

# POLLY: A Conversational System that uses a Shared Representation to Generate Action and Social Language

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## Abstract

We present a demo of our conversational system POLLY (POLiteness in Language Learning) which uses a common planning representation to generate actions to be performed by embodied agents in a virtual environment and to generate spoken utterances for dialogues about the steps involved in completing the task. In order to generate socially appropriate dialogue, Brown and Levinson's theory of politeness is used to constrain the dialogue generation process.

## 1 Introduction

Research in Embodied Conversational Agents (ECAs) has explored embedding ECAs in domain-specific Virtual Environments (VE) where users interact with them using different modalities, including Spoken Language. There are a wide variety of applications (Wahlster et al, 1993; Bersot et al, 1998; Traum et al, 2003; Kopp et al, 2003; Takenobu et al, 2003; op den Akker, 2000; Prendinger & Ishizuka, 2001; Paiva et al, 2005; Eichner et al, 2007). However, in order to support dialogic interaction in such environments, an important technical challenge is the synchronization of the ECA Spoken Interaction module with the ECA non-verbal actions in the VE.

We propose an approach that uses a common high level representation which is broken down to simpler levels to generate the agents' verbal interaction and the agents' non-verbal actions synchro-

nously for task-oriented applications that involve performing some actions to achieve a goal, while talking about the actions using natural language.

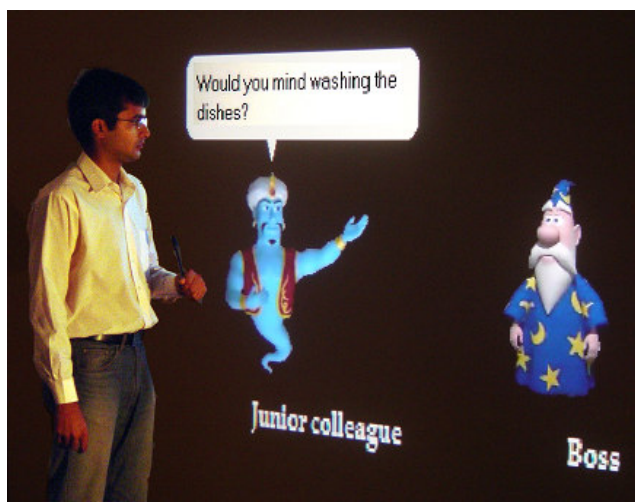


Figure 1. A user interacting with the Agents

Since these ECAs function in scenarios where they interact with the world, other agents, and the user, they must be 'socially intelligent' (Dautenhahn, 2000) and exhibit social skills. Our work is based on the hypothesis that the relevant social skills include the ability to communicate appropriately, according to the social situation, by building on theories about the norms of human social behaviour. We believe that an integral part of such skills is the correct use of politeness (Brown & Levinson, 1987; Walker et al 1997). For instance, note the difference in the effect of requesting the hearer to clean the floor by saying 'You must clean the spill on the floor now!' and 'I know I'm asking you for a big favour but could you kindly clean the spill on the floor?'

