoom in showing the manager tools

There are other low level tools that are contained within ACMA; for example, there are different types of museum metadata element sets based on different tools to facilitate digital heritage metadata collections management, e.g. Dublin Core metadata element set and Spectrum metadata element set are based on Dublin Core and the mda Spectrum [137]. Dublin Core metadata initially provides guidelines and proposed guidelines for XML schema [138]. There is another tool within ACMA called XML Data Exchange that allows the import and export of metadata from other museums [139]. The RCH DR workflows expand the methods for exporting data, collections and exhibitions for web presentation and migrating back to partner museums in XML format.

How the ACMA managers should be used to build an exhibition web site with multimedia contents. Figure 4.6 shows the process of building an exhibition using the presentation manager. This diagram shows how to implement the web exhibition with spaces that are called ‘Home’, ‘Collections’, ‘Browse’, ‘Glossary’, ‘Scrap Book’, and so on. Each space is associated with a number of X-VRML templates, e.g. for the whole Sierra Leone heritage web site, we have a ‘navigation’ template that all the spaces will inherit: ‘Home’ space has a ‘default’ template and the other spaces have appropriate functional templates. There is X-VRML technology behind the templates, which is beyond the scope of this thesis [37]. In the previous chapter, the ARCO system has already been discussed. X-VRML technology is an XML wrapper around the VRML scene graph language, which is designed for ARCO to enable dynamic updates of media contents, including 3D, and provides convenient access to the ARCO database [137].

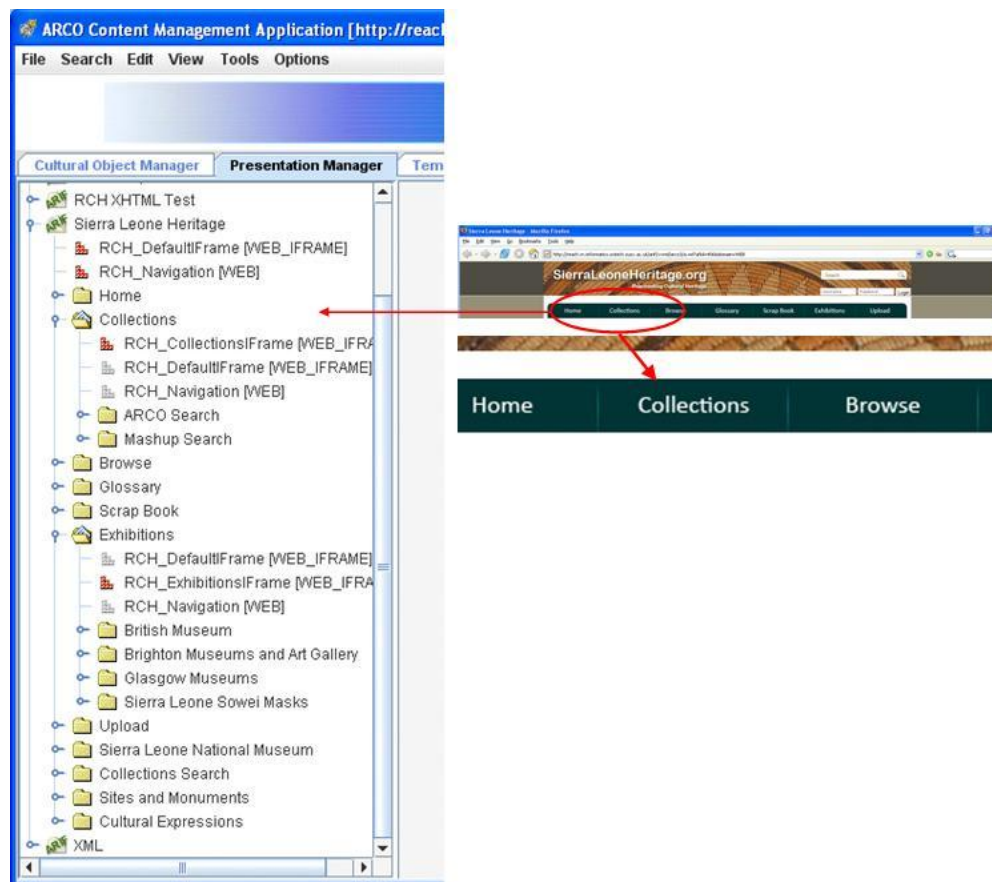


Figure 4.6: Illustration of the process for building an exhibition using the presentation manager

X-VRML templates are implemented for each appropriate web exhibition. In this example, X-VRML templates are designed for Sierra Leone heritage digital exhibitions. In Figure 4.6,

there are three main function templates: DefaultIFrame, CollectionsIFrame and ExhibitionsIFrame. Each folder can have several templates; some templates are inherited from its parent folders, and only one specific template is developed for the functionality of that particular exhibition. For example, in the ‘Collections’ folder, there are three templates: RCH_CollectionsIFrame, RCH_DefaultIFrame, RCH_Navigation. RCH_Navigation and RCH_DefaultIFrame are inherited from the Sierra Leone heritage project folder, and RCH_CollectionsIFrame is the actual specific template to execute the functionality of the exhibition of collections. In addition, it needs to be stated that the term IFrame means that function web page is embedded using HTML IFrame.

After the X-VRML templates are developed and assigned into the presentation manager, the heritage contents stored in the X-VRML are ready for web exhibition. If the user of ACMA right clicks on the RCH_Navigation [WEB] in the Sierra Leone heritage project space, the main web page including all the navigation functionality, will be displayed. Figure 4.7 shows the main web page (the Home Page) that is the combination of the defaultIFrame and all the navigation templates. It is interesting to note the URL of the home page:

<http://reach.rn.informatics.scitech.susx.ac.uk/arif/xvrml/arco3/a.wrl?afid=407&domain=WEB>

Where ‘reach.rn.informatics.scitech.susx.ac.uk’ is the web server in the Informatics research network, and

- ‘arif’ refers to the default ARCO web server (actually technically called the ARIF Server – Augmented Reality Interface Server)
- ‘xvrml’ refers to a sub folder and is a reference to the technology deployed, i.e. XML integrated with VRML
- ‘arco3’ refers to a folder with this particular prototype development of the RCH system
- ‘a.wrl’ is an X-VRML template that brings together the RCH digital objects into an exhibition on line
- ‘afid’ is the id of the exposition folder within the ARCO system

- ‘WEB’ is the domain in which the contents, i.e. RCH digital objects are presented (published)



Figure 4.7: Main page combined default IFrame and navigation templates

It is beyond the scope of this thesis to describe the ARCO system in any great detail, such detail can be found in [8, 37, 39, 138]. Instead, this discussion concentrates on how ARCO has been used to implement RCH functionality.

The ARCO ACMA tool is used to create web exhibitions online, however, ACMA is not intended for use directly by heritage end user communities, and it is implemented for the use of museum heritage exhibitions. There is a need, therefore, for end user communities to ‘personalise’ their own exhibitions to allow a better reconnection to the digital heritage

objects and resources of their communities. Digital heritage resources can then have both museum heritage exhibitions and user-generated exhibitions, rather than relying on the museum curators' interpretation. There are, however, some questions: for example, how can end user communities import their cultural perspective or knowledge into digital collections; how can communities augment the view of a digital heritage object; and how do the communities personalise their own exhibitions?

The RCH project addresses these issues and looks for potential solutions. There are a lot of potential solutions for meeting this new requirement of personalising end user communities' exhibitions. For example, the ARCO system functionality can be extended, e.g. extending the administrative rights to the end user communities, allowing them to use the ACMA tool to remotely access the object manager, presentation manager and template manager to create, interpret and use the digital heritage objects, and then build their own exhibitions online. In the approach discussed above, due to security reasons, there are some issues that should be considered. For example, how and to what level should user communities access the ARCO object manager, presentation manager and template manager? What is more, museums will spend time and money on developing digital collections for user communities to access, which will involve archival services, security issues, metadata exposition and presentation, etc. It is, therefore, probably not a good idea to open up CRUD access to end user communities on the ARCO collections managers.

Although there will be many issues involved to open access to end user communities on the ARCO collections managers, it would still be possible to design and implement a lightweight web-based ACMA. Restrictions could be given to some functionalities to user communities for using and building their exhibitions based on the heritage objects in ARCO. When the user communities want to use that lightweight ACMA to build their own exhibitions, they would only focus on the presentation manager with several predetermined X-VRML templates that will connect to the ARCO database through the ARCO web service. Facebook, YouTube and Flickr applications use the same method of connecting to their own repositories through appropriate REST web services.

So far the use of ARCO as an archival (Cultural Object Manager) and exposition (Presentation Manager) services for museum collections has been illustrated. However, the

work in this thesis focuses on exploring a potential solution using existing social networking technologies to allow end user communities to personalise their own heritage exhibitions, and so achieving the capture of user communities' knowledge. A solution is proposed, which is to integrate digital heritage objects that are created by end user communities from outside the ARCO system (e.g. from Flickr, YouTube and other social networking repositories) with digital heritage objects inside ARCO, using a very meaningful and interesting method. This solution will give users a large degree of control on generating their own digital heritage contents, e.g. allowing users to create their own digital heritage exhibitions. These user-generated digital heritage contents and exhibitions will be separated from ARCO digital heritage contents and exhibitions.

Many social networking sites now open up their application programming interface (API) to developers through an appropriate web service, and ARCO also provides their web service to allow developers to access ARCO. Service oriented architecture is designed to integrate digital content from social network repositories with the contents in the ARCO repository through appropriate third party web services and the ARCO web service. Social networking and Web 2.0 mashup technologies are utilized to achieve this integration. The next chapter will discuss social networking and Web 2.0 mashups in more detail.

This social networking and Web 2.0 mashups solution has a lot of advantages. For example, this solution is able to not only capture social network repositories heritage data, but also separate museums digital heritage collections and exhibitions from user-generated digital collections and exhibitions when integrating social network digital contents with ARCO digital collections from a presentation and interaction point of view. What is more, CRUD operations could be performed on user-generated content. An innovative example of a DISPLAYS (or RCH) component that allows users to generate their own content is called the '3D Scrapbook', see Chapter 6. Users could build their own scrapbooks through selecting digital heritage contents from social networking sites such as Flickr, YouTube, Bing and Yahoo, etc., and the museum's collections. The scrapbook function can access community digital heritage resources from social networking; if museums or users found any interesting heritage collections, they may want to 'copy' these digital collections (add

the digital contents permanently) from social networking repositories to their scrapbooks, and these scrapbook could be published into further exhibitions.

Figure 4.8 shows the ARCO-based RCH system architecture. In this diagram, there are five services: content services (CS), archival services (AS), exposition services (ES), presentation services (PS) and interaction services (IS). In the CS, museums provide digital heritage content such as images and videos of digital heritage objects and collections, and Excel spreadsheet that include associated metadata of digital heritage objects. There is a tool called the Excel to XML translator that can convert the associated metadata of digital heritage objects from the Excel format to the XML format. The XML metadata can then be archived into the ARCO database in the AS. Digital heritage objects and collections from ARCO and social network repositories can be retrieved and displayed as a RCH DR (Local RCH DR or Remote RCH DR) through the X-VRML technology and Web 2.0 technologies. The IS includes 2D interaction and 3D interaction that allow users to interact with digital heritage objects and collections.

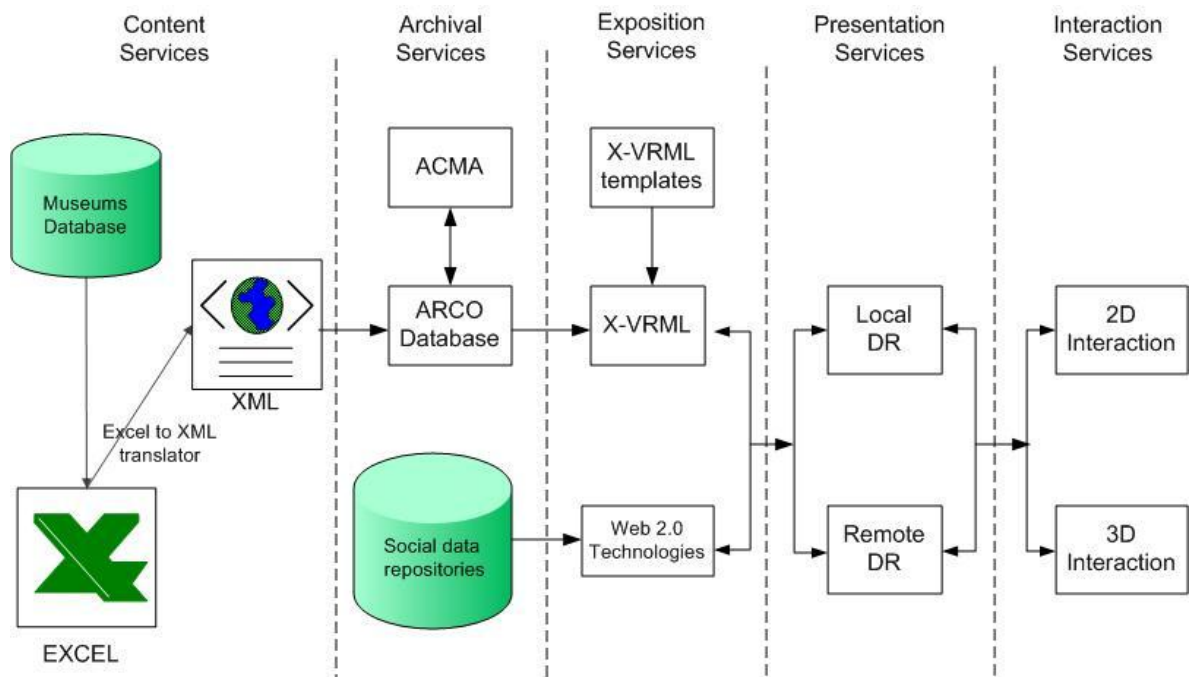


Figure 4.8: The ARCO based RCH system architecture

4.4.2 RCH based on XML and XSLT

A lightweight RCH system called the RCHLite has also been implemented. Basically, the RCHLite system is implemented using XML and XML Transformations (XSLT) to display digital heritage contents into the exhibitions – it is also possible to use XQuery. Compared to the ARCO based RCH system, RCHLite has some advantages:

1. RCHLite will not rely on a heavyweight Oracle database management system that is the ARCO system and X-VRML technology inside ARCO.
2. RCHLite could be easily installed on a personal computer, e.g. you could simply copy the whole RCHLite folder that contains all the files with different file extensions such as XML, XSLT, PHP, XQuery, XHTML, JavaScript, etc. into the local host of your computer, and then you can view the whole system functionalities locally.

The ARCO based RCH system integrates digital heritage collections in the ARCO system with digital content from social networking repositories to allow museums and communities to create, interpret and use those digital heritage contents in a visualization and interaction environment. The RCHLite system, on the other hand, eliminates several functionalities that rely on a more expensive ARCO system, for example, the Oracle database functionalities and dynamic update of VRML scenes using X-VRML technology. Instead, RCHLite utilizes an Excel spreadsheet to act as a Content management System (CMS), where content is exported to an XML format and XSLT is used to transform the XML file to a web display (XHTML), where presentation is formatted with CSS (Cascading Style Sheets) Such a system is extremely lightweight and could be expanded, for example a Web interface could be designed for use on top of the Excel spreadsheet, or an open source CMS such as Joomla or Drupal could be used to replace the Excel spreadsheet, with data stored in a database such as MySQL (in effect implementing a so called WAMP system – Windows, Apache, MySQL, PHP). In this case the database could still export an XML file for RCHLite for independence from the database. The RCHLite system is more suitable for small regional museums or for mobile applications, e.g. taking the digital repository to Sierra Leone on a mobile (no internet access in Sierra Leone) [140].

To achieve a lightweight and portable system, but present a similar solution to the existing RCH system, RCHLite decouples from the Oracle database and X-VRML technology through using more standard XML technologies. The museums digital exhibitions are stored as a collection of XML files, which are called XML storage or XML store. The visualization technologies are changed from ARCO X-VRML technology to the use of XSLT or XQuery (XML transformations). Figure 4.9 shows the overall architecture of the RCHLite.

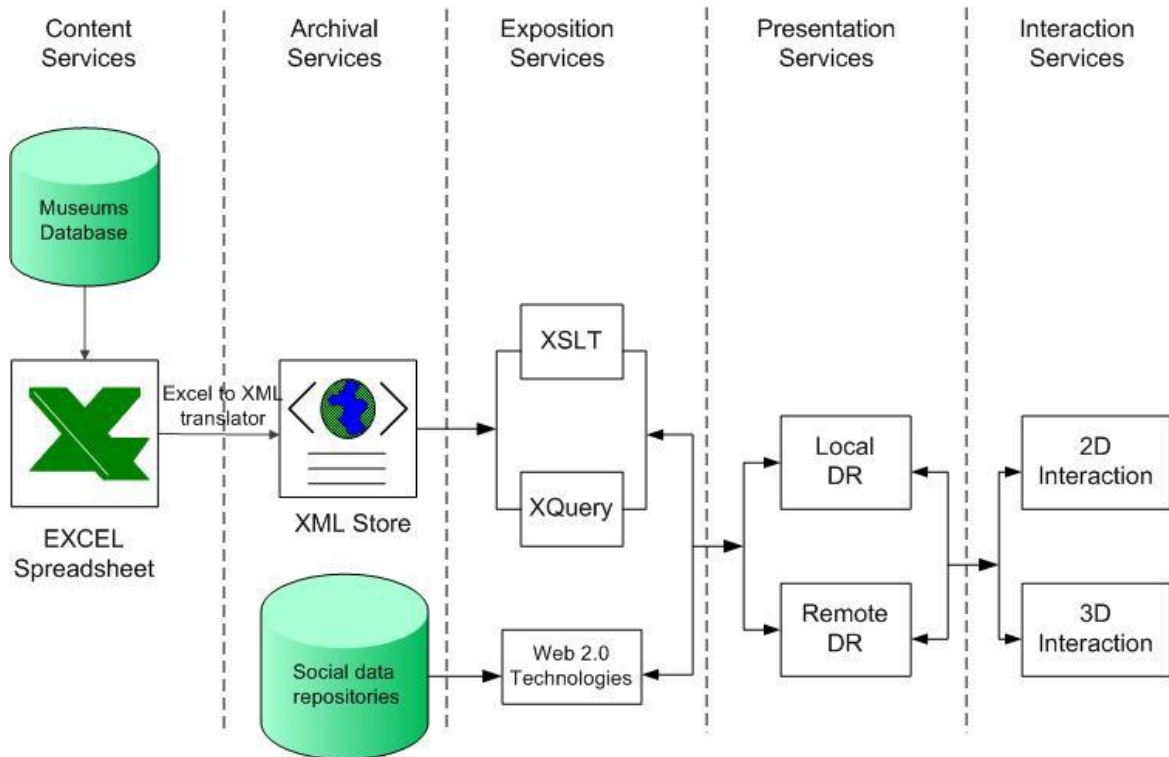


Figure 4.9: The RCHLite system architecture

Figure 4.9 shows that RCHLite consists of five components, which are:

1. Content Services (CS)
2. Archival Services (AS)
3. Exposition Services (ES)
4. Presentation Services (PS)
5. Interaction Services (IS)

The content services (CS) show museums (the British Museum, Glasgow Museums and Brighton Museum & Art Gallery) providing Excel spreadsheets that contain the metadata of digital heritage collections related to Sierra Leone. Then a tool called the Excel to XML translator will be applied to translate Excel files into XML files. These XML file collections, which are called XML Store, could work as an archival service (AS) to preserve the XML metadata associated with digital heritage objects. XML transformation technologies consist of XSLT or XQuery: either one or both XML transformation technologies can be used with PHP server-side script language to perform dynamically delivering the digital museum exhibitions to the presentation service (PS). Social network repositories such as Flickr, YouTube and Facebook can be worked as other archival services to preserve user generated digital content. Web 2.0 technologies can be used to deliver user generated digital heritage exhibitions to the PS. The PS consists of two visualization domains: local RCH DR Web presentation domain and remote RCH DR web presentation domain. The RCH DR web presentation includes several functionalities such as browse, search, scrapbook and exhibitions, etc. For example, in the 'browse' functionality, when a user clicks the 'browse' button, a web page will be presented to browse different museums digital heritage objects selected by different culture groups. These digital heritage objects are presented from XML metadata format into HTML format through XSLT. The IS enables users to interact with the PS through 2D and 3D interaction, more detail will be described in Chapters 5 and 6.

4.4.3 Software Design Methodology

The author adopted the 'evolutionary prototyping' software design methodology while developing applications for the RCH. This software design methodology is, firstly, to build a very robust structured software prototype based on basic requirements, and then constantly refine and evolve it based on the feedback of end users after they examined the prototype. There are some other software design methodologies such as the Waterfall development. The advantages of this methodology are that developers can focus on developing the partial system instead of the whole system that reduces inherent project risk; users can examine the prototype and give feedback throughout the whole process of the software development, increasing the degree of user satisfaction on the final application.

From the author's experiences of designing and implementing his applications by using 'evolutionary prototyping' software design methodology, it can be concluded that it is good software design methodology for developing applications because users can examine the prototypes the author has created, and give feedback to the author. The author can then improve the prototype and take the concept further to meet user requirements. It can also be evidenced as a good software methodology by the results of the user evaluation on the final system the author has created.

4.4.4 The Design of Applications

The web design principles that the author used in his applications are:

1. **Precedence** – this is a very useful web design principle for the author to lead users through different components of his web applications effectively and to be aware of all the functionalities in the applications in the proper order. There are many tools to achieve precedence, for example, position. In the 3D digital heritage scrapbook application, the author placed the search interface on the top of this application interface in order to allow users to search images and videos of digital heritage content from different data repositories in the first order. The author placed the virtual 3D environment at the bottom of search interface in order to allow users to easily drag and drop images and videos from the top gallery into the virtual environment. In addition, the author placed the playing 3D object category on the right hand of this application interface in order to enable users to easily drag and drop 3D objects into the virtual scene. From the user experiences on web applications the author created, this kind of web interface design is good for users to interact with the interface. For example, users think they could interact with the web applications very naturally, and were able to anticipate what would happen next in response to the actions that they performed.
2. **Navigation** – this is the web design principle that the author used to allow users to easily figure out where to go or where they are on the web site. In the author's web applications, there is a navigation bar on the top of interface to allow users to easily identify and navigate different functionalities. For example, when users put the mouse over the navigation button named "Scrap Book", the colour of the

button will become brighter, and when users click on the button, they will navigate into the 3D scrapbook functionality and the navigation bar will have additional information such as “Home | Scrap Book” to show the current location. What is more, while designing the “Browse” web interface, there is also a navigation bar designed on the top of the interface. The name and colour of navigation buttons indicate different areas of Sierra Leone in Africa, which enables users to easily identify different areas in Sierra Leone and browse digital heritage content from the identified area. Further, while designing the image or video gallery for the search interface, the arrow buttons were designed for users to easily go to the previous images (videos) and next images (videos), or to go directly to images and videos on the specific page number. From the user experiences on the web applications the author has created, it can be concluded that the navigation buttons are very useful for users to easily identify and navigate different functionalities in the applications. Particularly, users think that it is good to use arrow buttons to easily navigate a lot of images and videos.

3. Usability – this means making information and interactions to be easy and effective for users to use on the web site. For example, while designing the search interface, the author did not initially design the radio button for searching images and videos of digital heritage objects in the different social networking repositories. The author designed several parallel image or video galleries for displaying the search results from different social networking repositories. However, from the user experiences on the initial designed search interface, it is evident that it is not good web design to have many social networking repositories involved. This is because there will be many parallel image or video galleries displayed in the Web page, bringing difficulty for users not only to view all the image and video galleries but also to interact with images and videos of digital heritage object such as dragging and dropping them into a virtual environment. The radio button design was implemented into the final system so that users can easily search images and videos of digital heritage objects from different social networking repositories by switching different radio buttons. From the user experiences on the search interface with radio buttons, it can be concluded that it is a good web design because users think it is easier and more effective for them

to search different social networking repositories, to view images and videos, and to interact with images and videos.

4.4.5 Selected RCH System Functionality

The following discussion gives a brief overview of each of the RCH DR functionalities:

1. Browse:

- The author created two ways to implement the ‘browse’ functionality. As mentioned, one way is using ARCO and X-VRML technologies to dynamically present the digital museum exhibitions to the web visualization. The other way is using XML and XSLT to dynamically deliver museums digital collections to the web presentation. At the top of the web interface of ‘browse’, there are several image buttons that stand for different culture groups of Sierra Leone, such as Mende, Susu, Temne, Limba, Sherbro, etc. When a user clicks on any culture group button, there would be three lists of digital heritage objects that belong to that culture group displayed in the interface. Those three lists of digital heritage objects are digital heritage collections from the British Museum, the Glasgow Museums, and the Brighton Museum & Art Gallery. Yahoo Carousel technology is used to display a list of digital collections, so users could easily go to the next object or go back to the previous object. What is more, users could jump to any page to view digital heritage objects (see Figure 4.10). When a user clicks on the image of a digital heritage object, a new page will be opened and the object image and description will be displayed (see Figure 4.11). When users click on the ‘view record’ link in Figure 4.11, another page will be displayed and users can view the object’s metadata information and make comments on the object (see Figure 4.12). The author also developed the innovative commenting scheme shown in Figure 4.12; however this is discussed in more detail in Chapter 6.

