ARCOLite — an XML based system for building and presenting Virtual Museum Exhibitions using Web3D and Augmented Reality

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Abstract

This paper describes ARCOLite, our low cost XML based client-server architecture for building and presenting digital heritage content in virtual museums. Our system includes components for creation and refinement of virtual artefacts including virtual reconstruction of buildings; XML content management, XML technologies for content repositories and presentation; and content visualisation using Web3D, virtual and augmented reality.

1. Introduction

Museums are now taking a much wider interest in the use of ICT to leverage better value out of their collections; a simple internet search on museums and ICT reveals many hits detailing museum activity. For example, project ORION examines the business, technological and cultural landscape in the museum environment aiming to identify suitable ICT to represent a museums physical resources, e.g. over the Internet [1]. Museums are looking to exploit their rich collections both within their museums and over the Internet. In order to do this they need to examine how they currently present their collections with a view to how innovative ICT can be exploited or interfaced to museum legacy systems.

Museums commonly use metadata in their cataloguing systems [2], but do they exploit metadata in their presentation technologies? Clearly, the traditional museum displays or exhibition methods for presenting artefacts do not. A traditional display cabinet in a museum forces the visitor to take the museum curators perspective on that artefact. The visitor can only view the artefact in the display cabinet from certain positions defined by the curator and can only read the simple description given by the curator. A project that examines this problem and proposes a good solution is the Showcase project, which demonstrates a more exciting way for a museum visitor to view an artefact in a display cabinet [3].

A rich repository of information and context is locked into museum cataloguing metadata that is generally not available to the casual museum visitor without further complex research on their part. This heritage metadata can be built into novel ICT systems and made available in many exciting and informative ways. For example, simply making available the metadata for display is useful to museum researchers, or using the metadata to allow visitors to search collections is useful. Even better is using metadata to intelligently control presentations so that the user can define or build their own virtual exhibitions.

Museums need access to simple and low cost tools that will allow them to exploit their collections more effectively to deliver digital heritage over the Internet and within their museums. They need to use more exciting ICT such as Web3D [4], virtual reality, augmented reality and multimedia. But most of all, they need to be able to create and present digital heritage presentations in-house with their own affordable tools.

So what are these exciting ICT technologies, and how do we use them to build innovative museum systems or tools to digitise, create, manage and present virtual museums to the end user? In this paper we will describe the ARCOLite second prototype, our low cost XML based client-server architecture for building and presenting digital heritage content in virtual museums.

While ARCOLite has components for digital content production, management, XML processing and visualisation it is true to say that it is the visualisation that attracts the end user the most. Thus, the ARCOLite visualisation component exploits a careful integration of Web3D, virtual and augmented reality to provide an exciting interactive user experience.

In this paper we use the term Web3D to mean the use of XML technologies [5] and VRML [6] to deliver interactive 3D objects (virtual artefacts) and

worlds (virtual museums based on web browsers with VRML plug-ins integrated with a table-top augmented reality system) across the Internet or within a museum environment, e.g. kiosks. This definition complies with that defined by the Web3D consortium [4].

In the remainder of this paper we describe ARCOLite starting with section 2 which gives an overview of the ARCOLite architecture, while sections 3 to 7 describe the architecture in more detail including future work, and section 8 draws conclusions.

2. ARCOLite overview

In this chapter we describe how to create virtual museums or exhibitions using Web3D, virtual and augmented reality with ARCOLite. Figure 1 illustrates the overall architecture of ARCOLite, which consists of five conceptual parts:

- Content production
- Content management
- XML technologies
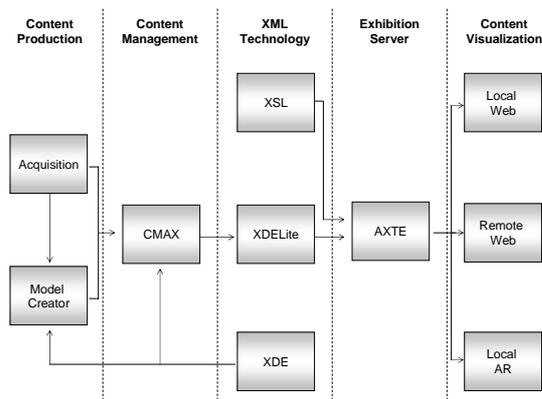- XML transformation engine
- Content visualization.

