

Realizing Intelligent Pedagogical Agents in Immersive Virtual Learning Environments

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Abstract:

While Learners enjoy the sense of presence and rich visualization in 3D Immersive Virtual Learning Environments, they require more interactivity and pedagogical guidance. Intelligent Pedagogical Agents, IPAs, which are autonomous and intelligent software entities can provide such demands if they are employed in the VLE. They provide interactivity (dialogues), increase motivation and engagement, support collaborative functions, provide tutorial support, and more. This paper discusses those aspects with educational grounds. Since our target is to practically employing IPAs in the Immersive VLE, the paper reviews the required elements of such integration, visits supporting models, architectures and standards. It discusses state of the art of IPA and Immersive VLE with future perspectives of such integration.

1 Background

Immersive Virtual Learning Environments provide a step ahead for engaging learners electronically. In addition to the virtual reality benefits for learning, they offer the sense of presence to the learner and put the social learning principles in action. They improve collaborative functions and support active exploration and authentic learning experiences. Recently there has been worldwide attention to employing Second Life [1] and Wonderland [2] for education. Second Life uses Linden Scripting Language (LSL) that is C like to create 3D interactive content. LSL describes objects in the virtual world and it is event-driven meaning that an object event will trigger execution of an LSL script. Wonderland is a client server pure Java-based environment. It allows importing X3D standard objects, [3][4]. Task advice, pedagogical guidance, and environment-learner verbal and non verbal interaction are essential to such environments. Intelligent Pedagogical Agents are autonomous software entities that can act on behalf or with the learner for a pedagogical objective. They are also equipped with intelligence capabilities taken from distributed AI [5] and thus can complement the VLE for effective learning experience.

In research, IPAs took various forms from simple characters to embodied agents and avatars. The use of such agents have been used for the purpose of improving learner interactivity and engagement by providing several functions such as expressing emotions, conducting dialogues with the learner, tracking learner actions and states, and providing learning feedback. Several IPA structures have been provided and studied in [6].

Realizing IPAs in the 3D VLE is not an easy task as it considers several factors including pedagogy, learning environment constraints - current and future functions, architectures, technologies and more, but it helps in the road map for effective learning in the environment. Our purpose is seeking the best model that suits our purpose of elevating educational functions of the immersive VLE to the learner by the means of IPAs working in this special environment.

The paper is organized as follows: Section 2 discusses relevant factors for immersive virtual learning environments and related 3D standards. Intelligent Pedagogical Agents, their learning functions, and relevant work are discussed in section 3. Section 3 also illustrates agent design factors. Section 4 shows the potential for IPA's adoption in immersive virtual learning environments, its requirements, and proposes a conceptual view. Section 5 gives a conclusion and our direction of work.

2 Reviewing Software Architectures and Standards

2.1 Immersive Virtual Learning Environments and Virtual Objects

Some standards have been used for immersive virtual environments. For example VRML, which is the Virtual Reality Modeling Language [3] and X3D. Some other examples from project Wonderland and Second Life provide example practical implementations. 3D representations in Virtual worlds are adopted by the use of a scalable object model by using the Virtual Reality Modeling Language, VRML. VRML supports URLs meaning that the user can select a part of the the 3D object to navigate to a website. VRML provides the environment objects and supports their animation as well. X3D is an XML like format for representing 3D objects [4]. X3D is used to create objects in those virtual worlds such as Second Life and project Wonderland. The use of X3D object format promotes reuse of objects and help in the scalability of the virtual world. The self-describing ability of those objects, if well utilized, can support learning functions and thus can also promote active learning through exploration. Furthermore, virtual worlds are evolving from multi-user gaming environments which provide user representation through avatars. Avatars can be human-like animations to represent the learner in the environment. Immersive VLEs rely on the co-existence of learners in the environment and therefore are supported by social-constructivism for learning. Users in those environments enjoy multi-channel communication as well.

Constructing an immersive 3D learning environment and giving avatar abilities although give the sense of immersion and create the immersion pedagogy to improve learning, several pedagogical services are still needed. Further potential learning scenarios can be developed on top of the available virtual world. Another contributing factor is the potential scale of the virtual world and the volume of possible undiscovered learning resources given the millions of contributing users to those environments. Also, Immersive Virtual Learning Environments provide learning opportunities that rely on active exploration. One major design factor for virtual worlds such as second life is the scalability of resources and users. This implies a potential for massive learning resources to exist and to be explored (active learning). In other words, the immersive VLE can enhance learning experiences with just in time learning is exploited. This represents a major design factor. Therefore, we find adopting IPAs in the environment can solve those problems.