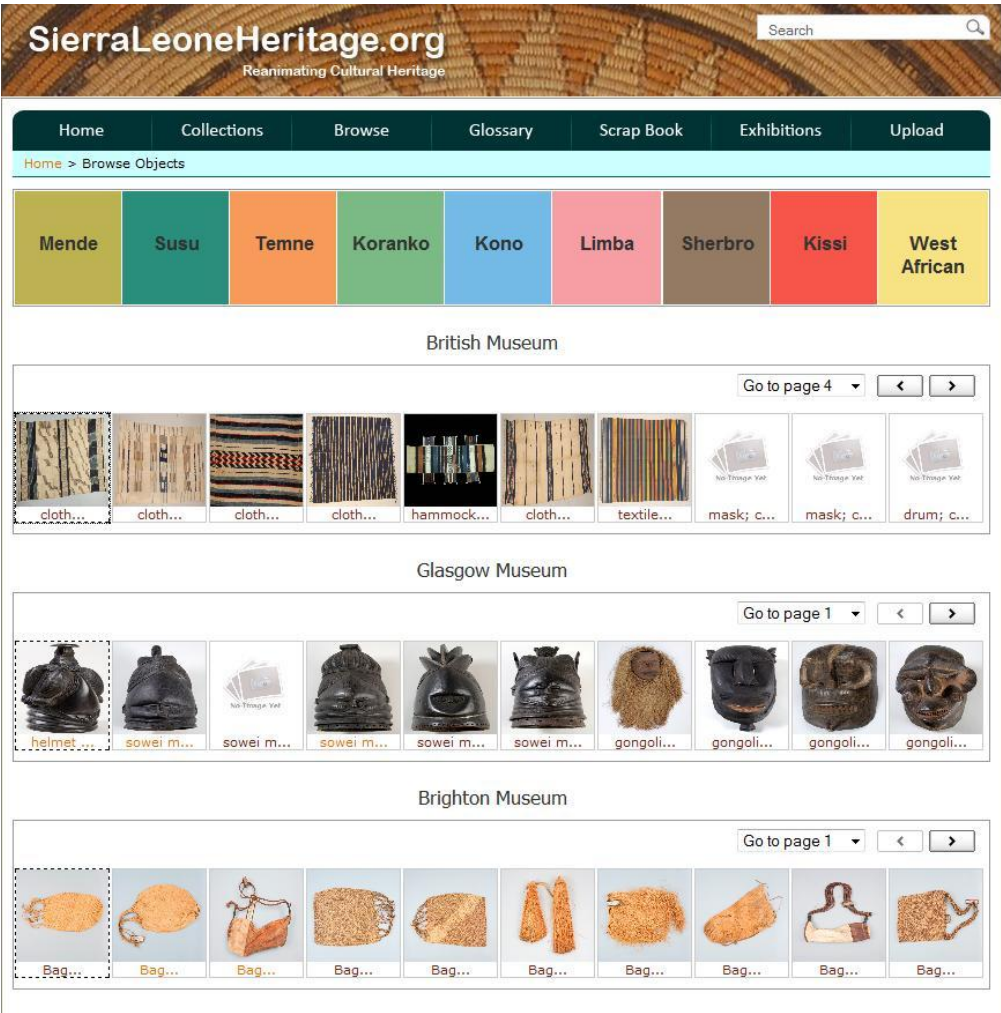


Figure 4.10: The Browse front page

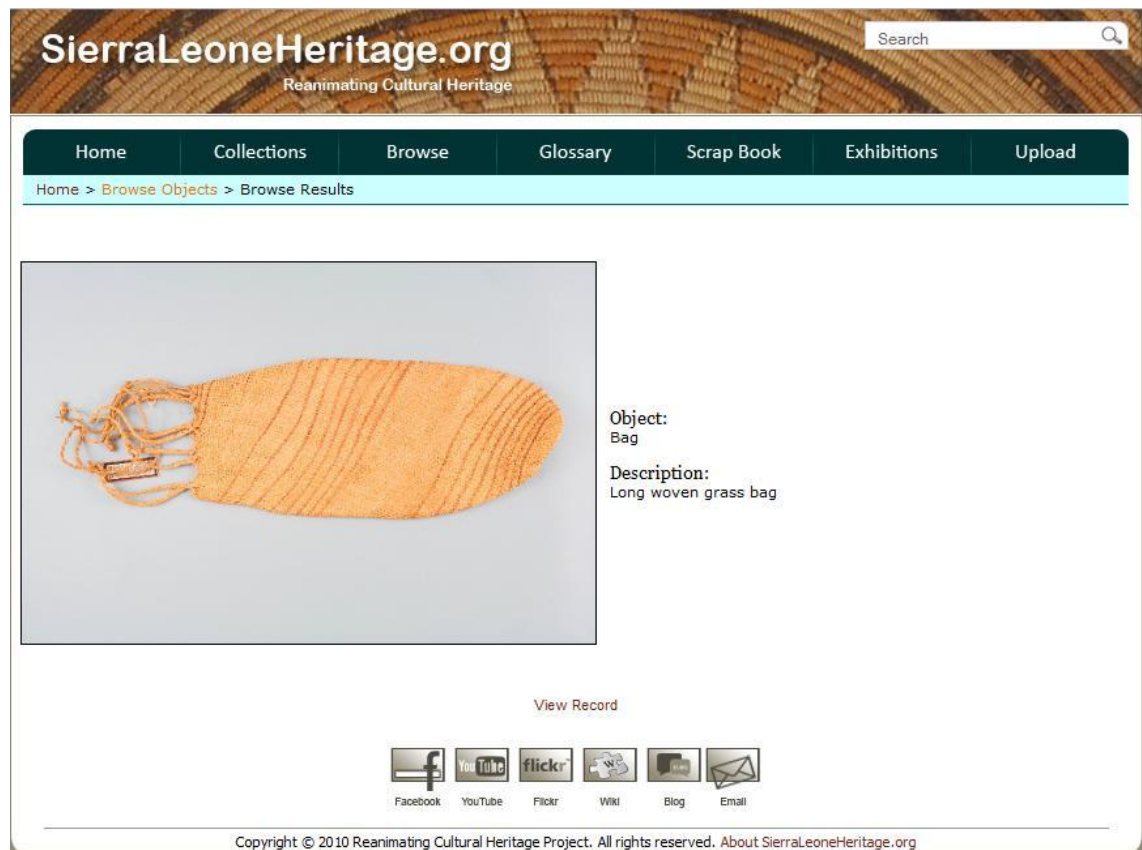


Figure 4.11: The Browse second page for object descriptions

SierraLeoneHeritage.org
Reanimating Cultural Heritage

Search

Home Collections Browse Glossary Scrap Book Exhibitions Upload

Home > Browse Objects > Browse Results

Glasgow Sierra Leone Objects: Images

Object:	Bag
Description:	Long woven grass bag
Materials:	Grass fibre
Culture Group:	Mende
Dimensions:	No Data
Production Date:	No Data
Associated Places:	Sierra Leone, West Africa, Africa
Creator:	No Data
Source:	No Data
Collector:	Thomas Joshua Aldridge
Museum:	Brighton Museum and Art Gallery
Accession Number:	BMAG-R3483/94d

Related Objects

Bag... Bag... Bag... Bag... Bag... Bag... Bag... Bag...

Comment:

Add a comment...

Name or [Log in](#)

Email Log in to Facebook to post your comment

[Post](#)

Figure 4.12: The Browse third page for object metadata and comments

2. Scrap Book:

- The 'scrap book' functionality is another innovative functionality in the RCH DR developed by the author. In 'scrap book', a user could search ARCO and social networking repositories and retrieve digital heritage objects from both museums and communities through the ARCO web service, and third party web services such as Bing, Yahoo, Flickr and YouTube. When the user receives a list of digital heritage objects from those repositories, they could select the images or videos of digital objects, drag and drop them into a virtual environment, and play with those images or videos in a 3D world. What is more, the user could then save this 3D scrapbook into his own computer for viewing or publishing later by clicking the 'save' button. In addition, the user could publish his scrapbook into the exhibitions. In Chapter 6, the

author will describe the ‘scrap book’ function in more detail. Figure 4.13 shows the ‘scrap book’ functionality.

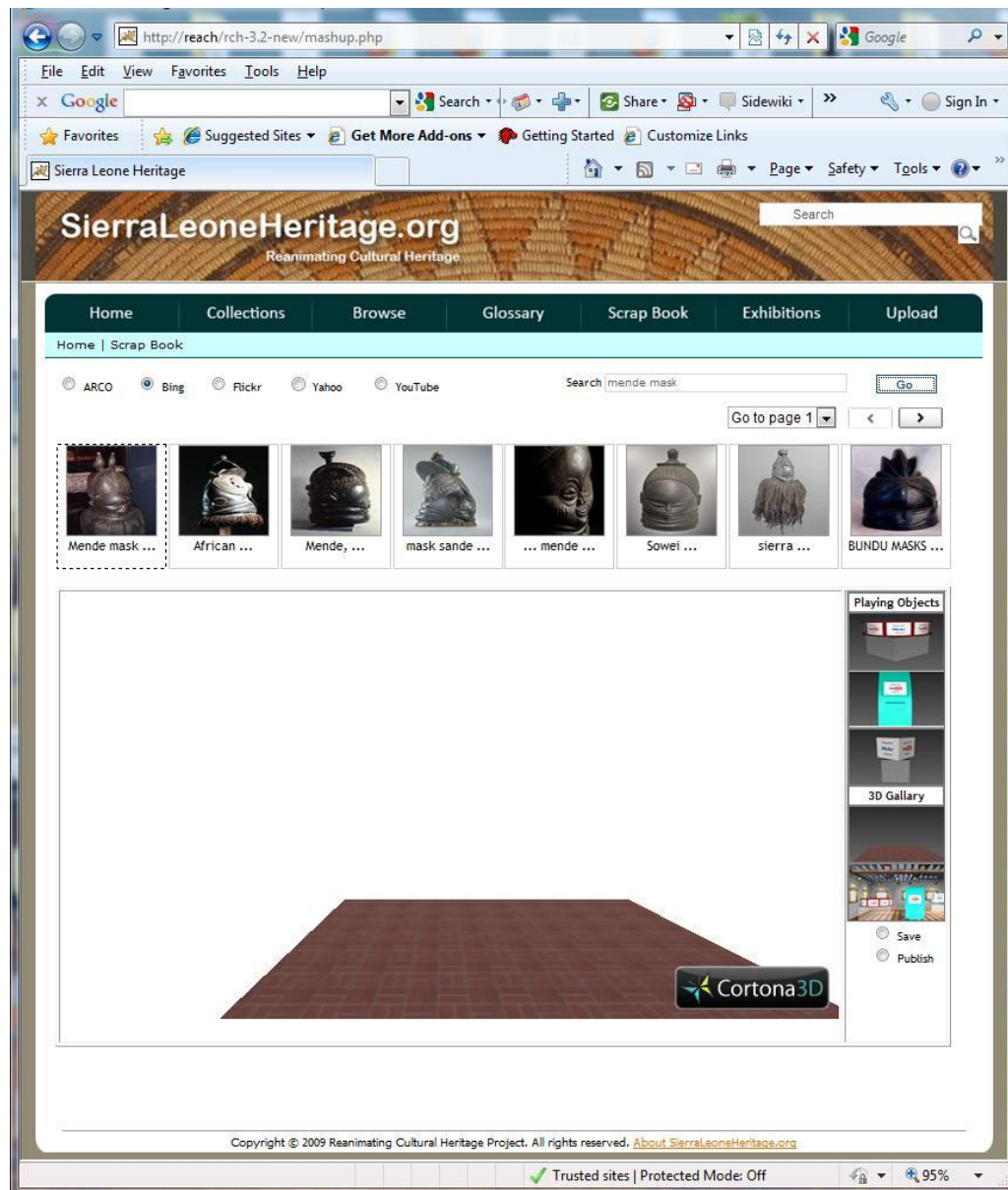


Figure 4.13: The Scrap Book functionality

4.5 Conclusion

As a part of the DISPLAYS concept, the RCH project focuses on integrating ARCO (museums' collections) with social networking (user-generated heritage collections). This would allow museums to integrate their own digital heritage collections with community heritage knowledge in an interesting visualization and interaction way, allowing the end

user communities to build their own digital heritage exhibitions. Web 2.0 mashups technologies are utilized to integrate museums' heritage content with user-generated heritage content together within one meaningful application.

In this chapter, two systems are discussed; one is the RCH system based on ARCO and X-VRML, the other is the RCHLite system based on XML and XSLT (XQuery could also be used). The RCH system uses X-VRML technology to publish the exposition of the digital heritage contents into digital heritage exhibitions. The RCHLite system uses XSLT (or XQuery), which belongs to XML technologies, to delivery heritage contents into the exhibitions. The RCH system is suitable for museums that need to achieve and maintain a large amount of data. Compared to RCH, RCHLite is lightweight and suitable for small regional museums; what is more, RCHLite can be easily installed into the local host of personal computers.

In conclusion, the RCH system presents a digital heritage resource that utilizes web services, workflows, social networking, Web 2.0 mashups and ARCO technologies to integrate user-generated digital heritage content with museum digital collections online. How to implement this RCH system to integrate museum digital heritage collections with user-generated digital heritage content from social network repositories, allow communities to access and interact with digital heritage objects and collections, and enable communities to create their own virtual exhibitions based on user-generated digital heritage content. The next chapter will demonstrate potential digital technology solutions in detail for these issues.

5 RCH Digital Technology Solutions

5.1 Introduction

This chapter explores several digital technology solutions that could be used effectively in the implementation of a digital heritage system based on the DISPLAYS concept. As such, this chapter describes experiments, where not all technologies finally made it into the RCH digital repository for various reasons.

The concept behind the RCH project focuses on integrating community heritage knowledge with museums' digital heritage collections in interesting visualization and interaction ways, allowing both communities and museums to build exhibitions together. During the implementation of the RCH project, many technical issues have been discovered. For example, how to capture community heritage knowledge? How to integrate museums' digital heritage collections with community heritage knowledge in interesting visualization and interaction environments that allow both end user communities and museums to personalise their own exhibitions? How do communities build their own exhibitions? How do they publish their own exhibitions?

To solve these problems, much research has been done on the technical solutions. For example, how to capture community heritage knowledge? In the previous chapter, a solution was discussed, which is to create a new version of the ARCO system's ACMA tool. This would extend administrative rights to communities to allow them access to the object manager, presentation manager and template manager to create, integrate and use digital cultural objects and build their own exhibitions. However, museums will spend time and money on making efforts to develop new digital collections for communities on archiving processes, security, metadata exposition and generation, etc. They will not allow such data to be potentially corrupted by an end user. Instead, museums will need to either design or implement their own database to allow communities to upload and archive their digital heritage images and videos, or open source access systems, e.g. social networks to allow the same. Additionally, museums need to spend time and money on database

maintenance and archival security issues, they can barely afford this for their own collections; accepting responsibility for user generated content is most likely beyond them. Furthermore, museums need to design and implement tools to exhibit and present digital heritage objects and collections from communities into exhibitions. How can they do this? It is not a desirable idea to open up CRUD type access to user communities on their collections manager.

One innovative way of achieving the goal of capturing community based heritage knowledge through user generated digital objects is to exploit existing social networking technologies. Social networking is currently used to describe how people socialize or interact with each other through the web [141]. To exploit social networking repositories such as Flickr and YouTube with a DISPLAYS type archival, exposition and presentation service, such as that implemented in RCH, is to integrate an ARCO repository through appropriate web services such as the REST web service and Web 2.0 mashups technologies. The integration of social networking technologies and the ARCO repository is possible because these social networking technologies expose their application programming interface (API) as a web service, the same as the ARCO system provides the ARCO web service [41]. Web 2.0 social networking and mashups technologies will be described in more detail in next section.

5.2 Heritage Mashups

Many examples of Web 2.0 mashups have been illustrated in Section 2.3.2. From these examples, it is evident that mashups are already applied in a lot of areas such as travelling, house searching, shopping, and security, and so on. In this RCH project, a DR (digital repository) could be a typical heritage mashup of several museums (e.g. the British Museum, Glasgow Museums, Brighton Museum & Art Gallery, and the Sierra Leone National Museum) who integrate their digital heritage data of Sierra Leone into one DHR interface through ARCO or XML technologies, with user generated content exploiting a social network based DHR. With a social network based DHR integrated into the DR, a user could retrieve digital heritage media objects such as videos and images from YouTube and Flickr repositories, and add their own comments through a Facebook interface, and so on.

The RCH project mainly focuses on providing an ICT solution that could aggregate museums' digital collections with a community-contributed digital heritage collection into one DR interface. This could be created, managed and used by both museums and communities, and allow them to personalize their appropriate digital exhibitions in an interesting visualization and interaction environment. In this context, social networking and Web 2.0 mashups are mainly used to achieve personalizing communities' digital heritage exhibitions for RCH. Social networking technologies are used to provide community-contributed heritage object repositories, and a mashup is used for communities to share their heritage and create their own exhibitions.

A DR based on a Web 2.0 mashup could access a DHR based on social networking repositories such as Facebook, YouTube and Flickr through their respective REST-based web services. Additionally, the DR mashup could access an DHR based on ARCO through the ARCO web service. Thus, the DR mashup aggregates digital heritage objects from all different repositories, such as ARCO, YouTube and Flickr, into one rich heritage application. Figure 5.1 shows the DR heritage mashup architecture, which shows that users could access data repositories such as ARCO, Flickr, YouTube and Facebook via a web interface through appropriate web services (e.g. ARCO provides the ARCO web service, Flickr, YouTube and Facebook provide the RESTful web service). In addition, the web server could set up the hosting web site for mashups.

The heritage mashup consists of three components:

1. The content providers, which could be several museums such as the British Museum, Glasgow Museums, Brighton Museum & Art Gallery, Sierra Leone National Museum and Sierra Leone stakeholder communities. They could also be ARCO and social networking repositories, because ARCO will hold all the digital heritage objects from those partner museums, and social networking repositories contain Sierra Leone stakeholder community contributed heritage objects.
2. A mashup hosting site (Web server), which is located at the University of Sussex in the UK, along with a back-up system at the University of Poznan in Poland.

3. A user interface, with which users would interact (e.g. here, a specific DR interface was designed for users to access the digital objects). The layout and control of the user interface are specially designed for representing the mashups functionalities.

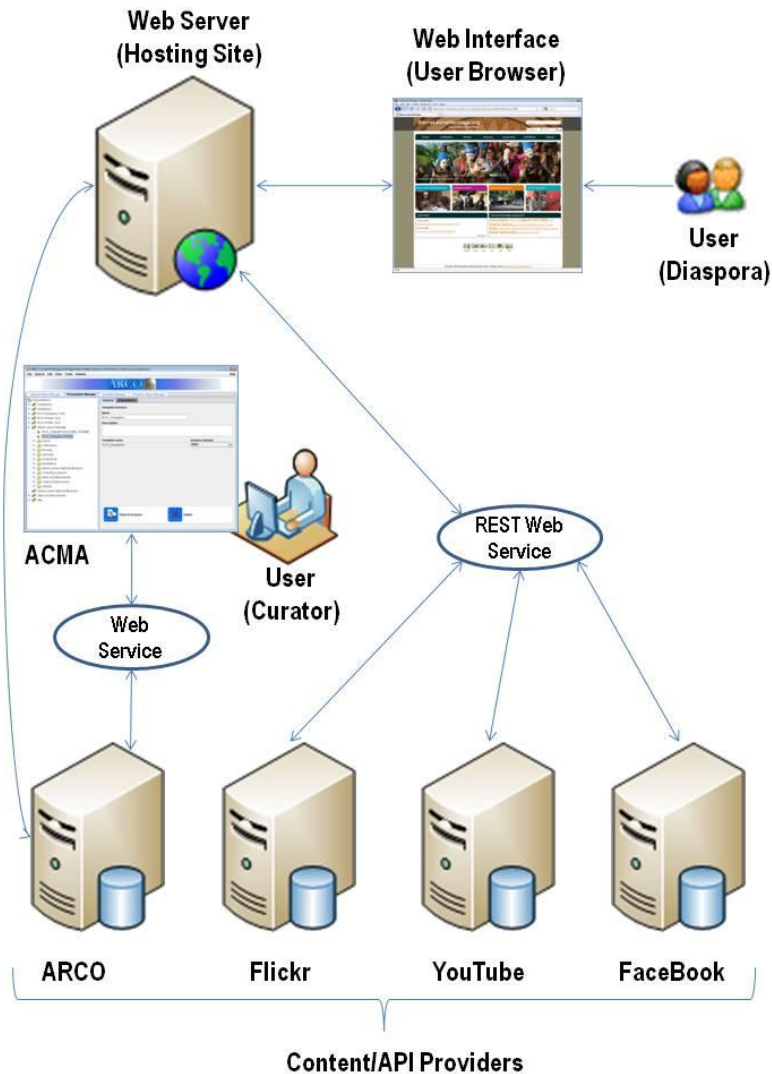


Figure 5.1: An RCH DR mashup showing an ARCO based DHR and a social network based DHR where digital heritage objects are merged through the web interface (presentation service)

The **content provider** is the provider (i.e. third party) who provides the content ready for mashing up, allowing users to retrieve and use their data and services. Some providers expose their content through an API and web-protocols such as REST, SOAP and RSS/Atom web services. Web services are application components designed for supporting machine-to-machine interaction over a network. In general use, web services enable clients and servers to communicate with each other over the HTTP protocol. An API is a set of

routines, data structures, object classes or protocols provided by libraries, applications and operating systems to support the building of communications with other applications. The difference between a web service and an API is that an API could take several forms and may contain object classes, data structures and web protocols: a web service is just one form of an API. Frequently web APIs are just provided and used as web services for building the interaction between applications through the web [142].

Web services are usually divided into two camps: big web services and RESTful web services. The big web services are based around technologies such as SOAP (Simple Object Access Protocol), UDDI (Universal Description, Discovery and Integration), WSDL (Web Services Description Language), WS-Addressing, WS-ReliableMessaging and so on. There are many different integration styles that could be used for integrating applications, for example, shared database, remote procedure call, message bus and file transfer. The key difference between big web services and RESTful web services is that the big web services technology stack transfers the interoperability for both remote procedure call and message bus integration styles [143], while RESTful web services are only used for implementing remote procedure calls over the web.

The remote procedure call is a protocol that allows one computer program to request a service from another computer program in a shared network, without having to understand the programming details for this network interaction [144]. The message bus is an integration of a common data model, a common command set, and a messaging infrastructure that allows different systems to communicate with each other through a set of shared interfaces [145]. The message bus integration focuses on transporting messages (e.g. XML messages) between applications. RESTful web services are gaining popularity in the APIs of many Web 2.0 services because of their better integration with HTTP protocols, and the simplicity of publishing and consuming because they do not require XML messages or adherence to WDSL [82].

REST-based web services use HTTP methods such as GET, POST, PUT and DELETE, which are often better integrated with HTTP than SOAP-based web services. Section 2.3.1 has already discussed and compared REST-based and SOAP-based web services. The key difference between REST and SOAP web services is that the SOAP structure is more

complicated and the SOAP requests must be deciphered when they are sent and received by the server. The server then decides which operation to perform and how to perform that operation. What is more, SOAP does not provide a solution to cache the results of operations, while REST is more simplified and mainly uses remote function calls to process data through HTTP. In addition, the results of some particular operations in REST web services could be cached locally in a web browser in some cases, so the REST web service can make requests faster than the SOAP web service. Suffice to say, for this RCH system. Facebook, YouTube and Flickr use RESTful web services, while some others may use REST-based or SOAP-based or both web services. A big advantage to RESTful web services is that they do not need XML or WDSL tools to implement a REST-based web service and a web service simply uses HTTP methods to publish and consume data in remote procedure calls across the web.

In RCH DR, ARCO, Flickr, YouTube and Facebook are all the content providers. ARCO provides museum-based digital content associated with Sierra Leone deposited by all the UK museums (e.g. the British Museum, Glasgow Museums, Brighton Museum & Art Gallery), and social networking repositories provide community-contributed digital content associated with Sierra Leone deposited by general users.

The **mashup hosting site** is where the mashup web application is hosted. The hosting site is implemented by aggregating data from different data sources in an interesting way and presenting to users. There are two ways for implementing mashups. One is using server-side dynamic content generation technologies such as Java servlets (JSP), ASP, PHP, or CGI. The other is using client-side scripting technologies such as JavaScript or applets. Mashups using the client-side technologies approach could also be called rich Internet applications (RIAs) [79] because they are focused towards very interactive user-experiences. The benefits of using client-side mashing up are that data could be directly retrieved from the content provider and provide more interactive user experiences.

RIAs are web applications that offer ‘rich’ features and functionalities approaching the characteristics of desktop applications. It was introduced in a White Paper by Macromedia in 2002 [146]. In early Internet applications, a basic HTML graphics user interface is supported and those applications do not have the characteristics of desktop applications. As

more advanced web technologies that could create advanced features and functionalities emerged, RIAs became more and more popular in web applications [79].

The **user browser** is the interface where the mashup is rendered graphically, and where users from different kinds of communities interact with the mashup. For example, the RCH DR user interface is such a user browser.

5.2.1 RCH Mashups based on Social Networking – an Early Example

The innovative work described in this section has been published by the author in [7], but it is re-stated here for clarity and context with this thesis. In order to explore potential functionality available in ARCO and social networking technologies, the author did an early mashup experiment for RCH. Figure 5.2 shows the mashup that could retrieve data from Flickr, YouTube and Google Maps. This mashup aggregates the search functionalities of Flickr and YouTube, a gallery of images from Flickr, a gallery of videos from YouTube, a Google Map and a 3D object. For example, users could make a search in the search area; in this case the keyword – ‘Parthenon Athens’ is searched, the mashup would retrieve search results from Flickr and YouTube and display a gallery of images and videos that related the key word ‘Parthenon Athens’ from Flickr and YouTube within a Yahoo carousel functionality.



Figure 5.2: A mashup aggregating YouTube, Flickr, Google maps and a 3D object [7]

The above paragraph shows the simple keyword search criteria: more advanced search criteria can be found in the ‘collections search’ functionality of the RCH.

Collections Search:

- The ‘collections search’ functionality is one of the functionalities in the RCH DR. There are also two ways of implementing the search functionality: one is by using ARCO and X-VRML, the other is by using XML with XQuery or XSLT. When a user clicks the ‘collections search’ button, he will enter a web search interface (see Figure 5.3). In that search interface, there is a textbox for a keyword search; several checkboxes are provided for users to select subjects, e.g. a user could search for digital heritage objects by selecting different subjects such as object categories, related museums, themes and locations. After a user does a keyword search, he will

enter another page showing all the heritage objects related to that keyword and subjects that the user selected in the search front page. Figure 5.4 shows the search results related to the keyword ‘cotton’. When the user clicks on the image of a search result, the process is the same as in Figure 4.11 and Figure 4.12.

