What common ground between a human and a virtual agent? The case of task-oriented dialogues for breaking bad news.

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1 Introduction

Doctors should be trained not only to perform medical or surgical acts but also to develop competences in communication for their interaction with patients. For instance, they often face the announcement of undesirable events to patients, as for example damage associated with care (i.e. a consequence of an unexpected event due to complication, unforeseeable medical situation, dysfunction or medical error). The way *doctors deliver bad news related to damage associated with care* has a significant impact on the therapeutic process: disease evolution, adherence with treatment recommendations, litigation possibilities (Andrade et al., 2010). However, both experienced clinicians and medical trainees consider this task as difficult, daunting, and stressful. Nowadays, training health care professional to break bad news, recommended by the French National Authority for Health (HAS)[1], is organized as workshops during which doctors disclose bad news to actors playing the role of patients. However, this training solution requires several persons: it is costly, and time consuming. We aim at developing a training system inhabited by an embodied conversational agent playing the role of a virtual patient to give the doctors capabilities to simulate breaking bad news situations.

In this paper, we present the dialog module we have developped in a project aiming at developing a multi-platform simulation system that has been designed to train doctors to break bad news with a virtual patient[2]. The doctors can interact in natural language with a virtual patient The dialog model of the virtual patient is based on the notion of "common ground" (Garrod and Pickering, 2004), *i.e.* a situation model represented through different variables that is updated depending on the information exchange between the interlocutors. The variables describing the situation model, specific to breaking bad news situations, have been defined based on the analysis of corpus of real training sessions in medical institutions and in light of the pedagogical objective in terms of dialog. The simulation training system can finally be run on three platforms: PC, virtual reality headset, and an immersive virtual reality room.

Corpus-based Virtual patient's multimodal dialog model In order to model the virtual patient's behavior, we have analyzed audio-visual corpus of interactions between doctors and actors playing the role of patients during real training sessions in medical institutions. Indeed, for ethical reasons, it is not possible to videotape real breaking bad news situations. Simulated patients are actors trained to play the most frequently observed patients reactions. The total volume of videos is 5 hours 43 minutes and 8 seconds for 23 videos of patient-doctor interaction with different scenarios (e.g. cancer diagnosis, digestive perforation's announcement, etc.).

The dialog model of the virtual patient aims at identifying automatically the dialog behavior of the virtual patient during the interaction with the doctor, that includes *verbal* (e.g. specific questions or remarks) and *non-verbal* (e.g. head nods, smiles) reactions to utterances of the doctor.

A dialog model based on the construction of a common ground Concerning the verbal behavior, in order to identify the contents of the virtual patient's verbal reaction, we propose a dialog model based on the notion of *common ground* introduced by Garrod and Pickering (Garrod and Pickering, 2004).

[1] The French National Authority for Health is an independent public scientific authority with an overall mission of contributing to the regulation of the healthcare system by improving health quality and efficiency.

[2] ACORFORMed Project: http://www.lpl-aix.fr/ãcorformed/.

Conversation is then viewed as a *joint activity* during which the interlocutors "work together to establish a joint understanding of what they are talking about" (Garrod and Pickering, 2004). The joint activity is based on the alignment of their *situation models* containing information about space, time, causality, intentionality, etc. In other words, the interlocutors interact to construct a common representation of a situation, called an *implicit common ground*.

In our context, the common ground that the interlocutors (the doctor and the virtual patient) have to construct concerns about the situation of disclosure a damage associated with care. The French National Authority for Health (HAS) produces recommendations and best practice guidelines to facilitate the disclose of unfavorable information to patients (Schnebelen et al., 2011). Based on this guideline and on the analysis of the training corpus (Saubesty and Tellier, 2015), five principal phases have been drawn from the data: "opening" (e.g. presentation, inquiring of the patient's state), "exposing the situation" (e.g. a reminder of the patient's care since he/she arrived in the hospital), "breaking the news" (e.g. clear exposition of known facts), "discussing the future" (e.g. what solution for the damage, who will perform it, where, ...) and "closing". For each phase, guideline describes the different information that the doctor should deliver to the patient concerning this breaking bad news situation. For instance, in the "breaking the news" phase, the doctor should, at least, inform the patient on the type of the problem (e.g. digestive perforation), when it occurred (e.g. during a surgical operation), the location (e.g. in the stomach), and the cause (e.g. the polyp wasn't positioned properly). In order to construct the situation model, *i.e.* the common ground that the doctor and the patient should construct together, we have associated a variable to each information that the doctor should deliver to the patient. For instance, we have defined for the step "breaking the news", 4 variables : type_problem, when_problem, location_problem, cause_problem. In total, we have defined 12 variables. Finally, a situation model is described by this set of phases and associated variables. A common ground is constructed if all the variables are instantiated, *i.e.* if the doctor has provided all the information characterized by the variables. In the following, we call these set of phases and variables the common ground.

The dialog model is based on this common ground representation. The variables are used both to store the information provided by the doctor and to determine the reaction of the patient. Indeed, depending on the recognized verbal utterances of the doctors, the variables will be instantiated. For instance, if the doctor provides information on the location of the damage, the variable location_problem will be instanced with the location. Moreover, the virtual patient will use the common ground, and in particular the non-instantiated variables, to determine his/her reactions. Indeed, the virtual patient will ask specific information to instantiate all the variables. Note that the variables describing the situation correspond to *pedagogical objectives* of the breaking bad news situation in terms of dialog. Indeed, the variables correspond to the set of information that the doctors have to provide to the patient concerning the damage as specified by the French National Authority for Health (HAS). The dialog model based on this notion of common ground is then particularly suitable in a learning context since it has the advantage of integrating the learning objectives concerning the content of the conversation.

In order to test the dialog model, we have selected a specific scenario of breaking bad news situation. The situation is a digestive perforation that had occurred during an endoscopy. The scenario has been carefully chosen with the medical partners of the project for several reasons : the panel of resulting damages, the difficulty of the delivery, and the bad news standard characteristics. To construct the dialog model for this specific scenario, we have manually analyzed transcribed corpus with this scenario with three objectives:(1) Validate the situation model: check that we can identify the different phases and variables of the situation model; (2) Identify the different values of the variables in this specific context of the digestive perforation; (3) Identify the appropriate verbal or non-verbal responses of the virtual patient. For this purpose, we have analyzed 7 dialogs of a total duration of 108 mn (each dialog lasts from 8 mn to 27 mn).

The dialog model with this sepcific scenario was implemented using OpenDial (Lison and Kennington, 2016). OpenDial is a java-based, domain-independent toolkit for developing spoken dialogue systems. Moreover, the dialog model has been evaluated with real doctors in different virtual reality displays (PC, virtual reality room, and headset).

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