Figure 1. ARCOLite architecture

In brief, content production provides a 3D authoring tool called the Model Creator (MC) based on 3ds max [7]. The content production part also allows for acquisition of other multimedia data such as digital photographs of artefacts, video clips, audio clips, etc. that are imported via CMAX.

Content management is based on the Content Management Application for XML (CMAX), which has two main functionalities. First, it provides connectivity with external digital culture systems via migration tools, which are in effect XML translators. An example is the translation of ARCO [8] XML Data Exchange (XDE) files to the ARCOLite format called XDELite. This tool applies migration XSL templates to the XDE file exported by the ARCO database to generate content packaged for

presentation conforming to the ARCOLite architecture. Second, it is capable of packaging raw digital data from a local or network file system into the XDELite format.

XML technologies consist of two XML data formats for packaging raw data: XDE and XDELite mentioned above, and two types of XSL style sheets, which are used to translate data from XDE to XDELite, and also to define the web browser layout of a virtual museum exhibition (XDELite data) on the visualization client.

The ARCOLite XML Transformation Engine (AXTE) is a standard servlet that processes the visualisation XSL style sheets in order to dynamically deliver the virtual museum exhibitions to content visualization clients. The AXTE servlet, known as ContentServ, can be configured in different modes whose purpose is to serve XML files and media files. We envisage implementing other servlet modes to process different presentation domains such as interactive heritage games using augmented reality.

The client visualization part consists of three visualization or presentation domains: Local Web, Remote Web and Local AR domain, which are similar to the ARCO presentation domains [8][9]. The Local Web and Remote Web (may collectively be called a Web presentation domain) clients consist of a typical web browser, e.g. Internet Explorer on Windows platforms. Any other standard XHTML compliant browser on any platform is also capable of rendering Local Web and Remote Web content.

The Local Web visualization domain provides a web presentation using Web3D and VRML visualization within a museum environment, whereas the Remote Web renders over the Internet, again using Web3D and VRML visualization. The only difference between Local and Remote Web is the browser layout using different XSL stylesheets and the quality of the visualisation data, e.g. perhaps lower resolution VRML on the Internet for the Remote Web.

The web browser used is responsible for rendering web content available from AXTE through the server. Both the Local Web and Remote Web are extended into the Local AR visualization domain, which retrieves virtual museum artefacts from AXTE and renders them on a table-top AR environment similar to ARCO [10]. More details on each part of ARCOLite's architecture will be given on the following chapters.

3. Content Production

The creation of realistic 3D models of heritage artefacts and monuments is the focus of much current research in computer graphics. Until recently realistic 3D models were modelled manually

and usually this process takes a great amount of time and skill to produce even a simple model. Image-Based Modelling is a relatively new field [11], but it has already produced degrees of interactivity and levels photorealism previously only dreamed of.

There are now many tools available using different methods to acquire 3D heritage models ranging from the cheap to the very expensive. Good laser scanners can be bought for a few thousand dollars [12], mechanical digitisers are even cheaper [13], and good photogrammetry software can be acquired for a few hundred dollars that can produce realistic 3D models of monuments and smaller artefacts [14]. All usually have one thing in common; their 3D output often requires some refinement in a 3D modelling tool. Thus, ARCOLite offers a Model Creator based on 3ds max.

3.1. Model Creator

The ARCOLite system provides a custom-built 3D authoring tool called the Model Creator (MC) based on the industry standard 3ds max modelling application. By customising 3ds max we provide a highly efficient means of quickly creating quality 3D content for digital heritage.

The MC tool can be used to create 3D content from scratch, but is also equipped with cutting-edge functionality for the refinement of 3D models captured using approaches such as laser scanning or photogrammetry.

The MC tool can also export 3D content along with associated technical, modelling and curatorial metadata to a single XDE instance, which can then be imported into the ARCOLite system. This approach targets many of the problems of digital archiving in that it keeps all relevant metadata associated with the resource packaged together in a non-proprietary format.

3.2.1. Modelling simple artefacts. The ARCOLite MC provides a usable customised interface for the creation of simple 3D models and a comprehensive online help system that guides the user through the 3D model creation process. This interface has been iteratively developed, tested and evaluated over three sessions of Museum User Trials during the ARCO project [15]. Our aim is to provide a customised tool that only exposes the 3ds max or plug-in functionality needed to build virtual artefacts.

