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Training 4 Skills in Virtual Environment

IO5. Formulation of a game-based, virtual reality educational platform

Roadmap on Virtual Reality and Virtual Worlds

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Introduction

Virtual worlds are a subset of Virtual Reality applications that offer a computer-based simulated environment in which many users create a personal avatar and simultaneously but independently explore the virtual environment and participate in various activities, as well as communicate with others. Virtual Worlds usually require that the world is persistent; in other words, the world must continue to exist even after a user exits the world, and user-made changes to the world should be preserved. While the interaction with other participants is done in real-time, time consistency is not always maintained in online virtual worlds. Several 3D Virtual Worlds exist, aiming for various purposes such as socialization, entertainment, commercial and education.

Virtual Worlds share the following characteristics:

- Shared space between multiple users
- Graphical user interface
- Real-time interaction between users
- Interaction with the virtual environment and content
- Persistence
- User communication through text and/or voice
- Networks of people formulate forming social groups
- User avatars: a digital representation controlled by a human in real time
- Networked computers that manage all the data

The characteristics of Virtual Worlds have the potential to transform them into "educational virtual environments." There is a growing interest in utilizing Virtual Worlds for learning and teaching, with numerous schools and universities adopting these platforms for educational purposes. These environments primarily serve as secure simulation spaces and virtual classrooms. What sets Virtual Worlds apart from other e-learning technologies is their utilization of immersive 3D experiences. This immersive quality allows learners to freely explore the educational environment, fostering a sense of purpose, encouraging active participation, accommodating mistakes, promoting collaboration and communication with peers, and ultimately providing a comprehensive understanding of the subject matter. Among the most crucial and unique features offered by Virtual Worlds are the sense of immersion, where learners feel as though they are truly present within the virtual environment, and the sense of presence, which entails perceiving oneself as an integral part of the virtual world, interacting with other entities in a manner akin to a physical environment. Additionally, the presence of anthropomorphic avatars further enhances this sense of being present. Virtual Worlds inhabited by human-like avatars can greatly enrich collaborative training activities such as games and simulations. Furthermore, immersion and interaction with virtual objects enhance learners' interest and engagement in the learning tasks, contributing to the development of a more profound conceptual understanding, contingent on the content being taught. It is worth noting, however, that the effective use of highly immersive technologies alone may not suffice; it must be coupled with specific design strategies to maximize its impact.

Types and Applications of virtual reality

Virtual Reality (VR) technology comes in various forms, each offering a unique immersive experience. The primary types of virtual reality include:

- **Immersive Virtual Reality (IVR)**: IVR is what most people typically think of when they hear the term "virtual reality." It involves complete immersion in a computer-generated environment, usually through a headset. Users can explore and interact with this digital world as if they were physically present. Examples of IVR systems include the Oculus Rift, HTC Vive, and PlayStation VR.
- **Augmented Reality (AR)**: Unlike IVR, AR overlays digital information onto the real world. Users view the real environment through a device (e.g., smartphone or smart glasses) that adds virtual elements to their surroundings. Popular AR applications include Pokémon Go and Snapchat filters. Microsoft's HoloLens is an example of AR hardware.
- **Mixed Reality (MR)**: Mixed reality combines elements of both VR and AR. It allows virtual objects to interact with and be aware of the real world, creating a more seamless blend of digital and physical environments. The term "mixed reality" is often used interchangeably with "augmented reality" in some contexts.
- **360-Degree Video**: This type of VR immerses users in a pre-recorded real-world environment captured using a 360-degree camera. While users can look around and explore the video, they cannot interact with or manipulate the environment. 360-degree videos are often used in storytelling, tourism, and educational applications.
- **WebVR**: WebVR is a technology that enables VR experiences directly within web browsers, eliminating the need for standalone applications. It allows users to access VR content through their web browser, making VR experiences more accessible and user-friendly.
- **Mobile VR**: Mobile VR relies on smartphones to provide a VR experience. Users insert their smartphones into VR headsets, which use the phone's screen and sensors to create a basic VR environment. While not as powerful as high-end VR systems, mobile VR is more affordable and portable.
- **Collaborative VR**: Collaborative VR platforms enable multiple users to interact and collaborate in the same virtual environment simultaneously. These systems are often used for remote meetings, training, and teamwork.
- **AR Glasses**: AR glasses, like Google Glass or Snapchat Spectacles, are wearable devices that display digital information in the user's field of view. They offer a hands-free AR experience and are designed for various applications, from industrial use to consumer tech.

