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Multi-user Virtual Environments for Education

Dilek Doğan[1], Murat Çınar[2] and Hakan Tüzün[2]
[1]Department of Informatics, Ankara University, Ankara, Turkey
[2]Department of Computer Education and Instructional Technology, Hacettepe University, Ankara, Turkey

Synonyms

3DMUVE: Three-dimensional multi-user virtual environment; HUDs: Head-up displays; LSL: Linden script language; MMORPGs: Massively-multiplayer online role-playing games; MOOs: MUD, object-oriented; MUDs: Multi-user dungeons; OpenSim: OpenSimulator

Definition

Multi-user virtual environments (MUVEs) are structured with three-dimensional objects, in which users can actively navigate their avatars to different areas of the immersive environment.

OpenSimulator (OpenSim) is an open source multi-platform and multi-user 3D application server.

Introduction

Online multi-user virtual worlds have been used since the late 1970s (Achterbosch et al. 2007; Shield 2003). Initially, these environments were text-based interaction called multi-user dungeons (MUDs). With the transformation of MUDs to MOOs (MUD, object-oriented), users started to modify these worlds (Tüzün 2006). Advances in information and communication technologies have driven the MOOs' evolution, resulting in diverse human computer interfaces such as multi-user virtual environments (MUVEs) and massively-multiplayer online role-playing games (MMORPGs) (Dieterle and Clarke 2009). Newer generations of these environments are called immersive virtual worlds or metaverses (Dalgarno and Lee 2010). All of these virtual worlds are displayed online in three-dimensions (3D), and users can move and interact in simulated 3D spaces (Dickey 2005) that can be changed and modified. Users are represented as modifiable 3D avatars that can interact with other 3D avatars and do many activities such as walking, flying, running, jumping, and dancing. Avatars can be designed based on a user's real-life appearance or imaginary appearance (Fig. 1).

Three-dimensional multi-user virtual environments (3D MUVEs) can be used for different purposes such as socializing, entertainment, education, or business. A number of opportunities

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Multi-user Virtual Environments for Education, Fig. 1 Avatar examples for 3D MUVEs

offered by 3D online virtual environments compared to 2D equivalents have led to great expectations, especially in the field of education. Using 3D MUVEs for education has the potential to create a constructivist learning environment where learners' interactions and communications using avatar-to-avatar activities can challenge them to figure things out for themselves (Educause 2006). Social organizations formed in 3D virtual microenvironments might make a significant contribution to learners' self-perception and moral values in the light of personal and social values. In this respect, 3D MUVEs seem to be well suited not only for cognitive and psychomotor learning areas but also for supporting affective learning (Barab et al. 2005; Bers 2001). Spatial knowledge representation provided by 3D MUVEs contributes to designing authentic learning environments, creating opportunities for experiential learning or learning contexts, and providing a rich learning experience that includes more effective collaboration and increases students' participation and motivation (Dalgarno and Lee 2010). In addition, students are encouraged to exhibit active involvement and learn by experience using applied activities (Coffman and Klinger 2008). 3D MUVEs contain teaching and learning activities such as problem-based learning, inquiry-based learning, game-based learning, role-playing, virtual quests, collaborative simulations, collaborative construction, design courses, language teaching and learning, virtual laboratories, virtual fieldwork, and attending classes (Duncan et al. 2012).

These environments' educational potential is summarized as follows (Kluge and Riley 2008; Freitas and Veletsianos 2010; González et al. 2013; Papachristos et al. 2014; Antonio et al. 2015; Dad et al. 2016):

- It reorganizes and extends social interactions and collaborations.
- It provides a free environment for learning.
- It supports active participation or "learning by doing" via authentic learning activities.
- It increases learner engagement, motivation, collaboration, and communication.
- It presents new opportunities and additional scope for creativity in learning such as role-playing and mentoring.
- It supports deeper learning by embedding simulations that are difficult to replicate in the real world including buying, selling, constructing

buildings, dancing, clubbing, and even learning and training.
- It opens up new learning spaces and customized environments for rehearsal and exploration, experimentation and design, production, and user-generated content.
- It provides broader capabilities for learner-led activity as well as problem-based and exploratory learning.
- It provides learners with interaction via text, voice chat, or some animation movements.
- It offers remote access.
- It allows creation of a parallel world without limits to creativity and possibilities as the financial, spatial, and material constraints and the laws of physics are not applicable.