Figure 2 illustrates the MC tools customised interface used to model relatively simple virtual artefacts. We classify simple artefacts as those that have some kind of regular structure that allows us to exploit modelling functionality such as splines and volumes of revolution, or extrusion, etc. In Figure 2 we see an Imbrex Roman roof tile from Fishbourne Roman Palace being constructed.
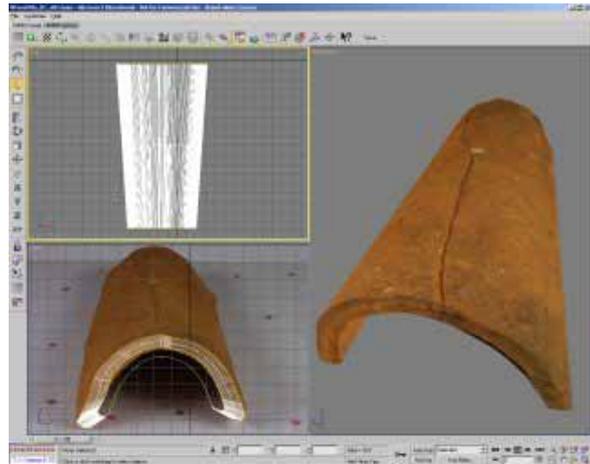

Figure 2. Modelling of simple objects—an Imbrex Roman roof tile

3.2.2. Complex models. For more complex models, which are defined as those with a more random structure such as statues, we provide a customised refinement interface. This interface allows the user to refine 3D models captured using other state of the art methods such as laser scanning and photogrammetry.

Our MC refinement interface includes functionality commonly needed to finish a complex model, for example:

- Alignment of scanned range maps, i.e. mesh shells in PLY or VRML format
- Elimination of overlapping mesh polygons, i.e. clipping one mesh against another
- Zipping or welding of resulting meshes
- Capping of any holes left in the model

The MC provides access to these mesh refinement functions using the 3ds max plug-in architecture. These plug-ins are written using the 3ds max scripting language, which provides a cost effective way of offering a complex 3D authoring tool to museums at low cost. There are other modelling packages that provide very rich functionality in this respect, such as RapidForm [16], but at a very large cost making it prohibitive for museums.

Figure 3 illustrates the MC refinement interface eliminating overlapping polygons from two meshes of a wooden statute that was digitised using a stereo photogrammetry system developed in the ARCO project [15]. In this case the user is working on pairs of meshes, which have been aligned, and then overlapping polygons are eliminated.
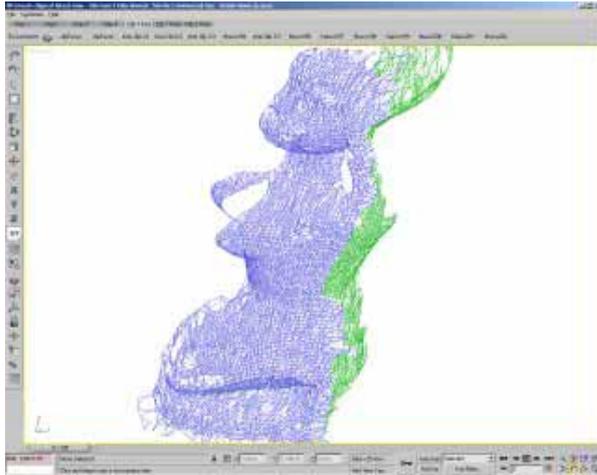
Figure 3. Eliminating mesh overlap with the Model Creator

The two meshes are then zipped or welded together as illustrated in Figure 4.

Figure 4. Rendered zipped meshs

3.2.3. Architectural reconstruction. There are many different solutions for the creation of a 3D model of architectural sites. For example, if an ancient building or monument still stands expensive surveying and digital laser scanning methods can be employed. Less accurate photogrammetry methods can also be employed using relatively cheap software packages [14]. The latter method is preferred from a cost performance point of view for two main reasons. Museums can afford such solutions, and the state-of–the-art in photogrammetry solutions gets better as time goes by. However, there are problems associated with this method; as usual some refinement is often necessary in a modelling tool. Again, 3ds max can be used for such a task, thus the