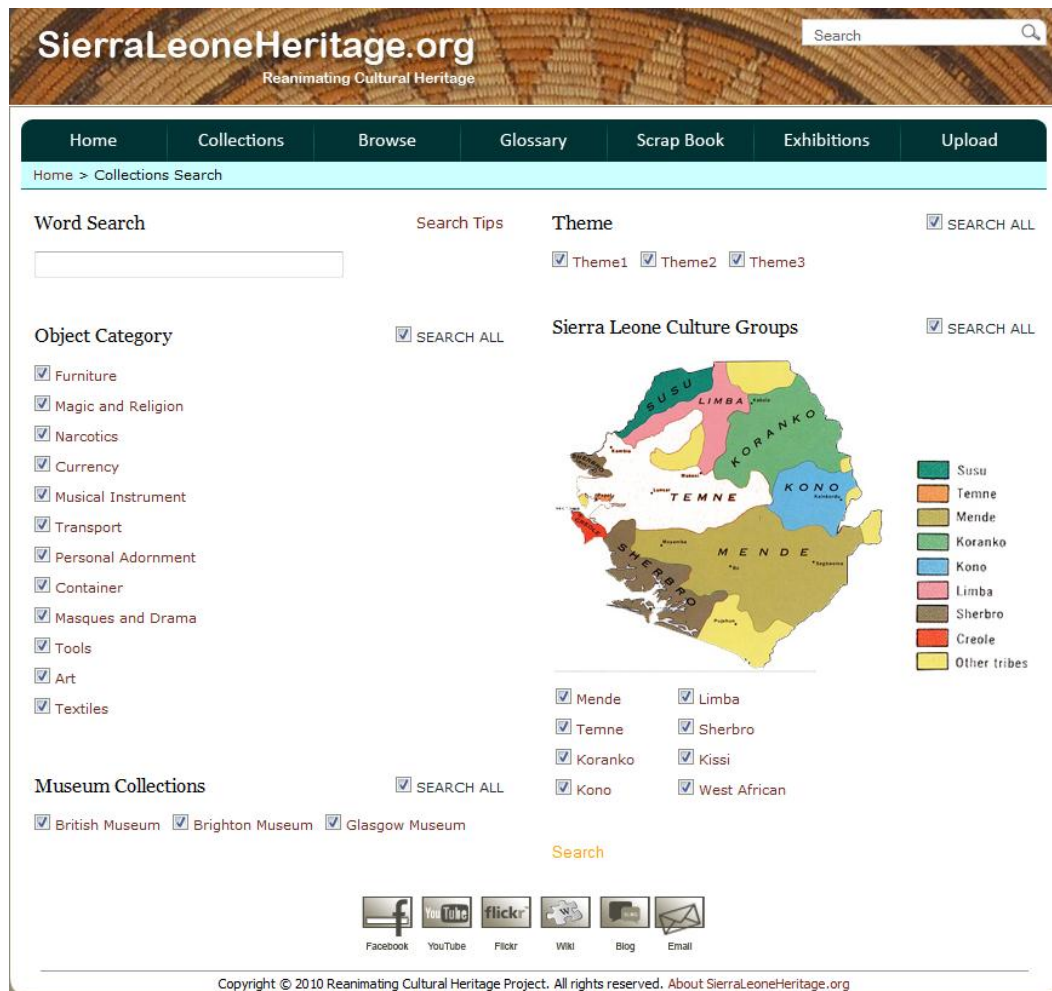


Figure 5.3: The collection search front page

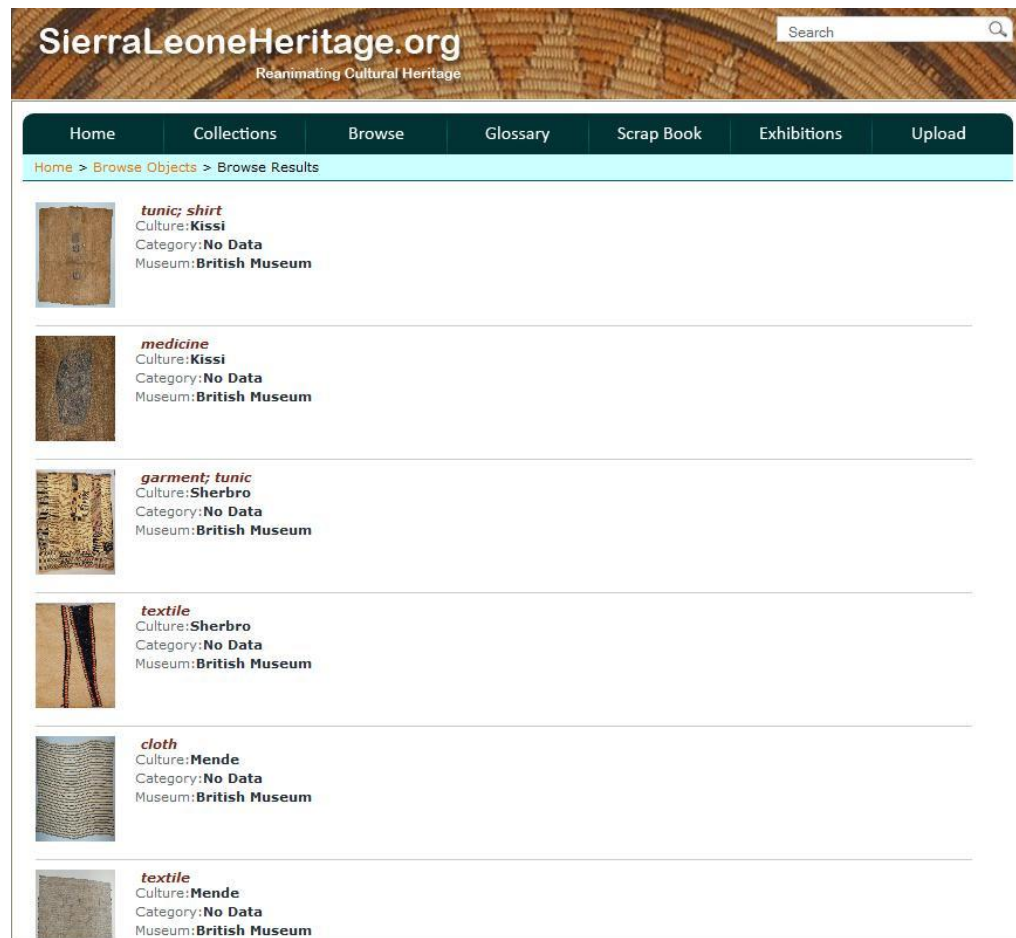


Figure 5.4: The collection search results

Yahoo carousel technology is a web technology that provides a widget for browsing a gallery of objects arrayed vertically or horizontally in an overloaded page region. The term ‘carousel’ originally derives from slide carousels of film photography. The carousel technology could maintain fidelity to slide carousels of film photography by enabling a continuous, circular navigation through all of the gallery objects. The Yahoo carousel could be created, configured and populated through the scripts such as JavaScript, CSS and HTML [147].

Users could click on a video or image within the carousels of that mashup interface to display a video or image in a shadow box. Figure 5.5 shows this technology.

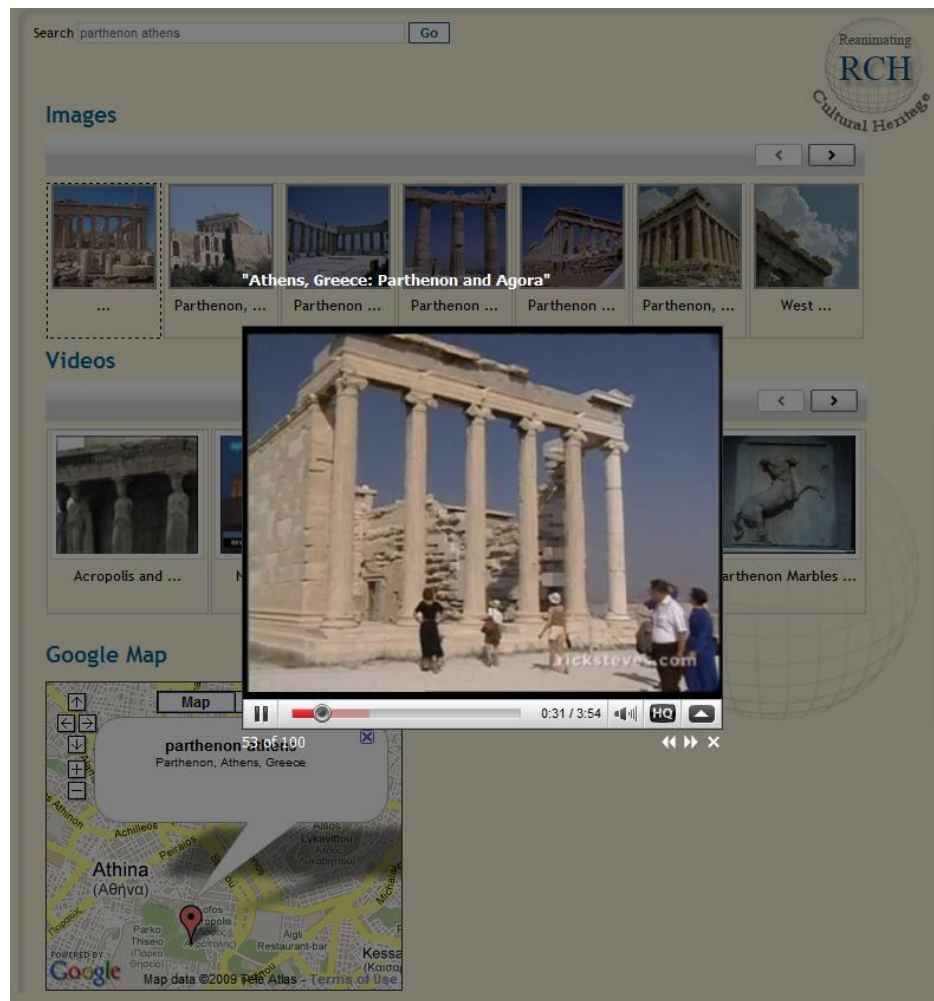


Figure 5.5: Illustration of showing a video in a shadow box in the mashup

Shadowbox is a web-based media viewer application that enables the showing of a wide assortment of media in web browsers without leaving the linking web page. Shadowbox is written in JavaScript and CSS, and it supports all the most popular media publishing formats over the web. Shadowbox could be easily be added to a web page with the set up and configuration, and gives users a great deal of flexibility to fine-tune the details of the look, feel and operation for a given object [148].

In the mashup, an image or video could be dragged and dropped onto the appropriate surface (Flickr image or YouTube video) of a 3D object. Figure 5.6 shows a video of ‘Parthenon Athens’ from YouTube that was dragged onto the YouTube video surface of the 3D box for visualization.

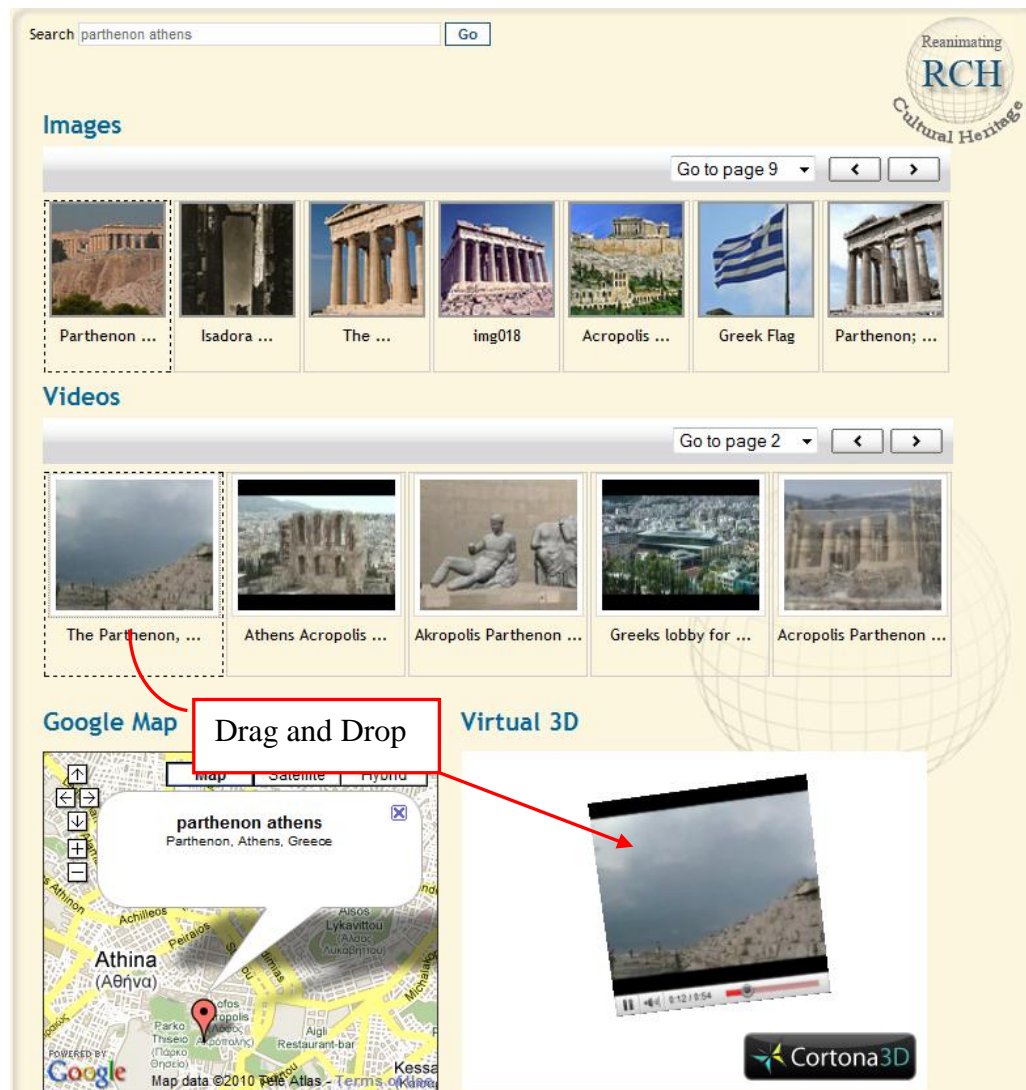


Figure 5.6: Illustration of dragging a video onto the surface of a 3D box [7]

Users could drag and drop as many images and videos as they want until all the 3D faces are used up. Users could manipulate the 3D box by rotating it in a virtual environment to view images and videos that they have selected from Flickr and YouTube galleries. This virtual 3D environment could be easily created in a different way. For example, a gallery could be created for the virtual 3D environment showing Flickr images on a wall and YouTube videos on a TV screen. The important thing is that heritage objects can be selected and visualized in more interesting visualization and interaction environments through 3D, and all the objects (images and videos) that users have selected can then be saved as a gallery of objects somewhere for viewing at the later time, or reused for further exhibitions through the virtual 3D. There is another function in the mashup that utilizes

Google Maps to show the search location for the Parthenon; Google Maps are widely used in mashups for exploring the geographical location of places. There could be more other interesting and sophisticated features included in the mashup.

5.3 Interaction with Heritage Mashup

In recent years, human-computer interactions have been rapidly developed, and more and more advanced interaction technologies have emerged. During the last several decades, a number of well-defined 2D user interface models have been built based on 2D interactions. 2D input devices such as the keyboard, mouse and other pointing devices utilize input events like keyboard pressing, button moving up or down to provide the base for developing the fundamental interaction technologies such as menus, buttons, clicking, dragging and so on [149]. As more advanced computer graphics technologies such as 3D technologies were developed, advanced 3D interactions became more popular and attractive. Virtual reality is a new generation of human-computer interface that aims to create a simulated environment where users can become immersed using a computer generated reality, proving more direct interaction between users and the environment created by the computer system [150].

With the development of new input devices, interaction technologies are used in virtual reality in order to give users the feeling of being a part of virtual environment, and users could manipulate 3D objects directly through 3D interaction input devices and technologies. Many advanced interaction technologies have emerged that interact with a virtual environment, for example, dragging and dropping objects from outside of virtual space into the virtual environment, interaction with standard input devices such as a gamepad (or joystick), or with complex input devices such as Spacemouse, BlackBox, Kromstaff Replica Interface [1].

The keyboard and mouse is the simplest I/O devices that can be used for interaction with the digital heritage object, e.g. a 3D virtual model of a heritage artefact. Compared to the other input devices, another cheap standard input device is a gamepad (or joystick) that provides an easier way for users to interact with the virtual environments. For example, children and adults are all familiar with using a gamepad to play computer games. Now,

Sony PlayStation 3 and the Wii provide more advanced and interactive gamepads that are wireless and have motion capture functionality to bring users more enjoyable interactive technologies.

In the web mashups interface described above, there are 2D visualizations such as Flickr images search, YouTube videos search and Google Maps, and 3D visualization such as the 3D box object. Users are expected to interact with this interface through the mouse and keyboard. However, it might sometimes be more appropriate to use more advanced interaction technologies to interact with this 3D mashups interface. For example, when users want to manipulate the 3D box object fully textured with Flickr images or YouTube videos remotely, they would like an input device to remotely control the 3D box object in the interface.

Spacemouse is one of complex input devices with the six degrees of freedom (6 DOF) control; this is an original 3D motion controller used for robotic manipulation. For example, Figure 5.7 shows the Spacemouse input device. Through the Spacemouse input device, users can rotate the virtual object using the Spacemouse puck, and display rich multimedia content utilizing the SpaceMouse buttons. However, there is a problem with Spacemouse; it does not provide a really intuitive solution for rotating virtual artefacts freely on all axes [1]. For example, when the user wants to perform translation or rotation of a 3D object, it is difficult to rotate the object accurately on one axis using the Spacemouse puck. The reason for this issue is that when the user wants to rotate only on one axis, the puck also senses micro-movement components on the other axis thus another axis of rotation of the 3D object is also affected [1].



Figure 5.7: Spacemouse [151]

BlackBox is another type of complex input device for interaction with virtual artefacts, which is described further in [1], Figure 5.8 shows the BlackBox interface. Compared to Spacemouse, BlackBox is a better method of supporting rotating virtual objects on all axes. This is because the BlackBox interface provides a really intuitive solution for rotating the virtual artefact freely on all the axes; however, it is expensive as it uses an orientation tracking device like the Inertia Cube 2. Users can hold the BlackBox and rotate it in their hands; the virtual artefacts would be slaved to the rotations and turn in real time. Users can also use the buttons on the BlackBox interface to activate the other features such as zooming in or out, or displaying the information of virtual artefacts [1].



Figure 5.8: The BlackBox interface [1]

These interaction technologies described above could be used to interact with a heritage mashup interface. In the next several sections, the methods of implementing the interaction with heritage mashups will be demonstrated in more detail.

5.3.1 Drag and Drop

‘Drag and drop’ is a well-known interaction technique applied in most graphical human-computer interfaces; it is widely used in applications from word processors to graphics interfaces, allowing users to select an object (a video, picture or other object) in the interface, then drag it and drop it onto somewhere else [152]. Wikipedia defines that drag-and-drop is the action of selecting a virtual object and then drag it and drop it to another location or another virtual object in computer graphical user interfaces [153]. The basic sequential action in ‘drag and drop’ is:

1. Press and hold down the button on the mouse or other pointing device to select (grab) the object or anchor (link) in the graphical user interface.
2. ‘Drag’ the object or anchor to another desired location.
3. ‘Drop’ the object or anchor onto another location or another object by releasing the button of the pointing device.

There are many examples using the drag-and-drop interaction technique, e.g. dragging a data file onto a program icon or web browsers for processing or viewing, moving and copying files to another location (folders or directories), selecting and adding objects to a gallery of objects in another location, dragging a command (changing the colour of an object) onto an object to apply that command, and so on [152]. The ‘Drag and Drop’ cannot only be utilized in a 2D interaction, but also used in a 3D interaction. The drag-and-drop interaction technology can be utilized to interact with a virtual environment by dragging and dropping an object from outside of a virtual space in the virtual environment. For example, users can drag and drop textures or links in Internet Explorer onto the surfaces of a 3D box in the Cortona3D virtual environment.

Cortona3D Viewer is a fast and interactive Web 3D viewer produced by the Parallel Graphics Company, which is ideally used for viewing 3D models over the Web. It serves as

a VRML plug-in for most popular web browsers such as Internet Explorer, Mozilla Firefox, Google Chrome, etc., and many office applications such as Microsoft Word and PowerPoint [154]. The Virtual Reality Modelling Language (VRML) is a standard file format providing a variety of powerful mechanisms for content creators to build 3D content with almost unlimited capabilities. However, using the scene element described in the VRML97 Specification to implement 3D content may lead to some problems, such as large file size and low performance of the VRML browser, etc. In order to broaden the capabilities of VRML, the Parallel Graphics Company produced a number of elements as VRML extensions in the Cortona3D viewer, and these VRML extensions were created as new extension VRML nodes or extended features of standard VRML nodes in VRML [155]. There are a variety of extended functionalities in VRML extensions such as advanced visual effects, geometry, layers and rendering, text, movies, drag and drop handling, behaviour and X3D nodes [156].

Drag and Drop Handling is one of important VRML Extensions in Cortona3D viewer, which can be utilized to interact with virtual environments by dragging and dropping objects (images or videos) from outside the Cortona3D virtual space into the virtual 3D world. The drag and drop function basically utilizes the DropSensor VRML node to achieve a ‘drag and drop’ interaction with virtual environments. The DropSensor node generates events that are based on input from a pointing device like a mouse, dragging an object into the 3D window through retrieving the object’s uniform resource locator (URL). Basically, the objects (e.g. images and videos, etc.) are dragged and dropped as a texture or links onto the surface of the object in the 3D window, and you can also drag a link to any images or videos (instead of an object) from your local machine or Internet into the 3D window [157].

```
DropSensor {
  exposedField      SFBoluenabled      TRUE
  eventOut          SFVec3f             hitPoint
  eventOut          SFVec3f             hitNormal
  eventOut          SFVec2f             hitTexCoord
  eventOut          SFTime              dropTime
  eventOut          MFNode              nodeChain
  eventOut          MFString            url
}
```

Figure 5.9: VRML DropSensor [157]

In the DropSensor node declaration (see Figure 5.9), there are seven fields defined. In VRML, these fields can be categorized into four classes:

1. Field: which is a private node number, holding the node data and the value cannot be changed.
2. ExposedField: which is a public node number, holding the node data and the value can be modified.
3. EventIn: which is an input event that can be received by the node.
4. EventOut: which is an output event that can be sent by the node [158].

The VRML drop sensor was actually utilized in the example mashup application in the last section, and this drag-and-drop functionality was also used in the author's other applications.

5.3.2 Augmented Reality

Augmented Reality (AR) is the creation of enriched users' real environments by adding predominantly virtual objects such as geometric models, 2D image textures, and textual annotations into it [159]. The AR generates a system that combines virtual objects that are generated by the computer with the real environment, and which is visualized by the user; this gives the user the impression that the virtual objects are part of the virtual environment [160]. Compared to the interaction using a mouse and keyboard, AR interaction gives users more live view of a physical real-world environment. The information about the real world in front of users can become more interactive and digitally usable by using Augmented Reality.

AR systems provide the possibility of enabling users to interact with an integrated virtual and real environment. The users of an AR system interact with the augmented environment through different display devices, which can either be worn on the body, such as head-mounted displays, or can be placed in the working environment, such as the ARToolkit with cameras and markers [131].

The ARToolkit is a tool for programmers to build AR applications. It was developed by the Human Interface Technology Laboratory (HIT Lab) at the University of Washington and written in C/C++ Language. The ARToolkit library utilizes computational vision technologies to calculate the real camera position and orientation that are related to a physical marker in real time. This information can be utilized by programmers to draw 3D computer graphics models exactly lined with the real ones and overlay them on the real marker [159]. From a technical perspective, AR faces three key challenges: (1) high quality rendering, (2) viewpoint tracking, and (3) virtual object interaction. ARToolkit solves the latter two major issues in Augmented Reality [129].

There are different versions of ARToolkit; one version is called JARToolkit, which is written in Java (i.e. Java3D can be used in this ARToolkit). Another version is called FLARToolkit, which is an Action Script 3 (AS3) port of the open source library ARToolkit. The FLARToolkit was developed by Japanese coders and allows users to detect a marker from an input image and calculate the position and orientation of the camera in a 3D environment [161]. The FLARToolkit is based on NyARToolkit, which is a java ported version of ARToolkit. The developer of NyARToolkit ported the code from C/C++ to Java, and the FLARToolkit developer ported the code from Java to ActionScript3, which enables users to build AR applications using the Flash IDE or Flex Builder [130].

An AR system can be utilized to interact with the mashups. In the author's experiment, the FLARToolkit was utilized for users to interact with images and videos in the mashup applications. For example, users can watch images and videos from social networking repositories such as Flickr and YouTube, and museum repositories such as ARCO in a 3D environment through the FLARToolkit. The FLARToolkit was set up by using a web camera, Adobe AIR and Flex Builder. Firstly, a pattern marker needs be created by using 'MarkerGenerator' AIR application, and then the Flex Builder was utilized to create the ActionScript project. In the author's application, images in the mashups can be visualized on a rotating curved plane, and videos can be watched on a screen in a 3D environment through the AR (FLAR) application.

Figure 5.10 shows viewing a Flickr image on a rotating curved photo frame in a virtual environment by using the FLAR application. In this example, there is an AR button below

the image in the mashup application. If users wish to use the interactive AR environment, they simply press the AR button; the application will transfer the information such as the image name into the FLAR environment, and the FLAR application will search for the result from the database according to the image name. The FLAR viewer is then launched and displays the result in the FLAR window. Figure 5.11 shows watching a YouTube video on a screen in a 3D environment using the FLARToolkit. This example is utilized in the same way as showing images.

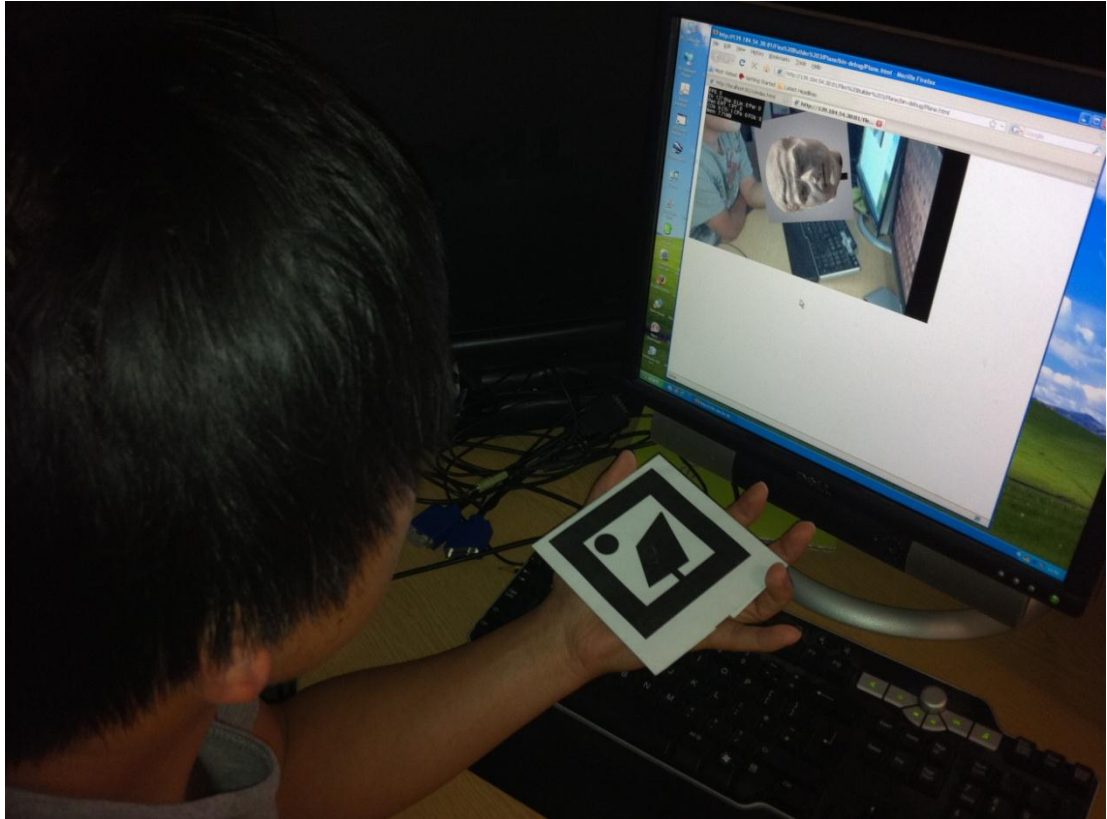


Figure 5.10: Viewing a Flickr image on a rotating curved photo frame in a virtual environment by using FLAR application



Figure 5.11: Watching a YouTube video on a screen in a 3D environment using the FLARToolkit

5.3.3 Multimodal Interface

The Web 3D technologies that integrate Virtual Reality and Augmented Reality provide sets of technologies that can be utilized to make the mashup application interactive. The additional multimodal input interfaces can be used in Web 3D to make the mashups more interesting and interactive, which is a benefit for user interactions. In the introduction of this chapter, several standard input devices, such as the gamepad and joystick, and complex multimodal input devices, such as Spacemouse, BlackBox, Kromstaff Replica Interface were introduced.

In this section, an example of using the BlackBox input device to interact with the mashup application will be demonstrated, and the BlackBox input device functionality will be described in detail. The BlackBox input device was introduced earlier in this chapter; it was also compared with the Spacemouse. The advantage of using the BlackBox is that it provides a cheaper alternative solution for free rotation about all the axes of the virtual artefact. Figure 5.8 shows the BlackBox input device.

The GUI of the BlackBox is utilized for setting up the BlackBox interface and responding to the 3D model in the virtual environment. The BlackBox GUI can be divided into two different components: one part is used for responding to the controls of the Inertia Cube 2, which is a small inertial orientation reference system providing Full 360 degree tracking in all axes; the other part is used to respond to the controls of the USB Micro Controller [1].

The orientation sensor (Inertia Cube 2) that is embedded in the BlackBox is connected to the virtual object through an ActiveX control, which enables users to initialise and set up the orientation of the BlackBox device, activate or deactivate the interaction, and freely rotate the virtual objects with three degrees. The users can restrict the rotation of the virtual object to one axis or three axes, initialise the orientation of the device by changing the values of X Offset, Y Offset and Z Offset, and so on [1].

In this BlackBox mashup interaction example, the ActiveX control of the BlackBox was defined as three axes rotation of the virtual object, and utilized as an ActiveX object embedded in the HTML web page. In this mashup application, firstly, users need to connect the BlackBox input device into the computer with the USB and set up the BlackBox device. After finishing setting up the BlackBox input device, users can select images from Flickr and videos from YouTube, and then they can drag and drop images and videos onto the surfaces of a virtual object (a 3D box) in the Cortona viewer environment. After that, users can view the images and videos on a 3D box by rotating the 3D box using the mouse, or they can click the 'Activate' button to use the BlackBox interaction. When users click on the 'Activate' button in the virtual 3D area of the mashup interface, the BlackBox device will be activated and connected to the virtual object (the 3D box); users can now interact with the 3D box, which is textured with images and videos from Flickr and YouTube by using the BlackBox input device.

