Interpersonal dominance in dialogue of cooperative negotiation

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1   Introduction

Dialogue systems are artificial systems capable to hold a conversation with a human user, usually to achieve certain objective or fulfill a task.

During a human-human dialogue, interlocutors establish a social relationship that affect their behaviors. Previous researches have shown that people tend to respond to computers as social actor [bickmore], which lead the community to assess the psychosocial relationship between the person and the agent during their interaction. A growing body of research is investigating the use of appropriate social behavior for virtual agents in different roles and types of user-computer relationship. For example, Bickmore studied the impact of trust ...

In this paper we are interested in modeling a dialogue system for social dialogue in which user and agent cooperate in order to achieve a common objective. We believe that individuals that collaborate to fulfill an objective (for example: find a restaurant for dinner), have both preferences in the way to do it, which lead them to conduct a *cooperative negotiation* about their preferences in order to determine a trade-off that satisfy both interlocutors. Moreover, scholars in psychology and communication investigated the impact interactive effects of relations and emotion in negotiation, and proved that *interpersonal dominance* adopt particular strategies depending on their perception of the relation of dominance. Our objective is to define an agent that can perceive the established relation of dominance and adapt its strategy of negotiation to the relation.

We present in section 1 our model of negotiation on preferences. In section 2, we present the agent strategies of negotiation during the dialogue.

2   Model of negotiation on preferences

The overall goal of a negotiation in our dialogue model is to choose an **option** in a set of possible options for a given topic. For instance, on the topic "Restaurant", we have a set of options: "Chuck's cake", "The ducking Duck", "Ginza sushis"...

Each interlocutor makes its decision by consulting its preferences about these different options. Let $\mathcal{O}$ be the set of options.

To be able to compare these options, interlocutors base their evaluation of each option on a set of **criteria** that reflect options characteristics. Let $\mathcal{C}$ be the set of criteria. Note that this set is dependent on the topic: the criteria for choosing a restaurant could be cuisine, ambiance, price, and location, while the criteria for choosing a movie could be type and location. Furthermore,

each criterion has to be measurable, in the sense that it must be possible to rate an option even in qualitative way. Therefore, $\forall\ c \in \mathcal{C}$, we note D_c its domain of values. For example, the domain values of the criterion cuisine is noted $D_{\mathsf{cuisine}} = \{\mathsf{chineese}, \mathsf{italian}\}$.

Each option $\mathsf{O} \in \mathcal{O}$ is characterized by a value for each criterion: $\mathsf{O} = \{c_1 = v_1, ..., c_n = v_n\}$ with $c_i \in \mathcal{C}, \forall i \in [1, n]$ and $v_i \in D_{c_i}$. Thus, we define $\{v(c, \mathsf{O}) \in D_c / \forall \mathsf{O} \in \mathcal{O}, \forall c \in \mathcal{C}\}$ as the *objective* value of the criterion c attributed the option O. By objective, we mean that this value is independent from the preferences: both interlocutors evaluate the option with the same values, regardless of their preferences. For example, Ginza is an expensive Japanese restaurant: $v(\mathsf{price}, \mathsf{Ginza}) = \mathsf{expensive}$ and $(\mathsf{cuisine}, \mathsf{Ginza}) = \mathsf{japanese}$.

In the following we will present the interlocutor preference model that allows him to represent and decide on preferences.

2.1 Representation of preferences

Preference is a transitive antisymmetric binary relation P defined on a set of elements A, such that:

$$\begin{cases} P(a,b) \text{ means } a \text{ is preferred over } b. \ a,b \in A \\ P(b,a) \text{ means } b \text{ is preferred over } a. \ a,b \in A \\ \text{Otherwise, neither is preferred.} \end{cases}$$

For example $P_{\mathsf{cuisine}}(\mathsf{Japanese}, \mathsf{French})$ means that the interlocutor prefers the Japanese cuisine over the French.

We define the notation $P(a,*) = \{\forall\ x \in A,\ P(a,x)\}$, which means that a is the *most preferred* element in A. By opposition, $P(*,b) = \{\forall\ x \in A,\ P(x,b)\}$ means that b is the *least preferred* element in A.

