Modeling Curiosity for Virtual Learning Companions
(Extended Abstract)

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ABSTRACT

Curiosity is an emotional motivation that drives knowledge acquisition in learning context. Studies have shown that curiosity positively influences social learning and a peer learner's curiosity may elicit the curiosity of other learners. Hence, modeling curiosity in learning companions may improve human learners' learning experience in virtual environments. However, curiosity has not been explored as one key personality trait in existing learning companions. In this paper, we propose a novel model of curiosity for learning companions to capture salient curiosity stimuli based on human psychology. Our model is based on Silvia's theory and considers three most salient appraisal variables in virtual learning environments, including novelty, surprise, and uncertainty.

Categories and Subject Descriptors

I.2.0 [**Artificial Intelligence**]: General - *Cognitive simulation*; I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence - *Intelligent agents*

General Terms

Theory, Experimentation, Human Factors

Keywords

Curiosity, Learning companion, Virtual learning environment

1. INTRODUCTION

Virtual learning companions take a peer metaphor to simulate peer interactions, which allow human learners to take advantage of the cognitive and affective gains of human peer-mediated learning in a virtual learning environment [3]. The general role of a virtual learning companion is illustrated in Figure 1. It can be shown from this figure that a human learner is the main actor in a virtual learning environment, who acts upon the environment and learns from it. A virtual learning companion performs as a peer who observes the human learner's actions and their effects, i.e., the environmental changes. Based on the observations, the virtual
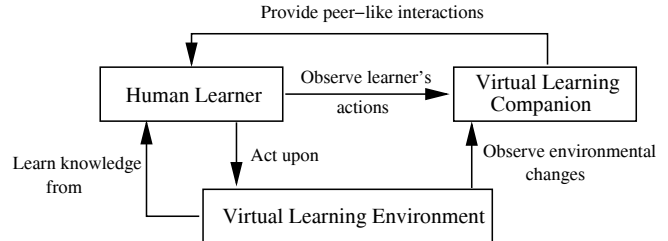
Figure 1: The role of a virtual learning companion.

learning companion performs cognitive and affective reasoning to provide appropriate peer-like interactions with the human learner.

Curiosity is an emotional motivation related to exploratory behaviors such as learning, investigation, and exploration, which drives human beings to ask questions and explore for answers [1]. Modeling human-like curiosity in a virtual learning companion may allow the companion to discover knowledge gaps and formulate questions. These questions add new ingredients into the interactions provided by the companion, which may help human learners notice the weakness in their knowledge structure and motivate them to actively explore the virtual learning environment. However, curiosity has not been studied as a key personality trait in existing learning companions. To study the impact of a curious learning companion on learners' learning experience in virtual environment, we propose a novel model of curiosity for virtual learning companions.

2. MODELING CURIOSITY APPRAISAL

Our model is built based on plan-based knowledge representations augmented with decision-theoretic planning techniques. For curiosity appraisal, the model takes Silvia's appraisal structure [2] as the theoretical foundation and considers three most salient variables in virtual learning environments, including novelty, surprise, and uncertainty, all of which reflect certain knowledge gaps.

Novelty refers to something new. For instance, a child would be attracted to a toy that he/she has never seen before. The appraisal of novelty involves of a comparison between the current stimuli with the previous experienced ones in memory. An object o is novel if the companion $\mathcal{C}$ has no priori knowledge about it. A novel object o indicates that the knowledge points associated with o do not exist in the agent's knowledge base and hence create a knowledge gap, which leads to $\mathcal{C}$'s curiosity.

