A Serious Game Engine for Interview Simulation: Application to the development of doctor-patient communication

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Application to the development of doctor-patient communication skills

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Abstract— **In this paper we present the architecture of a conversation engine aimed to simulate an interview process between a human and a computer player. This component is a central element of many serious games where educational goal is to develop player communication skills. We demonstrate the use of our engine in AgileDoctor, a serious game project for training medical students and general practitioners to communicate with their patients, so as to improve their long-term relationship and provide a higher quality health care. Our proposed conversation engine uses a generic method to combine the game scenario and the educational objectives. The game scenario is described by an instance of a model that formalizes the general doctor-patient interview process and the skills to develop. The conversation engine is able to use this model to engage a challenging dialogue with a human player where missing skills are focused. The proposed design methodology is not bound to the health domain and is transferable to a large range of educational usages.**

Keywords— serious games; conversation engine; healthcare communication skills

I. INTRODUCTION

In recent years, educational games, or serious games with educational or training purposes have become more and more popular. The nature of games which involves elements like challenges, free and immersive experience as well as sense of accomplishment has a great potential in stimulating instinct motivation of learners that make them more engaged and active to develop theirs skills. Although many serious games have not been evaluated or assessed, reviews of research and survey on serious games assessments show that serious games have a considerable positive effect on learning [1][2].

With the emergence of an abundant production of video games used for support learning and training in various fields, the design of serious game for educational purpose has become a common topic in research community, as developing such games tends to be complex, time consuming and expensive [3][4]. This inherent complexity of game hinders their wider use in education [5].

To solve this problem, many researches focus on automated or semi-automated generation of game contents [4][6][7]. However currently many approaches for auto-generation are only applied to narrative games that are based on the combination of traditional educational units with a fictional story-telling background. Indeed, this genre of educational game can provide fun elements like twisted storylines and attractive interactive virtual environments for players to explore. But the effectiveness of player's engagement is unclear as the motivation mechanisms are limited in terms of challenges and rewards. Learning methods are also constrained by a few number of presentation models like quiz, representation of educational contents by some virtual characters in the game scenario, etc. [8] has presented an approach of game engine that generate in real-time a sequence of tasks adapted to the player to meet his learning objectives, where tasks are a large panel of simple content units embodied in instances of minigames, quizzes, interactions with 3-D objects etc. However these simple units of content in the so called 'tasks pool' should be properly designed in the first place where the general development method is not defined.

The domain of game covers a great diversity of game genres and modes of play, but in most of them player communications skills doesn't have a lot of influence on the game play. Exceptions are multi-player games where players have to group and sometime join guild or clan to reach the highest game challenges. One can consider that these games improve player cooperative skills but developed strategies are not driven by the game but rather are the results of opportunistic behaviors.

Conversely, communications skills are first-class citizens in a lot of serious games. They are defined by educational objectives and the design phrases should ensure that some of these skills will be correctly acquired at the end of each play. As a matter of fact, competences on communications skills and relationship management in different aspects can be conveyed by a conversation-based interview simulation.

Our work focus on the development of a conversation game engine based on a design methodology tailored for serious games that need to simulate an interview process between two persons. Educational objectives that can be delivered by such kind of game include relationship management, conflict management and communications skills. This paper presents a use-case of this conversation engine (CE): doctor-patient communication skill learning. The interview simulation model used by the CE provides a formal structure enabling its transfer to a wide range of disciplines where similar categories of specific learning objectives can be tied up with different game play scenarios. This model is presented in Section 3 after we introduce the background of the project. Section 4 describes the

design of the CE and its mechanism, and how the knowledge content can be updated and adapted to different learning objectives. We conclude by summarizing the design proposed by the paper and discussing our future work.

II. THE AGILEDOCTOR PROJECT AND RELATED WORKS

Doctor-patient communication is a major component of the health care process [9]. As mentioned in studies in [10-14] and according observations made by experienced general practitioners (GPs), it is believed that good communication skills with patients are required to build a therapeutic doctor-patient relationship which plays a very important role in medical practice. Effective doctor-patient communication is essential to the delivery of high-quality health care, which enables doctors to detect problems earlier, prevent medical crises and expensive interventions, and provide better support to their patients. Unfortunately, communication skills education is relatively insufficient or difficult to be taught in medical school. One common idea for physicians is that they think they can gain this competence along their career of medical practice, which is true but can be improve by a specific training.

