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TOUCHING ARTEFACTS IN AN ANCIENT WORLD ON A BROWSER-BASED PLATFORM

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ABSTRACT

Innovations in teaching and learning process are influenced by the rapid emergence of a knowledge society and tremendous growth in demands for highly informed and educated individuals. Various kinds of computer-based learning systems have already been integrated into conventional teaching methods. However, there is a pressing need to provide a more accessible and immersive learning environment in order to increase learners' receptiveness towards the learning process. Complete involvement of learners in their learning environment will promote better absorptions of knowledge via experiential and exploratory pedagogies. In tandem with such pedagogic approaches, this paper discusses the deployment of tactile perception to complement virtual artefacts within the domain of cultural heritage. By stimulating visual and tactile perceptions, the learners' engagement and interest can be sustained. Towards enhancing accessibility to a wider demography in a more cost-effective manner, web technologies provide a platform that is widely available for mass consumption. The development capitalises on the fact that the majority of UK households have access to computers and internet.

KEYWORDS

Haptics, web technology, e-learning, cultural heritage, H3D, X3D

1. INTRODUCTION

Learning ancient history is fundamentally dependent upon intangible narratives often accompanied by illustrations and historical facts. To promote better absorption of knowledge, complete involvement of learners in their learning process is essential. Experiential learning (Kolb et al., 1984) advocates such engagement. However, virtualisation of the learning environment often implies experiences become abstract subsets of their real-world counterparts, and therefore fissures can emerge in the experiential model between action, (virtual) experience, and reflection. These often manifest themselves as unfulfilled learning outcomes due to inadequate fidelity, or reports of cognitive overload as learners struggle to address the additional demands required to reflect on virtual experiences in the context of real-world events (Warburton, 2008, Parker and Myrick, 2009). Hence, it is essential to narrow the gap between virtual and real spaces, and thus enable experiential learning techniques to be more readily and effectively applied.

Within the domain of cultural heritage, ancient artefacts that are physically unavailable in a class-room setting may be made tangible in a virtual environment (VE). 'Seeing is believing' - but physically touching a virtual artefact may narrow the gap between what we perceive as a virtual and real object. The educational benefits of such an approach are well-documented; Shams and Seitz (2008) advocate multisensory teaching approaches as mirroring more closely evolved learning processes, suggesting unisensory approaches are sub-optimal and that their selection is based in practicality rather than pedagogy.

Existing works exploring such an approach commonly employ specialist technologies, which can be expensive and are not easily available to a general audience. Hence, to promote engagement, the deployed technologies have to support accessibility to a wider demographic. The means of transfer thus require optimisation- simple, familiar, cost effective and easily available for mass consumption.

This paper describes an ongoing development based on the Rome Reborn Model (Guidi et al., 2007, Petridis et al., 2010) towards a multisensory learning platform within the domain of cultural heritage. The proof-of-concept advocates experiential learning by incorporating tactile interfaces in a VE and accessibility to a wider demographic by capitalising on the fact that internet access, coupled with graphical user interfaces and web browsers, is common in education and at home (Kaklanis et. al, 2009).

2. RELATED WORK

VEs have been employed within the domain of cultural heritage. Applications, such as Virtual Ancient Egypt and Virtual Gettysburg, present users with virtual recreation of ancient artefacts. Events such as a battle in a computer-generated scene can also be recreated, allowing users to move around and observe from any angle or location. First-hand experience is however not advocated by these environments.

Sound and sight may be the easiest senses to manipulate using conventional interaction techniques, but they are not the only senses. There is evidence that multimodal interfaces can create more immersive experience (Chalmers et al., 2009). Haptic technology is designed to communicate through the subtle and sensitive channels of touch and it has the potential to enrich experience in using cultural applications (Brewster, 2001; Barbagli et al., 2002; Bergamasco et al., 2002; Dettori et al, 2002). For instance, The Museum of Pure Form (Frisoli, 2007) allows visitors to interact with 3D art forms and explore the museum via stereo vision and tactile stimuli when interacting with virtual sculptures. The Interactive Art Museum (Brewster, 2001; Barbagli et al., 2002) provides the ability to touch rare art pieces. The visually impaired may also be empowered, where sight is no longer the only necessary sensory means to appreciate artwork.

