Educative Distributed Virtual Environments for Children
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Abstract: This paper presents a distributed virtual reality environment for children called EVE – Environnements Virtuels pour Enfants. The virtual environment architecture is reactive agents based. The FCM - like dynamic action planning mechanism assures agents’ adaptability to its environment changes. This virtual environment supports cooperation among members of a dispersed team engaged in a concurrent context. By the means of their avatars, special cases of agents, users are allowed to interact and to give decisions using cooperative mechanisms. A user-friendly interface enables teachers to create stories that fit with children’s pedagogical requirements and generate new virtual environments according to the teacher’s specifications. The implementation is based on DeepMatrix as environment server, VRML and Java as languages and Cortona VRML plug-in from ParallelGraphics.

1 Introduction

Learning to read is a difficult but important task for a child. It takes time and supposes a constant effort from its part. Like many other school activities, reading involves a child’s capacities as attention and memory, knowledge (of letters) and know how as searching and discovering the word’s sense in a given context. More, a task failure can generate a fear from on the child’s part concerning particular notions, or notions related with the unaccomplished task. At the beginning of primary school, some children have not achieved all the necessary acquisitions to basis tasks. For example, some have difficulties to place in order a set of labels in order to construct simple sentences. New technologies such as Internet, multimedia, and virtual reality are now parts of our children’s everyday life. For this reason, it is not surprising that educators grow their interest in distance learning and distributed education, and try to use these types of media in their lessons. Our paper presents a distributed non immersive virtual environment (VE), called EVE: Environnements Virtuels pour Enfants (Virtual Environments for Children), which helps primary school children learn to read.

2 Background

With ever-increasing computational processing power, the rapid growth of the World Wide Web, and the ongoing construction of a digital communications infrastructure, the creation of distributed (immersive), multi-participant VEs running on the Internet starts to prove its usefulness in child education. These learning experiences may come in many forms. Educational quiz-like or puzzle-like kids’ games for ABC activities such as reading, reading comprehension,
math, writing, and so forth, and digital libraries, such as QueryKids (Druin et al., 2003), are some examples of multimedia supported learning environments. More, these experiences realise cultural enrichment of a child’s knowledge. Dedicated Web sites provide online learning activities that are combined with games and information for elementary school projects as a help to navigate on the main Web sites. Much of the appeal for applying VR in education is derived from the observations of educational theorists (Bruner, 1986; Piaget, 1929) who have stressed the value of actualizing learning through making it more real for students. The opportunities for young users to visit places and interact with events that distance, time, or safety concerns would normally prohibit, the greater understanding of concepts through the creation of multi-modal metaphors or representations and the ability to scale and manipulate these representations (Winn, 1993) are the major benefits of applying VR in educational environments.

3 Virtual environment’s architecture

For the development of EVE as educational application, we have considered technological, domain specific, pedagogical and psychological aspects. In EVE, we consider that the virtual environment is populated by virtual entities that correspond to objects populating the real world. In our vision, the “meaning” of each virtual entity is its associated object in the real world. In the following, a virtual entity, briefly called entity, is the set of all informational shapes which complete its meaning. By using various criteria, we can structure the set of entities within the virtual environment. A receptor is a stimuli detector in an informational space, while an effector realises shape modifications by means of the entity’s actions in the virtual environment. The entities may be grouped in order to produce complex aggregations, themselves entities. The VE consists of a set of rooms that creates a simple maze: cooperation is basically supported by directly embodying the users in the VE using different avatars, and providing them with different inter-user communication facilities such as a set of predefined behaviours. The first one is the integration of different types of information and educational support other than 3D representation (such as audio annotations and images). More, we have defined specific tasks to the children through interaction. Participants are able to move their avatar around the rooms using the arrow keys and/or using the mouse. They are able to pick up objects (labels, images or speakers) in the VE by click-and-drag or just click them. Participants can communicate with each other using a chat channel. A story is defined by an ordered set of nine sentences. A picture illustrates each sentence. A sound file is also linked to the sentence in order to enable children to hear the sentence. A sentence is defined by an ordered set of words. According to this data model, which is really simple, we have chosen to implement this model using a simple directory structure. Another challenge was to provide teachers with a user-friendly interface that enables them to build their own stories. Using this tool, teachers can create stories that fit children pedagogical requirements all along the school year. When this job ended, the teacher saves the story on the server. Before proceeding to data transfer, the application automatically generates a gif file for each word taking into account word length in order to use the best character font size and transforms each wav file into an mp3 file in order to reduce the amount of data. The teacher can clear the interface, and load or delete a story from the server previously created. A new virtual world that implements the new story is generated when the teacher decides to publish its story.