Three-Dimensional Multi-user Virtual Environments for Authentic Learning

3D MUVEs can be used for pedagogical classroom activities that are costly, complex, and even dangerous for learners and educators. 3D MUVEs offer opportunities to design authentic learning environments that focus on real-world complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participating in virtual communities of practice (Lombardi 2007). Herrington et al. (2002) identified ten characteristics of authentic learning environments:

- Authentic activities have real-world relevance.
- Authentic activities are ill-defined, requiring students to define the tasks and sub-tasks needed to complete the activity.
- Authentic activities comprise complex tasks to be investigated by students over a sustained period.
- Authentic activities provide the opportunity for students to examine the task from different perspectives, using a variety of resources.
- Authentic activities provide the opportunity to collaborate.
- Authentic activities provide the opportunity to reflect.
- Authentic activities can be integrated and applied across different subject areas and lead beyond domain-specific outcomes.
- Authentic activities are seamlessly integrated with assessment.
- Authentic activities create polished products valuable in their own right rather than as preparation for something else.
- Authentic activities allow competing solutions and diverse outcomes.

3D MUVEs represent a powerful media for instruction and have the ability to adapt to different learner needs (Mascitti et al. 2012). In addition, they can provide innovative ways to create challenging tasks in context (Iqbal et al. 2010). Thus, they can act as venues for authentic learning. Learners are part of a constructed environment and are engaging with the simulated environment, which is similar to real-life interactions (Farley 2016). There are some 3D MUVEs that allow designers and users to design a virtual environment such as Worlds.com (1994), Active Worlds (1995), Traveler (1996), Whyville (1999), Moove (2000), Second Life (2003), There (2003), IMVU (2004), Kaneva (2004), vSide (2006), OsGrid (2007), Smeet (2007), Smallworlds (2007), PlayStation Home (2008), Twinity (2008), Blue Mars (2009), and Onverse (2009) (Pearce et al. 2015; Tüzün and Özdinç 2016). Users utilize these environments for different purposes such as education, business, and entertainment. They may not always be appropriate for education because of user safety concerns, and authorization is limited to a user's land and avatar. In addition, there is a fee to customize some of these environments. In these cases, the open source platform called OpenSimulator can be used to create custom 3D MUVEs without fees or limitations.

OpenSimulator

OpenSimulator (OpenSim) written in C# is not a virtual world. It is an open source multi-platform, multi-user 3D application server to create your

own virtual world (OpenSimulator 2017a) released under the BSD License. It provides the ability to customize and design virtual worlds for developers. OpenSim has features to support developers and users including:

- It runs on both a localhost and server using the Windows and Unix/Linux operating systems.
- It supports personal computers as a server.
- It supports online, multi-user 3D environments from one to thousands of simulators.
- It supports different sizes of 3D virtual spaces.
- Users access the same world at the same time.
- It supports real-time Physics Simulations.
- It supports users creating or modifying 3D content in real time.
- It supports using scripting including LSL (Linden Script Language)/OSSL and C#.
- It supports different database engines such as SQLite, MySQL, and MSSQL to store all content.
- It supports instant messaging by friends or groups.
- It supports loading different modules for configuration settings.
- It supports using external or internal VoIP services such as Freeswitch or Vivox.

The latest version of OpenSim was released on August 15, 2017 to users. However, some public distributors, such as diva distribution, add their own modules and configurations and later share their repackaged OpenSim with users through the BSD license. It contains the standard OpenSim plus add-ons that support more features and tools that make the process of running and upgrading the virtual world easier (Diva 2013). Running in diva distribution is easier than OpenSim binary packages.

OpenSim can be started in stand-alone or grid mode. Stand-alone mode refers to operating all the data services in a single process when run as one or many regions. On the other hand, grid mode refers to using separate machines when multiple OpenSim instances run on different machines. Running in grid mode is more complicated than running in stand-alone mode (OpenSimulator 2017b). According to the number of users and intended use of the virtual worlds, the technical specifications for computers and servers will be different. For example, if a server is used for 20–25 users who perform tasks in virtual worlds, the following specifications will be sufficient:

- CPU: 4 Dual-core
- RAM: 8GB
- Bandwidth: If 20 users log in simultaneously, 10 MB/sec is necessary because each avatar or a user will use a minimum of 500 KB.
- Network Latency: Pings between the client and server should be better than 350 ms. It is important and critical on both upload and download to the simulator. It will affect avatar movement and object or avatar position changes.

If a server is used for 30–34 users who design in virtual worlds at the same time with VoIP, the technical specifications for the computers and servers must be improved. In addition, the number of objects used is a critical issue for these environments so storage capacity is important for designers. According to this example, the following specifications will be sufficient:

- CPU: 20 GHz
- RAM: 32 GB
- HDD: 300 GB SAS 10 K
- Bandwidth: Unlimited, 1000 Mbps Uplink

OpenSim provides an unlimited ability to customize virtual world applications easily with scene plug-in modules, although it is a highly complex system (OpenSimulator 2017c). Some of these plug-ins are for the startup of virtual worlds such as the region management plug-in. Other plug-ins are responsible for extending the functions of the virtual worlds such as voice or the effect of clouds and fog (Sun et al. 2010).

