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A modelling and distributed simulation platform for immersive learning

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Abstract

The burgeoning interest in the application of virtual reality (VR) technologies within educational contexts reflects a diverse landscape of research initiatives. VR, known for its immersive qualities, has garnered attention for its potential to enhance learning outcomes in higher education by fostering active learning environments. This project seeks to expand upon these promising educational methods by introducing distributed simulation (DS) technology into pedagogical and academic settings. DS empowers students to fully immerse themselves in VR environments while concurrent process-based simulations run in tandem, affording them the opportunity to engage with intricate interventions and scenarios that would be impractical and costly to replicate in real-world contexts.

Keywords: *Distributed simulation, HLA, Virtual reality, mathematical modelling, immersive learning.*

1 Introduction

The diversity of research areas that have applied virtual reality (VR) technologies in education shows an increasing interest in using this technology in educational domains. The interactive experience of VR immerses the users in a digital setting by giving them a sense of presence. VR enables the visualization and interaction with digital representations of complex ideas and dynamic objects. It has the potential of enhancing learning outcomes for higher education students by promoting an active learning environment [2]. Therefore, pedagogical practices are shifting towards a more inclusive digital pedagogy using realistic virtual multi-user settings.

In this project, it is suggested to extend these methods using a distributed simulation (DS) approach in order to adapt them to pedagogical and academic learning activities. Thanks to DS technology, students will be able to fully immerse themselves in a virtual reality environment while a process-based simulation is running concurrently during the simulation run. Thus, enabling them to experience simulated interventions or exploration, which can be challenging and very costly to reproduce in real life scenarios.

2 Literature review

Different interoperability challenges exist to integrate a variety of heterogeneous systems that might form a more complex and powerful system. Blair et al. [1] highlighted four primary levels of heterogeneity as potential obstacles to integration and interoperability. The first level is data heterogeneity, where various models offer the data in various formats. The second level is the middleware heterogeneity, where a variety of available middleware necessitates interaction protocols. The third one is the application heterogeneity, where heterogeneous components are developed on different programming languages, which complicates the communication between components. The last obstacle is the nonfunctional heterogeneity that takes into account non-functional properties.

One of the most frequently adopted standards at the moment is the high-level architecture (HLA) standard, which was created by the US Department of Defense (DoD). It is largely used to address interoperability and reuse issues in DS [3–5]. HLA is an established standard used by many researchers and engineers to solve their interoperability problems in the industry [6, 8].

The concept behind this project is to run a discrete event and agent-based simulator in virtual reality settings. A DS system is built by integrating AnyLogic, a discrete event and agent-based modelling (ABM) and simulation platform, and Unity, a 3D game engine for developing virtual reality environments. Both programs have a common extension developed to make them HLA compatible. The DS has been implemented in a hemodialysis unit based in Toronto where AnyLogic simulates the process flow of the unit and creates emergency scenarios for risk assessment and Unity offers the 3D modelling that replicates the actual surroundings and design of the dialysis unit and allows students to confront unforeseen events in real time [7].

3 Materials and Methods

The primary idea behind DS is to run simulations across different machines that are all linked to the same network. Although each component may be found on a separate distributed computer or CPU, they are all integrated into the same global simulation. The division of complexity can solve complex procedures by distributing the calculation across a number of servers, computers, virtual machines, or threads. In some case studies, using DS to divide and relocate complexity into numerous related components can be a useful option. In DS, different components, software, or simulations communicate to build a more efficient simulation system.

To produce immersive educational content, the scenario descriptions are defined, created, launched, and orchestrated using Business Process Modeling and Notation (BPMN). The tasks required to build the immersive learning scenarios along with the diverse medical conditions are all constructed in the BPMN models [6]. This allows non-computer-scientists to build their own models without having advanced programming skills. AnyLogic tool is used to create high-fidelity scenarios based on discrete-event simulation (DES). AnyLogic is a Java-based application. Users with programming knowledge can develop and add their own classes and objects. The immersive experience locations, i.e., environments and territories, are built on Unity 3D. Unity is a game engine that allows users to incorporate custom C# scripts. BPMN orchestrates the global simulation allowing AnyLogic to collaborate with unity engine. This way, AnyLogic provides Unity with required data to generate and position the agents in the VR environment. Thus, permitting users to experience real scenarios in VR settings. There are several heterogeneous components and data in this kind of sophisticated simulation. Consequently, an interoperability layer based on the HLA standard and the Run-Time Infrastructure (RTI) is established for each component of the DS.

Every 0.1 seconds, AnyLogic uses the HLA publish/subscribe mechanism to provide the time-stamped and encrypted agent (patient, nurse, doctor, etc.) data: ID, Type, and Location (x, y, z) to the RTI. Unity acquires the position and, based on the type and ID received, assigns it to the appropriate agent. Unity is set up as an HLA federate connected to the RTI and subscribed to the published data.

4 Results and discussion

In this abstract, we discuss a DS system that was created for a hemodialysis unit in Toronto, Canada, to offer hospital administrators and doctors predictive analytics, visual models, and VR applications that aid in medical education and the discovery of solutions that enhance the safety and caliber of services. Figure 1 displays the AnyLogic-generated 2D depiction of the dialysis unit coexisting with the Unity-created 3D model.



FIG. 1 Unity 3D/AnyLogic 2D representation

5 Conclusion and Perspectives

A VR DS system of a hemodialysis unit is developed based on the HLA standard. This allows trainees to interact with the simulation and examine various scenarios and their effects on the unit. To prepare for uncertain events in the hemodialysis unit, many operational management strategies can be evaluated using this DS system. This project seeks to provide an immersive platform based on various elements.

Finally, the research plans to incorporate workshops, surveys, and discussions in focus groups with both instructors and users to implement adequate learning theories and develop the required learning content and outcomes. As part of our ongoing research, we are developing evaluation techniques that will allow us to gauge users' learning experiences and determine the level of their knowledge and skills.

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