MC offers a third interface focused on monument reconstruction. Similar in philosophy to the previous simple model and complex model refinement interfaces, the monument reconstruction interface exposes relevant functionality used in this process. Figure 5 illustrates the partially completed virtual reconstruction of Fishbourne Roman Palace. In this case, the user has selected the 3ds max default interface which is not locked from the museum user. We expect as museum users get more experienced they will unlock the full power of 3ds max.
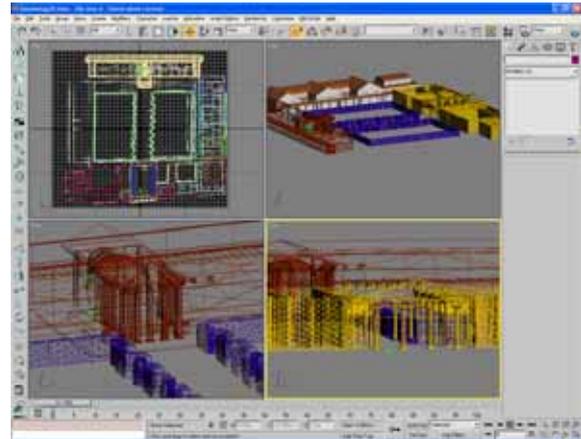

Figure 5. 3D virtual reconstruction of Fishbourne Roman Palace

3.2.4. Interoperability. Multimedia content management is a key area in digital heritage and archiving. By integrating MC into the ARCOLite system, which is built on the interoperability benefits of XML technologies, we address many of the key issues of this field. The interface mechanism between our modelling tool and the ARCOLite system is again achieved through a simple 3ds max plug-in. The tool produces a single XDE instance that packages together 3D content along with associated technical, modelling and curatorial metadata. The resulting XDE instance can either be imported into the ARCO system [15] or ARCOLite (using the CMAX migrator).

4. Content Management

ARCOlite uses a lightweight content management tool called CMAX—Content Management Application for XDELite. Museum curators will use CMAX to package raw digital cultural heritage data, which provide them with editing facilities to mange the XDELite repository. At the moment we have implanted the first prototype, see Figure 7. Future prototypes may also provide simple search techniques.

CMAX is also intended to act as a bridge between the data repository of any external digital culture system and XDELite through its migrator tool. The

CMAX migration tool (XDE to XDELite translator) has been developed and is ready for integrating into CMAX, but can also run as a standalone tool in console mode. ARCOLite will require other migratory tools or translators to allow external interoperability with other museum database systems.

The XDE to XDELite migrator accepts as parameters an XDE file exported from the ARCO system [9], the migration template (written in XSL) and any further presentation domain packaging templates (also written in XSL) and generates a corresponding XDELite repository conforming to XDELite schema, along with any presentation domain files that contain associated multimedia data. In future, this will be embedded into CMAX as a point-and-click functionality. Figure 6 illustrates a screenshot of the XDE to XDELite migrator run from the console.
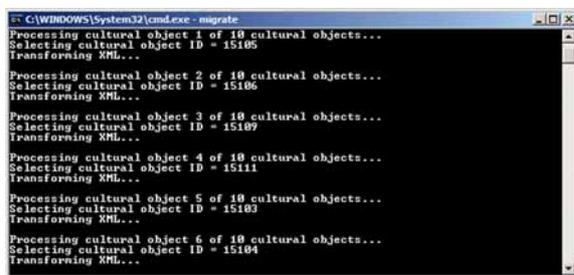

Figure 6. XDE to XDELite migrator in console mode.

Figure 7 illustrates a screenshot of the first prototype of CMAX. The CMAX interface consists of a toolbar that provides the main functionality to the user such as deleting, inserting metadata elements, editing new media object metadata, displaying more information on specific metadata, etc. The left panel is used to manage media objects associated with a virtual museum artefact. The top right panel is an editor for the cultural object metadata, and the bottom right panel is used edit media object metadata [17].
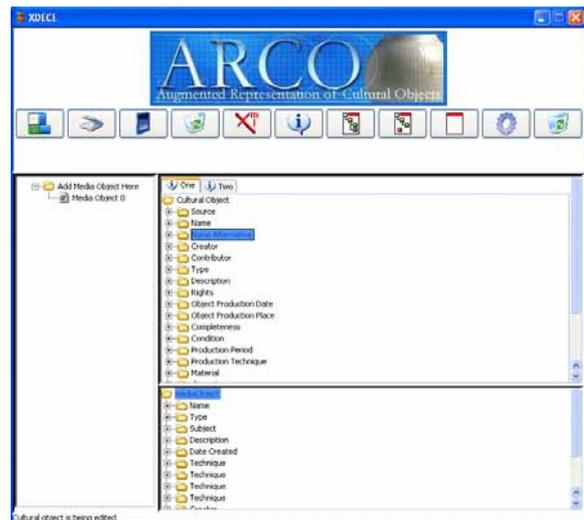

Figure 7. First prototype of CMAX.