Therefore in this context we decided to design and develop a serious game named AgileDoctor, which aims at training professionals communication skills suitable to build and maintain a good doctor-patient relationship. By now the game prototype focuses on two main fields: the communication skills in the medical interview in different kinds of situations, and the use of state of the art technologies from the e-health environment, such as the electronic health records [15]. Fig. 1 shows an example of the game interface.

Researches in dialogue modeling are mostly applied in the natural language processing with artificial intelligence technologies such as machine learning. However this domain is used mostly to generate dynamic conversations which are not suitable to implement a scripted scenario for domain knowledge delivery. There are also lots of games and applications that involve interactions with NPC or system. The common design patterns of player-NPC dialogue interaction include non-branching and branching dialogues, hub-and-spokes dialogue, parser-driven dialogues etc. Current implementations of player-NPC dialogue interactions need to be less scripted for a deeper immersive experience. For the serious games applications, the player profile should be taken into consideration as well as the methodology that enable the injection of domain knowledge and skills.

III. MODEL

In the following paragraphs we introduce our approach to model a dialogue scenario by explaining the definition of the different building blocks: process, dialogue and phrase, illustrated by a use case based on one GP and one patient in a medical consultation interview session.

A. Generic System Model

An interview session is a process where two or several people gather information and exchange their point of views by face-to-face conversations. The overall model structure is composed of three elements: phases, dialogue sessions and phrases. The model organizes these elements and defines the contents of each element.
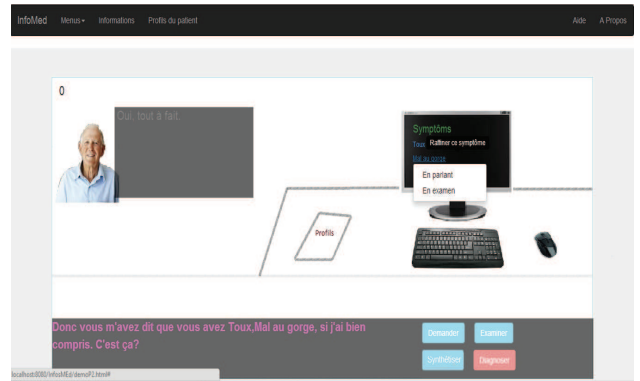

Fig. 1. Example of AgileDoctor prototype interface

Phrases are the smallest unit of the model. They represent spoken sentences, faces expressions, or short actions undertaken by one of the conversation actors (human or virtual). Usually, the scenario will define several implementations of a given phrase. For example several ways to concretize the phrase "greeting" can be: <Saying "Hi!">, <Saying "Hello!">, <bowing>, <winking>, etc.
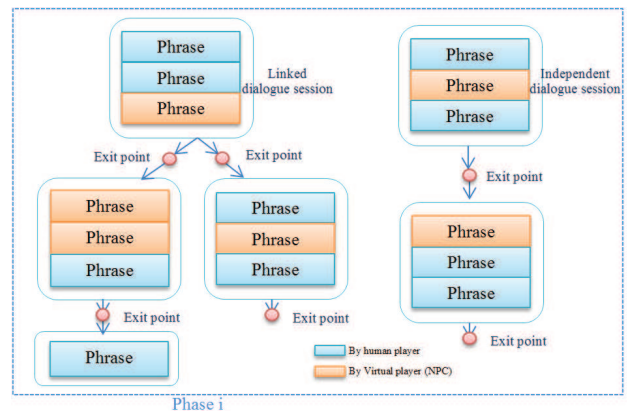
Fig. 2. Structure of system model

A dialogue session is a sequence of phrases essentially determined by the scenario. This means that this unit is used by the scenario to express a mandatory series of phrases which will be played by the artificial intelligence if the human player makes the "right" choices (more explanations will be provided about this in the Section IV). Dialogue sessions have exit points. Exit points represent the end state of the dialogue session and can be used by the scenario to chain dialogue sessions together. For a dialogue session, different exit points can be reached depending on the human player actions. When a dialogue session has only one exit point that leads to another dialogue session, we obtain a sequence of dialogue sessions. When multiple exit points lead to different dialogue sessions,

we obtain a graph of dialogue sessions. The latter is the general case.