2.2 Learner Representation in Immersive VLE

Most virtual worlds including Second Life and WonderLand provide avatar representations for representing the user in the environment. The avatar has two modes of operation. The user can control the avatar if he/she is online. Also the avatar may provide offline functions. Therefore avatar to avatar interactions occur based on different properties that can be embedded. For the learning purpose, an example property is related to pedagogical objectives and capabilities of the learner. Intelligent Tutoring Systems, ITSs considered personalization methods to improve Web-based learning by creating adaptive learning environments based on individual learning needs and properties. Evidently, understanding the learner is crucial to effective learning. Several personalization tactics can improve the active explorations and collaborations in virtual worlds as well if the learner is well modeled in the environment and if such representation can be safely discovered and used. The research work in [7] supports personalization in Virtual Environments in general through the use of Intelligent Pedagogical Agents. In this work, agents extended prior human-like characters to provide further personalized learning services such as the mentor-agent and the guide-agent [7]. The agent obtains information of the learner qualifications, interests, and activities through interaction and by reading the user model and act upon the learner based on those models. Personalization with IPAs should be considered as a major pedagogical design element.

3 Intelligent Pedagogical Agents - IPAs

Intelligent Pedagogical Agents are autonomous software entities with pedagogical purposes, [6]. Their functions include providing pedagogical guidance, tutorials, the ability to find learning resources, tracking learners progress, and aid collaborative and communicating learning functions. A main purpose is to provide a smart, pedagogical-aware and personalized learner-environment interaction. Therefore, it is crucial that integrating IPAs in the immersive environment should facilitate those functions. The immersive VLE is expected to be scalable with numerous learning resources as mentioned above. This provides advantages if the content is personalized to the learner depending on his needs and abilities. i.e. to have controlled active explorations in the environment rather than random ones. If the environment is scalable (see second life for example) to encourage users contributions with learning resources, one can conclude that design concerns exist. For example, considering reliability of the learning content, having combatability of learning resources, language, and cultural issues. Adding constraints to the design elements of the VLE does not solve those problems but can complicate and then hinders the environment scalability. The use of intelligent agents rather can overcome those obstacles to discover and present reliable, consistent, and cultural-safe resources and scenarios in those environments. Other agents (or the same ones) can be working in the background to support group communication and learning which is one of the major advantages of the VLE that brings distant learners closer. Agents can support this as well in the environment [5].

Design of the IPA should consider several aspects including interactivity, dialogues with the learner in different forms, emotions, pedagogy, and collaborative functions [5]. Irrespective of the VLE aspects, Intelligent Pedagogical Agents have several dimensions of design considerations:

- Learner-IPA interaction elements: IPA provide a smart user interface. As shown in [6] IPA can be a character that can provide gesture, provide smart moves to attract attention, and speak to the learner. IPAs are considered effective to improve the sense of presence in the immersive VLE and improves motivation. Several works include dialogue abilities as well.

- Agent Design: For the IPA to represent the learner in the environment, personalization properties are considered. For example, the ability to interact with a learner profile. Pedagogical goals are given to the agent.
- Multi-Agent Design: Agents are autonomous and intelligent software entities. Providing smart pedagogical functions are needed in the environment. Thus the agent design should consider those elements. An Agent-oriented design is needed to allow distributed intelligence and cognition abilities.
- Interaction with the environment objects. It is the ability of the agent to read a 3D object in the environment (X3D for example), present , and follow up on the relevant learning goals. The pedagogical agent can play a major educational role by interacting with self-describing 3D objects to aid learning, extending the avatar roles in [8].

IPAs inherit properties from multi-agent systems which is a field of Distributed AI. Here we are concerned with how the agent will interact with the learner, with the environment with other agents, and how pedagogical functions are conveyed by the agent to the learner. Other functions include motivation and engagement of the learner. How the IPA will provide navigation guidance to the learner? And what are the technologies and structures supporting IPAs?

3.1 Agent-based Design

An Agent-based design is a major design decision. One important demand of learning in virtual worlds is improving collaborative learning. An agent-based architecture can be the glue to link learners together and help achieve group learning goals. An intelligent agent-based model can help to resolve the following [5]:

1. Help in discovering peers online and provide best group formation
2. Help in multi-channel communication and facilitate social interactions
3. Aid in setting group-learning goals and resolve conflicts among the group
4. Monitor unhealthy interactions among the group

An individual Intelligent pedagogical agent can have the following characteristics

1. Visual appearance and interactivity with the learner. The visual appearance of the the Agent is important in engaging the learner and keeping the learner attention. Providing a smart Human-Computer Interaction with the world through an interactive character/avatar helps in the visual representation of the environment, improves interactivity and keeps the learner engaged. It also helps learners to discover learning resources. One such scenario is a learner looking for a specific tutorial on a subject matter. Both factors contribute to improving the sense of presence in the environment and thus making an effective learning experience.
2. Autonomous and Intelligent Pedagogical behaviour – Other pedagogical properties of the agent include pedagogical properties such as providing smart guidance in the massive learning resources, provide lesson plans, organize resources in a way that is suitable to the learner. While personalization supports learning, the pedagogical agent will be the middle point between the learner and the environment for achieving this personalization. The pedagogical agent will be able to provide several personalized learning services based on a stored learning profile for example.