However, the deployed technologies are restricted to specific audience and location due to their sophistication, complexity and cost. To reach a wider demographic, a more accessible media is crucial. For instance, over 75 percent of UK households have access to the internet (OFNS, 2009). To support a fully networked haptic application, the network architectures needed to support the addition of touch to the human computer interface have to be explored. Applications, such as The Hanoi Game and Pool Game (Ruffaldi et al., 2006) demonstrate a simple haptic interface over the web. However, it was a technology-led development rather than pedagogically-driven.

3. FRAMEWORK

Towards achieving an engaging environment on a more familiar and cost-effective platform within the context of cultural heritage, the two important parameters are the incorporation of tactile perception in a virtual environment in tandem with the experiential learning technique and the need to promote accessibility by employing a browser-based platform, off-the-shelf haptic technology and open-source software. Figure 1 illustrates the proposed architecture.

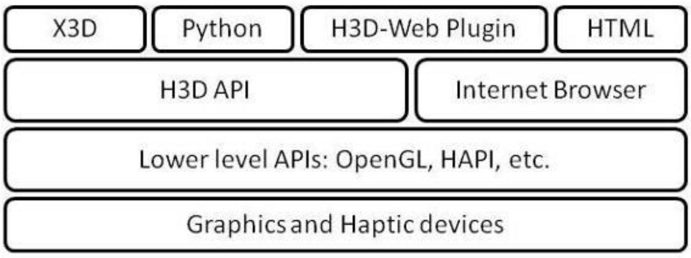

Figure 1. Architecture of a browser-based VE with haptics

In order to incorporate both tactile and visual elements within a VE, H3D by SenseGraphics provides an open source haptic software development platform (H3D API) that uses the open standards OpenGL and X3D with haptics in one unified scene graph. H3D API being cross platform and haptic device independent is feasible for web applications. Unlike most other scene graph APIs, H3DAPI is designed chiefly to support a rapid development process. To promote cost-effectiveness and therefore increase accessibility, an off-the-shelf haptic device (Novint Falcon) is employed due to its usability and stability within the domain of games, is also supported by H3D and does not require prior technical skills and experience. The following sections describe the artefact development that is built on top of the H3D API and web deployment enabled by a haptic-web plug-in for an internet browser.

3.1 Artefact development

3.1.1 Visualisation

X3D (the Extensible 3D file format) is an ISO open standard scene-graph design that is easily extended to offer new functionality in a modular way. The X3D file format is based on XML- the standard mark-up language used in a wide variety of applications. In tandem with XML for web semantics, models from the Rome Reborn, mainly in a 3D Studio max format, are repurposed and translated into X3D to provide the visual scene-graph, which will next be extended with haptic functionality. The complete Rome Reborn model includes a digital terrain map of the city and 7000 buildings within the late-antique Aurelian Walls, which will complement the resources required to teach ancient history and cultural heritage within this era.

3.1.2 Haptic definition

H3D comes with a full XML parser for loading scene-graph definitions of X3D extended with haptic functionality. With the haptic extensions to X3D via H3D API, tactile definition is incorporated into the scene-graph. In H3D API, a pre-defined Python scripting can be used to express more behaviour in the scene, such as the deformable behaviour upon interaction. Figure 2 and 3 demonstrate haptic interaction with virtual artefacts, which promotes a multisensory learning experience absence from a normal class-room setting. Tactile feedback respective of the texture, shape and material of the artefacts upon interaction will enrich learners' experience through such an exploratory engagement.