Finally, phases are dialogue sessions containers. They allow a sub graph of the dialogue sessions model to be labeled according to some domain knowledge and as such can represent a higher level view of the general scenario workflow. To illustrate, Fig. 2 give a visual representation of the model.

B. Use Case : The Medical Consultation Interview

The medical consultation is described as a four-phase process (P1, P2, P3 and P4) that involves two actors: a general practitioner (GP) and a patient:

- P1 Initialization of session.
- P2 Information gathering with or without physical examinations.
- P3 Explanation and planning.
- P4 End of the session.

In our game, the player plays the role of the GP. We have identified that in our model, the dialogue sessions can be organized as a graph because exit points can be linked to other dialogue sessions. But some of them aren't linked by others because no exit point leads to them. We call such sessions "independent" dialogue sessions. Such sessions are triggered by the actions of the human player through the game interface. These actions can happen at any moment as soon as the scenario has enabled the related interface.

Table I details the four phases of the medical consultation process by giving the different dialogue sessions for each phase. Linked sessions and independent sessions are given in a separate column.

For example, in the first phase, the scenario proposes a dialogue session beginning with a phrase from the doctor (player character) with the meaning of "greet patient". Different implementations of this phrase will be proposed to the player. Some of them will lead to the continuation of the sessions with the next phrase which will also be from the doctors and which will "invite the patient to sit down. Besides that, at any moment the player can choose to 'Ask general questions', which is an option available for the doctor to talk about matters that are not directly related to patient health issues. Notice that dialogue sessions in sequence are just possible moves proposed by the scenario and that they can be skipped by user.

C. Detailed dialogue model

In this section, we describe in more details the operation of a dialogue session. A dialogue session represents a logical sequence of phrases (from the scenario perspective) used by dialogue participants. The correct following of this sequence will lead to one of the exit points of the session.

Referring to the model described by [16], the dialogue process is presented in Fig. 3. As one participant starts the session, the conversation can go on as long as no participants

disagree with the others. The sense of the "disagree" word is quite large and denotes all choices that will prevent the following of the sequence of phrases planned in the session. From the game engine point of view, a safe zone is defined by the NPC profile. As long as the user's choices keep the NPC is in safe zone, no conflict occurs. When it doesn't, the game engine starts to apply a conflict resolution algorithm.

There are two ways to exit from a conflict state: to withdraw, or to confront. The withdraw situation represents a state when one participant disagrees or feels uncomfortable, but chooses to withdraw the argument and hide his discomfort, thus avoiding direct confrontation with the other person. In this case the current dialogue session can continue and effects will only concern on the NPC state (in modifying some parameters like his moods, stress…). This effect can be visualized on the UI as indication to the player.

TABLE I.   MODEL OF MEDICAL CONSULTATION INTERVIEW

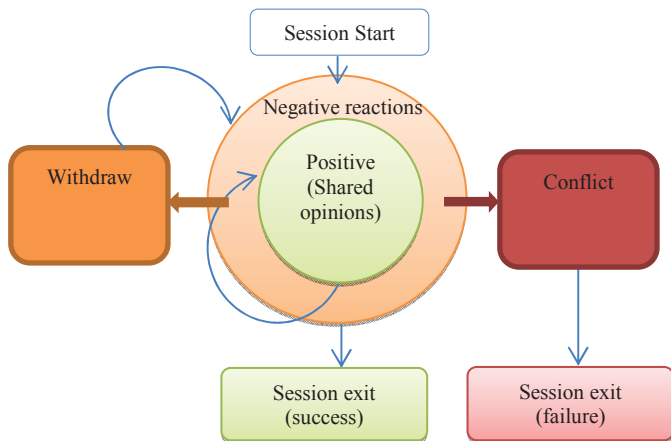|		Linked Dialogues	Independent Dialogues	
Phase 1		Prepare the session		Ask General Questions
		Greet patient and introduce self		
		Invite to sit		
		identify the reason(s) for the consultation session		
Phase 2	Section 1		Ask for 'symptoms'	
			Ask for details of identified 'symptoms'	
			Summarize	
	Section 2- physique examination	Invite to physique examination	Ask for cooperation of the examination	
		Preparation of examination	Observation of the examination result	
Phase 3			Provide information (correct amount and type)	
			Incorporate the patient's perspective	
			Provide a diagnostic	
			Define and communicate a treatment plan	
			Provide additional explanations to the patient	
Phase 4		Summarize the session		
		Fix appointment for next visit		
		Payment		
		Say goodbye		

