Preliminary Evaluation of the Augmented Representation of Cultural Objects System

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Abstract. We present a preliminary human-centred evaluation of the ARCO (*Augmented Representation of Cultural Objects)* system that provides museums with software and interface tools that allow them to build integrated Web3D, Virtual and Augmented Reality based virtual museums. Heuristic evaluation and cognitive walkthroughs have been employed, focusing on expert evaluation (curators of museums) and novices (visitors of museums), to evaluate various components and interfaces of the system.

1. Introduction

1.1 Virtual Museum Exhibitions

More and more cultural institutions, such as museums take advantage of the multiple opportunities offered by Web3D, Virtual, Augmented or Mixed Reality technologies (VR/AR/MR). Virtual Reality signifies a synthetic world whereas Augmented or Mixed Reality signifies computer generated 2D or 3D virtual worlds superimposed on the real world. Web3D is used to represent the application of XML and VRML technologies to deliver interactive 3D virtual objects in 3D virtual museums [1]. Previous research has made use of 3D multimedia tools in order to record, reconstruct and visualize archaeological ruins using computer graphics [2] and also provides interactive AR guides for the visualization of cultural heritage sites information [3]. Moreover, relevant research has demonstrated that 3D technology '*offers museums rich opportunities in a range of areas from public access to conservation*' [4]. These new emerging technologies are used not only because of their popularity, but also because they provide an enhanced experience to the virtual visitors. Additionally, these technologies offer an innovative, appealing and cost-effective way of presenting cultural information. Virtual museum exhibitions can present the digitised information of cultural objects, either in a museum environment (e.g. in interactive kiosks), or through the World Wide Web. In this paper, the methods and preliminary results of an explorative evaluation that examined the usability performance of such a system named ARCO [5] will be presented.

1.2 Description of ARCO system

The ARCO system allows museum curators to build, manage, archive and present virtual museum exhibitions based on 3D models of artefacts. ARCO also allows end-users to explore virtual exhibitions implemented using the system [6] (Figures 1, 2).

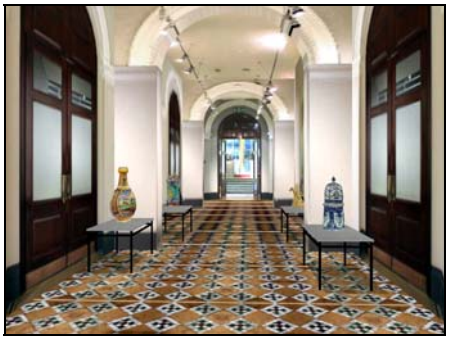

Figure 1: Museum exhibition using VR

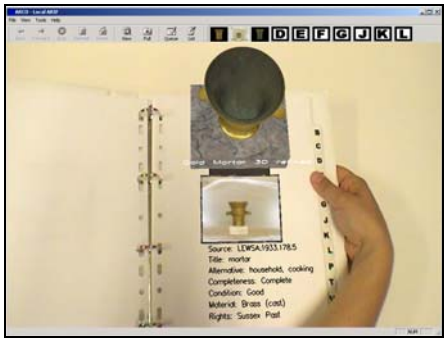

Figure 2: Museum exhibition using AR

The cultural artefacts are digitised by means of a custom built stereo photogrammetry system (Object Modeller), mainly for digitising small and medium sized objects and a custom modelling framework (Interactive Model Refinement and Rendering tool) that is used, in order to refine the digitised artefact [7]. The 3D models are accompanied by images, texts, metadata information, sounds and movies. These virtual reconstructions (3D models and accompanying data sets) are represented as EXtensible Markup Language (XML) based data to allow interoperable exchange between ARCO and external heritage systems [6]. These virtual reconstructions are stored in an Oracle9i database system and managed through the use of a specially designed ARCO Content Management Application, which also allows the museum to build and publish virtual museum exhibition to the Internet or a museum kiosk system.

The ARCO system is a complete tool that enables archiving of both content and context of museum objects. The interactive techniques offered can transform the museum visitors '*from passive viewers and readers into active actors and players*' [6]. Two main components of the ARCO system were of interest for evaluation: the ARCO Content Management Application (ACMA) and Augmented Reality Interface (ARIF). ACMA allows publishing of virtual museums to both web (Figure 1) and a specially designed application (ARIF) for switching between the web and an AR system (Figure 2).

2. Evaluation of the ARCO System

2.1 Aim of the Evaluation

The human-centred system evaluation undertaken focused on individual system components such as ACMA and ARIF described above. Three main assessment categories have been included:

a) *Technical usability* that refers to the perceptual and physical aspects of the human-computer interface,

b) *Domain suitability* that examines the appropriateness of the content of information and display presentations,

c) *User acceptability* that refers to the effectiveness of the system for supporting cognitive task requirements [8] and the satisfaction that provides.

Heuristic evaluation guidelines [9] were used to evaluate the user interface of the system inviting human observers. According to these guidelines, a system must provide feedback and visibility of the system status employing simple language with clearly marked exits. Consistency of user interface elements is required and user's memory load must be minimised. The user interface must have aesthetic and minimalist design and it has to be able to deal with errors. Finally, help and the appropriate documentation should be available. Cognitive walk-through methods [9] involve the 'walk-through' of a number of tasks, exploring the systems' characteristics, locating and identifying potential problems and their causes. The following steps have been undertaken:

1st step: *Goal setting*: The users start with a plan of the tasks to be accomplished

2nd step: *Exploration*: The users explore the interface and discover useful actions

3rd step: *Selection*: The users select the most appropriate actions for accomplishing their task

4th step: *Assessment*: The users interpret the system's responses and assess its progression.