Key characteristics of virtual reality include:

- **Immersive Environment**: VR aims to immerse users in a computer-generated environment to the extent that they feel as though they are physically present in that space.
- **3D Visuals**: VR environments are often presented in three dimensions, creating depth and perspective that mimic the real world.
- **Head Tracking**: VR headsets typically include sensors that track the movement of the user's head. This tracking allows the visuals to change in response to the user's head movements, providing a more realistic and interactive experience.

- **Interaction**: VR systems often include hand controllers or gloves that enable users to interact with objects and elements within the virtual environment. Some VR experiences also incorporate haptic feedback to simulate the sense of touch.
- **Audio**: Immersive audio is an important component of VR. It can include spatial audio, which changes based on the user's head orientation, and binaural sound to create a more realistic auditory experience.
- **Sense of Presence**: VR aims to create a strong sense of presence, where users forget their physical surroundings and become fully engaged in the virtual environment.

Virtual reality has a wide range of applications, including:

- **Gaming**: VR gaming is a popular application, allowing players to step into the game world and interact with characters and objects.
- **Education and Training**: VR is used for educational simulations and training in fields like medicine, aviation, and military training.
- **Virtual Tourism**: Users can explore virtual versions of real-world locations or historical sites.
- **Architectural Visualization**: Architects and designers use VR to create immersive walkthroughs of buildings and spaces before construction.
- **Healthcare**: VR is used for pain management, exposure therapy for phobias, and physical rehabilitation.
- **Entertainment**: Beyond gaming, VR is used for immersive storytelling and cinematic experiences.
- **Remote Collaboration**: VR enables people in different locations to meet in a shared virtual space for collaboration and meetings.
- **Industrial Design**: Engineers and product designers use VR for prototyping and testing.
- **Art and Creativity**: VR tools allow artists to create three-dimensional art and sculptures.
- The technology behind VR continues to evolve, with improvements in hardware, graphics, and interactivity. As it becomes more accessible, VR is increasingly integrated into various aspects of our lives, offering new ways to learn, play, and explore.

Technological Characteristics of Virtual Worlds

3D virtual world platforms are technologically sophisticated environments designed to replicate physical spaces or create entirely new digital landscapes. These platforms leverage advanced technologies to enable immersive experiences and interactions. Here are some key technological characteristics of 3D virtual world platforms:

- **3D Graphics**: The hallmark of these platforms is their use of 3D graphics to create realistic and immersive environments. This involves rendering detailed 3D models, textures, and animations to simulate the virtual world.
- **Physics Simulation**: Many 3D virtual worlds incorporate physics engines that govern object interactions and movement. This enables realistic physics-based behaviors, such as object collisions and gravity effects.
- **Real-Time Rendering**: Real-time rendering technology allows the virtual world to react dynamically to user input and changes in the environment. This responsiveness enhances the feeling of presence and immersion.
- **User Avatars**: Users typically create and customize avatars to represent themselves in the virtual world. These avatars may use advanced character animation and rigging technologies to mimic real-world movements.
- **Voice and Text Chat**: Communication is a critical component, and platforms often integrate voice and text chat systems. These systems enable real-time communication among users, facilitating collaboration and social interaction.
- **Cross-Platform Compatibility**: To reach a broad audience, 3D virtual world platforms are often designed to work across various devices and operating systems. This includes support for desktop computers, VR headsets, and web browsers.
- **Networking and Servers**: Virtual worlds require robust networking infrastructure to handle multiple users in the same space simultaneously. Servers play a crucial role in synchronizing user actions and maintaining a consistent virtual environment.
- **Scripting and Interactivity**: Many platforms provide scripting languages or tools that allow users to create interactive elements within the virtual world. This empowers users to build games, simulations, and educational experiences.
- **Content Creation Tools**: To populate virtual environments with objects, structures, and interactive elements, users often have access to content creation tools. These tools may include 3D modeling, texturing, and animation software.
- **Security and Privacy**: Given the social nature of virtual worlds, security and privacy measures are essential. These platforms implement features like user authentication, access controls, and encryption to protect user data and interactions.
- **Customization and Modding**: Advanced platforms allow for extensive customization and modding. This enables users to tailor the virtual environment to their needs, from designing virtual campuses to creating unique game worlds.
- **Integration with Other Systems**: Many virtual world platforms offer APIs and integration options to connect with external systems. This can include data sources, learning management systems, or business applications.
- **Streaming and Media**: Some platforms support media streaming, allowing users to share videos, audio, and other media within the virtual world. This enhances presentations, events, and educational content.

