Building The Virtual Reality Instructor

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1. Introduction

Building virtual reality instructors as 3D-animated characters that behave autonomously in networked virtual environments, responds to multi-modal input across computer networks, interact with human learners using context-aware intelligence, and apply proven pedagogical techniques during instruction exemplify the potential to provide human learning anytime, anywhere, at any pace. However, building a virtual reality instructor poses significant challenges for researchers due to interdisciplinary expertise required in areas such as cognitive science, sociology, computational humanities, artificial intelligence, 3D computer graphics, linguistics, and more.

Like a virtual instructor, a Pedagogical Embodied Conversational Agent (PECA) provides tailored instruction to human end-users. However, it pays special attention to human learning characteristics such as learning styles, empirical pedagogical techniques, human emotion, and other human characteristics that impact and elevate learning. A PECA is derived from research on Embodied Conversational Agents (ECA) s, which are three-dimensional (3D) representation of human-like characters and conversational in their behavior. Like ECA systems, PECA system implementations are composed of several real-time, multithreaded components that together provide a realistic multi-modal interface for human computer interaction. These interoperable software components may combine multi-modal input processors, multilingual dialogue generators, non-verbal dialogue generators, natural language processors, face recognition systems, gesture recognition systems, knowledgebase/expert systems, real-time 3D graphics processes/generators, among other components.

2. Joint Embodied Pedagogical Agent Architecture

To build virtual reality instructor systems more efficiently, an interoperable, scalable, and modular software architecture model, Joint Embedded Pedagogical Agent Architecture (JEPAA), was developed. The JEPAA is doctorial research conducted to provide an improved method for developing a computer system/software architecture that facilitates building PECAs that consistently apply empirically tested pedagogical techniques during interactive instruction delivered to human end-users. The JEPAA was developed to address limitations in dynamic 3D animation, knowledge domain dependence, autonomous operation within network virtual reality environments, realistic interaction with human end-users, and pedagogy intelligence. The JEPAA supports the “plug-in-play” integration of various system/software components ranging from speech recognition components and
animation algorithms to gesture recognition algorithms and input devices.

3. Prototype Discussion

The JEPAA was used to generate a 3D animated PECA and all of its corresponding software components. The resulting PECA demonstrates the ability to communicate with human end-users (utilizing natural language recognition components), recognize human gestures (using artificial intelligent image algorithms), and apply scaffolding and constructivist pedagogical techniques during instruction (utilizing stored knowledge). The resulting PECA was deigned with the knowledge to provide geometry instruction to human end – users. To prepare the PECA model for operation within a netVE, a 3D animated character was developed in 3D Studio Max with a controllable skeleton and bone structure. Subsystems within the JEPAA read the 3D file to analyze and store the PECA’s body and face structure in order to prepare it for dynamic animation within a netVE. Afterwards, the JEPAA was used to develop a target “virtual instructor” system. The resulting PECA system interface was developed using a combination of C++, OpenGL, and Commercial-Off-The Shelf Products (COTS). The C Language Integrated Production System (CLIPS) was integrated into the PECA system as the knowledge-base shell to store academic domain knowledge. A relational database system, Microsoft Access was utilized to store dynamic learning tracking data. In order for the PECA to see the learner, Intel’s OpenCV was integrated and custom image recognition components developed for recognizing the physical presence of the learner and analyze human gestures. IBM’s Via Voice was integrated into the PECA system to provide voice recognition services. Custom components were developed to enable the PECA to apply pedagogy techniques during its instruction.

4. Conclusion and Future Direction

The implication of autonomous interactive 3D-character instructors that provide instruction based on proven pedagogical models and knowledge of individual learning needs is paramount to increasing human learning performance. This type of interactive learning medium demonstrates a fun and effective learning environment for persons of all ages and especially addresses K-12 learning needs. Continued research is planned to extend JEPAA with capabilities from which pervasive and ubiquitous virtual instructors and PECA systems can be built. This architectural extension will allow PECAs to better interact in real-time with human learners and leverage a location-based context to facilitate tailored instruction by geographical location for both inside and outdoor environments.