Figure 5.12 shows the mashup application interface with the ActiveX object embedded (i.e. the ActiveX object is an ActiveX control interface that includes the 3D box in a Cortona 3D environment and 'Activate' and 'DeActivate' buttons). When the user interacts with the 3D box using the BlackBox device, he can switch the virtual 3D environment into full screen. The user can then rotate the BlackBox device, and the 3D box model in the screen is also rotated in real time. Users can rotate the 3D box freely on all the axes to view any image or

video on the six faces of the 3D box using the BlackBox. Figure 5.13 shows the user interacting with the 3D box, fully textured with Flickr images and YouTube videos using the BlackBox device after the user clicked on the ‘Activate’ button.

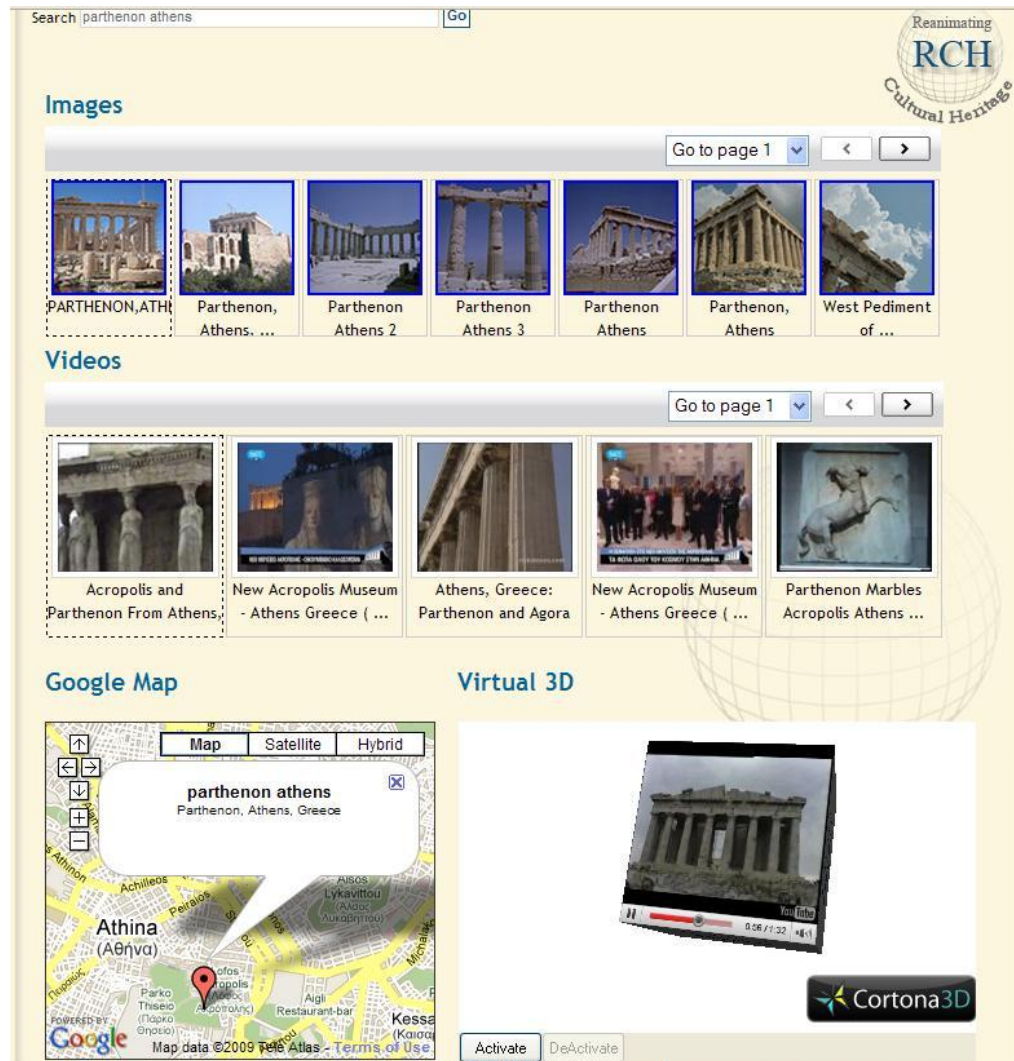


Figure 5.12: The mashup interface with the ActiveX Object embedded

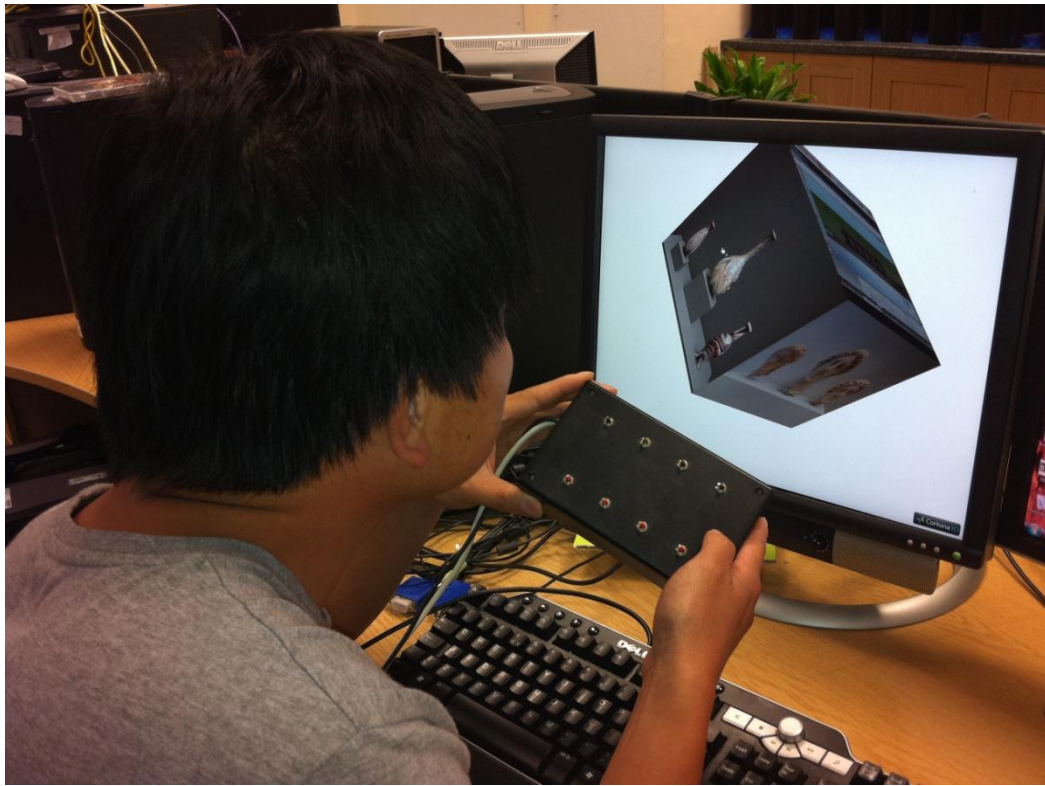


Figure 5.13: Interacting with the 3D box fully textured with Flickr images and YouTube videos using the BlackBox input device

5.4 Conclusion

In conclusion, this chapter demonstrated digital technologies such as Web 2.0 mashups, social networking, and 3D visualization and interaction, etc., which are potential solutions to enabling user communities to select user-generated digital content from social networking repositories and create their own digital exhibitions in a very interesting visualization and interaction environment. This is the goal of capturing community heritage knowledge for the RCH project.

In this chapter, social networking repositories such as Facebook, YouTube and Flickr have been introduced. Facebook can be utilized for building a Sierra Leone social community that allows heritage users to access this community, communicate with each other, share information, and contribute knowledge of the heritage objects; YouTube and Flickr can be used as data repositories in Web 2.0 mashups to enable users to access user-generated digital content. Web 2.0 mashups technology is introduced and utilized to aggregate digital heritage content from different social networking repositories into one single meaningful

application in a very interesting way. 3D technologies, especially 3D interaction technologies, have been introduced and utilized in several mashup application examples that enable users to interact with digital content, such as Flickr images and YouTube videos, using drag and drop, AR and multimodal interface interaction technologies. On reflection, the AR and multimodal interaction approaches are not really suitable for use by Sierra Leone Diaspora, because they will not have access to such technology. The final RCH solutions are described in Chapter 6.

CHAPTER VI

6 Mashing up RCH with Social Networking

6.1 Introduction

The previous chapter introduced the concept of the RCH project as an example architecture for DISPLAYS, which aims to integrate museum digital heritage collections with user-generated digital heritage content to allow museums and user communities to create their own digital exhibitions. In the previous chapter, the problem statement is also discussed, which is that museum digital heritage collections can be archived from museums' DHR, and organised as expositions (exhibitions) that are presented online using XML, XSLT, XHTML and database technologies. The question is, however, how to capture community heritage knowledge and allow user communities to build their own exhibitions. A potential solution has already demonstrated, which is using existing social networking technologies to capture user-generated digital content and allow user communities to personalise their exhibitions. Other potential digital technology solutions were also introduced, such as Web 2.0 mashups, 3D visualization and interaction; these could also enable user communities to build their own exhibitions.

In this chapter, these digital technology solutions will be selected, utilized and integrated in order to implement an innovative digital heritage multimedia system for achieving the goal of enabling communities to access and interact with digital heritage objects and collections and contribute their own heritage knowledge. They will also allow user communities to create and publish their own virtual exhibitions based on the community contributed digital heritage content in a very interesting visualization and interaction way.

6.2 RCH Social Networking System Requirements

The previous chapters have addressed the problems and difficulties of allowing communities to access and interact with digital heritage objects and collections, and enable communities to create their own virtual heritage exhibitions in the RCH project. The author created an innovative digital heritage social networking system that solved these issues. For

the system to be useful and enable communities to access and interact with digital heritage collections from museums, while allow user communities to build their own exhibitions, there are two main Web 2.0 mashup applications created by the author in this social networking system. One is a 3D scrapbook application and the other is a Facebook application.

For the 3D scrapbook application to be useful, it must enable users to search images and videos of digital heritage objects from different social networking repositories, such as Bing, Flickr, Yahoo and YouTube (the social network DHR), and the museum collections (the museums DHR). It must enable users to select, drag and drop images and videos that are returned for the search (they are temporarily stored in a gallery) into a virtual environment to create their own virtual exhibitions; it must then allow users to be able to save the virtual exhibitions they have created into their own desktop computer, and to publish their saved virtual exhibitions onto a server for further reuse.

For the Facebook application to be useful, it must allow users to be able to make Facebook comments on all the digital heritage objects from the museum's collections (the museums' DHR). It must enable users to interact with digital heritage objects and publish their comments along with the thumbnail of associated digital heritage object onto the Facebook fan page wall; it must also enable users to see the community discussions (user comments along with the thumbnail of the associated digital heritage object) in the home page of the web site. Table 6.1 shows the user requirements for the 3D scrapbook application, and Table 6.2 shows the user requirements for the Facebook application:

Table 6.1: User Requirements for the 3D scrapbook application

Requirement	Description
UR1	Users must be able to search images and videos of digital heritage objects from different social networking repositories such as Bing, Flickr, Yahoo and YouTube.
UR2	Users must be able to view images and videos of digital heritage objects.
UR3	Users must be able to select and drag and drop images and videos from the gallery into a virtual environment and create their own

	virtual exhibitions.
UR4	Users are able to interact with 3D objects in the virtual environment.
UR5	Users are able to interact with the image and video (textures) on the surfaces of 3D objects in the virtual environment.
UR6	Users must be able save the virtual exhibitions (3D scrapbook) they have created onto their own desktop computer.
UR7	Users must be able to publish their saved 3D scrapbook onto a server for further exhibitions.

Table 6.2: User Requirements for the Facebook application

Requirement	Description
UR1	Users must be able to make Facebook comments on all the digital heritage objects from museums.
UR2	Facebook users must be able to publish their comments along with the thumbnail of the associated digital heritage object onto the Facebook fan page wall.
UR3	Users must be able see latest community discussions (user comments along with the thumbnail of the associated digital heritage object) in the home page of the Reanimating Cultural Heritage web site.

6.3 Mashing up a 3D Digital Heritage Scrapbook

In the context of the RCH project, one of the user requirements is to implement a kind of ‘media album’ application that enables users to capture, select and organize their Sierra Leonean heritage photos or videos (digital objects) from different museum data repositories, e.g., the British Museum, Glasgow Museums, Brighton Museum and Art Gallery and Sierra Leone National Museum (museums’ DHR), and the social network DHR.

In this original requirement, the media album application, users are able to select photos or videos of the digital heritage from museum heritage photo or video collections search. After the user has finished selecting the desired heritage photos or videos, they are able to drag

and drop the selected images or videos into the media album area to start creating their own media album. When the user has finished building his own album, he is able to save his media album somewhere (e.g. to the local computer). In addition, the user is able to upload his media album to a project web site (e.g. the user is able to send his album file into the server, and then the administrator can take his media album into the exhibition of the project web site).

According to this requirement, the media album functionality is required to be created for museums only using museums' DHR. Using social networking technologies it is possible to implement elements of such a functionality separately; however, a better concept is to integrate the functionality of Web 2.0 technologies with the RCH project database functionality to create a media album for the Sierra Leonean heritage that includes the ability to search for Sierra Leone digital objects not only on the museums' DHR but also on a social network DHR, and integrate the results in the so called 'media album'. The question then arises; in what innovative way could such functionality be implemented. This thesis presents the concept of the 3D digital heritage scrap book as a solution for the 'media album'.

The idea of integrating features of Web 2.0 technologies for creating the 3D scrap book (for short) was to utilize Web 2.0 mashup technology to search for appropriate media content from several social networking repositories, e.g. Bing, YouTube, Yahoo, etc., through their appropriate search APIs, and the museum DHR. The selected media content would be dragged and dropped into the 3D scrap book before saving it to a local machine or publishing it into a server; the administrator can then retrieve it to make further exhibitions on the project web site.

From a museum's perspective, their virtual exhibitions would only enable users to access their own digital heritage from their own database repository. However, museum exhibitions normally do not access user-generated digital heritage objects, and a museum's web site functionality generally does not allow user communities to build community contributed heritage exhibitions. If museums want to access community contributed resources and generate community contributed exhibitions, it demands that the museum spends time and money building large museum resources to moderate and organize such

user-generated digital heritage content, which can then be effectively integrated with their own collections. This implies that there is a need to build a self-maintaining community contributed digital heritage content collection that could be mixed and mashed with regular museum digital heritage collections. However, this kind of user-generated digital heritage content is distinguishable as not necessarily having that museum ‘stamp of approval’. In this case, social network repositories such as Flickr, YouTube, Bing, etc., can be utilized to provide such self-maintaining community contributed digital heritage content, i.e. the community DHR. These social network repositories can be integrated with a museum DHR to provide user-generated content that can be used for generating community contributed heritage exhibitions.

Figure 6.1 shows the integration of the RCH digital repository (museums’ DHR + community DHR based on a social network). In this diagram, RCH digital exhibitions are composed of two parts: museum digital heritage exhibitions, and user-generated digital heritage exhibitions. Museum digital heritage exhibitions are generated from digital heritage objects and collections in the museum database repository using XML technologies such as XSLT or XQuery. User-generated digital heritage virtual exhibitions are generated from community contributed digital heritage objects and collections in the social network repositories, such as Bing, Flickr, Yahoo and YouTube, using social networking, Web 2.0 mashups and 3D digital technologies.

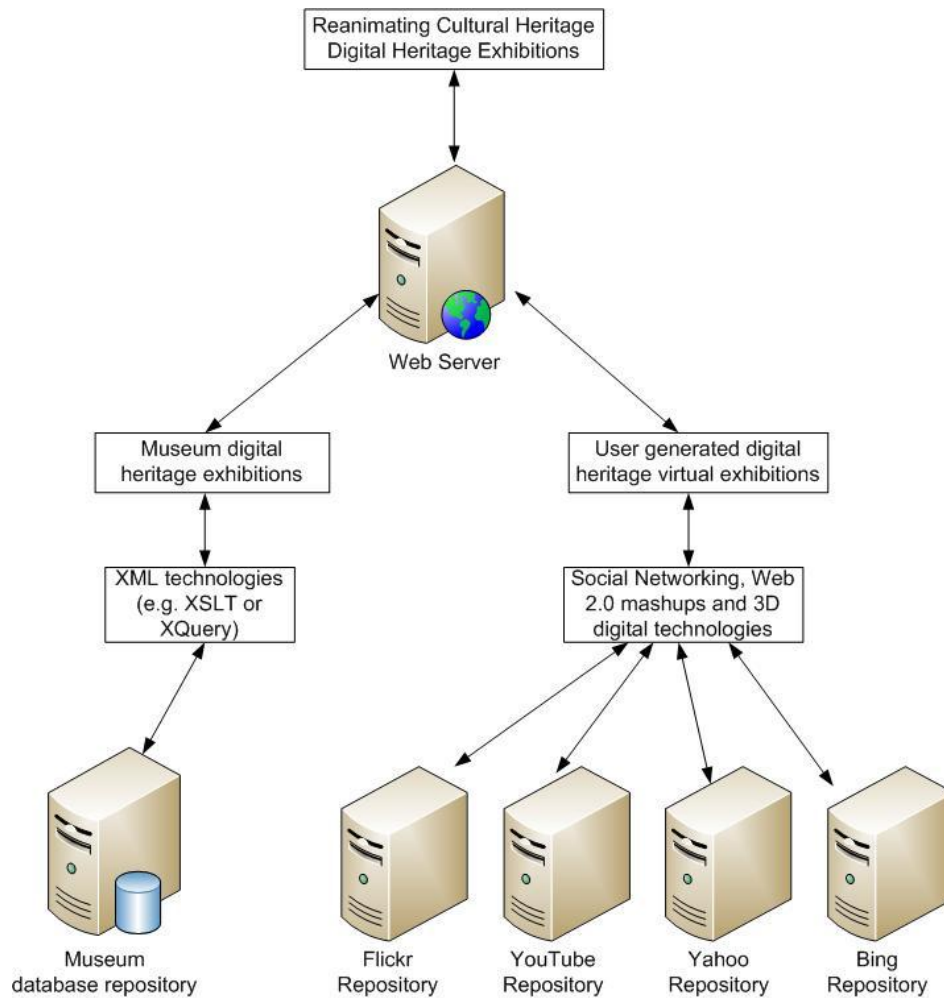


Figure 6.1: The integration of RCH digital heritage exhibitions

In addition, if a set of user-generated digital heritage collections is of particular interest, museum people may want to ‘copy’ specific digital heritage content (images and videos) from the social network DHR (community DHR), add them permanently to their own museum based ‘scrap book’ digital collection, and then preserve them for a future particular museum virtual exhibition. This implies that museums can create their own scrapbook collection that is composed of their own museum-based digital heritage objects and other user-generated heritage object resources from the community side.

According to the user requirements demonstrated above, what is now needed is a mechanism to easily create, save and publish the scrapbook based on user-generated digital heritage content from social networking repositories. For the requirement of RCH objects along with associated images, videos and other media, such as 3D, within a virtual exhibition space, and allowing users to build their own virtual exhibitions online, 3D

technologies are utilized in this scrapbook application. In order to achieve these requirements, the scrapbook was implemented with the use of virtual worlds and 3D objects coded in VRML. In this, there are surfaces onto which users can drag and drop images and videos of the digital heritage content. From this perspective, the scrapbook concept was extended into a 3D scrapbook.

This section will illustrate how Web 2.0 mashup technologies can be used to access social networking repositories, such as Bing, Flickr, Yahoo and YouTube, through their appropriate RESTful web services, and the museums DHR through its web service, e.g. the ARCO database. This access will capture user-generated digital heritage content in a 3D scrapbook that enables users to build their own multimedia-based heritage virtual exhibitions in a 3D environment.

6.3.1 Design

The overall design of the digital heritage 3D scrapbook will require an extraordinarily rich Web 2.0 mashup interface to be constructed. To fulfil the first requirement of the user interface shown in Table 6.1, radio buttons (see Figure 6.2) were designed and placed on the top of the interface for search functionality – note the ARCO radio button to search the museum’s collections, and the other button to search the social network.

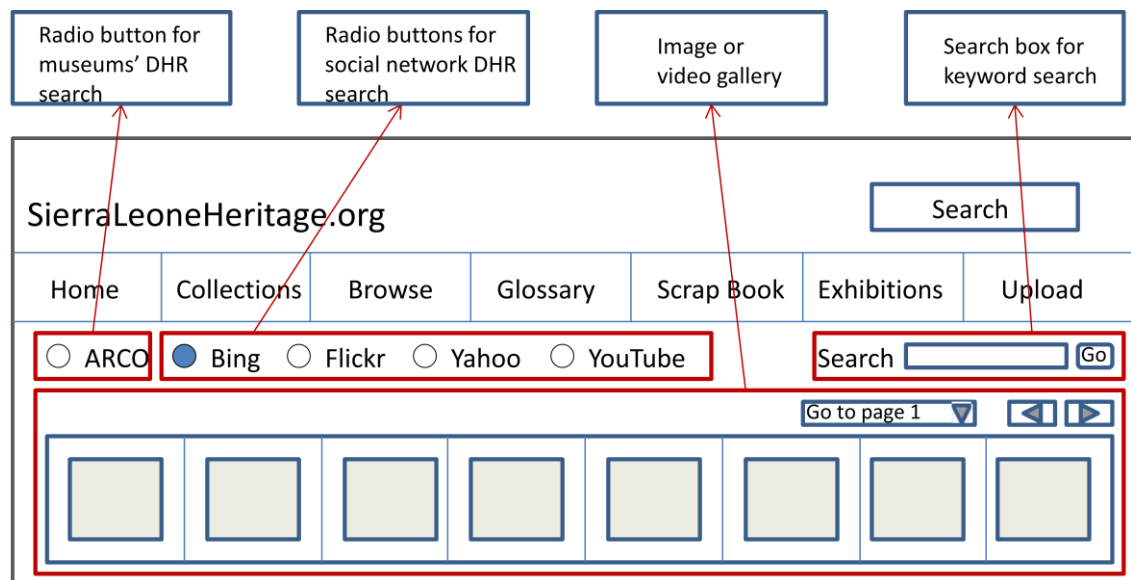


Figure 6.2: The design of 3D scrapbook search interface

The original design of the search functionality is to list all the Flickr, YouTube, Bing, Yahoo search results in the interface through one search. From my experience of designing this user interface, the disadvantage of this 'search' design is that when users search for a particular name of a digital heritage object, the interface will display all the search results including Flickr, Bing, Yahoo images and YouTube videos of that heritage object in one go. If many social network repositories are used in the search functionality, there will be a very long search result, whose results are too slow to display. It is not easy for users to identify heritage information, and it is also a bad design from the interface design perspective.

To achieve the second requirement of the user interface shown in Table 6.1, the author designed an image or video gallery placed under the search that enables users to look through all the thumbnails of heritage objects (images and videos) in the gallery by clicking 'previous' and 'next' buttons (see Figure 6.2). When the user clicks on the thumbnail, they are able to view the original photo or video of the heritage object within a Shadowbox. This interface design gives the user a good look and feel of the user interface, and allows the user to easily identify useful heritage object information without leaving the current page.

The third interface requirement shown in Table 6.1 is one of the most important pieces of the interface design. In order to enable users to drag and drop images or videos of heritage objects into the 3D world, a Cortona 3D environment was designed and placed in the centre of the interface. Several playing 3D objects were designed (Figure 6.3 shows the designed 3D box player object, Figure 6.4 shows the designed display wheel object, and Figure 6.5 shows the designed kiosk object), and their images (which link to the 3D objects) were created and placed at the top right of the interface; users can drag and drop these into the 3D environment. Several virtual scenes were designed (Figure 6.6 shows the designed virtual museum gallery), and their image buttons (which are used to switch the virtual scenes) were designed and placed at the right of the interface. This kind of interface design enables users to easily switch the virtual environment, and drag and drop images and videos of heritage objects into the 3D world.



Figure 6.3: The designed 3D box player object



Figure 6.4: The designed display wheel object

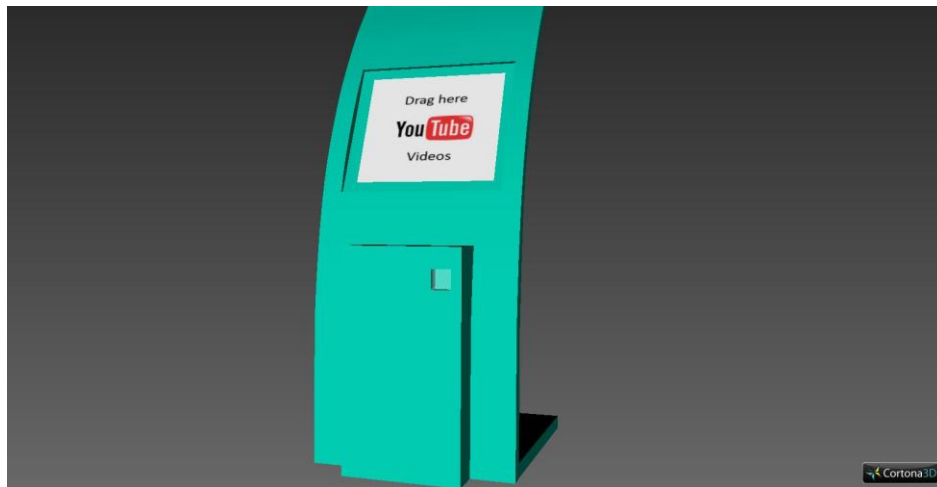


Figure 6.5: The designed kiosk object



Figure 6.6: The designed virtual museum gallery

Two radio buttons were designed and placed at the bottom right of the user interface for the ‘save’ and ‘publish’ functionality (see Figure 6.8). Originally the normal buttons were chosen to active ‘save’ and ‘publish’ functions, but from the interface design perspective, the radio button is better for the look and feel of the user interface.

6.3.2 Implementation

After finishing the requirement analyses and the interface design, an innovative digital heritage 3D scrapbook was created. The interface of the 3D scrapbook is a Web 2.0 mashup that could retrieve images and videos from different social network DHR, such as Bing, Flickr, Yahoo, YouTube, and museums’ DHR (including the RCH project database repository) through their appropriate web services. Third party services, such as Bing,

Flickr, Yahoo and YouTube, were effectively utilized to preserve community contributed digital heritage objects from user communities, and the project database repository was used to hold digital heritage objects from participating museums (currently there are partnerships with the British Museum, Glasgow Museum, Brighton Museum and Art Gallery, and the Sierra Leone National Museum). This 3D scrapbook interface integrates Bing, Flickr, Yahoo, YouTube and the museum's database search functionality, displaying the search results in a typical fashionable gallery created to allow users to retrieve digital heritage content from these social network DHR through their appropriate web services (e.g. Flickr, Yahoo, Bing and YouTube use RESTful web services) and the museum's DHR through their web service (e.g. ARCO web service). Web 2.0 mashup technologies are utilized to aggregate these data into one single meaningful interface to enable users to easily identify useful heritage information.

The implementation of the top level of the interface is now discussed in more detail. A radio box technology was chosen to switch to different data repositories for searching digital heritage objects in the selected data repository. Yahoo Carousel technology was utilized to implement image or video galleries for displaying a set of search results (images or videos of heritage objects) arrayed horizontally in an overloaded page region. When the user clicks on the thumbnails of images or videos in the gallery, an enlarged image or video player, together with the title or the other information associated with the selected image or video, will be displayed using the Shadowbox technology to allow users to view the digital heritage object and the associated object information.

