Emotional agent in serious game (DINO)

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ABSTRACT
In this paper, we introduce an novel emotional agent system in 3D virtual world based on OCC (Ortony, Clore and Collins) theory, FCM (Fuzzy Cognitive Map) and GoalNet. The agent system is designed based on Goal Net model. Emotional modeling and decision making are based on OCC and FCM inference. Emotions modeled by the OCC model are incorporated into FCM inference. It has been shown emotion has a great impact in decision making. The proposed agent system has been applied to design human-like dinosaur agents in the research project "Immersion and Embodied Learning: Traces of Dinosaurs in Earth System Science" supported by National Research Foundation (NRF) Singapore. In this project, we have developed an agent mediated immersive Interactive Digital Media that appropriately recreates and replays the traces of Earth's history using intelligent agent technology and 3D multi-user environment. The virtual world and emotional dinosaur agents are shown in the demo. The experiments conducted by students in secondary schools in Singapore have shown the emotional agents enable deep learning of earth science.

Categories and Subject Descriptors
I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems – *Games.*

General Terms
Algorithms, Design, Experimentation, Human Factors, Theory.

Keywords
Virtual Agent, Interactive Virtual Environment, Agent-Based Game, Affective Decision Making.

1. INTRODUCTION
Emotional agent has been an active field of agent research. Although in our daily usage "being emotional" suggests negative behaviors, it is shown that emotions sometimes provide more reliable information about situations than reasoning, and supply the best resources to accomplish goals [4]. Therefore, emotion plays an essential role in human-like agent simulations. In games and virtual worlds, emotions enhance the believability of the Non-Player Characters (NPCs), which are represented as agents.

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We designed an emotional agent system, in which emotions will play part in decision making. The planning system is designed based on Goal Net model [2], a goal-driven planning method. In Goal Net, agent's goals are achieved after accomplishing a serial of intermediary sub-goals. The decision making in Goal Net is implemented with Fuzzy Cognitive Maps (FCMs). FCM supports adaptive behavior based on empirical prior knowledge and provides a graphical representation of that knowledge that can be used for explanation of reasoning [3]. Emotions are represented in the FCM as concepts and are identified based on the OCC model [1]. The fuzzy values of the emotions will affect how plan is made. The responses from the world will affect the next emotions and therefore future decisions.

This idea is used in the project "Serious Immersion and Embodied Learning: Traces of Dinosaurs in Earth System Science" (http://www.isle.lsl.nie.edu.sg/VAD/wiki/index.php?title=Main_Page). The main purpose is to develop an immersive interactive and digital media (IDM) to support education of secondary level Geography in Singapore. In the form of an educational game, interactive virtual worlds with dinosaur agents are created for users to explore.

This paper is organized as follows. Firstly, the educational game is described. Then we explain how the dinosaur agents are modeled and how the emotional planning system is designed. In Section 3 we illustrate the proposed demonstration at the conference. Finally, a conclusion is drawn in Section 4.

2. GAME DESCRIPTION
The motivational, contextual, and conceptual anchors of the prototype are ancient creatures, history of Earth, and fossils. The learners enter into the 3D virtual world, within which there is no distinction between learning and play. The 3D world is an open-ended space for problem solving and collaborative investigation whereby learners can take up different roles. In order to increase children's feeling of presence and foster their studying interests, a first-person interface is adopted. Some tasks are designed to guide users to explore the world. A user plays a role and can learn geography knowledge through interactions with the world and completion of tasks. Another objective of this game is to cultivate students' teamwork spirit. This objective necessitates some roles to cooperate to accomplish a task. Dinosaurs will be implemented as automatic agents to show some intelligent and emotional behaviors.

The game is developed using Torque Game Engine Advanced (TGEA) developed by GarageGames. TGEA is a 3D game

so on are created and incorporated into the virtual world. Game stories and agent controls are implemented by using scripts.

3. DINOSOUR AGENTS

3.1 Agent Modeling

Dinosaur agents will show autonomous behaviors including foraging, resting, avoiding danger and wandering. The agent system is designed based on the BDI model. A dinosaur explores and learns about the world by itself; new information is summarized as belief. Based on its own status (hunger, thirst and energy, etc.) and the world information (locations of water, food and danger, etc.), the dinosaur will adopt new goals, make and execute action plans.

As users of this game are schoolchildren, dinosaurs are personified to show some human characteristics. This feature can foster children's interests and they can acquire knowledge through the interactions. For example, dinosaurs can talk with players. The Artificial Intelligence Mark-up Language (AIML) are used to input chat knowledge into dinosaurs based on the A.L.I.C.E engine. Emotion plays a crucial role in the human-like behaviors of the dinosaurs and user modeling.

3.2 Affective Planning and Decision Making

The OCC model is applied to identify emotions. In the OCC model, emotions are considered as human reactions to consequences of events, actions of agents, and aspects of objects. Emotions are identified according to appraisal based on goals, standards and altitudes. For example, if a dinosaur meets its goal of drinking water, it may feel joyful.

However, the OCC model does not describe procedures for quantitative evaluations and does not model the interactions of the emotions. More over, it does not tell how an identified emotion will affect the agent's future behaviors, including decision making and actions. We propose to include emotions in the planning system. Goal Net is adopt to model agent's planning system. To infuse emotion into agent planning for affective decision making, Goal Net is calculated as a Fuzzy Cognitive Map (FCM). A Fuzzy cognitive map is a cognitive map within which the relations between the elements (e.g. concepts, events etc) of a "mental landscape" can be used to compute the "strength of impact" of these elements. Fuzzy cognitive maps are signed fuzzy digraphs. For example, a fuzzy value for "hungry" shows how the status "hungry" will affect the agent's decision. FCM provides a natural way to quantity the emotions. The intensity of emotions will affect goal adoption and action selection. FCM also models the dynamics and interactions of emotions. An example of affective decision making can be seen when a dinosaur will feel fear near an erupting volcano and run away though there may be food around, as shown in Figure 1.

4. DEMONSTRATION

A prototype of the game has already been developed and experiments have been conducted by secondary-one students in schools in Singapore. In the game, students were asked to save dinosaurs from volcano eruptions. Volcano knowledge can be learned through the play. More over, the game play motivates the students to learn deeper knowledge of volcano. Currently we are planning and decision making are demonstrated through the game-play. The students like the "save dinosaur" storyline. Some boys wish to have more challenging levels in the game.

Figure 1. Dinosaur is running away from volcano.

5. DISCUSSION AND CONCLUSION

Although some studies have employed the OCC model to model emotions of virtual characters, their main focuses are on the identification, mapping and expression of a single emotion [5]. In this paper, we propose a novel emotional agent system. Emotions identified by the OCC model are incorporated into the FCM as interactive related concepts. The dynamics and the interactions of the emotions and affective behaviors have been modeled. Thus, how the emotions will affect the decision making and the agent's behaviors are addressed. The dinosaur agents in the DINO game show how the emotions will affect the agents' behaviors.

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