A Novel Virtual World based HCI Paradigm for Multimedia Scholarly Communication

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ABSTRACT

The sharing of academic knowledge through printed publications has been widely and successfully utilized for more than a hundred years. However, the need to process huge amounts of data in scientific analysis and communicate its results to the scientific community has presented a big challenge for researchers in the data-intensive era. In addition to providing accurate and flexible graphical representations of data, the entire research process should ideally be made verifiable by peers. While web-based tools have been proposed to address this problem, most of them lack important features for scientific work such as real-time collaboration, powerful multimedia visualization and interaction, and environment persistency. Therefore, in this paper, we will propose the use of virtual world technology to address these issues. In particular, we will give an overview of the different methods that we have implemented in the context of multimedia interaction, which is considered the most critical factor in the development of virtual worlds as sound platforms for human-centered multimedia systems.

Categories and Subject Descriptors

H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*computer-supported cooperative work*; H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems—*artificial, augmented, and virtual realities*

General Terms

Design, Human Factors

Keywords

Virtual Worlds, Scholarly Communication Life-cycle, Second Life, e-Science, OpenSim

1. INTRODUCTION

Scholarly communication involves the formal sharing of knowledge and results through the publication of manuscripts and their associated review process [18], which is typically performed by people who are considered peers in their corresponding research field. This method of (printed) communication has maintained a consistent form and structure for over more than a hundred years, despite the technological shift of the publication method – from paper to digital form [10]. While maintaining this consistency has been beneficial for knowledge distribution and understanding, the medium itself has presented a tough challenge for researchers when presenting graphical information. For instance, printed graphical devices such as graphs and tables show good overall views of the underlying data they represent, but they are mostly summaries of an application of a particular scientific method, and do not allow readers to manipulate some parameters to obtain a better understanding of the data [10]. Often, a published manuscript cannot reflect the whole research process it is intended to explain. It misses out important activities that lead to the actual publication of the research work, such as informal talks, tests and analyses, and so on (i.e. the "informal data"). In many cases, however, it is this 'informal' data that helps readers understand more clearly how and why the results stated in the publication were obtained.

Furthermore, in the modern context of collaborative science – also known as e-Science [16] – results presented in research publications are generated by processing ever increasing amounts of data. The fact that this data cannot be easily published makes it more difficult to advance science since peers are not able to replicate, validate, and/or contribute to these results. Therefore, other more dynamic publication methods for intermediate research processes have been proposed, and new genres of publication are becoming increasingly important, such as blogs or Wikipedia [12]. Due to the popularity of Web 2.0 based technology and tools, there has been a growing interest in the utilization of web sites to share informal data and intermediate research results [7, 14]. In the case of informal data sharing web sites, their type of data ranges from general, public domain information, such as Wikipedia and digital libraries [11] to more specialized domains, such as OpenWetWare [4], which is utilized by biologists and biological engineers. Sites such as myExperiment [2] support the sharing of intermediate processes, and are proving to be increasingly popular among computer science related researchers.

However, the majority of these web sites lacks the ease of data analysis visualization, environment persistency, and collaborative features required for analyzing scientific data in the context of the new e-Science paradigm. Hence, in this paper, we propose the utilization of virtual worlds as a platform for e-Science, which emphasizes the integrative aspect of the virtual world technology by providing consistent multimedia interaction through the different methods that we have developed so far. This is considered as the most important issue concerning the development of virtual environments as platforms for human-centered multimedia systems [9].

2. MULTIMEDIA INTERACTION IN VIRTUAL WORLDS FOR SCHOLARLY PUBLICATION

Virtual worlds like "Second Life" [5] and OpenSim(ulator) [3] are free networked multi-user three-dimensional (3D) environments, where users, in the form of 'avatars' (graphical self-representations) can interact with other avatars and virtual objects. Recently, they started to attract the scientific community [6, 15] besides entertainment and business people, their original target audience.

To explain the potential of virtual world technology as a multimedia human-centered integrative platform, we will describe the work developed under four major aspects: (a) Collaborative interaction and 3D visualization, where we will present the collaborative nature of the platform and the devices created to interact with visualization systems; (b) external multimedia tools integration, where we will show how third-party tools can interact with virtual world based applications to enhance knowledge dissemination; (c) online multimedia data input for real time analysis, where we will describe how multimedia data can be transferred into the virtual world to speed the research analysis cycle; and (d) ambient information processing, where we will detail how external environmental data is processed and utilized in the virtual world.

2.1 Collaborative Interaction and 3D Visualization

One of the most salient advantages of the virtual world technology is its simple, intuitive client interface based on avatar interaction. However, this simplicity also brings about some limitations on how users can interact with virtual world based applications in general, with the additional challenge of handling interactivity in a multi-user environment. An obvious strategy is to create well known application interface objects (e.g. buttons, sliders, bar charts, etc.) inside the world itself, while taking into consideration the 3D perspective of their implementation. In AstroSim [13] (a star kinematics simulation visualization application) and its successor, OpenAstroSim, a rather intuitive way to navigate through the different steps of the simulation process was chosen, using a feature selection wizard scheme based on button arrays. Buttons are implemented as cubes, which can be activated by any user in the world. Figure 1 shows the selection menu implementation for OpenAstroSim.