In the centre of the scrapbook interface, a Web 3D application in a Cortona3D environment, together with several 3D galleries was implemented. Users can switch into different virtual environments by clicking on the image button of the selected virtual galleries. Furthermore, several 3D objects (they are not digital heritage objects) such as 3D box player, display wheel and kiosk, were created to allow users to be able to drag and drop these 3D objects into the virtual environment. When these 3D objects were dragged and dropped into the virtual scene, users could interact with these 3D objects in all kinds of ways (move, wheel and rotate). For example, the display wheel can be moved on the floor of the virtual gallery by dragging its bottom stand, and users can view its different surfaces

by wheeling it (i.e. there are several faces created on the display wheel object that users can drag and drop Flickr images and YouTube videos onto). In the same way as the display wheel object, the 3D box player can also be moved on the floor of the virtual gallery; furthermore, the 3D box on the top of the object can be rotated to view six box faces (i.e. similar to the display wheel, the 3D box has six faces created to allow users to drag and drop Flickr images and YouTube videos). The kiosk can also be moved to anywhere in the virtual gallery by dragging it.

As part of the implementation of the interaction with the 3D objects, several VRML sensors were utilized. For example, the drop sensor was utilized for ‘drag and drop’ interaction with the digital heritage objects (e.g. to drag and drop 3D objects into the 3D gallery); the cylinder sensor was used for wheeling a 3D object (e.g. the display wheel object); the sphere sensor was used for rotating a 3D object (e.g. the 3D box player object); the plane sensor was used for moving a 3D object in the virtual scene (e.g. the kiosk can be dragged and moved on the floor in the virtual gallery). Furthermore, VRML scripts were also used along with VRML sensors to complete the 3D interaction tasks.

The drop sensor was already introduced in the last chapter. The cylinder sensor is a type of dragging sensor, which is used to map the mouse movement to a conceptual cylinder’s surface, and rotate a 3D object in the Y axis of its local coordinate system [162]. The sphere sensor is also a type of dragging sensor, which is used to map the mouse movement into a conceptual sphere’s surface, and rotate a 3D object in the centre of its local coordinate system [163]. The plane sensor is another type of dragging sensor, which is utilized to map the mouse movement into the XY plane, and move a 3D object in the XY plane of its local coordinate system [164].

Although VRML sensors can be utilized to perform wonderful interaction for users in the VRML world, they are limited in some types of interaction users can perform. The VRML script provides this missing flexibility to allow users to perform almost all the interactions they require. The VRML script enables programmers to define the interaction behaviours by utilizing different programming languages such as Java, JavaScript [165].

```
DEF displaywheel Transform {  
    translation -16.04 53.42 -1.089
```

```

        scale      0.75 0.75 0.75
        children [
        DEF SS CylinderSensor {}
        .....
        ]
    }
    ROUTE SS.rotation_changed TO displaywheel.rotation

```

The above code shows that the cylinder sensor was utilized in the VRML code of the display wheel object. In this code, CylinderSensor was defined and set the name ‘SS’, and a route was created between the eventOut ‘rotation_changed’ from the CylinderSensor ‘SS’, to the exposed field rotation of the Transform node, called ‘displaywheel’. The code to achieve this is:

```

ROUTE SS.rotation_changed TO displaywheel.rotation

```

By using the cylinder sensor in the VRML code, users can then interact with (wheel) the display wheel object (i.e. rotate the display wheel object in the Y axis of its coordinate).

```

DEF videoplayer Transform {
    translation 9.942 43.36 -0.1955
    children [
    DEF VS SphereSensor {}
    .....
    ]
}
ROUTE VS.rotation_changed TO videoplayer.rotation

```

The above code shows the sphere sensor was used in the VRML code of the 3D box player object. Similar to the cylinder sensor, a route also needs to be created between the eventOut ‘rotation_changed’ from the SphereSensor to the rotation of the Transform node. By utilizing the sphere sensor in VRML, users could interact with (rotate) the 3D box player object in the centre of its coordinate.

When a user selects images and videos from the image or video gallery on the top level of the interface, they can then drag and drop them onto the wall frame or the surfaces of 3D objects in the virtual gallery. Furthermore, users can still interact with the image or video (textures) on the wall frames or the surfaces of 3D objects (e.g. users can click on an image

or video texture on the surfaces of the 3D box player object to view the original image or video). This behaviour was performed by using the VRML anchor node.

There are several technical issues that the author has come across during this implementation, for example, when users drag and drop a YouTube video onto the surface of 3D objects such as the 3D box player and the display wheel in a Cortona3D environment. The YouTube video plays on the surface of the 3D box or the display wheel as a movie texture in the Mozilla Firefox browser (i.e. Cortona3D viewer supports for Firefox 3.0); however, the YouTube video is not playing as a movie texture in the Internet Explorer (IE) browser because of IE security reasons. Furthermore, if a user drags and drops many YouTube videos onto wall frames or the surfaces of 3D objects in the virtual gallery, there would be a lot of videos playing as movie textures: this is not good for the user to watch the single video content.

To solve the IE security and multi-video playing issues, VRML script, drop sensor and VRML anchor technologies were used. For example, the drop sensor was utilized for dragging and dropping images or videos into the wall frames or surfaces of 3D objects inside the virtual gallery; at the same time, the drop sensor was also utilized to capture the URL of the image or video that was dragged into the virtual gallery. VRML script was utilized to separate the URL string of a YouTube video that has been captured by the drop sensor into two parts: the VRML script then assigns one part of the URL string to the URL of the movie texture in the VRML code of the wall frames or 3D objects that the YouTube video would be dropped onto; this will avoid multi-video playing because the movie texture will only display the first video frame of the YouTube video along with a start button. The VRML script assigns another part of the URL string (i.e. this part of the URL string links to the original YouTube video) to the URL of the VRML anchor that was already applied in the VRML code of the 3D object. When the user clicks on the movie texture on the surfaces of the wall frame or 3D object, they will see the original YouTube video playing in another window.

```
DEF Box03 Transform {  
  translation 0 -12.5 0  
  scale 0.5 0.5 0.5  
  children [  
    DEF B1 Anchor {  
      description "Click on me to watch youtube movie"    }  ]  
}
```

```

        parameter "target=_blank"
        children[
        DEF DS1 DropSensor {}
        .....

        textures [
        ImageTexture {url "youtube.jpg"}
        DEF IP MovieTexture {loop TRUE}
        ]
        ]
    }
] }
.....

DEF SE Script {
    eventIn MFString URL
    eventOut MFString newUrl
    eventOut MFString aUrl
    url "javascript:

    function URL(value){

        aUrl[0]=(value[0]).substring(0, (value[0]).indexOf('#'));
        newUrl[0]=(value[0]).substring((value[0]).indexOf('#')+1);

    }"
}
ROUTE DS1.url TO SE.URL
ROUTE SE.newUrl TO IP.url
ROUTE SE.aUrl TO B1.url

```

The above code shows how to use the drop sensor, VRML script and VRML anchor technologies to capture the URL string of the YouTube video, and then assign the two parts of the URL string of the video to the URLs of the movie texture and VRML anchor. This can avoid multi-video playing, and the user still can watch the video by clicking the movie texture on the surface of the wall frame or 3D object. In the above code, the drop sensor ‘DS1’ captured the URL of the YouTube video (i.e. ‘DS1.url’ is the URL of the YouTube video that the drop sensor has captured) when the user dragged and dropped a YouTube video into the virtual gallery. This URL of the YouTube video has two small URLs that are concatenated by using the symbol ‘#’. The author created a VRML script that was defined as ‘SE’. A VRML script can receive any number of events, and the values of these events are stored in the eventIn type variables. A script can also generate any number of events, and the values of these generated events are stored in eventOut type variables [166]. In this VRML script, the author defined an eventIn type variable and two eventOut type variables. The author also defined the data type that is ‘MFString’ for both eventIn and eventOut type variables. The ‘MFString’ data type is a String Array which stores multiple Strings. The

URL of the drop sensor was assigned to the VRML script 'SE' eventIn type variable 'URL'. The code which achieves this is:

```
ROUTE DS1.url TO SE.URL
```

In the VRML script, a javascript function was implemented to separate the URL value of the eventIn variable to two parts by the symbol '#'. One part string is assigned to a eventOut type variable called 'newUrl', and another part string is assigned to another eventOut type variable called 'aUrl' (i.e. because the data types of the eventIn and eventOut type variables are all set to 'MFString', and the 'MFString' is a String array, the value of the variable 'newUrl' should be set to 'newUrl[0]', and the same as the variable 'aUrl'). The code to achieve this is:

```
url "javascript:
function URL(value){
    aUrl[0]=(value[0]).substring(0, (value[0]).indexOf('#'));
    newUrl[0]=(value[0]).substring((value[0]).indexOf('#')+1);
}"
```

After that, the author assigned the values (which are MFString data type) of two eventOut type variables to the appropriate URLs of the movie texture and the VRML anchor (e.g. the variable 'newUrl' is assigned to the URL of the movie texture, and the variable 'aUrl' is assigned to the URL of the VRML anchor). The code that achieves this is:

```
ROUTE SE.newUrl TO IP.url
ROUTE SE.aUrl TO B1.url
```

When the URL of the YouTube video is separated into two parts and assigns them into the appropriate URLs of the movie texture and the VRML anchor in the VRML code, the user can identify the YouTube video by the movie texture and watch any YouTube videos by clicking on the YouTube movie textures on the surfaces of the objects.

During the implementation of the interaction with the images and videos of heritage objects, there was another technical issue the author came across: when images or videos that the user has selected are dragged and dropped onto the surfaces of the 3D objects such as the display wheel and 3D box player in the virtual scene, these 3D objects are flipping when the user starts to interact with (wheel or rotate) them. For example, if a user wants to

click on one surface of the 3D box player that is textured with an image or video of heritage objects from an image or video gallery on the top level of the interface, the 3D box flips onto another surface of itself. This brings the difficulty of interacting with images or videos on the surfaces of the 3D box (e.g. rotating the 3D box to view the different image or video (textures) or clicking on the image or video textures to view the original images or videos). The reason for this issue is that when the VRML drop sensors were applied into every face of the 3D box, each 3D box face not only becomes an object but a shape. When a sphere sensor is applied onto the 3D box main Transform node, the 3D box rotation does not work properly because the sphere sensor applied on the 3D box cannot control the rotation of this object very well.

To solve this technical issue, each 3D box face should be treated as an object, and the sphere sensor should be applied into every face. All the faces (objects) of the 3D box should be rotated synchronously (e.g. when one face of the 3D box is rotated, the other faces of the 3D box should be rotated in the same direction). The same issue appears in the display wheel object and it can be solved in the same way.

When drop sensors are applied in every face of the 3D box for dragging and dropping images and videos of heritage objects onto the surfaces of the 3D box object, the sphere sensors also need to be applied to every face of the 3D box for rotating the 3D box object. Each face of the 3D box object is treated as an object, and the main transform node should be rotated in the same direction as every box face. The code that achieves this is:

```
ROUTE SS.rotation_changed TO videoplayer.rotation
ROUTE SS.rotation_changed TO Box06.rotation
ROUTE SS.rotation_changed TO Box03.rotation
.....
ROUTE SS.rotation_changed TO Box01.rotation
ROUTE SS.offset TO videoplayer.rotation
ROUTE SS.offset TO CS.offset
ROUTE SS.offset TO CS1.offset
.....
ROUTE SS.offset TO CS5.offset
```

Every 3D box face should also be rotated in the same direction as the main transform node.

The code that achieves this is:

```
ROUTE CS.rotation_changed TO videoplayer.rotation
ROUTE CS.offset_changed TO SS.set_offset
ROUTE CS1.rotation_changed TO videoplayer.rotation
```

```
ROUTE CS1.offset_changed TO SS.set_offset
.....
ROUTE CS5.rotation_changed TO videoplayer.rotation
ROUTE CS5.offset_changed TO SS.set_offset
```

When a user selects images or videos of heritage objects from the image or video gallery on the top level of the 3D scrapbook interface, and drags and drops them into the virtual gallery, the virtual gallery then becomes a 3D scrapbook that contains images or videos from social networking DHR or museums' DHR. The user can save the 3D scrapbook that has been created for future use.

The save function is one of the most important pieces of functionality in the scrapbook. It was implemented to save the user-generated 3D scrapbook onto the user's desktop computer; this allows the user to view his scrapbook on his own computer at any time, or publish his scrapbook for further exhibition in the future. The save functionality uses the VRMLSaver object that is a COM object provided by the Cortona SDK to save VRML scenes or sets of nodes to VRML files [167]. Furthermore, another COM object, called the 'Common Dialog Control', was utilized to show a Windows File Save dialog box that enables users to choose the filename of the VRML file that is going to be saved and location (where to save), and then save the VRML file onto their computer. The code for using the VRMLSaver object to save a VRML scene is:

```
<object ID="grabarVRML" CLASSID="CLSID:18D4B075-AE23-4186-8C84-
1967714BBD85" codebase="PGVRMLSaver.dll"> </object>
```

The above code shows the VRMLSaver COM object that includes the 'CLASSID' of the VRMLSaver object and the code base that is the route to the VRMLSaver object DLL file.

```
<object ID="dlg" classid="clsid:F9043C85-F6F2-101A-A3C9-08002B2F49FB"
codebase="COMDLG32.OCX"> </object>
```

The above code shows the 'Common Dialog Control' object that includes the 'CLASSID' of the object and code base that is the route to the 'Common Dialog Control' object OCX file.

```
function save()
{
    dlg.DefaultExt = ".wrl";
    dlg.Filter = "VRML World|*.wrl";
    dlg.CancelError=true;
```

```

        dlg.ShowSave();
        if (isLoading == 1)
        {
            grabarVRML.Open(cortona1.Engine, dlg.FileName);
            grabarVRML.SaveScene(cortona1.Engine);
        }
        else if (isLoading == 2)
        {
            grabarVRML.Open(cortona2.Engine, dlg.FileName);
            grabarVRML.SaveScene(cortona2.Engine);
        }
        grabarVRML.Close();
    }

```

The above code is a JavaScript function that shows how to use the VRMLSaver object and the ‘Common Dialog Control’ object to save the VRML scene. In the code, the ‘dlg’ is the ID of the ‘Common Dialog Control’ object, and the ‘grabarVRML’ is the ID of the VRMLSaver object. A Windows File Save dialog box will be shown when users click on the ‘save’ button of the interface. The code to achieve this is:

```

dlg.DefaultExt = ".wrl";
dlg.Filter = "VRML World|*.wrl";
dlg.CancelError=true;
dlg.ShowSave();

```

When users click on the ‘save’ button on the File Save Dialog box, the VRML file is saved onto their own computer using the code below:

```

grabarVRML.Open(cortona1.Engine, dlg.FileName);
grabarVRML.SaveScene(cortona1.Engine);

```

During the implementation of the ‘publish’ function, the server side technologies, such as PEAR and PHP, were utilized to perform the file submission, email notification and XML generation functionality. An XML file is written to describe the 3D scrapbook for publication of the project web site.

6.3.3 Results

After the design and implementation of the 3D scrapbook, the completed results were generated for users to create their own 3D scrapbook exhibitions based on digital content from social network DHR and museums’ DHR. For example, users can search for ‘Mende mask’ from Bing, Flickr, Yahoo and YouTube by switching the radio button and searching in the 3D scrapbook interface. Figure 6.7 shows a gallery of ‘Mende mask’ images from the

Bing repository. Users can also switch to the ‘Flickr’ radio button to search ‘Mende mask’ images in Flickr, and the ‘YouTube’ button for searching ‘Mende mask’ videos from YouTube, and so on.

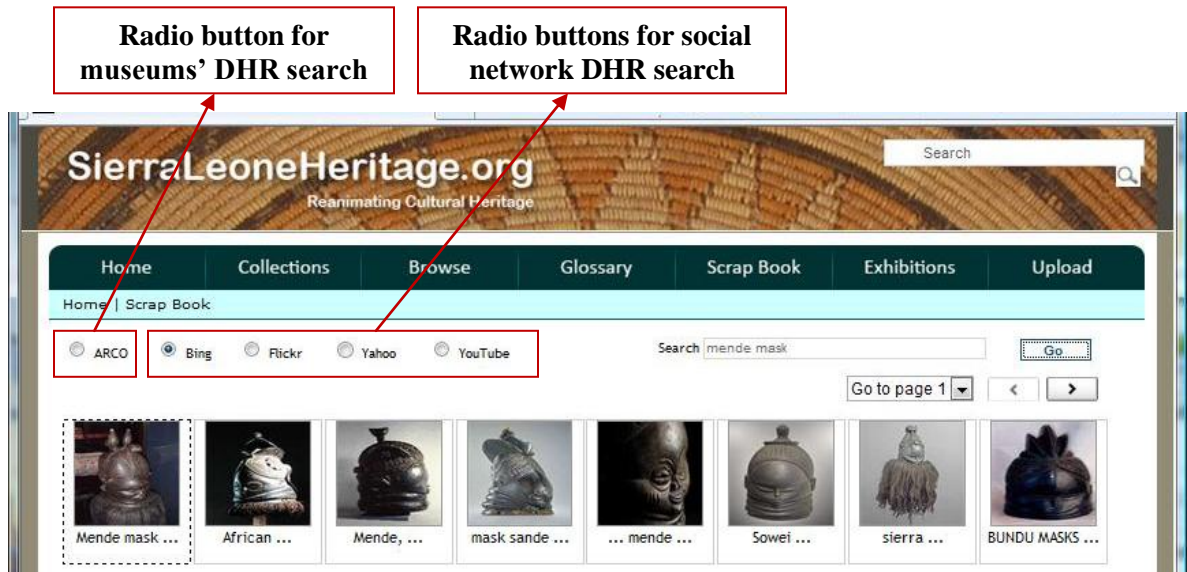


Figure 6.7: The 3D scrapbook search interface

After a search for suitable images and videos of heritage objects has been made, the search results are displayed in the gallery (see Figure 6.7); the user then wants to create a 3D scrapbook. This is achieved by choosing options from the virtual gallery interface on the right hand side of Figure 6.8. Users can drag and drop 3D objects from the ‘Playing Objects’ category into the virtual gallery; Figure 6.8 shows the display wheel, kiosk and 3D box player objects that were dragged and dropped into the virtual scene. Users can then interact with these 3D objects, for example, a user can move these 3D objects inside the virtual gallery by dragging their bottom stands, the user can wheel the display wheel, or rotate the 3D box.

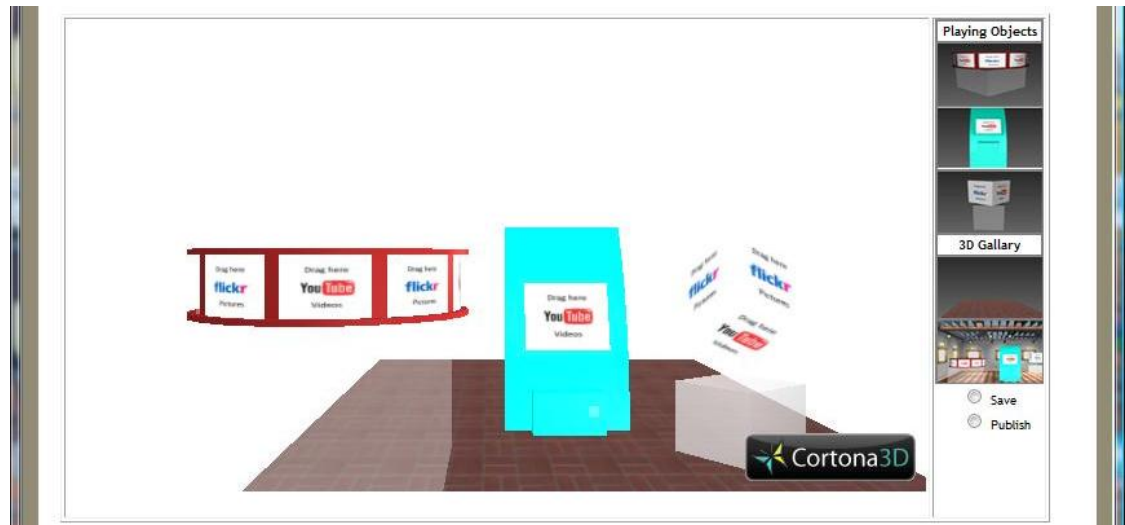


Figure 6.8: Dragging 3D objects into the virtual scene

After the user has dropped those 3D objects into the virtual environment, he can then drag and drop images and videos of heritage objects from the image or video gallery (see Figure 6.7) onto the surfaces of the 3D objects – the surfaces are textured with Flickr and YouTube labels to indicate where to drag and drop images or videos. Figure 6.9 shows images from Bing, Flickr and Yahoo repositories, and videos from the YouTube repository that were dragged and dropped onto the surfaces of those 3D objects such as the display wheel, kiosk and 3D box. The user can still interact with the image or video (textures) on the surfaces of the 3D objects. When the user clicks on the image or video textures, the original image or video will display or play in another window.

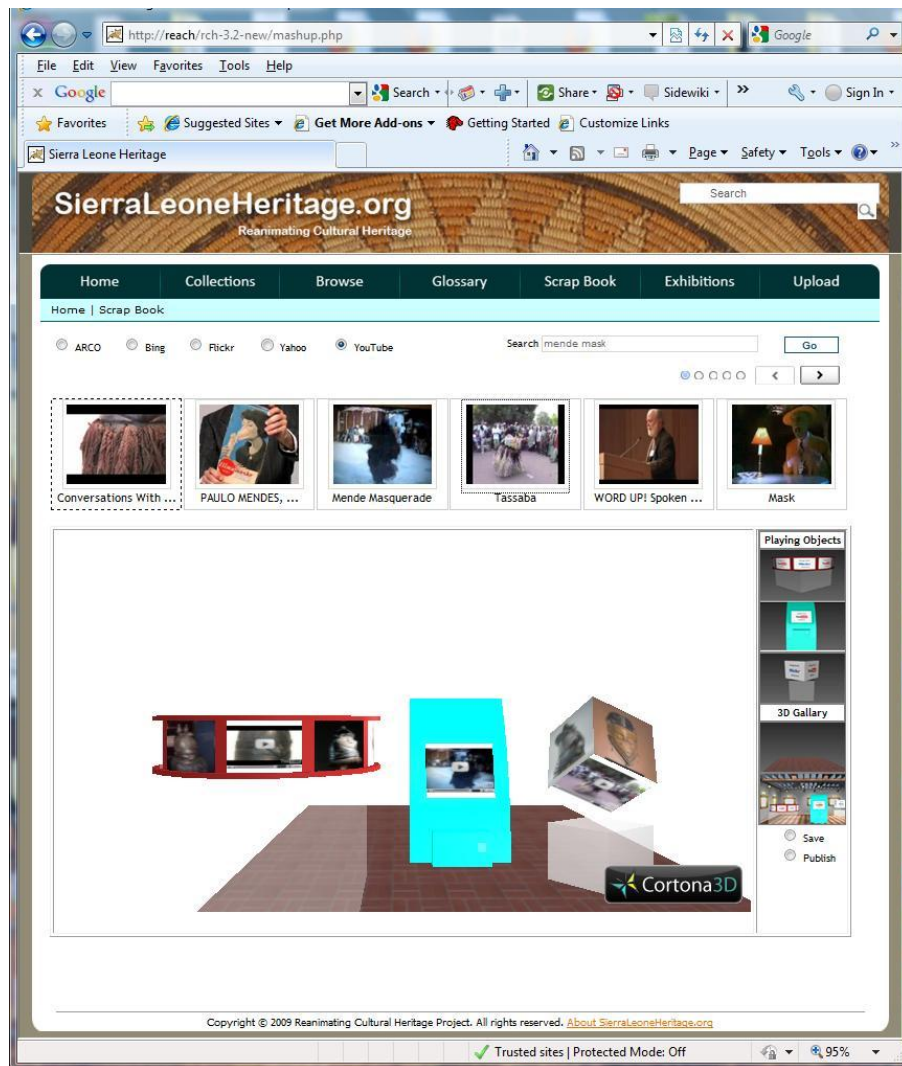


Figure 6.9: Illustration of dragging and dropping images and videos from the gallery onto the surfaces of the 3D objects

If a user wants to create a 3D scrapbook and save it to his computer, he can switch to another virtual scene called 'Saving scene' by clicking on the image button for 'Saving scene'. Figure 6.10 shows the 'Saving scene', which is a predefined virtual gallery with all the 3D objects such as the 3D box player, kiosk and display wheel placed inside. The user can interact with these 3D objects(move, wheel and rotate). The author can create many different predefined virtual scenes for the user to utilize and interact with. Here, the predefined virtual scenes are mentioned because the image and video textures on the surfaces of 3D objects that are dragged and dropped into the virtual scene from the 'playing objects' category, cannot be saved in the 'save' function. This is because the drag and drop function of the 3D object creates an inline code call to its corresponding VRML code file.

The problem with this is that when the video or image is dropped onto the inline version of a 3D object, it will not retain the media object URLs; thus it will not allow an effective save for the future display of images and videos of heritage objects, and the author has to predefine the virtual scene. There may be ways to code around this, but the concept is illustrated.

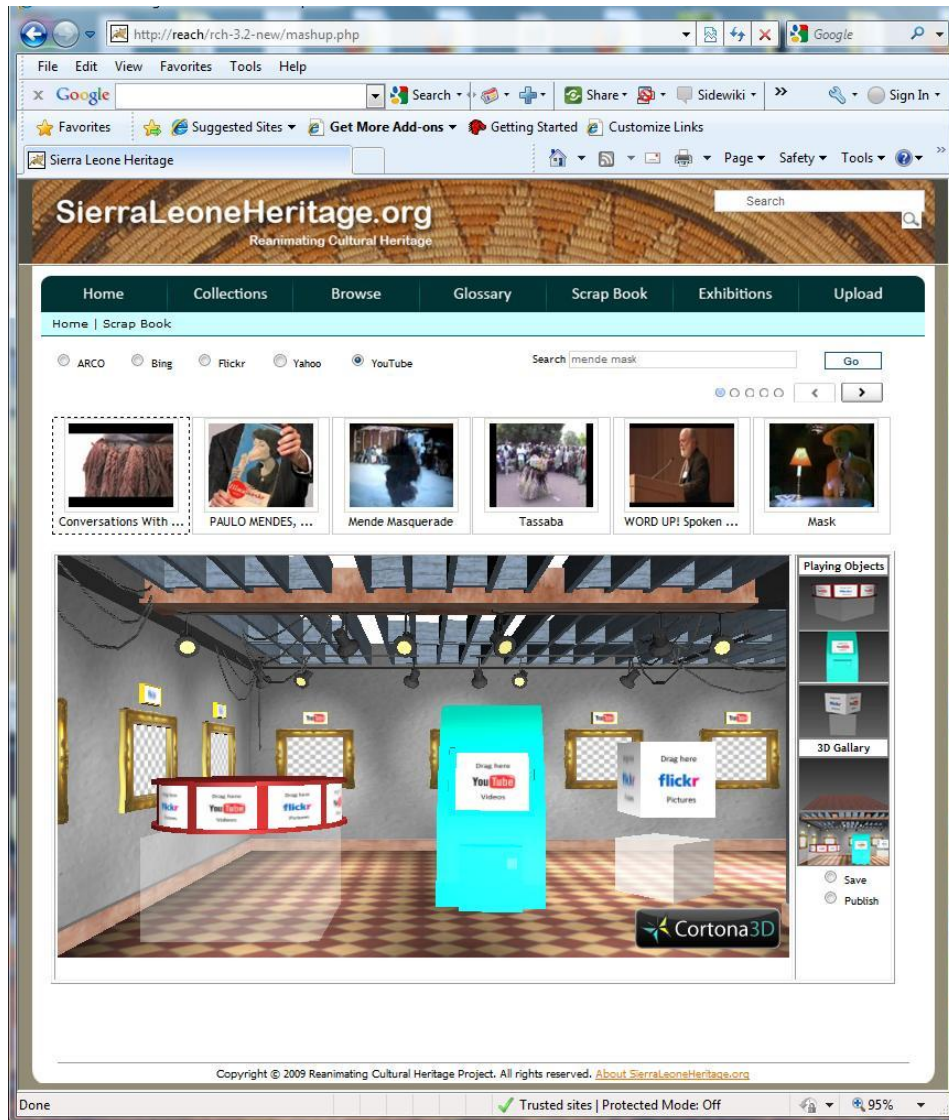


Figure 6.10: The virtual gallery for saving a 3D scrapbook

The user can select one of the predefined virtual scenes by clicking on the image button of the selected virtual gallery: note, the example in Figure 6.10 only illustrates one predefined scene. The user can now create a 3D scrapbook by dragging and dropping selected images and videos of heritage objects from an image or video gallery into the virtual scene (e.g. the

user can drag and drop images and videos onto wall frames or the surfaces of 3D objects in the virtual scene), which is the same process as described in Figure 6.9.