These technological characteristics collectively contribute to the immersive and interactive nature of 3D virtual world platforms. They enable a wide range of applications, from virtual meetings and social gatherings to immersive learning experiences and beyond. As technology continues to advance, we can expect these platforms to become even more sophisticated and accessible.

Overview of Popular Virtual World Platforms

Virtual World platforms are the tools for creating highly immersive 3D interactive online environments that can be either replicas of existing physical places, or even imaginary places. They can represent places that are impossible to visit in real life due to restrictions such as cost or safety. There exist proprietary and open-source VW platforms. In the following of this section we will describe the most important and popular proprietary and open-source VW platforms.

Second Life

Second Life (SL) - www.secondlife.com (2003 by Linden Lab) is the most popular VW platform and the largest active community.

Most important Features:

- 3D graphical environment
- Fully customizable avatars
- Built-in voice and text communication
- Includes a social network, groups, as well as information and object sharing
- Includes in-world virtual currency (Linden Dollars (L$): 2500L$=10.09USD
- Has an enormous market: users are able to build objects and goods and write scripts in-world
- Registration and basic usage is free but there is an option of paying a monthly fee for virtual land to build a home and become 'residents' (however, large building projects require the purchase of a large piece of private land - or an island)
- Private land can be accessible only to specific group members
- Many learning organizations from all around the world are augmenting their current curriculum with virtual learning modules of SL, or even conduct classes and educational programs in SL

Architecture

- Client – Server
- Client or 'viewer':open-source, free, runs on many platforms
- Server:owned & hosted by Linden Lab

Technical Characteristics

- Physics engine: Havok 7
- Communication methods: Vivox, Inc. built-in voice, text chat and IM
- In-world scripting: Linden Scripting Language (LSL)

- Built-in 3D building tool
- Fully customizable avatars
- Image, video, audio file upload
- Web pages and media on virtual objects
- Groups and full user profiles
- Region backup and upload for landowners
- In-world economy
- Restriction in access and building rights
- Terrain modification
- Head Up Displays (HUDs)

Virbela

VirBELA https://www.virbela.com is a 3D virtual world platform designed for a range of applications, including education, business, events, and social gatherings. It offers immersive and interactive virtual environments that enable users to meet, collaborate, and interact in a digital space.

Architecture:

VirBELA was developed by eXp World Holdings, Inc., and it was originally created to serve as a virtual headquarters for eXp Realty, a real estate company. However, it has since expanded to cater to various industries and purposes. VirBELA is built using Unity3D, a popular game engine and development platform. This architecture allows for the creation of visually rich and interactive 3D environments.

Key Characteristics:

- ability to create and customize virtual campuses
- users can customize their virtual spaces, avatars, and environments to suit their specific needs
- supports both voice and text chat, facilitating real-time communication and collaboration among users
- emphasizes security and privacy, with options for private meetings and secure access controls
- offers various interactive elements within its virtual spaces. Users can engage with presentations, virtual whiteboards, and collaborative tools, enhancing the learning and collaboration experience.
- accessible on multiple platforms, including desktop computers, virtual reality headsets, and web browsers
- suitable for hosting large-scale events, such as conferences, conventions, and seminars
- encourages community building and social interactions within its virtual spaces
- provides event management tools to plan and execute virtual events efficiently

- supports learning through immersive experiences.

Active Worlds

Active Worlds - www.activeworlds.com (1997) is similar to SL in functionality. There is a “tourist account” for free usage, however paying a small monthly fee buys "citizenship”: “citizens" have a unique name, unrestricted access to the VW, avatar customization, object building, access to social networking and communication features such as voice chat, Instant Messaging (IM) and file sharing.