Fig. 3. Dialogue flow

The confrontation situation however blocks the current dialogue session which will prevent the player to continue the advancement of the scenario. In this case, the player will be proposed by some actions to resolve the problem. These actions can start a new dialogue session with some exit points leading to the conflict resolution, or take some actions planned by the game that specific to the conflict situation. In all cases, the conflict resolution will lead to two situations: a recovery of the normal session flow, or a cancellation of the session.

D. Phrase model for GP

In an interview simulation the phrase is the core composition of a dialogue. We have defined them in section III-A and in this section we explain how phrases implementations can reflect educational objectives.

In our model, phrases are like interfaces in object programming languages. They define some patterns that instance objects will follow. For each phrases, the scenario can define several objects implementing a phrase. The phrase expresses the meaning of the action to do and phrase implementations are a concrete way to express this meaning. For example a phrase with the meaning of "invite to sit down" can be implemented by some sentences like "Please sit down", "Have a seat", "Please take a seat", "Sit down!" and so on. Or even by some gestures, like a nod designing a seat.

A concrete phrase is characterized by parameters that allow classifying it. Table II presents such parameters for the domain of the medical consultation interview. Parameters and concrete phrases are defined by the specialists (linguists, psychologists) and the domain experts (general practitioners) and are stored in the phrase repository. The values of parameters are specified for each phrase implementation. For example, a patient with non-cultivated profile responds to the style "cultivated" as being disturbed and may reach an exit point that leads the scenario into a conflict situation.

Each time a concrete phrase is chosen by the player (or by the computer), the game engine uses the value of these parameters to check if NPCs are staying in their conflict safe zone (see section C), calculate effects by NPC profiles, and determine whether a dialogue session exit points is reached and if so, which session to enter next.

TABLE II. PHRASE PARAMETER EXAMPLES

Parameter	Description
Action id	*Phrase Id*
Penalty Vector	Array of binary values, each value matching a communication skill that to be learnt for the considered domain. If the phrase implementation goes against a skill, then this value is 1 (see table IV for an example).
Approach	The phrase implementation is evaluated according some approach recommended by the domain (details in table III).
Style	The phrase implementation is given a style which will be confronted to the patient profile. (eg. Cultivated, Child, Religious, Normal)

TABLE III. APPROACH DEFINITION EXAMPLES

Approach	Illustrations
Shot-put approach	Well-conceived, well-delivered message
Frisbee approach	Interaction, feedback, relationship, confirmation, common ground, repetition
Normal	

Table IV presents an example of the phrase Penalty Vector and the correspondent patient non-verbal reaction type. The penalty types of the phrase are defined according to the principle of good physician-patient communication skills in [13], while correspondent patient non-verbal reaction type depends on the patient's profile.

TABLE IV. EXAMPLE OF PHRASE PENALTY VECTOR AND PATIENT REACTION

Type	Patient reaction type (non-verbal)
Impolite	Frown
Long and complicated questions	Perplexed
Has jargon and without explication	Perplexed
Has jargon but with explication	Impatient, bored
Directive	Angry
Non-structural	Suspicious

IV. THE CONVERSATION ENGINE

The CE is a component in the runtime system game engine that retrieves the dialogue session and represents the phrases for user's choice as well as the NPC phrases. Now we explain how the CE is able to use the models that we have discussed in the previous section III to deliver the training of skills to the user.