When the user has finished creating the scrapbook, they can save their 3D scrapbook locally by clicking on the 'save' button. When the user clicks the 'save' button, a window file save dialog box will pop up to enable the user to save the created scrapbook file onto their computer.

After the 3D scrapbook has been saved, it can be viewed and played on the computer at any time. Figure 6.11 shows the 3D scrapbook that the user has saved. The user can navigate this virtual gallery to view all the pictures and videos around it. Furthermore, the user can still click on the image or video (texture) to view the original image or video, which links back to the social networking repositories such as Bing, Flickr, Yahoo and YouTube.

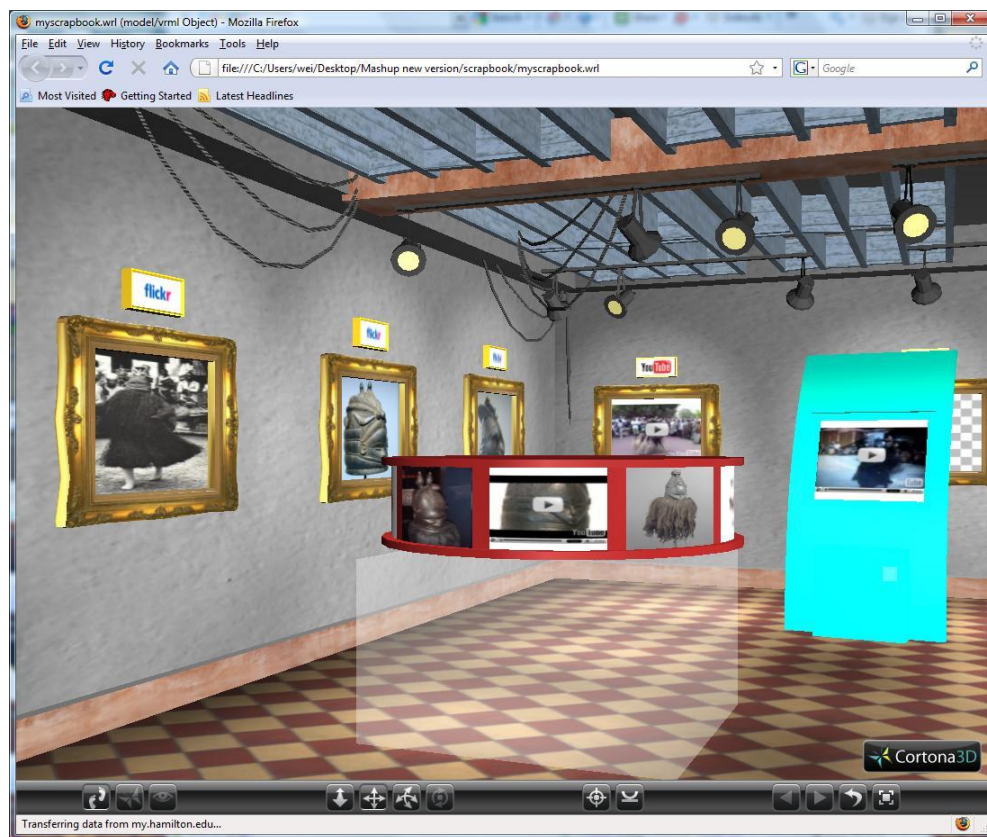


Figure 6.11: The 3D scrapbook which the user has saved

If the user then wants to publish the scrapbook they have saved onto the server (i.e. the project web site) for inclusion in the RCH exhibitions, they can click the 'publish' button.

When the user clicks the ‘publish’ button, a submission form will pop up to allow the user to fill in information, such as name, Email address, comment (which describes the user’s scrapbook), and then the user can browse their 3D scrapbook file from their computer and submit the file (see Figure 6.12). When the file submission is completed, an XML file, which is associated with the scrapbook, will be generated and all the files (including the VRML file of the scrapbook and XML file associated with the scrapbook) will be sent to the server; an email will be sent to the administrator for notification. The XML file associated with the 3D scrapbook is then utilized by the system to create an exhibition on the project web site. Figure 6.13 shows a sample of the associated XML file.

The screenshot shows a Mozilla Firefox browser window with the title "File upload form - Mozilla Firefox". The address bar displays "http://reach.rn.informatic". The page content includes a form with the following elements:

- Name:** A text input field containing the text "wei".
- Email:** A text input field containing the text "tang1982@hotmail.com".
- Comment:** A text area containing the text "This is my 3D scrapbook".
- Select A File To Upload:** A section containing a text input field with the file path "C:\myscrapbook.wrl" and a "Browse..." button.
- Submit:** A button at the bottom of the form.

The browser's status bar at the bottom indicates "Done".

Figure 6.12: The publish pop up form for submission

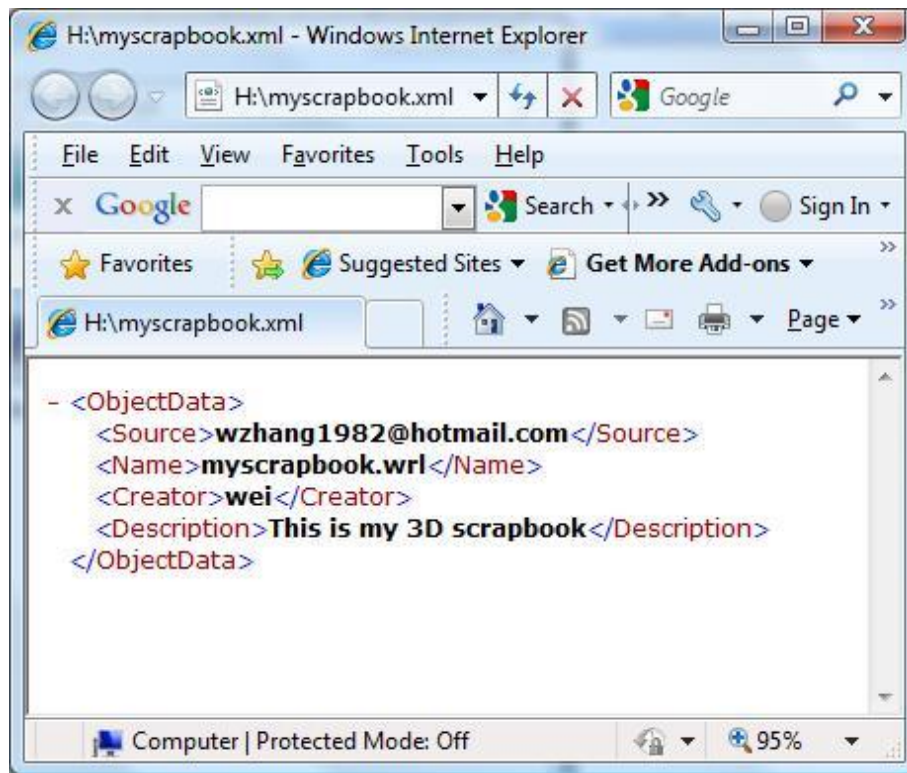


Figure 6.13: The associated XML file

In conclusion, this section has demonstrated a Web 2.0 mashup solution that implements a 3D scrapbook application that integrates digital content from different social network DHR, such as Bing, Flickr, Yahoo and YouTube and museums' DHR such as ARCO, in a very interesting visual and interactive way to allow communities to select user-generated digital heritage content and museums' digital heritage objects and collections, and then build their own virtual exhibitions. This 3D scrapbook multimedia application utilizes digital technologies such as Web 2.0 mashups, social networking and 3D visualization and interaction, and server side technologies such as PEAR and PHP.

6.4 Facebook

Facebook is one of the most popular social networking web sites that allows users to create profiles, connect with other users, join groups of shared interests, post pictures and comments, and communicate with friends and contribute knowledge, etc. In the context of the RCH project, an innovative Facebook application has been implemented for Sierra Leonean Communities to allow them to communicate with each other, share information about their shared heritage and contribute their knowledge of digital heritage objects.

To achieve the goal of the Facebook functionality in the RCH project, a Facebook page was created for building a Sierra Leonean heritage community to allow users to communicate with each other, share information about Sierra Leonean heritage objects, and contribute knowledge of Sierra Leonean heritage. Any user who joins this RCH Facebook community can post messages on the wall on its Facebook page. When the user posts a message, the message will appear in the latest news column of the home page (which is the Facebook News functionality). The users (including Facebook users and non-Facebook users) are able to make comments on all the digital heritage objects from the British Museum, Glasgow Museums and Brighton Museum and Art Gallery. When the users write and post their comments, the comments will appear on that web page and be stored in the Facebook repository (which is the Facebook Comments functionality). Users are able to publish their comments along with the associated digital heritage object image thumbnail into the Facebook fan page wall; the Facebook news in the home page will be affected and updated with the latest news information (which is the Facebook Comments Publishing functionality).

6.4.1 Facebook News

When a Facebook user becomes a fan of the Facebook page of the RCH, they can post messages on the wall of the Facebook page. These messages will be selected and the latest two messages will be displayed in the latest news column of the home page of the project web site. Figure 6.14 shows the latest news column in the home page of the RCH web site.

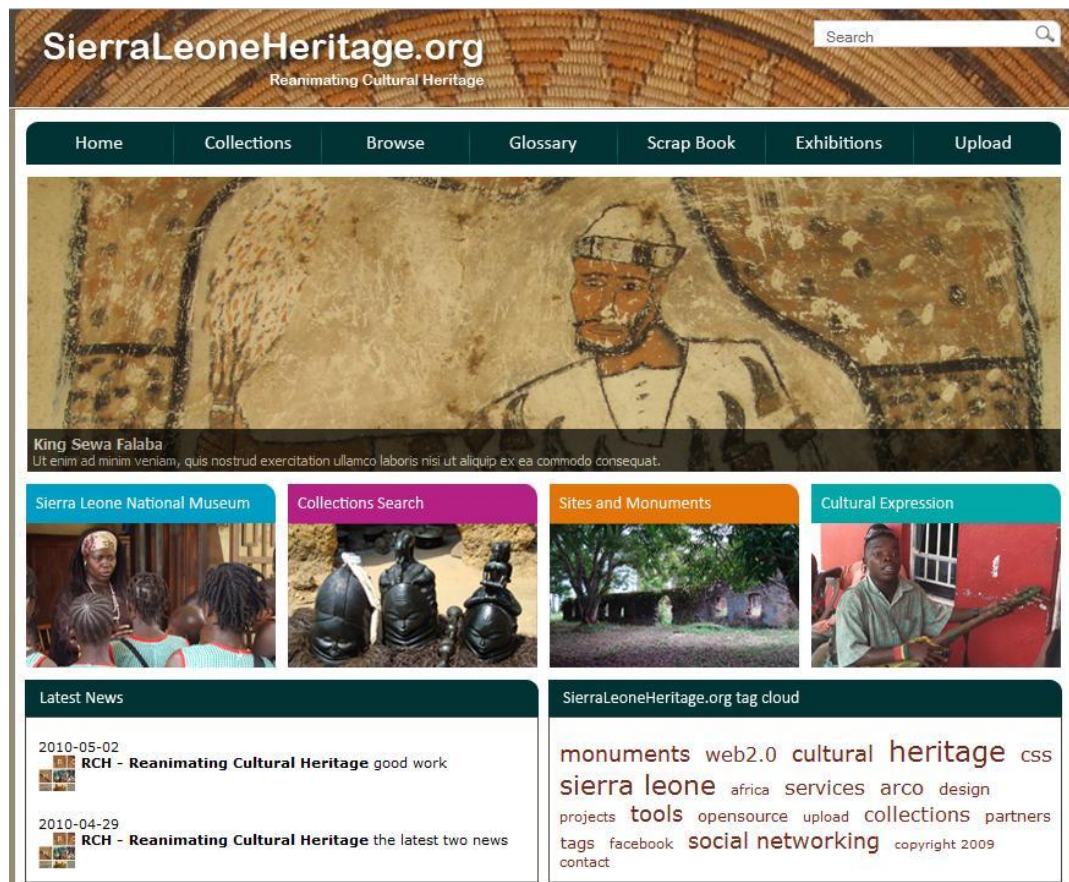


Figure 6.14: The Facebook news column in the home page of RCH web site

In the latest news column of the home page, the date when the user created the message, the profile picture of the Facebook user who created the message, the Facebook user name and the message the user has posted were displayed. The code which achieved this is:

```
<?php
$id = "171018220068";
$url = "http://graph.facebook.com/".$id."/feed";
$out = json_decode(file_get_contents($url,0,null,null));
for ($i = 0; $i < 2; $i++)
{
    if (@$out->data[$i]->message) {
        $time = substr($out->data[$i]->created_time, 0, 10);
        echo "<div class='box' style='margin-left:10px;
        min-height:50px;'>".$time."<br>
        <img style='float:left; margin-
        right:5px;' width=30px height=30px
        src='http://graph.facebook.com/".$out->data[$i]->from
        ->id."/picture'
        alt='".$out->data[$i]->from->name.'" title='".$out->data[$i]-
        >from->name.'">
        <strong>".$out->data[$i]->from->name."</strong> ".$out-
        >data[$i]->message."
        </div><br>";
    }
}
```

```
}
?>
```

In the above code, the Facebook graph API is utilized to retrieve the data from Facebook and display them in HTML format. In this example, the Facebook graph API was utilized to retrieve the wall data of the Facebook page of the RCH. The code that achieves this is:

```
$id = "171018220068";
$url = "http://graph.facebook.com/" . $id . "/feed";
$out = json_decode(file_get_contents($url,0,null,null));
```

In the above code, 'file_get_contents(\$url, 0, null, null)' is a json encoded object containing the wall data of the Facebook page. This needs to be decoded by using the 'json_decode()' method, and now \$out is an object containing the results of the wall data that can be utilized to display the useful content in the HTML format.

```
$time = substr($out->data[$i]->created_time, 0, 10);
echo "<div class='box' style='margin-left:10px; min-
height:50px;'>" . $time . "<br>
```

The above code is used to display the date when the user created the message. '\$out->data[\$i]->created_time' is the string that displays the time the message was initially published, and '\$time' is the string displays the date the message was initially posted (i.e. the data string is the first ten characters of the time string).

```
<img style='float:left; margin-
right:5px;' width=30px height=30px
src='http://graph.facebook.com/" . $out->data[$i]->from-
->id . "/picture'
alt='"' . $out->data[$i]->from->name . "' title='"' . $out->data[$i]->from-
->name . "'>
<strong>" . $out->data[$i]->from->name . "</strong> " . $out->data[$i]-
->message . "
</div><br>";
```

The above code is utilized to display the profile picture of the Facebook user who posted the message on the wall, the Facebook user name and the message the user has posted in HTML format.

In conclusion, this section demonstrated how to use the Facebook graph API to display the Facebook news in the front page of the RCH project web site. In this section, the Facebook

page for building RCH communities is created, and the wall data of the Facebook page is retrieved and displayed in the home page of our project web site through the Facebook API.

6.4.2 Facebook Comments

In the RCH project web site, the Facebook Comment Box was utilized in the Sierra Leone heritage object web page to allow users to make comments on digital heritage objects. For example, in the ‘browse’ functionality of the RCH project, images of digital heritage objects from the British Museum, Glasgow Museums and the Brighton Museum & Art Gallery are displayed and categorized by different Sierra Leone Culture Groups, such as Mende, Susu, Sherbro and West African, etc. (see Figure 4.10). When the user clicks on the image of the heritage object, another web page will be displayed to show a bigger image with the object name and description (see Figure 4.11). There is a link named ‘View Record’ at the bottom of this page: when the user clicks on the link, they will go to the Sierra Leone heritage object page that shows the object image thumbnail, related objects and metadata information such as object name, description, materials, creator, accession number, etc. (see Figure 4.12). The Facebook comment box is at the bottom of this page allowing users to make comments on this object.

In the RCH project, there are nearly 2,000 digital heritage objects. Each object should match a unique Facebook comment box that is used for users to make comments. The problem is how to make unique Facebook comment boxes for nearly 2,000 digital heritage objects.

The parameter of the comments box, ‘XID’, was utilized for building a unique comments box for each Sierra Leone heritage object. The comments box is actually the XFBML [168] version of the fb:comments tag [169]. The ‘XID’ is one of the parameters of the comments box that uniquely identify a set of comments that belong to this comments box. In the RCH project, the unique ID of each heritage object can be utilized as the ‘XID’ of their associated Facebook comments box. The code that achieves this is:

```
<?php
error_reporting(0);
function getUrlStringValue4($urlStringName, $returnIfNotSet) {
    if(isset($_GET[$urlStringName]) && $_GET[$urlStringName] != "")
        return $_GET[$urlStringName];
```

```

        else
            return $returnIfNotSet;
    }
    $firstName = getUrlStringValue4("id", "firstName");
    $array = explode(',', $firstName);
    $array1 = $array[0];
    $array2 = explode(':', $array1);
    $array3 = $array2[0].$array2[1];
    $array4 = explode('/', $array3);
    $array5 = $array4[0].$array4[1];
    echo '<div style="position:relative; left:140px"><h1>Comment:</h1><fb:
    comments xid="'.$array5.'" numposts="2"></fb:comments></div>';
    ?>

```

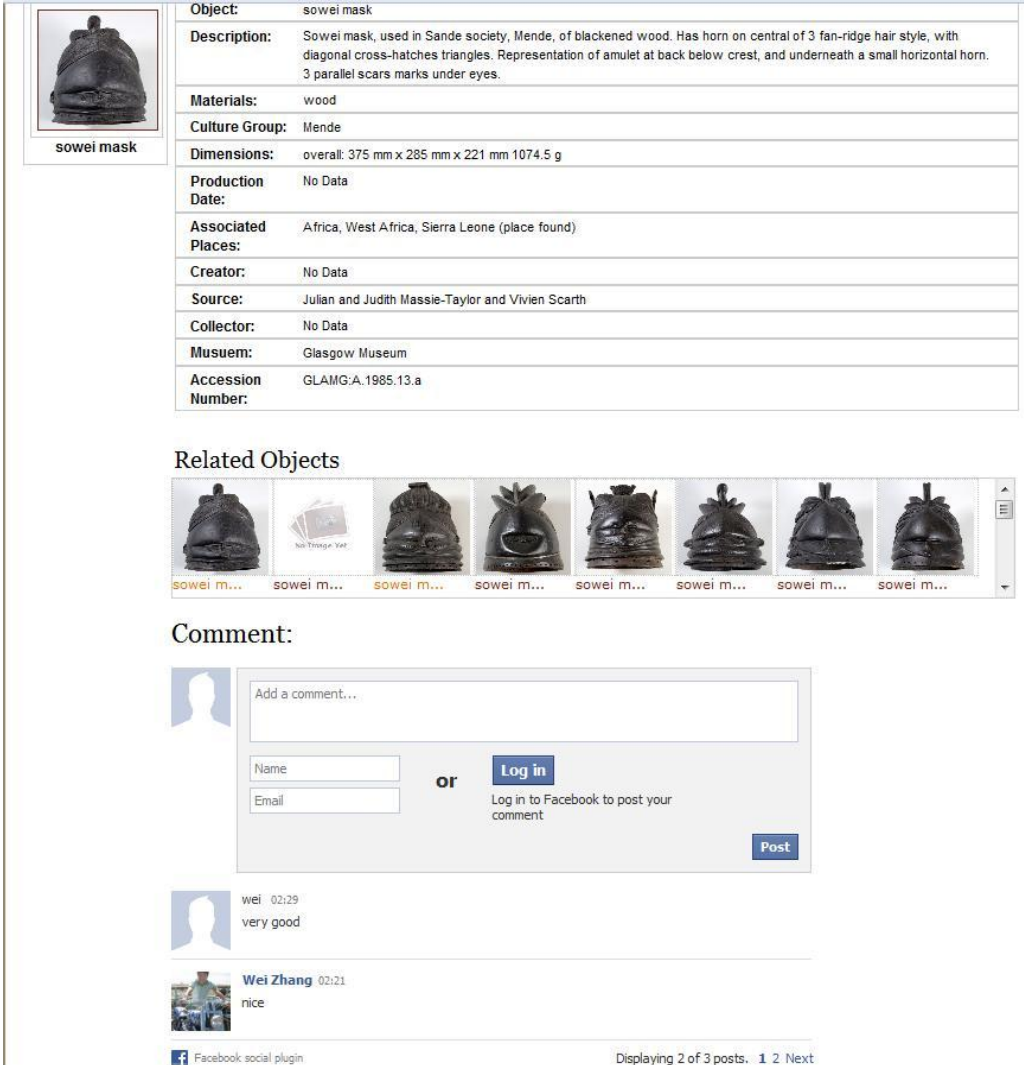
In the above code, \$firstName is the ID of the Sierra Leone heritage object that includes the accession number and object name of that heritage object. For example, the ‘helmet mask’ object has the ID ‘GLAMG:A.1971.14,object=helmet mask’, where ‘GLAMG:A.1971.14’ is the object’s accession number and ‘helmet mask’ is the object’s name. As the string that contains the characters such as comma (,), equal (=), colon (:), slash (/) cannot be a valid XID, the id of the object cannot be used as the XID of the comments box. The string ID of the object is then exploded into two parts at the character comma (,); the first part of string (which is the accession number of the object) is taken as the current ID of the object. As the accession number string still contains colon (:), which is not valid in XID, the current ID was then exploded again into two parts at the character colon (:); these two parts strings (which do not contain the colon) are then concatenated into one single string that can be used as the XID of the unique Facebook comments box associated with that heritage object. Note: the accession number string of the heritage objects from the Brighton Museum is a little different from the other museum’s objects. For example, the Brighton Museum’s heritage object, ‘Bag’, has the accession number ‘BMAG:R595a/6’; this accession number string contains slash (/) that is not valid in XID either. The same process is done as the character colon (:). The code that achieves this is:

```

$firstName = getUrlStringValue4("id", "firstName");
$array = explode(',', $firstName);
$array1 = $array[0];
$array2 = explode(':', $array1);
$array3 = $array2[0].$array2[1];
$array4 = explode('/', $array3);
$array5 = $array4[0].$array4[1];

```

In the above code, \$array5 is then used as the *XID* of the unique Facebook comments box that matches the associated heritage object. Figure 6.15 shows the Facebook comments box in the Sierra Leone object page.



The screenshot displays a web page for a 'sowei mask'. On the left is a large image of the mask with the label 'sowei mask' below it. To the right is a table with the following details:

Object:	sowei mask
Description:	Sowei mask, used in Sande society, Mende, of blackened wood. Has horn on central of 3 fan-ridge hair style, with diagonal cross-hatches triangles. Representation of amulet at back below crest, and underneath a small horizontal horn. 3 parallel scars marks under eyes.
Materials:	wood
Culture Group:	Mende
Dimensions:	overall: 375 mm x 285 mm x 221 mm 1074.5 g
Production Date:	No Data
Associated Places:	Africa, West Africa, Sierra Leone (place found)
Creator:	No Data
Source:	Julian and Judith Massie-Taylor and Vivien Scarth
Collector:	No Data
Museum:	Glasgow Museum
Accession Number:	GLAMG-A.1985.13.a

Below the table is a 'Related Objects' section showing a row of eight small images of similar masks, each with a truncated label 'sowei m...'. Below this is a 'Comment:' section with a Facebook-style comment box. It includes a text input field 'Add a comment...', a 'Name' field, an 'Email' field, a 'Log in' button, and a 'Post' button. Below the comment box, two comments are visible: one from 'wei' at 02:29 saying 'very good', and another from 'Wei Zhang' at 02:21 saying 'nice'. At the bottom, there is a 'Facebook social plugin' logo and a pagination bar showing 'Displaying 2 of 3 posts. 1 2 Next'.

Figure 6.15: The Facebook Comments Box in the Sierra Leanne object page

In the Facebook comments box, there is a parameter called 'numposts' that determines the maximum number of posts to display in the current page. The author sets numposts to two, so there are a maximum of two posts displayed in the current page. If a user wants to view more comments, they can click the 'Next' link.

6.4.3 Facebook Comments Publishing

After Facebook users have made their comments on the digital heritage object, they might wish to publish their comments along with the digital heritage object image thumbnail into the RCH Facebook fan page wall to allow the community to see the discussions on the digital heritage objects. The home page of the RCH web site will be affected, and the latest news column of the home page will be updated to display the latest users' comments on the digital heritage objects. Figure 6.16 shows the whole process of Facebook Comments Publishing.

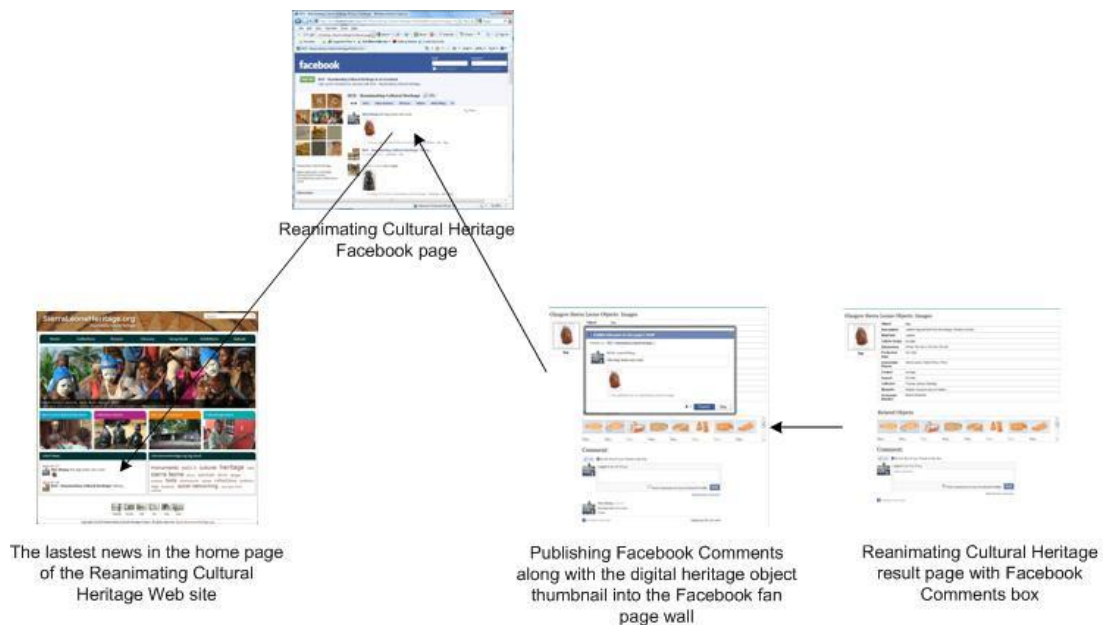



Figure 6.16: The process of the Facebook Comments Publishing









In the process of the Facebook comments publishing, firstly, the Facebook user must be a fan of the RCH fan page before they can publish their comments onto the Facebook fan page wall. If they are not 'fans' the comments will not be published, and an alert message will pop up to warn users to click the 'Facebook' button on the page and enter the RCH fan page to become a fan before they can post their messages to the fan page wall. After the Facebook user logs in, they can write comments on the digital heritage object in the Facebook comments box of the RCH result page (see Figure 6.17). When the user finishes writing their comments and clicks on the 'post' button, the comments will be displayed under the comments box on the results page, and a Facebook publishing dialog box will be displayed to allow users to publish their comments along with the digital heritage object

thumbnail onto the Facebook fan page wall. Figure 6.18 shows an example of publishing Facebook comments along with the digital heritage object thumbnail onto the Facebook fan page wall. In this example, the user writes a comment, ‘this bag looks very nice!’, on a digital heritage object, and tries to publish that comment along with the thumbnail of the bag onto the wall of the Facebook fan page.