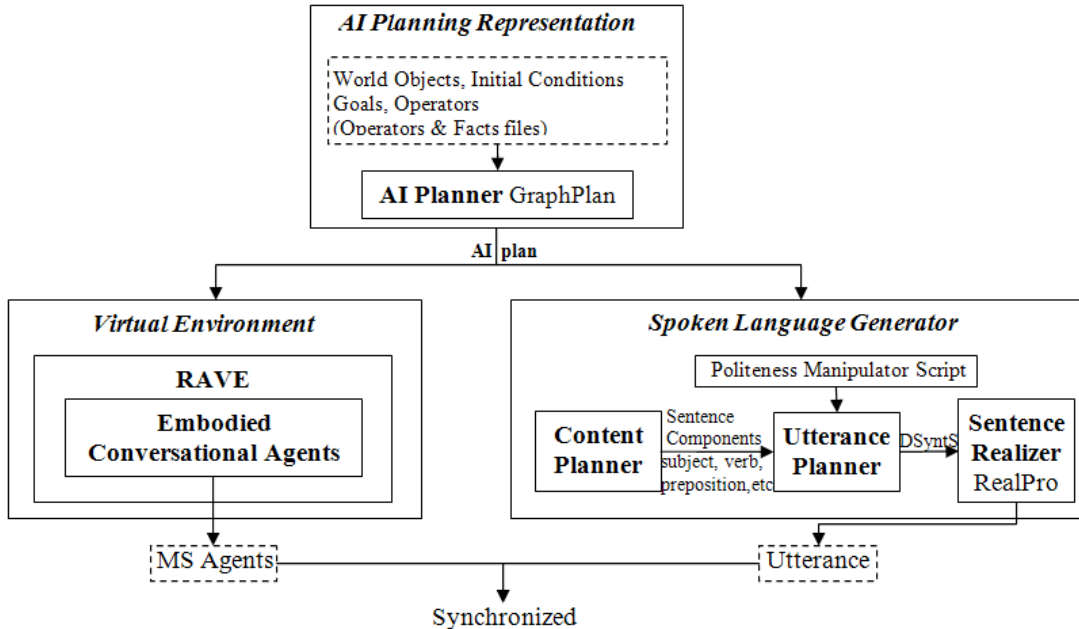


Figure 2: POLLY's Architecture

According to Brown and Levinson (1987) (henceforth B&L), choices of these different forms are driven by sociological norms among human speakers. Walker et al (1997) were the first to propose and implement B&L's theory in ECAs to provide interesting variations of character and personality in an interactive narrative application. Since then B&L's theory has been used in many conversational applications e.g. animated presentation teams (André et al 2000; Rehm & André, 2007), real estate sales (Cassell & Bickmore, 2003), and tutorials (Johnson et al, 2004; Johnson et al, 2005; Porayska-Pomsta 2003; Wang et al 2003). Rehm & André, 2007) show that gestures are used consistently with verbal politeness strategies and specific gestures can be used to mitigate face threats. Work in literary analysis has also argued for the utility of B&L's theory, e.g. Culpeper (1996) argues that a notion of 'impoliteness' in dramatic narratives creates conflict by portraying verbal events that are inappropriate in real life. Thus impoliteness often serves as a key to move the plot forward in terms of its consequences.

This demo presents our Conversational System POLLY which produces utterances with a socially appropriate level of politeness as per the theory of Brown and Levinson. We have implemented POLLY in a VE for the domain of teaching English as a second language (ESL). It is rendered in our VE RAVE at Sheffield University as well as on a

normal computer screen, as explained in section 3. Figure 1 shows a user interacting with POLLY in RAVE. Since RAVE is not portable, we will demonstrate POLLY on the computer screen where the user will be able to verbally communicate with the agents and the agents will respond with computationally generated utterances with an appropriate level of politeness as per a given situation.

## 2 POLLY's Architecture

POLLY uses a shared representation for generating actions to be performed by the ECAs in the virtual domain on one hand and on the other, for generating dialogues to communicate about the actions to be performed. It consists of three components: A Virtual Environment (VE), a Spoken Language Generation (SLG) system and a Shared AI Planning Representation for VE and SLG as illustrated in Figure 2. A classic STRIPS-style planner called GraphPlan (Blum & Furst, 1997) produces, given a goal e.g. cook pasta, a plan of the steps involved in doing so (Gupta et al., 2007). POLLY then allocates this plan to the Embodied Conversational Agents (ECA) in the VE as a shared collaborative plan to achieve the cooking task with goals to communicate about the plan via speech acts (SAs), needed to accomplish the plan collaboratively, such as Requests, Offers, Informs, Acceptances and Rejections (Grosz, 1990; Sidner, 1994; Walker, 1996). It also allocates this plan to the SLG com-

ponent (Gupta et al., 2007) which generates variations of the dialogue based on B&L’s theory of politeness that realizes this collaborative plan, as in (Andre et al, 2000; Walker et al, 1997). Some example dialogues are shown in section 3. In the VE, the human English language learner is able to interact with the Embodied Conversational Agent and plays the part of one of the agents in order to practice politeness real-time.