5. XML Technologies

ARCOLite XML technologies, i.e. XDE, XDELite and XSL, are used to 'package' raw multimedia data for virtual museum exhibitions based on XML schemas; govern the look and feel of those exhibitions; and migrate data from external data format to XDELite format. The following three sub-sections describe the two XML formats and the XML presentation style sheets used in ARCOLite.

5.1. XML Data Exchange

A key element of the ARCO project [15] is the use of XML technologies to enable internal interoperability between components and external interoperability with other systems and applications (e.g. ARCOLite). For this purpose the ARCO project has implemented an XML schema called XML Data Exchange (XDE) [18]. An XDE instance may contain the cultural objects, their associated media objects and metadata and presentation information that comprise a complete virtual museum exhibition.

5.2. XML Data Exchange Lite

XML Data Exchange Lite (XDELite) architecture defines the data used in a virtual museum exhibition. Figure 8 illustrates the concept of XDELite. At the moment XDELite consists of four XML schemas called 'IR', 'Presentation', 'Folder' and 'AR'. For the moment the first three have been implemented and tested, and 'AR' is currently being specified to allow the Local and Remote Web presentation domains to be extended into an AR table-top environment.
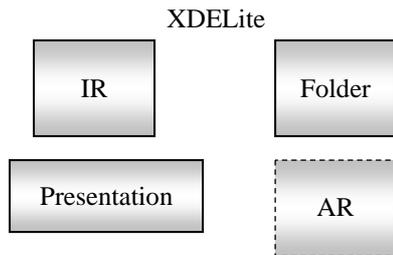
Figure 8. XDELite conceptual diagram

'IR' defines an information resource. In ARCOLite an information resource is comprised of cultural artefact metadata, a series of digital representations (e.g. multimedia data including VRML objects) of the cultural artefact and finally their associated technical metadata

'Presentation' groups together a series of IR instances i.e. a series of information resources in order to create a virtual museum exhibition.

'Folder' makes possible both the existence of different stylesheets and multiple presentations on the same raw data using ARCOLite.

'AR' will define which cultural object data will be transferred to the 'LocalAR' for table-top Visualization, e.g. VRML models of the artefact.

5.3. XSL Stylesheets

XSL (Extensible Stylesheet Language) provides the means to manipulate and display XDELite presentations or exhibitions in a variety of ways, e.g. XSL can be used for XHTML document creation; selective display of data using predefined parameters; or sorting of XML entries, etc. Thus, layout presentation templates can be implemented in XSL to represent a wide range of virtual museum functionalities.

Figure 9 illustrates a Local or Remote Web based virtual museum exhibition. In this case an XSL stylesheet or template presents a museum collection in an archive-styled scenario, where users can browse through a collection of artefacts and request information for any of them.

We can implement different XSL stylesheets for different learning scenarios adapted for different viewers. That is, we can present the same cultural heritage data using different XSL stylesheets for children and adults.

XSL stylesheets could also be used to present contextual artefact categories, e.g. household or religious artefacts can be presented with different templates all the while maintaining an independency between content and presentation.

Figure 9. Web based virtual museum using XSL stylesheets to define an archive style

6. Exhibition server

The ARCOLite exhibition server is composed of the ARCOLite XML Transformation Engine (AXTE) deployed on a JSP/Servlet container, and accesses the exhibition data repository (XDELite) and the XSL stylesheets (i.e. the XML technologies). We use Apache Tomcat as our JSP/Servlet container. The exhibition server directs client requests from Local and Remote Web as well as Local AR clients to AXTE, which then serves the exhibition data after applying appropriate XSL stylesheets associated with the presentation.