Glasgow Sierra Leone Objects: Images


	Object: Bag
	Description: Leather bag and belt from Konnodugu, Koranko Country
	Materials: Leather
	Culture Group: No Data
	Dimensions: Whole: 520 mm x 330 mm x 50 mm
	Production Date: Pre 1894
	Associated Places: Sierra Leone, West Africa, Africa
	Creator: No Data
	Source: No Data
	Collector: Thomas Joshua Aldridge
	Museum: Brighton Museum and Art Gallery
	Accession Number: BMAG.R3483/90

Related Objects



Bag... Bag... Bag... Bag... Bag... Bag... Bag... Bag...

Comment:

 Like Be the first of your friends to like this.

Logged in as Wei Zhang

Add a comment...

☒ Post comment to my Facebook Profile **Post**

Facebook social plugin [Administrate comments](#)

Figure 6.17: The Facebook Comments box in the RCH result page

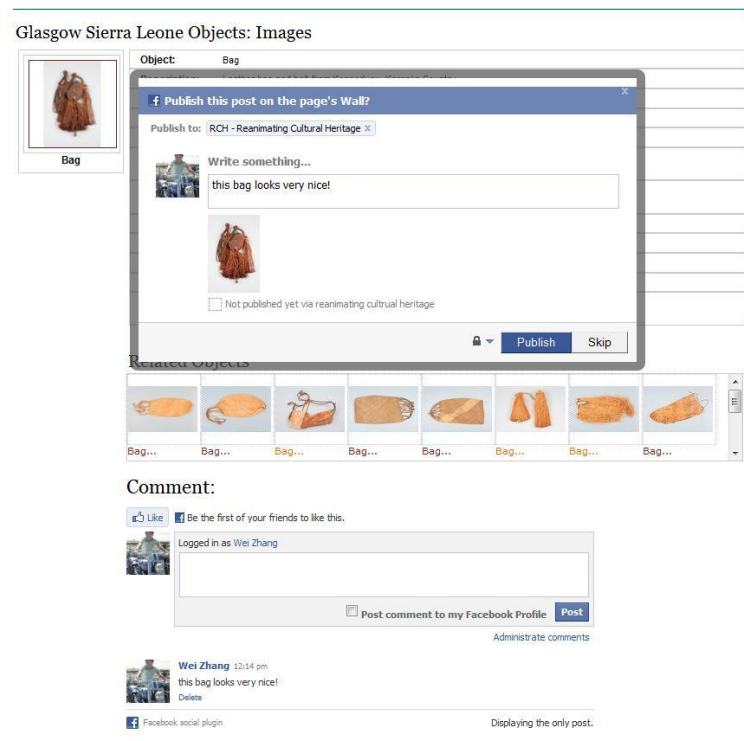


Figure 6.18: Illustration of publishing Facebook Comments along with the digital heritage object thumbnail onto the Facebook fan page wall

During the implementation of the Facebook comments publishing, the author came across some technical issues. For example, there is an important technical issue that is how to publish Facebook users' comments from the Facebook comments box onto the Facebook fan page wall. There are some examples that show the ability to publish a Facebook user's comments from normal comments box [61], However, they can only publish a Facebook user's messages from a normal comments box, not from the Facebook comments box. This application shows the ability to publish different Facebook users' comments from the Facebook comments box. The following code shows the Javascript method to publish messages onto the Facebook fan page wall.

```
<script type="text/javascript">
function streamPublish(message, description, hrefTitle, hrefLink, targetId, autoPublish){
    FB.ui(
        { method: 'stream.publish',
          message: message,
          attachment: {
            name: '',
            caption: '',
            description: (description)
          },
          target_id: targetId,
```

```

        auto_publish: autoPublish
    },
    function(response) {});
}
</script>

```

When users click on the ‘post’ button to post their comments in the Facebook comments box, the comments will be added under the Facebook comments box on the web page. When the comments have been added, the users’ comments should be captured and published onto the Facebook fan page wall. The following code shows how the user’s comments are captured and published onto the Facebook fan page wall when the user posts their comments and the comments have been added.

```

FB.Event.subscribe('comments.add', function(response) {
    $(document).ready(function() {
        send();
    });
    function trim(s) {
        s = s.replace(/(^\\s*)|(\\s*$)/gi, "");
        s = s.replace(/[ ]{2,}/gi, " ");
        s = s.replace(/\\n /, "\\n");
        return s;
    }
    function send(){
        $.ajax({
            type: "POST",
            url: "publish.php",
            data: "post=<?php echo $array5; ?>",
            dataType: "text",
            success: function(data){
                var string = data.substring(data.lastIndexOf(">")+1);
                var message = trim(string);
                streamPublish(message, '', '', '', '171018220068',
                    true, "");
            }
        });
    }
}

```

Another important technical issue the author has come across is how to publish the digital heritage object thumbnail associated with the user’s comments onto the Facebook fan page wall as well. The following code shows the JavaScript method to achieve publishing the image thumbnail along with messages onto the Facebook fan page wall.

```

<script type="text/javascript">
function streamPublish(message, src, href, description, hrefTitle, hrefLink, targetId, autoPublish){
    FB.ui(
        { method: 'stream.publish',

```

```

        message: message,
        attachment: {
            name: '',
            caption: '',
            media: [{
                'type': 'image',
                'src': src,
                'href': href
            }],
            description: (description)
        },
        target_id: targetId,
        auto_publish: autoPublish
    },
    function(response) {});
}
</script>

```

The above code shows that the source and link of an image thumbnail should be found when users want to publish the thumbnail of the digital heritage object onto the Facebook page wall.

After the user clicks the ‘publish’ button on the Facebook publishing dialog box, the user’s comments, together with the digital heritage object thumbnail, will be displayed on the wall of the RCH fan page, Figure 6.19 shows the user’s comment – ‘this bag looks very nice!’ – together with the thumbnail of the digital heritage object; a bag has been published onto the wall of the RCH fan page. On this Facebook community page, users can still make comments on the comments, together with a thumbnail of the digital heritage object that has been published on this fan page wall. So users can make comments based on other users’ comments and so form a big community to share the heritage knowledge based on the digital heritage object that has been published on the wall.

At the time this innovative Facebook application was developed, it was possible to embed the Facebook wall page within an iFrame inside the RCH web page for proof of concept. At the time of writing this thesis however, Facebook has changed their security policy such that this can no longer be done. The reason is that Facebook require all users who log into a Facebook application to go through an authenticated login process. One way to do this is for them force all Facebook applications that do not use their authenticated login to see that they are actually on the Facebook site. Figure 6.20 shows the original implementation, and Figure 6.21 shows how a newly coded version has to be done (courtesy of Zeeshan Patoli).

The issue here is that in coding social network applications, such as this, you have to be wary about changes to third party policies, that could affect an application.

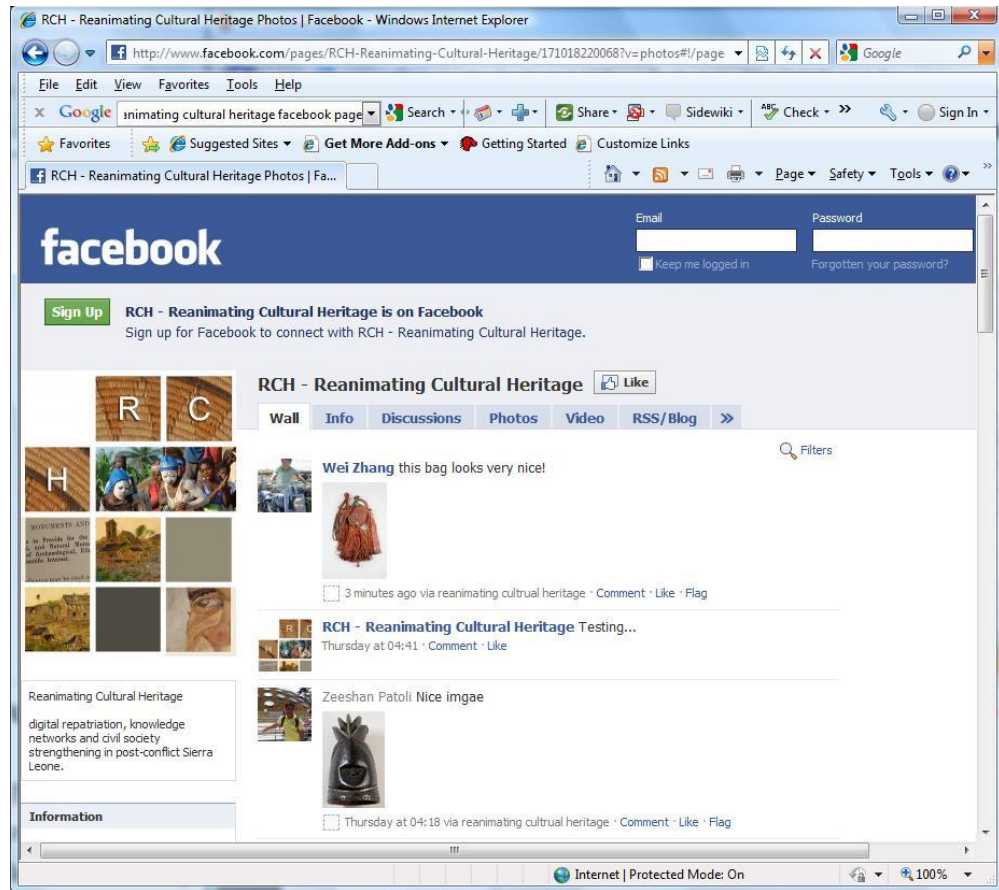


Figure 6.19: The RCH 'Facebook repository' wall page

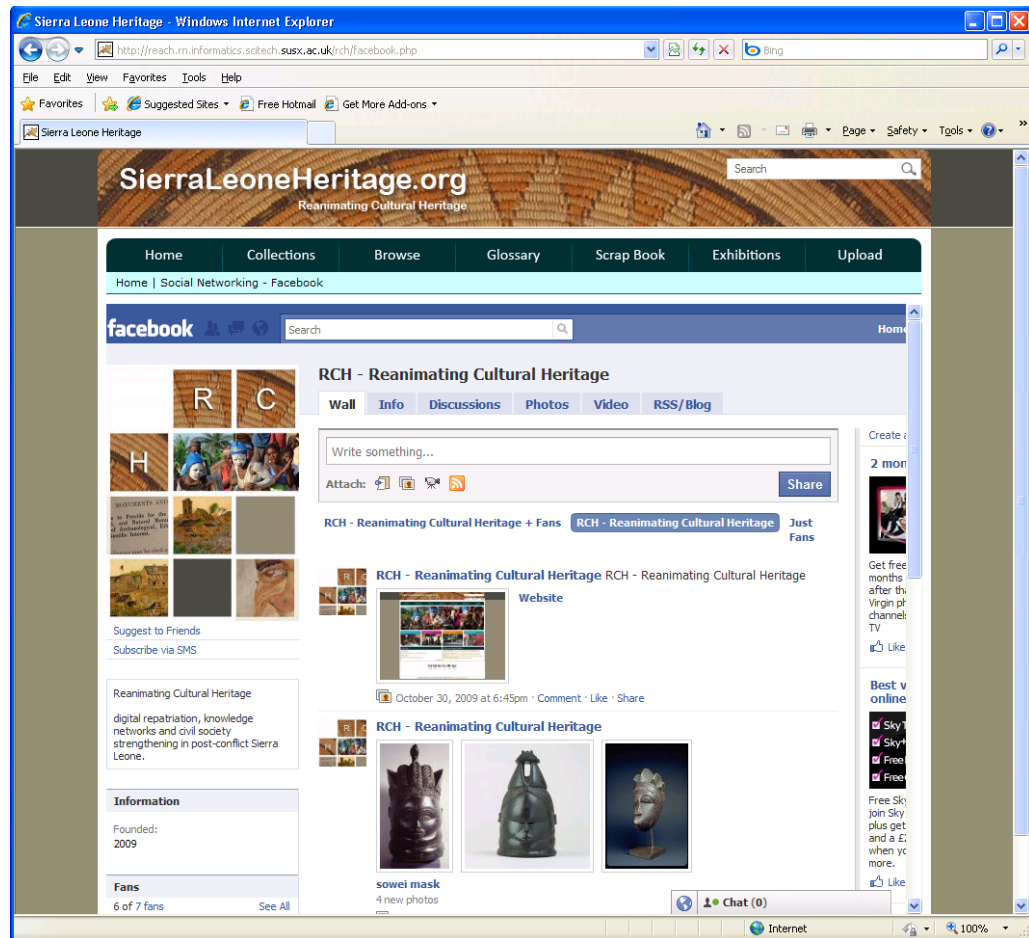


Figure 6.20: The RCH Facebook DHR page

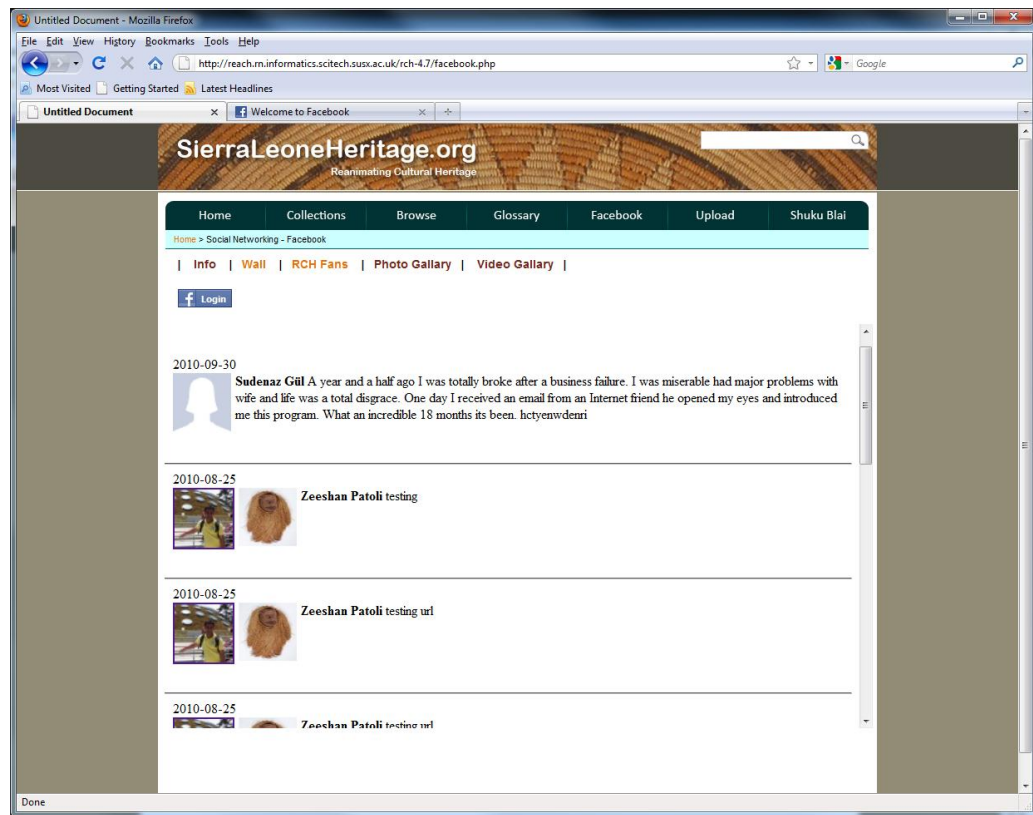


Figure 6.21: The new version of RCH Facebook DHR page

When the user has published their comments onto the wall of the RCH fan page, the home page of the RCH web site will be affected. The latest news column of the home page will be updated and will display the latest Facebook fan page wall information. In this example, the user's comment – 'this bag looks very nice!' – together with the thumbnail of the digital heritage object, will be displayed on the latest news of the front page of the RCH web site (see Figure 6.22).



Figure 6.22: The front page of the RCH web site

6.5 User Evaluation

In the following sub-sections, the methodology and results of a usability evaluation for the RCH social networking system are presented.

6.5.1 Participants

There are ten participants recruited from the University of Sussex student population joining this usability evaluation. In order to cover different people with different backgrounds, the author tried to find participants at the University of Sussex who are from different schools and departments, and have different sex and ages. For example, the author emailed informatics school students and asked who wanted to join this evaluation; he also asked them whether they can find any participants from other Schools and departments. At the end, the author randomly selects ten participants. There are five males and five females

among these participants: they are from different schools, are different ages, and have different computing backgrounds. For example, there are two participants from the School of Informatics, two participants from the School of Engineering and Design, three participants from the School of Media, Film and Music, one participant from the Social Science schools, one participant from the School of Life Sciences, and one participant from the Sussex Institute. These ten participants already cover people from different backgrounds; the author can imagine that if there are 20 or more participants joining this user evaluation, the results of user evaluation on this final system will be similar.

6.5.2 Procedure

The author invites each individual participant to the Lab to do the user evaluation. Before a participant comes to the Lab, the author arranges the time with the participant for the evaluation through emails. This kind of experiment organisation has many benefits. For example, the author can talk to the individual participant, which is similar to interviews. The author can ask the participant some questions, for example, what do they think of this system in general, do they like this system, and which parts of the system do they think need to be improved. Before each participant starts the experiment, the author introduces the system and tells them the purpose of the system. The author then gives the assigned tasks for this usability evaluation to the participants to allow them to start their experiments. After they have finished their experiments according to the assigned tasks, the author gives them questionnaires including a number of questions to allow participants to rate their experiences with the RCH social networking system. What is more, after the questions in the questionnaire, there is a comments area that allows participants to leave their comments on the system that they have evaluated. The author collects all the answers from participants for each question in the questionnaire. In order to see what percentage of participants stand on each scale (answer) for each question, the author draws histograms based on the participants' answers to each question from the questionnaire. In addition, the author collects all the comments that participants have put on the questionnaires. These comments will be included in the result findings and will be discussed in the following section. This means of evaluation data collection has advantages. For example, the histogram could easily show the degree of user satisfaction on the system that they have

evaluated. Particularly, the histogram could clearly show what percentage of participants stand on each scale for each question. Furthermore, the comments of participants that the author has collected could really show whether they like the system, what they think of the system and functionalities, whom the system will benefit, and which parts of the system need to be improved, etc. Questionnaires that the author has used are based on the standard Presence Questionnaire [170] that has been validated. The author references this standard Presence Questionnaire and designs his own questionnaires through modifying the questions in the standard questionnaire to adjust them into his experiment purpose. The author uses the questionnaire instrument to do the user evaluation on the system that he has created and this instrument has some advantages. For example, questionnaires are quite objective because the feedback of participants is collected using a very standard method. Furthermore, it is normally a quick way of collecting the feedback of participants and analyse the results of the user evaluation. However, sometimes participants may not be willing to answer the questions in the questionnaire; this may indicate that, occasionally, the response does not reflect their real opinion. According to this point, interviews might be a better approach. However, in the author's user evaluation, each participant is invited to the Lab to do the evaluation individually, and the author asks every participant to reply to the questions honestly and tells them that the negative response is as useful as the more positive response. In addition, the author asks some questions about whether they like the system, whether the system is useful and so on, after they experience the system and begin to complete the questionnaires, which avoid the negative point of the questionnaire instrument to the greatest extent. Questionnaires are attached in Appendix A.

6.5.3 Analysis of Results

In this section, the results of the usability evaluation will be analysed. The first part will show the feedback of participants after they have finished the experiments and completed the questionnaires. The responses of participants for each question in the questionnaires (the questionnaire for the 3D Heritage Scrapbook Application and the questionnaire for the Facebook Application integrated inside the heritage system) are attached in Appendix B. The second part will analyze the results and discuss the findings from this usability evaluation.

6.5.3.1 Feedback of Participants

This section will show two parts of the feedback of participants: one is for the 3D Heritage scrapbook application, and the other is for the Facebook application integrated inside the heritage system. Figure 6.23 shows the feedback of participants after they have experienced the 3D Heritage scrapbook application. In this diagram, there are 15 bars that stand for the 15 questions in the questionnaire. In each question, there are five scales (from Scale 1 – worst, to Scale 5 – best) that participants can rate after the experiments. From these results no participants answered in either of the two poorest categories (Scale 1 and Scale 2), thus the diagram starts showing the scores that participants have rated from Scale 3. This diagram displays the percentage of participants standing on each scale.

Figure 6.24 shows the feedback of participants after they have experienced the Facebook application. In this diagram, there are 10 bars which stand for the 10 questions in the questionnaire for the Facebook application. The same as 3D Heritage Scrapbook Application, there is no Scale 1 or Scale 2 rated by participants in each question of questionnaire for the Facebook application, and this diagram also shows the percentage of participants on each scale for the Facebook application.

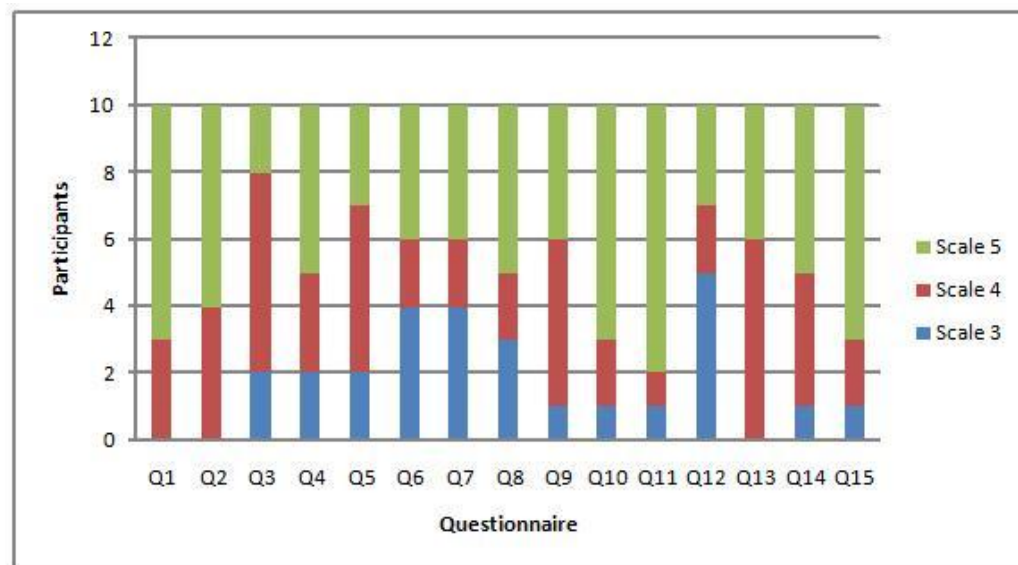


Figure 6.23: The feedback of participants experiencing with the 3D Heritage Scapbook Application

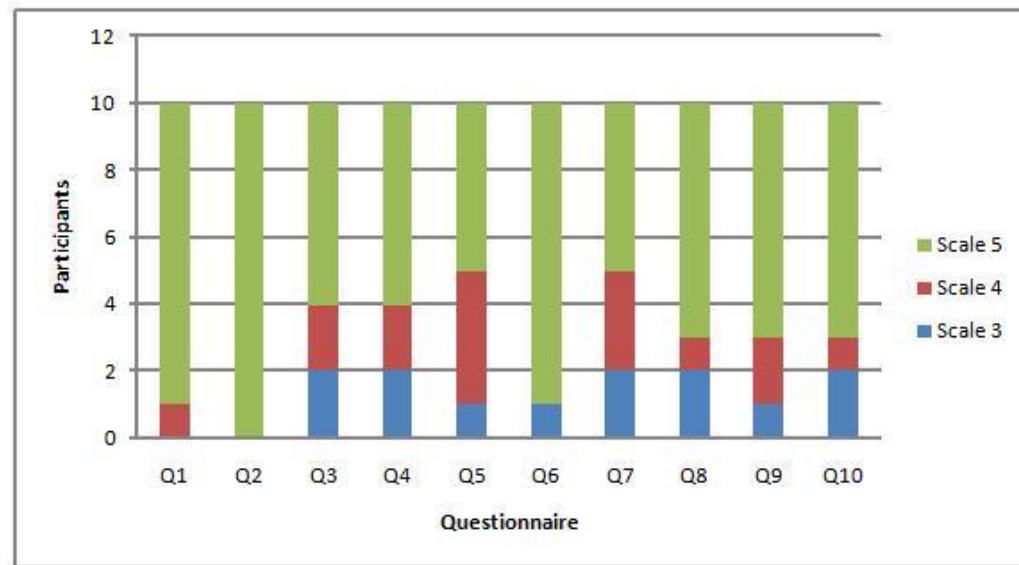


Figure 6.24: The feedback of participants experiencing with the Facebook Application

6.5.3.2 Discussing the Findings

From Figure 6.23, it is evident that all the responses obtained in this 3D scrapbook application questionnaire range between Scale 3 and Scale 5, which indicates a high degree of user satisfaction on this 3D heritage scrapbook application. In their comments, most of the participants said they liked this application and enjoyed the experience very much. Some users said it was a novel way for a more constructive purpose. Some users said it could also be a good tool for children to learn by searching and creating content, and the interface is easy to master. Most users think they are much more engaged than with a 2D image and text heritage application because it is more interactive and manoeuvrable.

From Figure 6.24, it is also evident that all the feedback obtained in this Facebook application questionnaire ranges between Scale 3 and Scale 5, indicating a high degree of user satisfaction on the Facebook application integrated in the heritage system. In their comments, most participants liked this application and thought it was very good involving social networking like Facebook element inside heritage application. Some users said it was a nice feature to share knowledge you contribute to the site with friends online, spreading awareness of the things that interest you.

From the results of Q1 and Q2 in Figure 6.23, all the participants answered in either of the two best categories (Scale 4 and Scale 5), thus it shows the interface of the 3D scrapbook

application is good and the functionalities in this interface are easy and fast to use. From the results of Q1 and Q2 in the Figure 6.24, all the participants also answered in either of the two best categories, particularly all the participants answered in the best category (Scale 5) in Q2 in Figure 6.24., This shows that the functionalities in the Facebook application integrated inside the heritage system are very easy and fast to use. Furthermore, from the result of Q6 in Figure 6.24, 90% of the participants answered in the best category (Scale 5), thus it shows users adjust to the experience of the Facebook application very quickly. On the one hand, this means the interface of the Facebook application is easy to use; on the other hand, this relates to most users' previous experience with social networking such as Facebook. During the user evaluation, there was one participant who did not have any previous experience with Facebook. However, she just needed a little bit more time to adjust using Facebook. Importantly, when she signed in Facebook and experienced this Facebook application, she liked it very much and found it very useful for museums to enable users to share their knowledge.

For the 3D scrapbook application, although some users mentioned that the graphics of the interface could be better, and the 3D part could be more interactive, the overall user response is very good and they enjoyed the experience of this RCH social networking system very much.

6.6 Conclusion

In conclusion, this chapter has demonstrated a solution using Web 2.0 mashups, social networking, 3D visualization and interaction, and other digital technologies to implement a digital heritage multimedia system embedded in the RCH DR. This system integrates user-generated digital heritage content from social network DHR with digital heritage objects and collections from museums' DHR, to allow users to capture community contributed heritage knowledge and enable user communities to build their own virtual exhibitions based on community contributed digital heritage content and actual museums' digital heritage collections in a novel visualization and interaction environment.