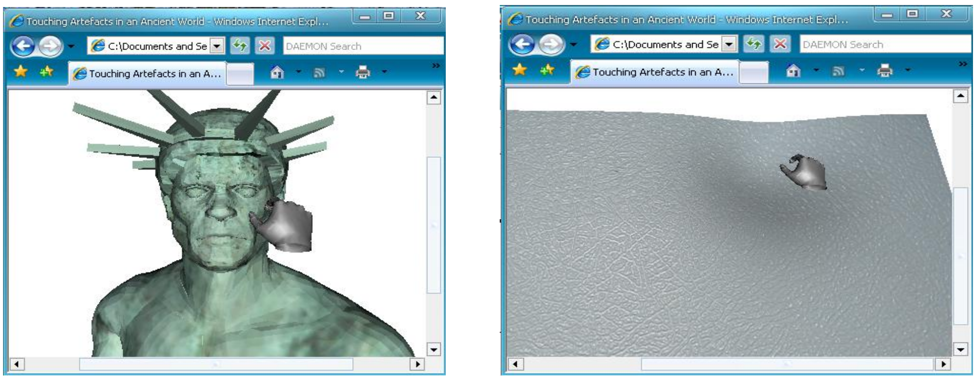

Figure 2. Haptic interaction (hand cursor) with a rigid artefact and a soft surface

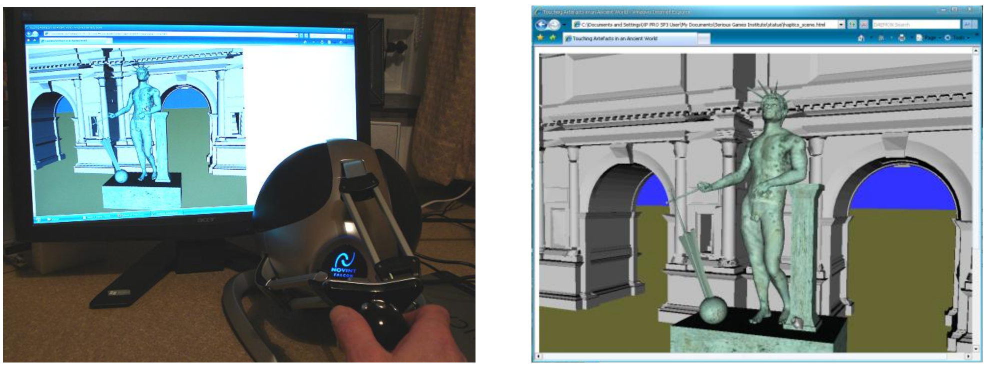

Figure 3. Ancient Rome on a haptic-enabled web browser with a Novint Falcon device

3.2 Web deployment

HTML encapsulates the scene-graph definitions developed using H3D API, which can be displayed on the web browser via the H3D-Web plug-in. Figure 3 illustrates a haptic-enabled browser, where users can experience tactile feedback from real-time interactions with the artefacts over the web using a Novint Falcon device. To optimise the learning environment, the platform architecture has to be set up on the client's machine as a downloadable installer that encapsulates the required components. The runtime processing, such as rendering, is thus delegated to the client. The web content including the haptic-enabled visualisation resides at the server side.

4. CONCLUSIONS

By engaging both visual and tactile perceptions in a virtual learning environment, a firsthand learning experience may be advocated. This paper has briefly described an innovative approach in introducing tactile perception in learning over the web, which aims to reach a wider demography in a cost-effective way. This development complements the existing project on cultural heritage based on the Rome Reborn model at the Serious Games Institute

Several limitations exist with current techniques. Firstly, challenges exist in providing high levels of realism, in terms of both visual and tactile fidelity, for deformable objects. Existing work such as Arnab & Raja (2008) can be adopted to address these concerns through an increase in realism and accuracy in object behaviour. Secondly, there are also possible latency and bandwidth issues when attempting to provide real-time high quality graphics to non-broadband users; however, this can be addressed by providing an option to download virtual scenes for local interaction. The immediate future work is to evaluate the level of engagement, motivation and cognitive benefit of the proposed learning platform. Findings will be disseminated via future publications.

By making available a whole new category of sensations on a web platform, haptic technology will open up gigantic possibilities for developers. The framework can be further adopted and extended by other developers of virtual cultural heritage, game-based learning, healthcare technologies and commercial applications within the context of business-to-business (B2B) and business-to-customer (B2C) scenarios.

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