In Multi-agent systems instead, each agent acts in the environment and interacts with other agents to achieve an encoded goal. Therefore, agents negotiate objectives among themselves

and resolve conflicts. They have such autonomous behavior in the environment. The use of agent communication can be a background mechanism to aid to user communication. Agents can interact in the environment via an agent communication language such as FIPA-ACL, [8]. FIPA itself is an IEEE supported standard for multi-agent systems. The research work in [10] developed personalized pedagogical agents based on FIPA.

Currently several virtual worlds are evolving as separate worlds while there are minor efforts to link them. IPAs can be considered for bridging the learning between separate worlds (federated virtual worlds) as well.

4 IPAs in Immersive VLE

Some related research works targeted employing the MAS model in 3D Virtual Worlds. The work in [11] provided a proof-of-concept of an agent architecture that works in VRML-based Virtual Worlds. Benefits of this model include reasoning abilities and the ability of extension to improve collaborative work. In this work the agent is an autonomous avatar that can find his way in a 3D maze. For the the project of River City in Virtual Singapura, authors in [12] recognize the importance of employing an agent-based model that uses goal-net architecture. A goal-net a heirarchy of goals that agents need to go through in order to achieve a bigger goal. In this project the avatar is equipped with goal-net agents, see Figure 1.



Figure 1: Agent Controlled 3D Avatars in River City, from [12]

Furthermore, work in [13] denoted the importance of employing an MAS model in the VLE for learning architectures to achieve several gains relevant to the sociability nature of the environment. It also denoted its importance for the cooperation in the environment. It coincides with our work towards collaborative learning functions in the distributed learning environment by means of Intelligent Agents.

Our study suggests a conceptual view of the IPA working in an immersive VLE to reflect new possible scenarios for learning in the environment and to provide intelligent pedagogical functions in the immersive environment. It considers the following aspects:

1. IPA functions and structures – an IPA model
2. The learning services the VLE will provide – the VLE components model
3. The learner model
4. Pedagogical model
5. Possible interactions for a pedagogical objective
 - a. IPA-Learner : for learning functions and supporting collaborations
 - b. IPA-VLE
 - c. Learner-VLE for active learning functions
 - d. Others; Learner-Learner or IPA-IPA

Therefore, we propose an agent model to complement the virtual world environment to consider the following:

- Agent individual roles:
 - o An avatar (user) is a visual representation that can interact with other avatars / agents.
 - o Individual non-visual agents can provide pedagogical services to the learner such as information about learning 3D models (lab device for example).
 - o Other visual pedagogical agents have a teaching /tutorial roles. Those are avatar like characters but they are autonomously non-controlled by a learner with the possibility of being controlled by human instructors instead. A visual agent may be associated (or be able to interact) with VRML objects to provide a tutorial (simulation) of assembling an object or replay certain steps of an experiment by interacting with the learner. An Intelligent pedagogical agent might be able to create a 3D learning object on the fly.
- Multi-agents can form societies of learning to cooperate to form bigger goals (making a big building for example).

Conclusion

This paper presents an on going study direction of physically implementing agent functions in Immersive Virtual Learning Environments and check implementation possibilities. Immersive Virtual Learning Environments should be different from regular virtual worlds by having rich learning services and capabilities by means of intelligent pedagogical agents. In analogy to real worlds where people can watch a building but need teachers to give them knowledge on the building process, in virtual worlds users need pedagogical guidance and tutorials to get the required knowledge. Adding pedagogical functions with multi-agent intelligence to those environments is expected to improve learning experience for learners. Thus the architectures and standards of current environments have been visited and the requirements of agents have been investigated. The paper visited models that attempted to integrate agent and IPAs in those environments.

We suggest an architecture that considers the requirement a component (object) based architecture that integrates VRML/X3D requirements with an a multi-agent implementation and include the pedagogical functions of IPAs. Therefore, our future work is targeting implementing the agent-based model to support pedagogical functions described in the virtual world. The FIPA environment is suggested for an intelligent agent environment and project wonderland or SecondLife for Virtual World implementation. We also propose to further equip the avatar with intelligent agent functions.

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