For more control and privacy over environments, private firewall-protected Universes are available usually for enterprise and educational purposes. These Universes are separate worlds from the main world and their cost varies. A separate set of worlds and a community for educational projectswith over 80 organizations also exists under the name“Active Worlds Educational Universe”.

Architecture

- Client – Server
- Client: free only for Windows
- Server: free for Windows & Linux

Key Characteristics

- Physics engine: NVIDIA PhysX
- Support modeling programs (Truespace, Blender, Studio Max, Google Sketchup, Collada, etc) & import of custom created 3D models
- Library of over 6000 models
- Basic scripting system (for basic object interactivity)
- Active Worlds SDK (C/C++ and Visual Basic/COM versions), for development of in-world applications
- Built-in VOIP, text chat, IM
- File transfer
- Built-in 3D building tool
- Avatar customization
- Development of NPCs
- Heads-Up Display
- Office documents display tools
- Ability to restrict access and building rights

Unity

Unity - https://unity.com/ is not a VW platform; rather, it is a 3D professional game development tool which can also be used to create suitable training simulations and educational 3DVWs. It can be accessed through a client or a web based player.

Unity can be used to develop a game along with its user interface without the need to program. The development of single-player games/apps requires only to download and install Unity but the features and properties of the developed training environment depend mostly on the ability to use the content creation tools.

The Unity Asset Store is a Unity global marketplace which provides content such as character models, landscape painting tools, game creating tools, audio effects, visual programming solutions and scripts for free or low cost. Unity evolves with the latest mobile (iOS, Android), desktop (PC, Mac, Linux), Web (web player, Flash) and console (Wii U, PS3, Xbox 360) technology.

Key Characteristics of the free version

- NVIDIA PhysX Physics Engine
- Audio 3D
- Multiplayer Networking
- Mechanim: complete animation system for characters and objects
- Professional graphics
- Single-Click game deployment to any platform
- Web-browser integration
- Scripting API (supports JavaScript, C# and Boo)

OpenSimulator

OpenSimulator, Opensim- www.opensimulator.org (2007) is a free, open-source, 3D application server for the development of multiuser 3DVWs. The VWs are accessible through various open source clients.Moreover, VWs can be private or public.OpenSimulator is based on C# and is easily extensible through external modules.
OpenSimulator's history is interesting: it started as an open source server to Linden Lab's Second Life open-source client. In this manner, the architecture of OpenSimulator is heavily influenced by that of Second Life, allowing the user to produce similar highly detailed 3D graphical environments at low cost, or at no cost provided that the hardware/software and the building/scripting/technical skills are offered for free. Furthermore, the avatars are fully customizable and resemble those of Second Life.

The in-world communication is based on chat and IM. Free voice service with lip sync is currently provided by Vivox Inc., after request. An important feature of OpenSimulatoris Hypergrid. Hypergrid

is a protocol that allows hyperlinking between OpensimVWs and supports seamless avatar transfers among these worlds.

The aforementioned and the freedom to anyone of owning, building and configuring the VW have made OpenSimulatorquite popular among the educational and science community.

Architecture

- Client – Server
- Client ('viewer'):open-source, multiplatform, free downloadable
- OpenSim Server: open-source, multiplatform, free downloadable

Key Characteristics

- Physics engine: OpenDynamics (ODE)
- Text and IM communication in-world. Voice not built-in: through external free modules: Vivox, Freeswitch, Mumble
- In-world scripting: Linden Scripting Language (LSL), OpenSim Scripting Language (OSSL)
- Built-in 3D building tool
- Hypergrid protocol
- High quality fully customizable avatars
- Image, video, audio file upload (free)
- 3D COLLADA format meshes upload (free)
- Web pages and media on virtual objects
- Region and avatar inventory backup and upload
- Access and building rights restriction
- Groups and full user profiles
- Terrain modification
- Bots (or NPCs)
- Head Up Displays (HUDs)

OpenWonderland

OpenWonderland, OW- www.openwonderland.org is an open source Javatoolkit for creating 3DVWs. OW is in early stages of development:the graphics are rather simplistic but other features of theplatform are comprehensive. The toolkit allows the creation of modules that can extend the client or the server functionality-wise. Moreover, customized, special-purpose VWs can be created.
Examples of the external modules that have been created by different developers (can be found in Module Warehouse) are: Authentication system, webcam viewer, writable text/HTML poster, collaborative text editor, and more.