In addition to heuristic evaluation and cognitive walkthrough techniques, users' level of 'presence' or 'sense of being there' was assessed [10], [11]. The ACMA & ARIF set of tutorial questionnaires [12] map the original museum user requirements into appropriate assessment and evaluation questions. The AR presence questionnaire [13] assesses the degree to which individuals experience the presence of virtual objects in a real environment. The VR presence questionnaire was heavily modified from an existing presence questionnaire, which originally focused on immersive environments [14] and explored whether participants felt that the particular 'space' of the application was the dominant reality as well as whether the application was a 'locality' or a 'place' that was visited rather than merely seen. Moreover, the QUIS questionnaire [15], [16] evaluated aspects of the ACMA and ARIF interface design such as readability of characters, the meaningfulness of command names, the helpfulness of error messages and the layout of displays. All tools were modified accordingly.

2. Materials and Methods

2.1 Apparatus and Visual Content

The ARCO system has been implemented with of-the-self hardware components. It is based on an HP workstation with two 2.4GHz Xeon processors and 2048 MB of memory. The workstation or PC is equipped with an Nvidia GeForce 6800 graphics card, and a low cost Logitech web camera. Standard display technology, such as PC 19' inch monitor has been used.

The AR software architecture and rendering of the synthetic artefacts is built around the ARToolKit tracking library12 [6], an OpenVRML rendering engine and ARCO database described above. The ARToolKit can translate the live video to images and also calculate the camera calibration parameters in real time in order to overlay the virtual models in the real world environment [6].

2.2 Participants

Twenty-nine (29) end-users and ten (10) museum experts (curators) took part in this study.

2.3 Procedure

Data from the Victoria and Albert Museum of London, UK have been used for the virtual showcase. The ACMA & ARIF set of tutorial questionnaires are designed to assess the usability of each of the ARCO components, not only at the system level, but also at the sub-component level. These tutorial questionnaires were completed by the Victoria and Albert Museum curators, whereas the end-users were only required to complete the ARIF tutorial questionnaire. The museum curators were provided with a tutorial to guide them through the navigation of ARIF and ACMA and the end users with a tutorial to guide them through the ARIF interface. Both qualitative and quantitative information has been collected. Issues concerning the navigation of the ACMA interface and the virtual museum exhibition implemented in ARIF involved the ability to move through the contents of an interactive program in an intentional manner. The user's subjective impression of the interfaces was also investigated. Finally, handling possible user errors was considered a significant aspect of this evaluation for both interfaces.

The AR presence questionnaire [13] subsequently assessed end-users perceived presence of the 3D models in the real world and the degree to which the virtual objects seem real. The VR presence questionnaire [14] assessed end-users perceived 'sense of being there' in the virtual museum exhibition. The QUIS (Questionnaire for User Satisfaction Interaction) questionnaire [15], [16] assessed museum curators' contentment while interacting with the ACMA and ARIF interfaces.

3. Preliminary Results

The ACMA and ARIF tutorial questionnaires received varied comments. This was also due to the fact that the museum curators were from different backgrounds and worked within different departments ranging from records and collection services, word and image, learning and interpretation, furniture, textile and fashion and information systems. The comments offered by each curator reflected the nature of their profession and their level of capability in using computers. For example, a specialist in museum education suggested some alterations to the learning scenario of the interactive games. The tutorial questionnaires which were related to the ARIF interface and completed by the end users offered information about the strengths and weaknesses of the system. Most of the comments concerned the text accompanying the VRML model in the AR environment, which was not easily distinguished. Users also mentioned that the quality of both the 2D image and the 3D model could be improved. These remarks have been taken into account for future development and enhancement of the system.

Large proportions of the end-users had significant previous experience with VR and computer games and therefore were enthusiastic trying such technologies. According to the AR presence questionnaire, they perceived the interaction with the SpaceMouse—an input device for manipulating cultural objects in the AR environment—to be intuitive. Most of the users were able to naturally interact using their hands in the AR environment. Almost all of them considered the 3D models of the cultural artifacts as three-dimensional objects and not as flat images, though they were easily distinguishable from the real objects. There are also varied responses that need further examination and analysis concerning whether the virtual cultural artifacts belonged to the real environment or whether they were completely separate from it. The VR presence questionnaire revealed that users' 3D visit in the virtual museum exhibition was a new experience as if they were visiting a real museum. Furthermore, multimedia contents provided a better understanding of the virtual museum exhibition and contributed to the enhancement of the visitors' experience.

Most responses obtained via the QUIS questionnaire ranged between 5 and 8 of an eight-point Likert scale indicating a high degree of expert users' satisfaction. Most of the museum curators were satisfied with the separate information windows provided in the ACMA tool. This includes the display of the characters and the layout and the sequence of the windows. Museum curators regarded both the terminology and information used in ACMA to be context-specific. Certain thought that ACMA was quite a complex tool therefore it took a while to absorb all the functions and to learn how to use it intuitively. The final aspect of the tutorial questionnaire dealt with the multimedia presentation in ARIF. Museum curators were impressed with the AR exhibitions and the visualization of cultural objects. However, some of them suggested certain improvements to the design of the ACMA interface concerning the layout of the system and more specifically the background, text and colour of the interface, when viewed in the web browser.

Though preliminary, the results show that there is a convergence between usefulness and enjoyability that has been identified also in previous relevant research [17].

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