## 2.1 Brown and Levinson’s theory

B&L’s theory states that speakers in conversation attempt to realize their speech acts (SAs) to avoid threats to one another’s face, which consists of two components. Positive face is the desire that at least some of the speaker’s and hearer’s goals and desires are shared by other speakers. Negative face is the want of a person that his action be unimpeded by others. Utterances that threaten the conversants’ face are called Face Threatening Acts (FTAs). B&L predict a universal of language usage that the choice of linguistic form can be determined by the predicted Threat  $\theta$  as a sum of 3 variables: P: power that the hearer has over the speaker; D: social distance between speaker & hearer; and R: a ranking of imposition of the speech act. Linguistic strategy choice is made according to the value of the Threat  $\theta$ . We follow Walker et al.’s (1997) four part classification of strategy choice. The Direct strategy is used when  $\theta$  is low and executes the SA in the most direct, clear and unambiguous way. It is usually carried out either in urgent situations (Please Help!), or where the face threat is small as in “I have chopped the vegetables” or if the speaker has power over the hearer, “Did you finish your homework today?” Theijc Approval strategy (Positive Politeness) is used for the next level of threat  $\theta$  - this strategy is oriented towards the need for the hearer to maintain a positive self-image. Positive politeness is primarily based on how the speaker approaches the hearer, by treating him as a friend, a person whose wants and personality traits are liked, for ex. by using friendly markers “Friend, would you close the door?” The Autonomy Strategy (Negative Politeness) is used for high face threats, when the speaker may be imposing on the hearer, intruding on their space or violating their freedom of action. These face threats can be mitigated by using hedges, “I wonder if you would mind closing the

door for me,” or by minimizing imposition, “I just want to ask you if you could close the door.” The Indirect Strategy (Off Record) is the politest strategy and is used when  $\theta$  is greatest. It usually has more than one attributable intention so that the speaker removes himself from any imposition. For ex. using metaphor and irony, rhetorical questions, understatement, hints etc. For instance, “Its cold in here,” which implies a request to close the door.

## 2.2 Example Dialogues

Here are some example dialogues that illustrate the difference in the politeness strategies used in discourse contexts of varying power. Two Microsoft Agents, Merlin and Genie are involved in a conversation while cooking and cleaning in a kitchen together. Consider the difference in the degree of politeness in each situation.

**Conversation 1:** This is an example conversation in which Merlin is Genie’s boss.

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### Agent (Speech act: Politeness strategy): Utterance

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**Merlin:** *Would you mind washing the dishes?*  
(Approval: RequestAct)  
**Genie:** Sure, I will wash the dishes. (Direct: AcceptRequest)  
**Genie:** I am wondering whether I should boil the pasta.(Autonomy:Offer)  
**Merlin:** *Yeah you can.* (Direct: AcceptOffer)  
**Merlin:** *You have burnt the vegetables.* (Direct: Inform)  
**Genie:** Yeah. (Direct: AcceptInform)  
**Genie:** The oven is dirty. (Indirect: RequestAct)  
**Merlin:** *I’m sorry I cannot clean the oven.*  
(Approval: RejectRequest)  
**Genie:** Ok. (Direct: AcceptReject)  
**Genie:** If you don’t mind, can I clean the burner?  
(Autonomy: Offer)  
**Merlin:** *No, forget it.* (Direct: RejectOffer)  
**Merlin:** *I must wipe the slab now.* (Direct: Offer)  
**Genie:** Alright, if you insist. (Autonomy: AcceptOffer)  
**Genie:** Do you know that you have broken the baking dish mate? (Approval: Inform)  
**Merlin:** *Yes.* (Direct: AcceptInform)  
**Merlin:** *I will cook the vegetables.* (Direct: Offer)  
**Genie:** No please do not bother yourself.  
(Autonomy: RejectOffer)  
**Genie:** The vegetables are healthy. (Indirect: RequestAct)  
**Merlin:** *Alright, I will add the vegetables to the pasta.*  
(Direct: AcceptRequest)  
**Merlin:** *Could you please add the cheese to the pasta for me?*  
(Approval: RequestAct)  
**Genie:** Please don’t mind but I can’t do that.  
(Autonomy: RejectRequest)  
**Merlin:** *Alright.* (Direct: AcceptReject)

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**Conversation 2:** In this case Genie and Merlin are colleagues at an equal level in hierarchy.

