I'm the Mayor: A Robot Tutor in Enercities-2 (Demonstration)

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ABSTRACT

We are addressing the problem of creating empathic robot tutors to support school students studying geography topics on a multi-touch table. A multi-role serious game Enercities-2 has been developed from an earlier single-user version in which a Mayor, Economist and Environmentalist have control over differing resources. The game explores the tension between individual and collaborative success. A robot tutor, embodied as a NAO Torso robot, can play any one of these roles. This interactive demo using a large tablet and the NAO will allow attendees to play with the robot, which currently tries to maximize the collaborative score.

Categories and Subject Descriptors

I.2.1: Applications and Expert Systems: games; I.2.9 Robotics; I.2.11: Distributed Artificial Intelligence - Intelligent agents;

Keywords

Serious games; Social robots; Human-robot interaction

1. DOMAIN AND SCENARIO

In this paper we discuss a showcase we are developing involving an empathic robot tutor playing a collaborative educational game on a multi-touch table. Our work aims at the development of artificial robot tutors with the ability to perceive emotions experienced by learners so as to improve its pedagogical strategies (Deshmukh et al., 2013). This includes determining the appropriateness of its affective interventions through empathic strategies in response to a learner's emotional state and strategies for keeping students in an affective state that promotes learning. Recent research on artificial companions has demonstrated the key role that embodiment plays in user perception of an artificial entity: experiments comparing robots with their virtual representations demonstrated that the robotic embodiment was preferred by users in terms of social presence, enjoyment and performance.

Geographical learning domains have been targeted in this work as ones in which spatial reference is fundamental and the use of deictic gestures is likely to add to the learning experience.

The Enercities game (http://www.enercities.eu/) was developed in the EC programme Intelligent Energy Europe during 2009-2011 and won the 2010 title of 'Best Learning Game 2010' in

the ENGAGE Quality Awards. It was originally a single-user online game teaching sustainable development through discovery learning about concepts such as pollution energy shortages or renewable energy and schools across Europe have already used it in their curriculum (Knol, & De Vries, 2011).

The original Enercities code has been licenced from its distributer, Paladin Studios, and used as the basis for a multi-player collaborative learning version of the game, using a multi-touch table, in which the empathic robot acts both as a tutor and a player. The robot collaborates with two students in developing a virtual city with a focus on environmental issues. Here, the empathic agent acts more as a peer than as a traditional tutor. This results from asking teachers about the role that a robotic tutor should have in a learning scenario. Most conceived them as peers that can guide and motivate students, seeing such a relationship as promoting students' independent learning.

Enercities-2 is turn-based and playable by three players: two human players and an AI-equipped robot (see **Figure 1**). As the game starts, each player chooses one of three roles: Environmentalist, Economist or Mayor. Each has the same resources to spend: non-renewable resources (oil), energy and money. Oil never increases (though its decrease can be slowed), money can be earned by building or improving certain structures, and energy can be generated through power plant structures or structure upgrades. All players must build or improve structures in order to advance to the next level while maximizing a global score. There is an in-built tension between

Figure 1: Nao and MT Table (left); Nao taking turn (right)

maximizing individual scores and maximizing the global score.

The game is over when the players run out of non-renewable resources or when they complete the final level of the game. The players' final score is the sum of three individual scores: Environment, Economy and Wellbeing.

At each turn, the possible moves are:

- **Build a structure:** Every player can build housing or power plant structures. Only the Environmentalist can build parks; only the Economist can build industries and commerce structures; only the Mayor can build service structures. As the game advances, more structures are available to be built. Building structures may decrease current resources, as well as improving or decreasing individual scores.

- **Upgrade a structure:** Each structure type has a set of possible upgrades that may save certain resources or increase certain scores while simultaneously consuming resources. Each role can upgrade the same kind of structures they can build. Each player can make at most three upgrades per turn.

- **Implement a policy:** the City Hall is a special kind of structure already available at the start of the game: It allows players to apply certain improvements to other buildings. It also increases the money value at every turn.

- **Skip:** A player can press the "Skip" button if they do not want to play any of the actions above. Skipping will still cause the money and non-renewable resources value to update.

2. TECHNOLOGY

Enercities-2 is developed in Unity3D/C#[1], and runs as a full-screen application on a multi-touch table. It communicates with the rest of the system using a C# Client within the Thalamus middleware.

Thalamus is a framework developed in C# for creating body-independent modular interactive characters. It is based on the Censys framework for interactive embodied characters (Ribeiro, Vala & Paiva, 2013), developed to provide a flexible framework to support multi-modal behaviour by robotic characters with feedback from the real physical environment. It has been further developed in EMOTE to support the configuration of interactive characters from a set of independent modules, each with a designated role in the behaviour of the character. Unlike most other such frameworks, there is no specific module designated as 'Mind' or 'Body'; rather one can include for example, a module that deals with text-to-speech, another dealing with recognition of humans using a Microsoft® Kinect®, another acting as a Dialogue Manager, and still other modules controlling the different parts of the character's body (virtual or robotic) or sensors (camera, speech recognition, etc.).

The main advantage of using Thalamus is that by creating these modules once, one can later re-use them with different characters in different scenarios with similar requirements. Thus it supports module sharing in the research community at large where there are different characters, scenarios, dialogues and interactive goals.

Thalamus implements the SAIBA framework (Kopp et al., 2006), which specifies an Intention planning phase producing Functional Markup Language (FML). This information is a high-level description of the behaviour that the character, without specifying how it should be performed in detail. A Behaviour Planner receives this FML and then generates Behaviour Markup Language (BML) containing discrete animation names, and specific timing values for the intended behaviour to be realized. The BML is sent to a Behaviour Realizer, which performs the behaviour on the specific characters. Within Thalamus, different modules can produce BML code that is then scheduled and executed on the robotic tutor using a robot-specific realizer.

3. THE ROBOT IN ACTION

The robot tutor is equipped with a game-specific AI player that allows it to play any of the three roles in the game. This kind of AI can rank actions by their individual or global return and so can either select the action that produces the biggest gain for its role or the action that maximises global score. Using the same information, it can also evaluate the actions of other players. This allows it to make contextual tutorial comments on the relation between individual and global gain.

Alongside its choice of game actions, Thalamus modules generate BML blocks that specify animations, gaze, deictic gestures and speech behaviour of the tutor.

Figure 2: Nao with tablet

Given the impossibility of transporting a full-size MT table, this demo will take place with a small touch-enabled screen or tablet, as shown in Figure 2. The video showing the robot in action can be seen at: https://vimeo.com/84476099.

4. FUTURE WORK

Our next steps in this scenario will be to use the AI to generate appropriate commentary feedback from the robot in a way that it can seem empathic to the users while still portraying its tutor role. We will be developing appropriate non-verbal expression based on the analysis of recorded studies so that the robot may express itself more like the actual teachers and students do while commenting on the game and the learning topic. We are also integrating several perceptual modules using a Microsoft® Kinect® and webcams, in order to capture non-verbal feedback from the users in real-time. This feedback will provide the tutor with important information about how to react to the player's moves and thus to generate believable empathic behavior.

5. Acknowledgements

6. REFERENCES

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