Towards a Serious Game Playing Empathic Robotic Tutorial Dialogue System

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ABSTRACT

There are several challenges in applying conversational social robots to Technology Enhanced Learning and Serious Gaming. In this paper, we focus in particular on the dialogue management issues in building an empathic robotic tutor that plays a multi-person serious game with students to help them learn and understand the underlying educational concepts.

Categories and Subject Descriptors

I.2.11 [**Intelligent Agents**]: [Dialogue management]

Keywords

Dialogue management, Empathic robotic tutor, Serious games, Tutoring systems

1. INTRODUCTION

Serious games are educational games that provide learning content to players in addition to entertainment [1]. Such games have shown to be very effective in helping players to learn new concepts in particular those that are able to adapt to the users and their context. Our objective is to build an empathic robotic tutoring environment where multiple participants collaborate with a robotic tutor playing a serious game on a large touch-table to learn about environmental issues. This learning environment is set apart from traditional Intelligent Tutoring Systems (ITS) in that the robot has the ability to indicate intention to interact and can make use of gaze, mutual eye contact and other ostensive signals (such as pointing) that have been shown to improve learning [2].

In this environment, we hope to test a number of dialogue strategies that look to optimise student learning gain and engagement by taking into account the student's state, the game state, the pedagogical goals of the robotic tutor as well as the dialogue context. In this paper, we will examine the issues related to development of these dialogue strategies as part of the dialogue manager module.

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2. THE GAME

The serious game adopted here is called Enercities[1] and focuses on environmental issues such as sustainability and energy use. This on-line game has been adapted into a 3-player game where each student plays a role of either the Mayor, Economist or Environmentalist. Players have to work collaboratively to grow and sustain the city for as long as possible and in doing so, hopefully, learn how the environment, economy and citizen's happiness affect each other and thus instigate behaviour change in the students.

3. DIALOGUE MANAGEMENT

Dialogue management is the task of managing the conversation between the system and its users, deciding what to say when. We aim to design and implement a dialogue manager (DM) that will interleave pedagogical and game conversations optimally, taking inputs from other modules such as the game module, learner module, and affect recognition module. It will produce dialogue actions, that will be translated into utterances and gestures by the Behaviour Generation module. The embodied robot will then present these to the players as a combination of head/body movements, diectic pointing gestures and spoken utterances.

3.1 DM state

The DM state is the context based on which the DM decides which moves to make and when to make them. This includes the following information: game state, user affective state, user pedagogical state and the dialogue state. The game state will include the state of the game, environment, economy and citizen scores, etc. The affective state of the user informs the system about the emotional state of the user(s), e.g. happy, sad, confused etc. and how engaged he/she is in the game. The pedagogical state of the player informs the system what concepts the players might already know/have already learned. Finally, the state of the dialogue contains information about the conversation in general such as current speaker, turn holder, current addressee(s), etc.

3.2 DM actions

The system plays two roles: game player and tutor. Therefore, we divide the set of decisions or moves the DM should be capable of into two sets, namely Game moves and Dialogue moves.

Game moves: Game moves are actions related to the underlying game. As a game player, it will have to generate

[1]www.enercities.eu

Table 1: Example dialogue

User/System action	Move type	DA type
User builds a business complex	Game Move	
System: "Congratulations, Mr.Economist. The economy is booming now"	Dialogue Move	Affect
System: "This means more money in our coffers"	Dialogue Move	Pedagogical
System: "I see that we need more power now"	Dialogue Move	Game
System builds a solar power station	Game Move	
System: "Solar power does not need non-renewable resources like coal"	Dialogue Move	Pedagogical
System: "It's your turn now"	Dialogue move	Dialogue control

game moves which are equivalent to a user's game moves such as building a new structure or upgrading an existing structure, etc. The system should be able to choose game actions based on a variety of rewards. It should consider playing moves that will enable it to introduce concepts that are unknown to the students. However, it should also be able to play with a range of strategies such as playing collaboratively or competitively.

Dialogue moves: In response to the dialogue context, the system communicates with the user(s) using dialogue moves. Dialogue moves are processes that create dialogue actions. Dialogue actions (DA) abstractly represent the content and form of what a dialogue participant wants to present. We categorise the set of dialogue actions into four types: (1) game DAs (2) pedagogical DAs (3) dialogue control DAs and (4) affect management DAs. See Table 1 for an example dialogue.

Game DAs represent utterances that relate to the game moves. For example, the system can say "I am going to build a solar power plant right next to the river" as it is doing so. Pedagogical DAs are actions that relate to the pedagogical goal of the system. The system can use DAs such as *questioning*, *prompting*, *hinting*, *explaining*, *suggesting*, etc. to have a pedagogical conversation with the players. For instance, the system could explain why it made a certain game move by linking the move to its effects on the environment, economy or any other game parameter. In addition, dialogue control DAs include actions concerning clarification (*repeating*, *rephrasing*, *request and provide clarification*, etc.), time management (*stalling*) and turn management (*assigning turns to other players*, *grabbing turns*, *backchanneling*).

One of the main goals of this work is to develop empathic strategies so that the robot can react appropriately to the student's emotional state. For example, there can be elation at times when they are winning and confusion and frustration when they are losing. Affect management DAs such as *congratulating*, *comforting*, *encouraging the user* and affective *feedback* to users' game moves and responses to questions can be used to handle these situations where the user's affect comes into play.

3.3 Mapping states to actions

Mapping the dialogue state to DAs is challenging because the DM has to manage multiple tasks: playing the game and tutoring the student, in addition to managing the dialogue. For this, we plan to take a *divide and conquer* approach by having these tasks handled by separate dedicated agents using multiple conversational threads [3]. A game playing agent will decide the game moves and appropriate game DAs, a pedagogical agent will generate a pedagogical DA and so on based on the current dialogue state. The outputs from each of these agents can be queued up separately, evaluated and executed on the basis of priority. This allows the system to choose those actions that contribute more towards achieving the system's goals. Other DAs can be executed later or purged based on the dialogue context.

3.4 Research questions

We have briefly discussed a host of issues concerning the design and implementation of a dialogue management module for an empathic robotic game playing tutorial dialogue system. Using the above setup and a variety of dialogue management strategies, we plan to examine a host of research questions concerning human-robot interaction in tutorial scenarios, such as:

1. Can empathic tutors improve learning gain and engagement over non-empathic tutors?
2. What game strategies should the robot adopt to improve learning - compete or collaborate?
3. How does a robotic tutor compare to a human tutor in such scenarios?
4. Can embodied robots improve learning gain over virtual avatars?

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5. REFERENCES

[1] L. Annetta. Video Games in Education: Why They Should Be Used and How They Are Being Used. *Theory Into Practice*, 47(3):229–230, 2008.

[2] G. Csibra and G. Gergely. Natural pedagogy. *Trends in Cognitive Sciences*, 13(4):148 – 153, 2009.

[3] S. Janarthanam, O. Lemon, X. Liu, P. Bartie, W. Mackaness, and T. Dalmas. A Multithreaded Conversational Interface for Pedestrian Navigation and Question Answering. In *Proceedings of SIGDIAL 2013*, 2013.