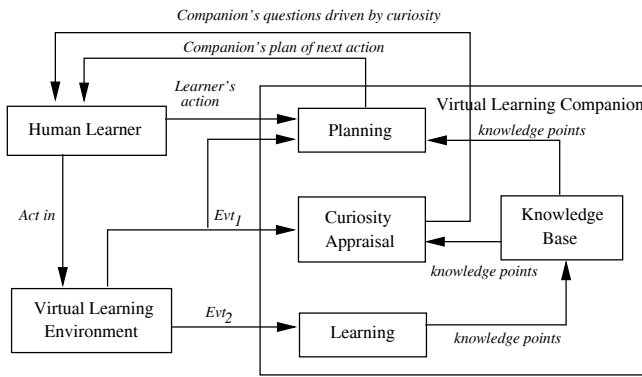Surprise implies the existence of an expectation with which

Figure 2: Architecture of the Curious Learning Companion.

the stimulus disagrees. For instance, a child would be surprised if a toy car goes backward when the forward button is pressed. The appraisal of surprise involves comparisons between an expectation and true facts. An object o is surprising if it does not follow the companion $\mathcal{C}$'s expectation when the human learner's actions are performed upon o. Surprise indicates that $\mathcal{C}$ is not clear about how an object is affected by an action, which reflects a knowledge gap between the agent and the environment, leading to $\mathcal{C}$'s curiosity.

Uncertainty arises when there is difficulty in selecting a response to a stimulus. For example, a child would feel uncertain which road to choose for his/her remote control toy car when not enough information is provided for two roads. The appraisal of uncertainty involves comparisons among multiple competing responses. The companion $\mathcal{C}$ is uncertain when multiple actions are applicable in one world state. Hence, uncertainty indicates that some preconditions are not yet complete for certain actions and reveals a knowledge gap, which leads to $\mathcal{C}$'s curiosity.

3. IMPLEMENTATION

The proposed model of curiosity is implemented in a virtual learning companion (Figure 3). Figure 2 presents the architecture of the curious learning companion. It can be seen from this architecture that the agent observes actions of the human learner and listens to two types of events in the environment. The learner's actions are sent into the agent's planning module to facilitate its decision-theoretic planning process. Type I event Evt_1 triggers two process: (a) the agent's planning process to suggest actions for the human learner, and (2) curiosity appraisal procedure to discover curiosity stimuli and formulate questions. Type II event Evt_2 occurs when a knowledge point is discovered, which triggers the agent's learning procedure to update its plan structure and to satisfy its curiosity.

In the virtual learning environment, learning concepts are visualized as virtual objects, the states of which are changed through actions. For example, the concept *water* is visualized as a water molecule object in the virtual world, and the location of water changes from ground to root if the action *osmosis* is applied on the water molecule object. Learning goals can be achieved by following a correct plan of actions. For example, to complete the goal *bring water into root*, the correct plan is a_1: *collect water molecules*, a_2: *collect partially permeable membrane*, a_3: *adjust water ratio*, and a_4: *osmosis*. The virtual learning environment provides knowledge points that can be learnt by human learners to form

Figure 3: The virtual companion is showing curiosity towards the novel concept osmosis by asking "What does osmosis transport? Let's ask the Sage."

plans. For example, an important knowledge point that is required to form the plan for the task *bring water into root* is *partially permeable membrane is required for osmosis*. In a virtual learning environment, a knowledge point can be acquired from other knowledgeable non-player characters.

The learner is the main performer in the virtual learning environment, whereas the companion act as a collaborator which observes both the learner and the environment. Evt_1 happens when the world state changes due to the learner's actions. This will trigger the companion's planning component to plan for the next applicable actions for the learner. The agent shares its plans with the learner through dialogs. For example, when the companion finds the next applicable action to be *osmosis*, it will inform the learner saying that "Hey, my plan is to get into the osmosis hole now."

In parallel, Evt_1 triggers the companion's curiosity appraisal process introduced in the former section to discover curiosity stimuli (novelty, surprise, and uncertainty) in the virtual environment. When the agent's curiosity arises, it will demonstrate curious behaviors by asking thought provoking questions to the learner and encourage the learner to actively look for answers. For example, when surprise arises upon the failure of action *osmosis*, the companion will show curiosity and ask "It surprises me! I'm wondering what condition is missing. Shall we ask the Sage?".

Once the learner acquires a new knowledge point, Evt_2 occurs and triggers the companion's learning process to incorporate the new knowledge point into its knowledge base, which contributes to forming better plans in the future.

4. ACKNOWLEDGMENTS

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