A distinct feature of Open Wonderland is easily embedding existing content. There is an enormous list of document types that can be dragged and dropped into the world. Moreover, any content within the Google 3D Warehousecan be imported. Open Wonderland does not offer in-world 3D building;3D objects can be imported from Maya, Google SketchUp, Blender, etc.

Within OW Vws, users can communicate with high-fidelity, immersive audio, share live desktop applications and collaborate in an education or business context (simulations, meeting rooms, mixed-reality worlds, etc.).

Architecture

- Client – Server, both provided free, open-source

Key Characteristics

- Scripting in Javascript, PHP, Groovy, JRuby, Java, Jython
- In-world embed scripts in 3D models
- In-world run Open Office, Firefox, NetBeans, etc.
- Shared application framework (whiteboard, PDF viewer, sticky notes, etc.)
- Screen sharing
- Drag-and-drop content
- High quality immersive audio
- Telephone integration
- Webcam viewer, video player, audio recorder
- Group and private text chat, private voice chat
- Portals ("teleport") creation to locations on same server or on different servers
- LDAP plug-in for connecting to existing LDAP authentication systems

Mozilla Hubs

Mozilla Hubs, https://hubs.mozilla.com/ is an open-source virtual reality (VR) and 3D social platform developed by Mozilla, the creators of the Firefox web browser. It is designed to facilitate immersive and collaborative experiences in virtual spaces directly within web browsers, without the need for additional downloads or plugins.

Key Characteristics:

- entirely web-based, allowing users to access virtual spaces through a web browser without the need for specialized VR hardware or applications.
- click a link to join a virtual space, making it user-friendly and accessible.
- immersive 3D environments where users can meet, collaborate, and socialize

- compatible with a variety of devices, including desktop computers, smartphones, and VR headsets
- can create and customize avatars, allowing for personalization and self-expression
- real-time communication and collaboration through voice chat and text messaging
- can share images, videos, and 3D models within virtual spaces

Virtual World Platform for the T4SVEN project

In the context of the T4SVEN project, there is a need for a 3DVW environment and platform that is technically mature, as well as immersive, providing a sense of presence to the users. Immersion and sense of presence do not only refer to the quality of graphics that must be high; they also refer to avatar personalization and easy, straightforward in-world interaction.

In addition, VWs used for educational purposes might need to include programming capabilities in order to provide interactive objects and special functionality such as bots (NPCs) that will be able to support the scenario requirements, as well as mechanisms to track the user's performance and provide feedback and recommendations.

We have identified several VW platform selection criteria that are in accordance with the T4SVEN project goals:

1. Cost-free and open-source
2. Allow the development of fully customizable and multiuser VWs to simulate various scenarios
3. Good system stability
4. Straightforward server configuration and parameterization in order to fully control the VW and the usage rights at will
5. Self-hosting possibility
6. Reasonable hardware and bandwidth requirements
7. User-friendly, free downloadable, multi-platform client software
8. High-quality 3D graphics and human-like fully customizable avatars to support immersion and sense of presence
9. The platform must be popular regarding educational projects, while a large, active and supportive community of developers should exist

Based on the criteria, the platform of choice was OpenSimulator as it is more mature and fulfils all the aforementioned requirements. In addition, OpenSimulator 's compatibility to SL, the most popular 3D virtual world platform for educators worldwide, as well as its open and modular design, makes the OpenSimulator platform ideal for educational institutions and enterprises that need to have full control and maximum flexibility on their 3D simulations, while the Virtual Worlds offer graphics of similar quality to Second Life, similar functionality and similar building possibilities as Second Life but with significantly reduced cost.
Furthermore, there exist two very large and active educators' and developers' communities for OpenSimulator, which is a major advantage especially for developers not so experienced in this field. Other platforms present interesting features but they seem to be in earlier stages of development. They are also supported by smaller communities of developers.

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