In this chapter, many existing social networking technologies were introduced, such as Bing, Flickr, Yahoo, YouTube, and Facebook, and these social networking repositories

were utilized and their contents were retrieved and integrated into a very meaningful system (which is a Web 2.0 mashup) through their appropriate web services (APIs). A usability evaluation has been performed in order to evaluate the usability of this RCH social networking system. By analysing the results of this user study, it can be concluded that the RCH social networking system is effective to use. The results show a high degree of user satisfaction on the RCH system. Most participants liked this social networking system and thought it was useful for museums and art galleries to allow users to generate their own virtual heritage exhibitions based on their own 'favourite' content, and allow users to contribute their knowledge to the site while spreading the awareness of the things that interest them.

7 Conclusions and Future Work

This chapter concludes the research carried out in this thesis and discusses the main findings and the benefits for museums. The cultural heritage fields and problems raised from this area are addressed and discussed. The Web 2.0 technologies integrated with other digital technologies are used as solutions, and the development of several Web 2.0 functionalities integrated with cultural heritage are evaluated. The future work section discusses how Web 2.0 technologies can be further used in the cultural heritage area.

7.1 The Main Results

The main results discussed in this thesis include proposal for an innovative digital library concept called DISPLAYS [6, 9, 10, 11, 12, 13, 14], from which the development of novel architectures, in the case RCH [7, 15, 16, 17] serves as an example, for creating cultural heritage exhibitions using Web 2.0 technologies, mashing up a 3D digital heritage scrapbook, Facebook news for a cultural heritage Facebook community, Facebook comments for cultural heritage objects, and Facebook comments publishing have evolved [7, 15, 16].

7.1.1 Innovating Digital Heritage Exhibitions through Web 2.0 Technologies

In recent years, it has been shown that museums and education institutions have led efforts for creating digital heritage exhibitions. Modern digital heritage exhibitions have evolved from static digital exhibitions to more dynamic multimedia exhibitions. Modern digital exhibition technologies such as 3D, virtual reality and augmented reality have been involved in the creation of cultural heritage exhibitions to enhance the experience of learning for visitors. In addition, advanced 3D interaction technologies have been used to allow users to examine 3D cultural heritage objects, navigate virtual heritage worlds, and interact with 3D heritage content. For example, standard input devices such as a mouse and gamepad are utilized to examine and interact with 3D heritage objects. Advanced input devices such as the Spacemouse, BlackBox and Kromstaff Replica Interface have been

used to interact with 3D heritage objects. With the experiments using the BlackBox to interact with 3D heritage mashups, it can be concluded that advanced input devices like the BlackBox enable users to control the 3D heritage object more freely than using a mouse. For example, users can rotate the 3D heritage object remotely using the BlackBox. This is an argument for better interaction technologies to explore digital heritage resources.

However, in most cultural heritage projects developed by museums and education institutions, museums are only the content providers and visitors just perform as content consumers. Web 2.0 provides technologies to enable users to integrate new content from other data sources (i.e. generate their own content to augment a museum's collection), share knowledge over networks by adding their understanding to an object through social network technologies, e.g. the Facebook comment API, etc. Web 2.0 technologies mean that digital heritage content providers are not just museums, and visitors are not just content consumers; now museums and users can collaborate by sharing knowledge that can impact the museum's collections. From the usability evaluation of the RCH social networking system, the author can conclude that this is a good idea. This is because Q15 in the questionnaire on the 3D heritage scrapbook application, and Q10 of the questionnaire on the Facebook application integrated inside a heritage system, show that this can allow the user to access more information than before and be more engaged with the data.

The architecture that the RCH system provided marks a new digital heritage system architecture for museums. This utilizes the novel Web 2.0 mashups integrating user-generated digital heritage content with museum digital heritage content to allow both museum and community sides to create their own virtual exhibitions. In addition, this system architecture allows the integration of a social networking functionality such as the Facebook functionality inside the heritage system. This provides an innovative solution to allow users to access and interact with museum digital heritage collections and contribute their heritage knowledge into the community. For example, this new digital heritage system architecture enables users to search images and videos of the digital heritage content from different social networking DHR, such as Bing, Flickr, Yahoo and YouTube, and museums' DHR, drag and drop them into a 3D environment, and preserve them into a virtual museum exhibition. This new system architecture also enables users to make

comments on the digital heritage objects and collections using the Facebook functionality, and publish their comments together with the thumbnail of the associated digital heritage object into a social networking community (e.g. a Facebook page). This Facebook functionality enables all the users in the community to comment on the comments, together with the associated digital heritage object from museum collections that have been published into the community.

From the results of Q14 and Q15 in the questionnaire on the 3D heritage scrapbook application, and the results of Q9 and Q10 in the questionnaire on the Facebook application integrated inside a heritage system, the author can conclude that the RCH system integrated with Web 2.0 functionalities can enable users to access more varied information than before, and enable users to be more engaged with the data and more immersed in the information than before.

From the results of Q1 and Q2 in the questionnaire on the Facebook application, it can be concluded that the functionality of the Facebook application integrated inside a heritage system is very easy and fast to use. The author can conclude that this Facebook functionality is useful for museums to enable users to share knowledge that they have contributed to the site. It also enables users to spread awareness of the things that interest them so that other people can contribute knowledge if they are interested in those things.

Furthermore, from the results of Q1 and Q2 in the questionnaire on the 3D heritage scrapbook application, it can be concluded that the functionality of the 3D heritage scrapbook application is easy and fast to use. The author can conclude that this 3D heritage scrapbook application is useful for museums to enable users to generate their own virtual exhibitions based on their own 'favourite' heritage content, and thus increase engagement and interest.

7.1.1.1 Mashing up a 3D Digital Heritage Scrapbook

In most digital heritage systems, museums are the only main digital heritage content providers and users are only content consumers. There are still some digital heritage systems using Web 2.0 technologies. However, they just develop tools to allow users to explore the Web 2.0 exhibitions that have already been made for them; this is different

from a full Web 2.0 approach where users are the main content creators. Although a few digital heritage systems allow users to be not only visitors of a Web 2.0 exposition and to be the main content creators, they just develop applications to enable users to update wikis, chat with other visitors or write comments, and so on. There is a need for users to really be content creators to create and publish their own virtual exhibitions based on both user-generated digital heritage content and museums' digital heritage objects and collections.

From a museum's perspective, their virtual exhibitions would only access their own digital heritage. However, a museum's exhibition generally does not access user-generated digital heritage content and generate community contributed heritage exhibitions. In addition, museums need large resources to moderate and organize such user-generated digital heritage content to be effectively integrated with their own digital heritage collections. This implies that there is a need for cultural heritage sites to create a self-maintaining user-generated collection that can be mashed with regulated museum digital heritage collections. Furthermore, a museum may be interested in a particular user-generated digital heritage collection on various social networking web sites, and may wish to 'copy' specific digital heritage objects from those social networking repositories, add them into their digital heritage collections, and preserve them for a further particular virtual exhibition in a cultural heritage web site.

What cultural heritage sites now need is a mechanism to create and publish digital heritage exhibitions based on social networking DHR and museums' DHR. For this the author created a 3D digital heritage 'scrapbook' multimedia application utilizing social networking APIs, a 3D web browser, and Web 2.0 mashup technologies to enable user communities to create and publish their own virtual exhibitions. This application utilizes Web 2.0 and 3D visualization and interaction technologies, and demonstrates how 3D, social networking and Web 2.0 mashup technologies can be integrated together to enable user communities to create and publish interesting digital heritage exhibitions, based on community contributed digital heritage content and museums' digital heritage collections.

From the results of Q14 and Q15 in the questionnaire on the 3D heritage scrapbook application, the author can conclude that the 3D heritage scrapbook application can make users more engaged with data, more immersed in the information, and is more fun than

using the existing 2D image and text based applications. From the results of Q1 and Q2 in the questionnaire on the 3D scrapbook application, it can be concluded that this application is easy and fast to use. In particular, the functionality of switching radio buttons to search for images and videos from different social network repositories, such as Bing, Flickr, Yahoo and YouTube, was highly valued by the users as a way of finding new and interesting material that would not have previously been available. In addition, the functionality of allowing users to drag and drop images and videos of heritage objects from the gallery into a 3D environment to create their own exhibitions, and then save the exhibitions they have created, increased user engagement as shown by the answers to Q15.

There is one thing that did not work very well in the interface. In this scenario, when users click on the links in the playing objects control of the interface, a browser window pops up to show 3D playing objects. Users think there is no reason to click to show the 3D playing objects, because they just want to drag and drop those playing objects into a 3D environment. So the links of 3D playing objects should be made not clickable.

7.1.1.2 Innovating a Digital Repository through Facebook Functionality

The author also created other Web 2.0 applications, such as the Facebook application that allows communities to access and interact with digital heritage objects and collections from museums and contribute their heritage knowledge to the community. For example, the author implemented the Facebook news functionality for the Facebook cultural heritage community, and this functionality enables users to see the latest news from the cultural heritage Facebook community in the home page of a cultural heritage web site. The author integrated this functionality into the RCH project to allow users to see the latest news from the RCH Facebook fan page, which is built as a RCH community.

The author implemented the Facebook comments functionality for cultural heritage sites to enable users to make comments on all the digital heritage objects from museum cultural heritage collections. This functionality enables both Facebook users and non-Facebook users to write their comments on digital heritage objects. The author integrated this Facebook comments functionality into the RCH project to allow users (including Facebook users and non-Facebook users) to make comments on digital heritage objects from Sierra

Leone heritage collections. The author implemented the Facebook comments publishing functionality to allow Facebook users to publish their comments from the Facebook comments box, together with the thumbnail of the associated digital heritage object, onto the Facebook fan page wall.

From the results of Q9 and Q10 in the questionnaire on the Facebook application integrated inside a heritage system, the author can conclude that the Facebook application makes users more engaged with data and more immersed in the information than other applications having no element of social networking. From the results of Q1 and Q2 in the questionnaire on the Facebook application, it can be concluded that the application is very easy and fast to use. In particular, the functionality allows Facebook users to make comments on every digital heritage object from museum collections; the comments the Facebook user made, and the link of the web page on which the Facebook user commented, can be displayed on their own Facebook profiles and spreads digital heritage sites around their families and friends. In addition, the functionality of enabling Facebook users to publish their comments, together with the thumbnail of the associated digital heritage object, into a Facebook community (Facebook fan page wall), and enabling other users in this community to comment on the comments together with the digital heritage objects that have been published, adds a level of functionality that truly takes the heritage repository from a museum owned resource to a complete Web 2.0 resource. The author can conclude that it is good to involve social networking like Facebook element inside a heritage application so that users can share knowledge that they contribute to the site, while spreading the awareness of the things that interest them.

7.2 Future Work

This thesis identified the potential problems to museum consortia and education institutions. For example, in general cultural heritage sites, museums are the sole cultural heritage content providers and visitors are just content consumers. This research is a significant step closer to introduce how Web 2.0 technologies can be integrated with other digital technologies such as 3D visualization and interaction to solve the problems of current ‘museum 2.0’ projects. It could allow user communities to create their own virtual heritage exhibitions based on user-generated digital heritage content, and this content from

user-generated can be integrated with the content from actual museums to preserve the quality of museum collection data.

Additionally, this research demonstrated how Web 2.0 social networking, like a Facebook element, can be integrated inside a heritage system to allow users to access and interact with digital heritage objects and collections from museums. It could also enable them to share knowledge that they contribute to the site and spread awareness of the things that interest them.

In order to improve the experience of the RCH Social Networking system, further research could be carried out on improving the quality of graphics for the user interface, and involving technologies more deeply into the 3D. In this scenario, it will become more interesting, interactive and enjoyable for users to visualize and interact with the 3D scrapbook application, e.g. the application will be able to provide tools to enable users to create their own 3D galleries, and users will be able to add their own defined 3D galleries to the digital heritage 3D scrapbook interface. They could then start to create their own virtual heritage exhibitions based on their own defined virtual galleries.

In addition, users will also be able to interact more deeply with a 3D environment, e.g. users can interact with a 3D environment using an avatar like the Second Life. A further improvement on the RCH system will be the combination of the 3D heritage scrapbook application with the Facebook application integrated inside a heritage system. In this scenario, users will be able to link to the RCH results web page to make comments on digital heritage objects, and publish their comments together with a thumbnail of the associated digital heritage object to the Facebook community by clicking the image of the digital heritage object in the 3D environment.

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Appendix A

Questionnaires for Usability Evaluation

Questionnaire

Please rate your experience with the 3D scrapbook application by placing an 'X' in the box that best fits your answer to the question. Please answer all questions in the order they appear on the page, and leave any comments at the end.

1. How much were you able to control events in this 3D scrapbook application?

NOT AT ALL		SOMEWHAT		COMPLETELY

2. How responsive was the 3D scrapbook to actions that you initiated (or performed)?

NOT RESPONSIVE		MODERATELY RESPONSIVE		COMPLETELY RESPONSIVE

3. How natural did your interactions with the 3D scrapbook seem?

EXTREMELY ARTIFICIAL		BORDERLINE		COMPLETELY NATURAL

4. How much did the visual aspects of the 3D scrapbook involve you?

NOT AT ALL		SOMEWHAT		COMPLETELY

5. How natural was the mechanism which controlled movement of 3D objects in the 3D scrapbook?

EXTREMELY ARTIFICIAL		BORDERLINE		COMPLETELY NATURAL

6. Were you able to anticipate what would happen next in response to the actions that you performed in this 3D scrapbook application?

NOT AT ALL	SOMEWHAT			COMPLETELY

7. How compelling was your sense of moving around inside the virtual environment?

NOT AT ALL	MODERATELY COMPELLING			VERY COMPELLING

8. How well could you move or manipulate 3D objects in the virtual environment?

NOT AT ALL	SOMEWHAT			EXTENSIVELY

9. How involved were you in the experience of the 3D scrapbook?

NOT INVOLVED	MILDLY INVOLVED			COMPLETELY INVOLVED

10. How quickly did you adjust to the experience of the 3D scrapbook?

NOT AT ALL	SLOWLY			LESS THAN ONE MINUTE

11. How proficient in interacting with the 3D scrapbook did you feel at the end of the experience?

NOT PROFICIENT	MODERATELY PROFICIENT			VERY PROFICIENT

12. How much did the visual display quality interfere or distract you from performing the assigned tasks of the 3D scrapbook application?

NOT AT ALL	INTERFERED SOMEWHAT			INTERFERED VERY MUCH

13. How well could you concentrate on the assigned tasks or required activities of the 3D scrapbook application rather than on the mechanisms used to perform those tasks or activities?

NOT AT ALL		SOMEWHAT		COMPLETELY

14. How completely were your senses engaged in this experience of the 3D scrapbook?

NOT ENGAGED		MODERATELY ENGAGED		COMPLETELY ENGAGED

15. Did this experience (3D scrapbook application) engage you more than using the existing 2D image and text based applications?

NOT AT ALL		SOMEWHAT		COMPLETELY

Comments:

Questionnaire

Please rate your experience with the Facebook application by placing an 'X' in the box that best fits your answer to the question. Please answer all questions in the order they appear on the page, and leave any comments at the end.

1. How much were you able to control events in this Facebook application?

NOT AT ALL		SOMEWHAT		COMPLETELY

2. How responsive was the Facebook functionality to actions that you initiated (or performed)?

NOT RESPONSIVE		MODERATELY RESPONSIVE		COMPLETELY RESPONSIVE

3. How natural did you interactions with the Facebook application seem?

EXTREMELY ARTIFICIAL		BORDERLINE		COMPLETELY NATURAL

4. How much did the visual aspects of the Facebook functionality involve you?

NOT AT ALL		SOMEWHAT		COMPLETELY

5. Were you able to anticipate what would happen next in response to the actions that you performed in the Facebook application?

NOT AT ALL		SOMEWHAT		COMPLETELY

6. How quickly did you adjust to the experience of the Facebook functionality?

NOT AT ALL		SLOWLY		LESS THAN ONE MINUTE

7. How proficient in interacting with the Facebook application did you feel at the end of the experience?

--	--	--	--	--

NOT PROFICIENT

MODERATELY
PROFICIENTVERY
PROFICIENT

8. How well could you concentrate on the assigned tasks or required activities of the Facebook application rather than on the mechanisms used to perform those tasks or activities?

--	--	--	--	--

NOT AT ALL

SOMEWHAT

COMPLETELY

9. How completely were your senses engaged in this experience of the Facebook application?

--	--	--	--	--

NOT ENGAGED

MODERATELY
ENGAGEDCOMPLETELY
ENGAGED

10. Did this experience using Facebook inside heritage application engage you more than other applications having no element of social networking?

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NOT AT ALL

SOMEWHAT

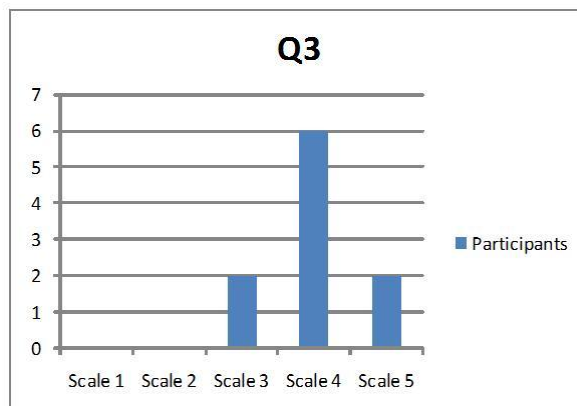
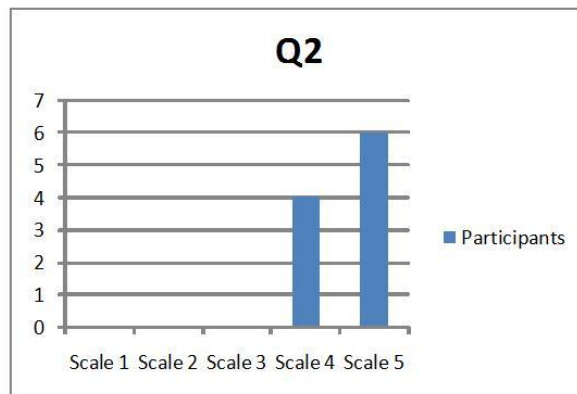
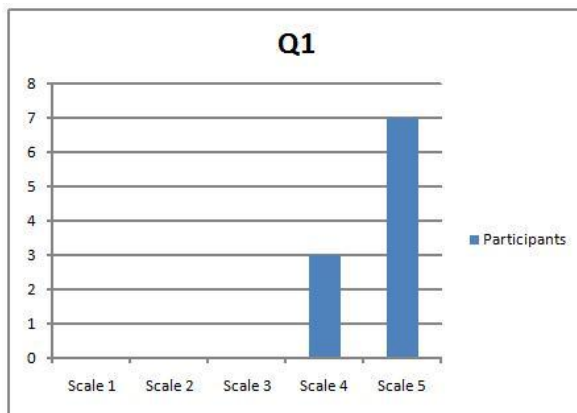
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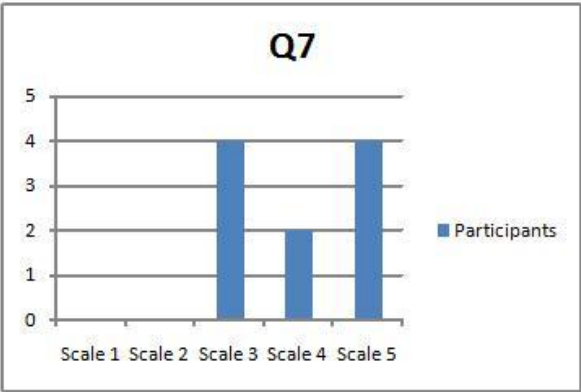
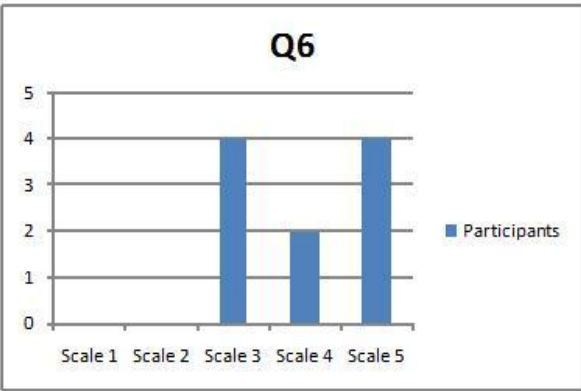
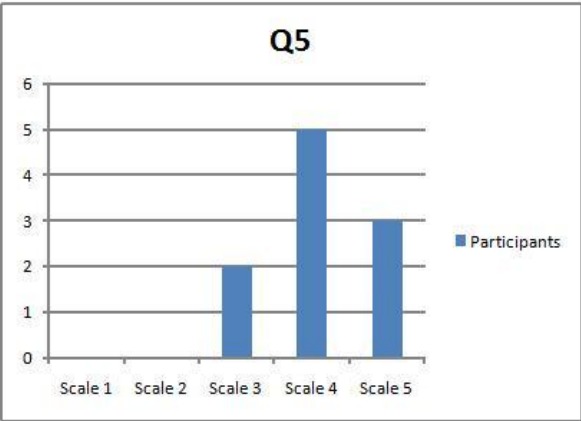
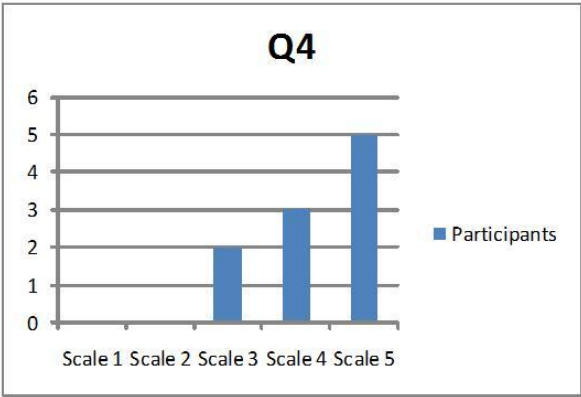
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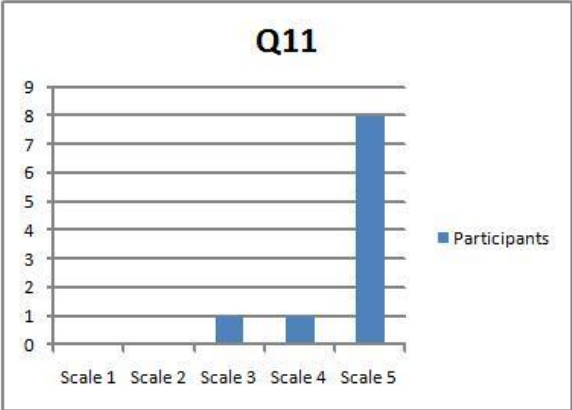
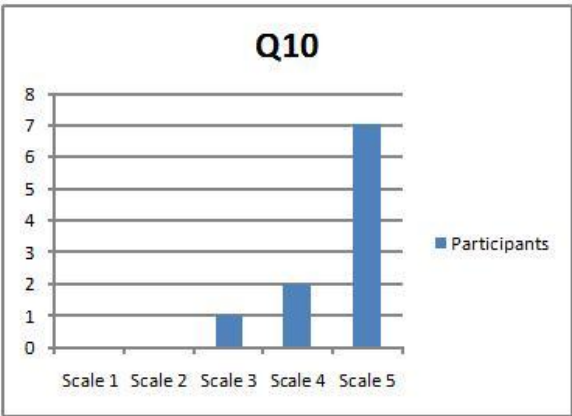
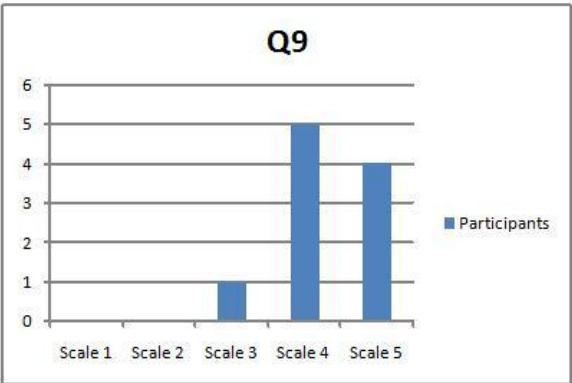
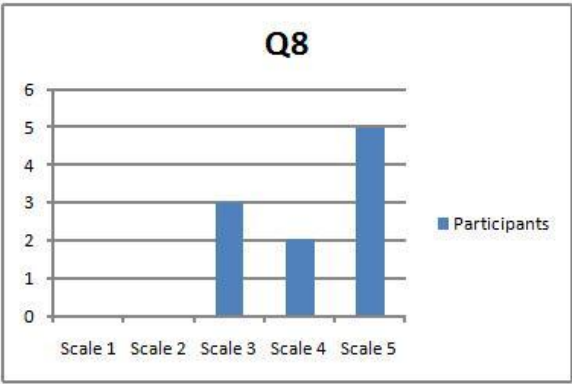
Appendix B

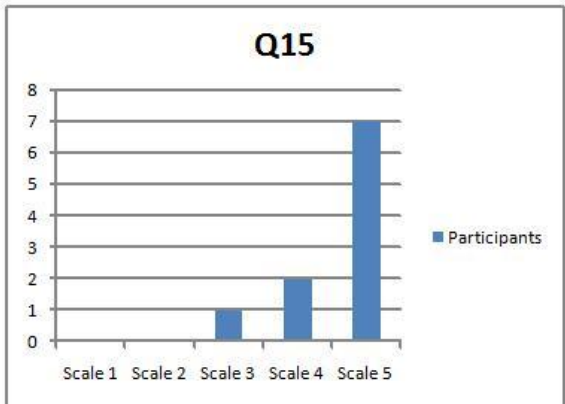
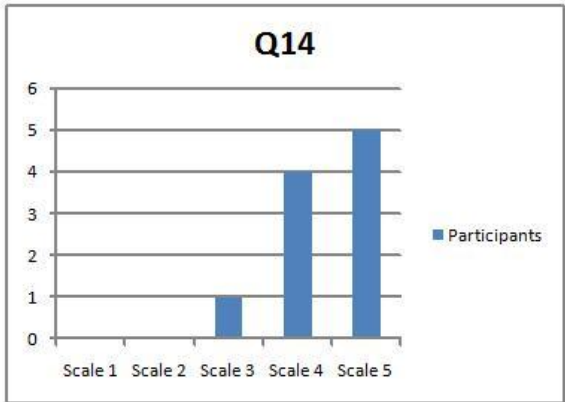
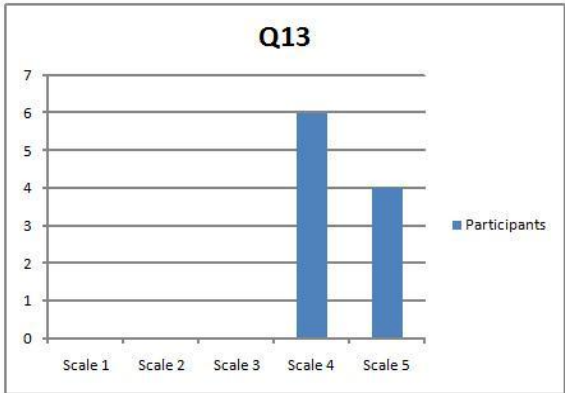
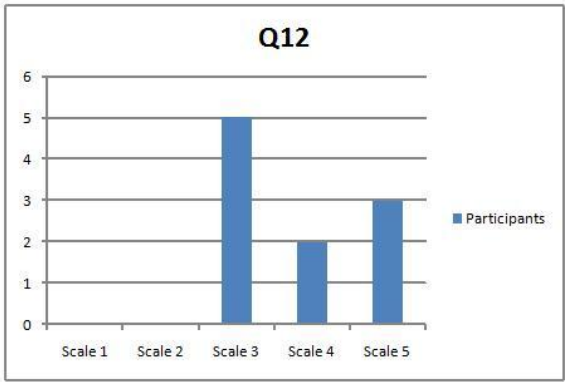
Results of Usability Evaluation

3D Heritage Scrapbook Application









Facebook Application integrated inside Heritage system