4 Implementation

In our approach, a virtual agent is a complex entity in the virtual environment able to perceive, decide, and react based on its profile, internal structure, and tasks. Users’ avatars are particular cases of virtual agents. In order to realise the agent’s setting in situation into the virtual
environment we have followed the immersion, the interaction and the autonomy principles (Tisseau & Harrouet, 2003). Our approach uses perception and emission fields of the entities, which are generalisations of medium, nimbus, aura, and awareness notions as they were introduced in Benford and Fahlén (1993). The entities are supposed to populate a multi dimensional informational space. This space is called virtual environment and it is viewed as the union of all entities’ fields. The interactions between agents are of cause-effect type: any change of the agent’s state represents a possible cause and may be followed by a stimulus emission.

In our approach, the stimulus contains information regarding the agent state (Popovici, Serbanati & Gerval, 2003). All the agent’s actions are followed by stimuli emissions. Our virtual agents are autonomous in the measure of their adaptability to their dynamic environment. For this, they have to be able to perceive the environment changes, to decide and to react accordingly (Figure 1).

![Figure 1. Agent’s Architecture](image1)

A more detailed view of the agent’s architecture is given in Figure 2.

![Figure 2. View of the Agent’s Architecture](image2)
During the virtual agent’s life, its state is given by the values of its attributes that are the generators of its structure. The structure’s variations are produced by the effectors and are perceived by means of the receptors, under the form of stimuli. In their turn, effectors, founded in the action module, may operate structural modifications followed by stimuli emissions, or may trigger themselves specific stimuli. In this way, the agent’s life cycle is completed. The problem that arises concerns the dynamical aspect of the agent’s environment. In order to eliminate this inconsistency we use a dynamical FCM like action planning mechanism, based on agent’s perception, situated at decision level. Using fuzzy cognitive maps (FCM), instead of the hierarchical task networks (HTN) (Cavazza, Charles & Mead, 2002), we are able to ensure the agent’s adaptability to environment changes. A FCM is an influence graph having as nodes elements of a set of concepts. Concepts may be sensorial concepts (if they express perception values), internal concepts (for knowledge or decisional values), or driving concepts (for actions/objectives values) that the agent possesses. This way, each time the FCM is computed, the agent’s behavioural (re)-activation is realised. Let us consider the following FCMs, associated to the agent that plays the role of the tutor in EVE (Figure 3).

![Figure 3. Parts of the Tutor's FCM](image)

Here, the sets of FCM concepts are “obstacle left,” “obstacle right,” “child far,” “child close,” “good answer” and “bad answer” as sensorial concepts, “motivation to approach” and “need to assist” as internal concepts, and “turn left,” “turn right,” “approach” and “assist” as driving concepts. “Advice,” “valid sentence” and “valid story” are also driving concepts but, as we shall see in the next section, they are used in “assist” action plan. This means that they are not involved in the decisional process but the behavioural one. In our model, not only are the agent’s objectives viewed as fuzzy goals (El-Nasr, Yen & Ioerger, 2000), but also the action plans. We use three behavioural operators, “all,” “first of” and “sequence” in an action plan expression. To briefly describe them, let us denote by wait the action with any arbitrary effect (i.e., any set of resulting stimuli) on the agent’s state/structure and which is by default accomplished, and by none the action that is never accomplished. We will denote by $A$ the set of an agent’s
actions, by $A^*$ the set $A\{-\text{wait}\}$, and by $Time$ a linear temporal structure assumed to be discrete for the sake of simplicity. We define the $ALL$ pattern by means of the binary operator “all” $\Theta$: $A2 \rightarrow A$ with the following semantics: we say that an action $A_{res}=A1 \Theta A2$ is completed, and so the associated context is validated if $\exists t_j \geq t_0 \in Time$ for which both $A_1$ and $A_2$ are completed in the moment $t_j$. Here $t_0$ denotes the moment of parallel activation of the actions.