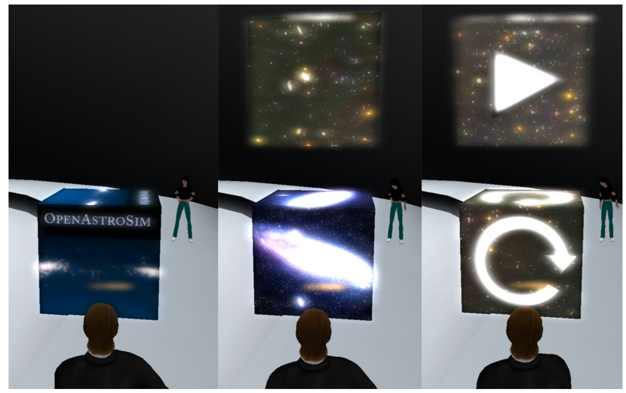

Figure 1: Different stages of the simulation selection process in OpenAstroSim. Left: at first, the main button is selected to initialize the simulation environment. Middle: in this stage, a simulation is selected. Right: the users can either play the simulation (upper button) or unload it (lower button).

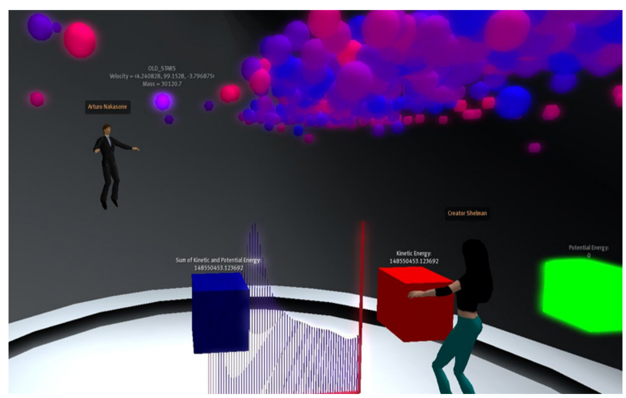

Figure 2: Information visualization in OpenAstroSim. The text adjacent to star objects indicates physical attributes and is displayed upon selection. The chart-like object in the back reflects the time-based values for the total energy of the system.

To display the numerical values obtained from the simulation, the functionality of the visualization interface is divided into two main areas: online, real-time information display and pre-computed, time-based information display. In the first case, the star's physical information is displayed as a floating text over each star and a real-time computed energy value is shown in separated cubical structures. In the second case, a three-dimensional chart-like object is used to display the pre-computed total energy of the system (see Fig. 2). Examples like these show the capability of virtual worlds to collaboratively manipulate application interfaces and visualize both online, real-time calculated information and pre-computed, time-based information.

2.2 External Multimedia Tools Integration

To overcome the restricted nature of the virtual world client interface, external tools can be integrated with virtual world based applications so that these tools can use virtual worlds as visualization environments. The key advantage is that users can obtain the benefit of operating in an inherently collaborative environment using their own programs and usual way of working. For that purpose, the OpenMol application was implemented, which can display complex molecular structures in the virtual world (see Fig. 3).

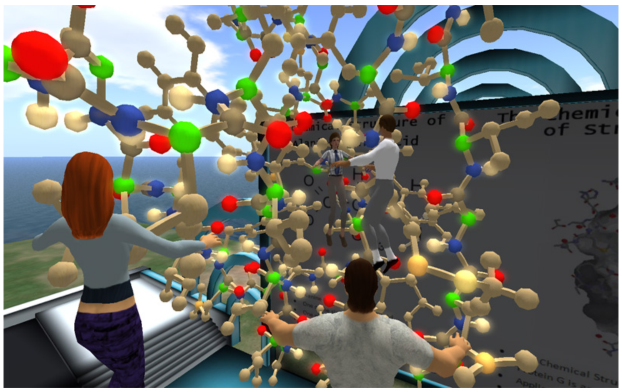

Figure 3: Display of the 1PGB molecule using OpenMol with three avatars engaged in collaborative analysis and discussion.

To create and manipulate the molecules in the virtual world, BALLView [1] (a molecular modeling and visualization application which lacks collaborative features) was chosen as the external tool. A two-way communication protocol module was implemented as a plug-in [8]. The plug-in allows users to perform modifications in molecular structures on either BALLView or the virtual world, and have them reflected in both platforms at the same time. Figure 4 shows the creation of the AH1N1 flu molecule in OpenMol, which was first generated in BALLView. This example demonstrates the capability of virtual world technology to offer a stable connection to third-party applications. In this way, the virtual environment can be used to permanently display intermediate and final research results.