6.1. AXTE

AXTE is configured as a servlet called ContentServ. AXTE reads the XDELite directory structure on the file system through an exhibition folder XML file called Folder, see Figure 8. AXTE uses virtual museum exhibition information stored in HTTP sessions, as long as the session exists, and the as long as the user does not request a different exhibition. Depending on the requested mode of operation (currently Mode 1 or 2), the servlet generates XML (XHTML) or binary content (e.g. images) for content visualisation. The AXTE modes of operation are illustrated in Figure 10.
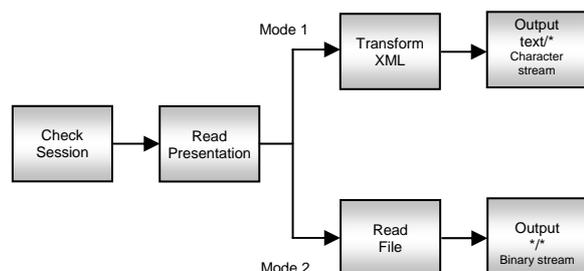

Figure 10. AXTE modes of operation

7. Content Visualization

One of ARCOLite's innovative features is its ability to allow museum visitors to visualise the same heritage content remotely, locally or within an integrated table-top augmented reality environment [19]. For example, museum visitors can browse on a museum kiosk display a web presentation of several virtual artefacts and then see the same artefacts using augmented reality on a so called 'table-top', Figure 11 and Figure 12 illustrate this concept.

Content visualization is performed by ARIFLite, which offers three distinct visualisation modes: Local web, Remote web and an extension of these into AR visualisation. These visualisation modes can be configured in many different ways by changing content and presentation style using XSL stylesheets. For example, Figure 9 illustrates use of an archive lookup exhibition XSL stylesheet showing pictures and metadata, etc., while Figure 11 illustrates use of a 3D VRML visualisation XSL stylesheet.

The museum user will carefully design different XSL stylesheets them to target different types of visitors to their virtual museum exhibitions. In the following sections each component is briefly discussed.

7.1. Web

ARIFLite encapsulates the concept of Local web and Remote web presentation modes into a single view by providing an embedded web browser (i.e. Microsoft Internet Explorer). When a visitor browses the virtual museum exhibition they can choose to view the virtual artefact as a VRML object in the web view or in the AR view. If the AR view is chosen the web view, see Figure 11, is swapped with the AR view, see Figure 12.

Figure 11. ARIFLite web view showing a virtual Imbrex Roman roof tile.

These two views can also have a learning scenario, such as an interactive game depending on the nature of the content and target audience [8][10] associated with each view. Also we envisage the concept of an interactive learning view that uses a browser split-pane presenting interactive questions to the user and collecting responses that cause the AR view to change its content, see section 7.3.

7.2. Augmented Reality View

Although there have been many different visualisation techniques proposed for presenting virtual exhibition environments, there has been less work conducted on user friendly AR environments. Our ARIFLite system offers the ability to support parallel activity where web visualisation and AR visualisation can operate at the same time from a windows interface. Thus, a user can browser a web based virtual exhibition and switch to AR visualisation for a more interactive experience with the virtual artefact.

Our AR system is a visualisation application that runs on a standard PC with Windows XP. We integrated a web browser environment with the well known ARToolKit [20] using a simple USB web camera.

Visitors using the AR environment can see the real world (e.g. a simple table-top environment) through the USB camera enhanced with virtual artefacts rendered in VRML. Interaction with the augmented information can be performed in a tangible way using a set of predefined marker cards [21]. The marker cards may be located anywhere in the scene as long as they are always in line of sight of the web camera. Figure 12 illustrates a view on a display of the virtual artefact the real world. The display could also be the view from an HMD.

Figure 12. ARIFLite showing a virtual Imbrex Roman roof tile in augmented reality

7.3. Future Work—an Interactive Learning View

The interactive learning scenario view is a unique feature of ARIFLite where an AR view is presented along with a browser view in a split-pane view. The browser view contains a learning scenario, for example encapsulated as questionnaire (or interactive quiz) associated with a virtual artefact displayed on a marker in the AR view. The quiz data is served by the exhibition server using a different mode for the Contentserve servlet and a different XSL stylesheet. The content in the browser view is not served through the servlet as pure XHTML. Instead, an embedded Macromedia Flash movie is rendered on the client side in the split-pane view. This flash movie communicates with the exhibition server to fetch dynamic virtual artefacts for viewing in the AR view.

8. Conclusion

This paper describes our second prototype XML based system for building and presenting Virtual Museums using Web3D and Augmented Reality. Currently, we are designing and implementing educational scenarios within the cultural heritage area. The basic component technology has been implemented and we are now working on a tighter integration. In the future, we also plan to provide more interaction techniques by incorporating haptic devices so that museum visitors can interact in a natural and intuitive manner.

9. Acknowledgements

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