A. User's choice among all the possible phrases in a dialogue session.

We explained in the previous section, how each phrase implementation is characterized according to the skills to develop. This means that each time a player is playing a phrase, the system is able to give a "score" to the shot. So, a basic way to challenge the player would be to present him at each step, all the phrases implementations planned by the scenario, and give him his score at the end of the game. The conversation engine tries to choose among all possibilities to select only the ones that will truly challenge the player in focusing on the skills that he hasn't. This is possible in matching the user profile with the

game history. The user profile gives information about the player initial weaknesses of skills, and the game history informs about how well the player is doing during the scenario. All these can be expressed by the penalty vector. This vector is then used by the conversation engine to focus on phrases which are likely to increase the penalty value.

B. Player's choice about the independent dialogue session

Recommended approaches and styles for a good communication process can be implemented via the independent dialogue sessions. These sessions should be occasionally triggered by the player in using the UI. So when the player fails to take actions using the appropriate approach or styles, the game engine will highlight the corresponding UI element to give him some tips.

C. Conflict situation

The conflict situation provides an extra training unit for communication skills specific to conflict resolution. The condition for entering a conflict situation can be adapted by the scenario so it occurs more or less often.

D. Illustration

Let's consider a dialogue session about quitting smoking. In a first consultation the patient agreed with his doctor to stop smoking and is coming back one month later. An example dialogue session with possible choices for the player could be the following:

Doctor: Do you keep smoking?

Patient: Yes, but just a few cigarettes a day… certainly no more than a half a pack a day.

Doctor:

- I thought you were going to quit? (*open*)

- Are you lying to me? You clothes smell like smoke (*rude*).

- Last time, we agreed that you should stop smoking; you have not kept your word (*guilty*).

Patient: I guess I just don't have the willpower to quit smoking.

Doctor:

- What are your current thoughts about quitting? (*open*)

- So you don't want to stop smoking anymore? (*showdown*)

- I know it's hard to stop, but if you don't your health will be affected (*guilty*).

- So you want to stay a prisoner to your cigarettes. (*showdown*)

- It's not a question of will but of treatment compliance (*rude*)

Patient: I want to quit smoking because I feel pressured to quit by others, but perhaps I'm not ready.

Doctor:

- So you don't want to quit smoking, we will speak again about that when you'll be ready (*dead-end*).

- It's good to have friends that will help you to stop smoking, but perhaps we should talk again about the benefits of stop smoking (*reframe*).

- You are in a very risky situation. If you don't stop smoking, your life is in danger (*stressful*).

- You should stop because it will improve your health and save you some money (*direct*).

Good choices for the doctor (player) will depend on the patient profile (scenario). Most choices will lead to the normal dialogue flow where the patient will be saying his three sentences, but with different impacts on the player score. Some other choices will lead to conflict situations that may prevent the dialogue to go to his end (these exit points can be considered as a failure of the dialogue session).

CONCLUSION AND FUTURE WORK

Serious games are recognized to have a great potential for education and training, as they have shown various advantages such as immersive and fun-learning, risk-free, and motivation-driven engagement. However research on the effective design methodology with adapted learning objectives remains challenging.

We have presented a methodology to design serious educational games aimed at improving communication skills of users. The game is animated by a conversation engine following a three components model: phase, dialogue sessions and phrases. This model allows designers to define a scenario according to the domain considered and to classify sentences on the basis of the skills to develop. Scenario is represented by linked dialogue sessions and sentences are the implementation of sentences pattern called "phrases" by the model. The genericity of the model allows a broad spectrum of applications and several domains to be covered.

We illustrated the use of the model through some examples related to the medical consultation and the interview process that takes place between a doctor and his patient. This interview simulator is part of a larger project called AgileDoctor that is developed in the Serious Game Research Lab of University of Champollion in Castres, France. AgileDoctor is dedicated to teach the use of new technologies to general practitioners. The presented model has been validated by a first implementation of the conversation engine module. Cooperation has been established with the University of Medicine of Toulouse (France) to enrich the phrases repository. The model currently limits the evaluation of skills at the phrase level. The model engine algorithm should be improved to be able to evaluate player's actions at the phase level.

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