After the installation process, a viewer must be install as a user interface that allows users to modify or add connection settings to grids. The most popular of these viewers are Firestorm, Singularity, Cool VL, Kokua, Alchemy, and Radegast Metaverse Client (OpenSimulator 2017d). Most of these viewers are available for Windows, Linux, and MacOSX systems.

Multi-user Virtual Environments for Education, Fig. 2 OpenSimulator default context on viewer

A default avatar and an empty island will be displayed in the viewer in the first uploaded environment (Fig. 2).

After installation, OpenSim offers unlimited possibilities for users and designers based on their level. User powers are determined by User Level and Title (OpenSimulator 2017e).

- If a user's level is 0, the user is defined as default without any permissions.
- If a user's level is 1, the user may rename objects without modifying permissions.
- If a user's level is 100, the user may toggle character geometry, take copy, set to linden content, claim public land, and take ownership of an object.
- If a user's level is 150, the user can enable land auctions.
- If a user's level is 200 or 250, the user has full powers in the virtual world.

Initially, users' characters, called avatars, are displayed in the default view. However, they have an inventory and appearance options. Users can customize their avatars' shape, skin, hair, eyes, clothes, etc. and design their avatars' outfit.

OpenSim supports file formats and extensions as follows:

- Video: Flash (.swf), QuickTime (.mov), AVI (.avi), Mpeg (.mpeg), and RealNetworks Stream (.smil)
- Audio: MP3 (.mp3), WAV (.wav)
- Text: Text (.txt)
- Image: Bitmap (.bmp), Jpeg (.jpeg), Mpeg (.mpg, .mpeg), Portable Networks Graphics (.png), Macintosh PICT (.pict), Silicon Graphics (.sgi), Graphics Interchange Format (.gif), Targa (.tga), and Tagged Image File Format (.tiff, .tif)
- 3D Model: Digital Asset Exchange (.dae), COLLADA (COLLAborative Design Activity), and Extensible Markup Language (.xml)
- Compressed files: Compressed TAR Archive file (.tgz), OpenSimulator Archive (OAR), and Inventory Archives (.iar)
- Animation: Biovision Hierarchy Animation File (.bvh, .anim)

3D objects are designed using basic objects called prims such as a cube or cylinder. Authorized users create prims, determine their position, scale, movement, and rotation, and combine them. Prims have different features:

- General: Object's name and description, owner, and permissions.

- Object: Object's x-y-z location, rotation, size, type, and physical features.
- Features: Object's light cast and flexible path.
- Texture: Textures can be 2D images or web contents on 3D objects.
- Content: All objects have the ability to store script or animation files.

Avatars interact with 3D objects and other avatars by touching them or script triggered behaviors. In addition, Head-Up Displays (HUDs) are useful objects for interaction. These objects can be attached to an avatar to create custom interfaces on a user's screen. Some interactions, messages, or textures can be added in the 2D view on HUDs.

OpenSim provides many opportunities for authentic learning utilizing customized virtual environments. The National Aeronautics and Space Administration (NASA) sponsored one of the largest projects with OpenSim, Virtual Missions, and Exoplanets (vMAX), between 2014 and 2017. vMAX developed a 3D virtual world using OpenSim to engage middle school students and educators. The overall project goal was to create a comprehensive NASA resource to engage students, educators, and the public in the search for worlds beyond Earth. In addition, it aimed to increase student engagement in STEM (Science, Technology, Engineering, and Mathematics), knowledge of exoplanet missions, and awareness of NASA-related careers (NASA n.d.). In this project, STEM includes astronomy and physics, technology such as telescopes and satellites, and the engineering process and mathematics as applied to orbits and measurements. In addition, participants learn about exoplanets and related methods of detection as well as investigate via authentic learning activities using 3D MUVEs. Their avatars look like an astronaut and they complete tasks.

Conclusion and Discussion

3D immersive technologies, which initially came into daily life with modern computer games, have attracted research interest in the education field because of their pedagogical affordances such as enhanced learner engagement, motivation, and positive attitudes together with their openness to explore, design, and manipulate 3D objects. Today, there are increasing attempts to use 3D virtual learning environments in both face-to-face and distance learning settings to provide learners with more realistic and authentic learning environments.

OpenSim is an open source platform for building MUVEs. Unlike development platforms that offer ready-made services for accessing 3D spaces and 3D objects that can be used in these areas, OpenSim offers designers more manipulative design environments where all users can access the same design environment synchronously. Designers can also create 3D tools and objects that can be shared with other designers. Designers can modify shared 3D elements easily in accordance with their purposes. In addition, user security is high in OpenSim because of the use of private servers that are not accessible to everyone. It is important to know how to integrate pedagogy into these environments as well as how to use 3D environments created with OpenSim. However, the lack of guidance on how to organize instructional design elements and pedagogical arrangements in 3D MUVEs is a major limitation for educators.

Cross-References

▶ Online Games, Social Games and Multiplayer Games

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