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**Agent (Speech act: Politeness strategy): Utterance**

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**Merlin:** *Could you possibly clean the oven for me?*(Approval:RequestAct)

**Genie:** Sure. (Direct:AcceptRequest)

**Genie:** I'll clean the burner. (Direct:Offer)

**Merlin:** *Ok.* (Direct:AcceptOffer)

**Merlin:** *You have burnt the vegetables.* (Direct:Inform)

**Genie:** Yeah. (Direct:AcceptInform)

**Genie:** Would you mind washing the dishes?  
(Approval:RequestAct)

**Merlin:** *I'm sorry but I can't wash the dishes.*  
(Approval:RejectRequest)

**Genie:** Alright. (Direct:AcceptReject)

**Genie:** I must boil the pasta. (Direct:Offer)

**Merlin:** *No, thanks.* (Direct:RejectOffer)

**Merlin:** *I can wipe the slab.* (Direct:Offer)

**Genie:** Yeah you can. (Direct:AcceptOffer)

**Genie:** You have broken the baking dish. (Direct:Inform)

**Merlin:** *Yes.* (Direct:AcceptInform)

**Merlin:** *I'll cook the vegetables.* (Direct:Offer)

**Genie:** No, forget it. (Direct:RejectOffer)

**Merlin:** *Could you please add the vegetables to the pasta?*  
(Approval:RequestAct)

**Genie:** Please don't mind but I can't do that.  
(Approval:RejectRequest)

**Merlin:** *Ok.* (Direct:AcceptReject)

**Genie:** Will you please wipe the table mate?  
(Approval:RequestAct)

**Merlin:** *Sure.* (Direct:AcceptRequest)

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### 3 Virtual Environment

We rendered POLLY with Microsoft Agent Characters (Microsoft, 1998) in our Virtual Environment RAVE at Sheffield University as well as on a desktop computer screen. RAVE consists of a 3-dimensional visualisation of computer-generated scenes onto a 10ft x 8ft screen and a complete 3D surround sound system driven by a dedicated computer. Since Microsoft Agents are 2D, they are not rendered 3D but a life size image of the characters is visible to the users on the screen to make them appear believable. Figure 1 showed a user interacting with POLLY in RAVE. The MS Agent package provides libraries to program control using various developing environments like the .NET framework and visual studio and includes a voice recognizer and a text-to-speech engine. It also provides controls to embed predefined animations which make the characters' behaviour look more interesting and believable (Cassell & Thórisson, 1999). We have

programmed MS agent in Visual C++ and have embedded these animations like gesturing in a direction, looking towards the other agents, blinking, tilting the head, extending arms to the side, raising eyebrows, looking up and down etc while the agents speak and listen to the utterances and holding the hand to the ear, extending the ear, turning the head left or right etc when the agents don't understand what the user says or the user doesn't speak anything. The Agents share the AI plan to collaborate on it together to achieve the cooking task. Goals to communicate about the plan are also allocated to the agents as speech acts (SAs) such as Requests, Offers, Informs, Acceptances and Rejections, needed to accomplish the plan collaboratively. While interacting with the system using a high quality microphone, the user sees one or two agents on the screen and plays the part of the second or the third agent, as per the role given to him/her. When we extend this to a real-time immersive Virtual Reality environment, a Virtual Kitchen in this case, the ECAs will actually perform the task of cooking a recipe together in the virtual kitchen while conversing about the steps involved in doing so, as laid out by the AI plan.

This setup makes it possible to design a 2x2x2 experiment to test three conditions: *Interactivity*, i.e. whether the user only sees the agents interacting on the screen vs. the user interacts with the agents by playing a role; *immersiveness of the environment*, i.e. rendering in RAVE vs. rendering on a desktop computer; and *culture*, i.e. the difference between the perception of politeness by people from different cultures as in (Gupta et al., 2007). We are now in the process of completing the design of this experiment and running it.

### 4 Conclusion

We presents a demo of our conversational system POLLY which implements MS Agent characters in a VE and uses an AI Planning based shared representation for generating actions to be performed by the agents and utterances to communicate about the steps involved in performing the action. The utterances generated by POLLY are socially appropriate in terms of their politeness level. The user will be given a role play situation and he/she would be able to have a conversation with the agents on a desktop computer, where some dialogic utterances would be allocated to the user.

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