2.3 Online Multimedia Data Input for Real-Time Analysis

We have also experimented with novel ways to let users upload their own data into virtual world applications, so that they can analyze data on the fly. One of our first successful attempts allows users to upload simple image files to the virtual world server, and use those images to generate a 3D representation. In this project, called OpenZebraFish, users can upload a series of pictures that represent consecutively sliced views of a part of a zebrafish brain and visualize a 3D representation obtained through the use of the 'voxelization' technique. In this technique, pixel areas of an image are represented as small cubes in the virtual world. Through a simple in-world control pad (see Fig. 5), users can load pictures to the OpenZebraFish application and manipulate the coloring scheme of the voxelized brain part. Here, we make use of two other interface elements: a slider to select the color gradient of the visualization, and an enhanced button object, which takes a variable parameter through the chat command area provided by the client interface.

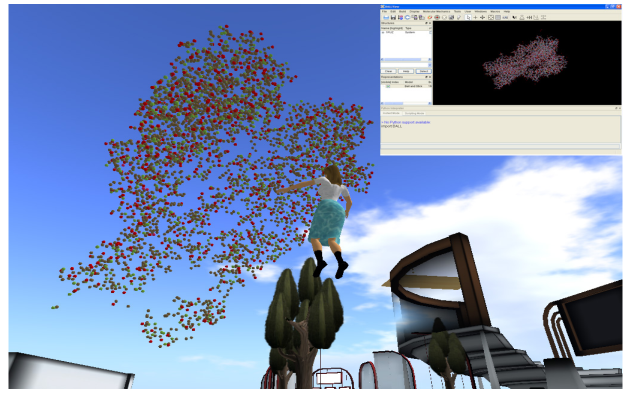

Figure 4: Representation of the AH1N1 flu molecule in BALLView (top-right corner) and in OpenMol.

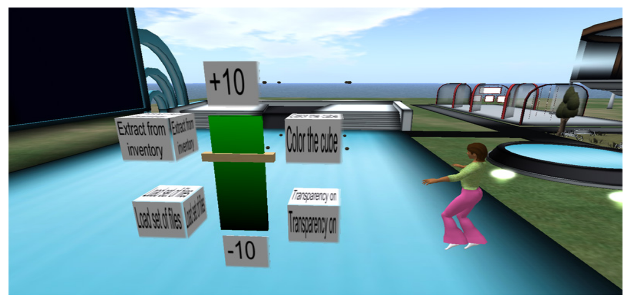

Figure 5: OpenZebraFish Control Pad.

OpenZebraFish illustrates the potential of the virtual world technology to visualize in real-time multimedia data provided directly by the user. Figure 6 shows the final visualization of a 3D representation of part of a zebrafish brain.

2.4 Ambient Information Processing

Virtual worlds can also convey sensor-based information in a novel way. In one of our projects [17], a sound based activity recognizer module is used to determine the meaning sound (e.g. hand clapping, cup stirring, etc), and the corresponding activity is mimicked by an avatar in the virtual world. The implementation of this type of interfaces is beneficial for applications that require human activity monitoring. Figure 7 shows the results of initial tests of the application's prototype.

3. CONCLUSIONS

In this paper, we presented a concise overview of the different aspects involving the development of multimedia, virtual world based applications from the user interaction point of view. Although some of the available work is rather preliminary, it clearly shows the potential of virtual worlds to address the challenges of research publication in light of data-intensive science or e-Science. The storage of produced intermediate and/or informal data is facilitated due to the per-

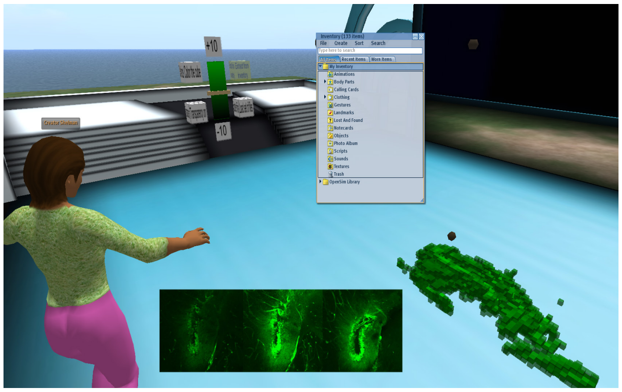

Figure 6: 3D representation of part of a zebrafish brain. The lower part of the picture shows a small subset of the pictures that are represented in the virtual world.

Figure 7: Sound detection and virtual world mapping setup. The avatar displayed on screen reacts to the human-induced clapping sound by clapping at the same time.

sistent nature of virtual worlds. Discussions can be stored as world chat logs and research analysis stages as visual devices on separated three-dimesional spaces. The collaborative aspect of virtual worlds facilitates dynamic publication and interaction with research results. Overall, it is the natural integration of persistency and collaboration what gives virtual world technology its power as a research publication platform. Since this technology is still in its early stages, it has some shortcomings in terms of visualization power and interaction flexibility, if compared to stand-alone multimedia tools. However, we believe that these limitations will be overcome with improvements in networking and computer graphics. In the near future, the most pressing issue is to provide the research community with the appropriate tools to develop their own virtual world based solutions.

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