Here, the set of FCM’s concepts will correspond to the action’s components, actions themselves. For each of the agent’s effectors there will be one action that the effector controls. This means that an activated action will not activate its influenced actions (i.e., the actions activated by the current one in the FCM) until the corresponding effector completes its job. In Figure 4, we have associated the effector $i$ to the action $A_1$ and the effector $j$ to the action $A_2$. With $ALL$ pattern we can express parallel cooperative actions (non-sequential). Using the same FCM structure but with different influence values we obtain another binary operator, the “first of” $\oplus : A^* \rightarrow A$, which gives us the $FOF$ behavioural pattern. Its semantics are the following: we say that an action $A_{res}=A1 \Theta A2$ is completed if $\exists t_j \geq t_0 \in Time$ and $\exists k=1,2$ such that $A_j$ is completed at the moment $t_j$ and $A_k$ is not completed before, that is, at any moment $t_i$, $t_0 \leq t_i \leq t_j$. In this case, the context consists in the first accomplished action’s effect. We use the $FOF$ pattern when parallel concurrent actions (non-sequential) are needed. When an order between the plan’s actions is needed, we can use yet another pattern, the “sequence” one (SEQ), defined by the operator $\Theta$: $A \rightarrow A$. We say that an action $A_{res}=A1 \Theta A2$ is completed if $\forall j=1,2 \exists t_j \geq t_0 \in Time$ and $t_j \geq t_j-1$ with the property that $A_j$ is completed starting with the $t_j$ and $A_{j+1}$ is activated at $t_{j+1}$. Here $t_0$ represents the moment of the activation of the action $A1$. In other words, the actions are activated and completed in the indicated sequence. By constraining the action(s) completion into a time interval, we obtain the bounded versions of the above defined $ALL$, $FOF$, and $SEQ$ operators, as van Lamsweerde suggests (Lamsweerde & Letier, 2000). FCM convergence to a fixed-point attractor assures the action’s accomplishment or failure, depending on the value of completed concept at this point. In our notation, we can express our tutor agent’s global objective as $O=ALL(AC,F,ASC)$, where we have noted by $AC$ the “avoid collision,” by $F$ the “follow the child” and by $ASC$ the “assist the child” objective. According to the proposed operators semantic, the tutor will evaluate and then activate the three objectives, based on their corresponding values in the FCM. If there are some concurrent actions with similar effects, then they are let to cooperate; otherwise the action with lower priority is made inactive. In our case, the only concurrent actions may be $AC$ and $F$. For this, the value of the corresponding driving concept for $AC$, respectively for $F$, is given by the inverse of the distance to the object the tutor will try to avoid respectively the child the tutor is following. After the currently active action will be accomplished, the rest of the actions will be re-evaluated and activated accordingly. We have to remind that the associated effectors control the values propagation through a fuzzy plan. This makes them different than but as simple as classical FCMs.

5 Conclusions

In this paper we have presented a virtual environment specially dedicated to pedagogical purposes. The application is successfully now in use as a complement of traditional learning exercises in primary schools from France and Romania. On a pedagogical point of view, planned for the primary courses, EVE is now adaptable for older children. The teacher may pass from a text comprehension to grammar or syntax studies. More, new applications should be developed in other domains of interest. On a technical point of view, current experiments will help us to design and implement new avatar behaviours according to end users’ needs. We are also working on a more sophisticated mechanism, which is the integration of streaming audio and video into the virtual world.

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References