Our goal is to be able to define preferences over options of negotiation. In the literature [1], preference of one option over others depends on the options performances on the set of criteria. This is called multi-criteria decision. In general [1], preferences on options are built by inference from preferences over criteria values. This inference can be done using different methods such as ordered weight average (OWA [3]) or Choquet's integrals [2].

2.2 Decision based on preferences in our model

To produce dialogue with cooperative negotiation, interlocutors have to take coherent decisions about their preferences over options of a certain topic. Decision on options imply comparing theses options based on interlocutors preferences. Since defining preferences over options is a multi criteria decision that involves calculating how well each option performs on its set of criteria. We have to build a **preference model** that contains interlocutors preferences on criteria, from which we can infer option preferences. In the following, we present the different elements of the preference model noted $\mathcal{P}$:

- *Preferences on option's criteria* noted $\mathcal{P}_\mathsf{O}$ is a partially ordered list of interlocutor preferences about the importance of each criterion in the choice of an

option. For example, $P_{Restaurant} = \{(\text{Cuisine}, \text{Cost}), \ldots\}$ means that the criterion of cuisine is more important than the Cost to choose a restaurant.

- *Preferences on the values of criteria*, $\forall c \in \mathcal{C}$, the interlocutor has a list of preferences noted $\mathcal{P}_C = \{(a_1, a_2), ..., (a_i, a_n) | a_i \in D_C\}$ that contains all its pair of preferences on the values of this criterion.
- The preference model $\mathcal{P}$ is thus the aggregation of all the preferences defined on the different criteria that define the option O.

Running example: To illustrate our approach, we shall use the following running example:

User and agent discuss about the topic *Restaurant. Restaurant* options are defined with the set of criteria $\mathcal{C}= \{$ *Cuisine, Cost, Location, Ambiance* $\}$ and each criterion has its domain of values. We define in this example a simple representation of the preference model on the topic *Restaurant* $\mathcal{P}$ that contains the following information:

- $\mathcal{P}_{Restaurant} = \{(\text{Cuisine, Location}), (\text{Cost, Ambiance}), (\text{Location, Ambiance})\}$. $\mathcal{P}_{Restaurant}$ defines the agent preference model about the criteria that define a restaurant. In this case, the agent believes that the criterion of *Cuisine* is more important than the criteria *Location* to choose a restaurant.
- In the following, we define agent preferences on the values of each restaurant criterion:
  - $\mathcal{P}_{Cuisine} = \{(\text{French, Japanese}), (\text{Italian, Japanese})\}$
  - $\mathcal{P}_{Cost} = \{(\text{Cheap, Expensive})\}$
  - $\mathcal{P}_{Location} = \{(\text{Paris01, Paris02}), (\text{Paris09, Paris01}), (\text{Paris01, Paris14})\}$
  - $\mathcal{P}_{Ambiance} = \{(\text{Calm, Noisy})\}$

Thus the preference model of our interlocutor is the aggregation of the all the preferences that defines the topic Restaurant.
$\mathcal{P}_{=}\{\mathcal{P}_{Restaurant}, \mathcal{P}_{Cuisine}, \mathcal{P}_{Cost}, \mathcal{P}_{Location}, \mathcal{P}_{Ambiance}\}$

Selection based on preferences Once preferences on criteria of the topic are identified and the preference model $\mathcal{P}$ of the interlocutor is built, the interlocutor is provided with enough information to be able to compare two options and calculate the relation
$P(O_1, O_2)/O_1, O_2 \in \mathcal{O}$. This comparison is done by calculating each option utility with a multi-criteria decision function. We selected for our model the WA [3] function (weighted averaging) that offers a way of aggregating the preferences calculated on individual criteria to provide an overall utility rate for options.

We note $score(a)$ the number of a successors in the preference model $\mathcal{P}$, which means $|\{x \in \mathcal{D}/(a, x) \in \mathcal{P}\}|$. $rank(a)$ is the normalized score of the criterion a, which is calculated by ranking all the values of the specified domain $\mathcal{D}$ by their scores.

Therefore, calculating the utility of an option using the WA is performed as follows:

$$U(O) = \sum_{c_j \in \mathcal{C}} \text{rank}_R(c_j) \times \text{score}\left(v(O, c_j)\right)$$

The relation of preferences between two options is calculated by comparing options utilities.

$$P(O_1, O_2) = \begin{cases} P(O_1, O_2) \; \textit{if} \; U(O_1) > U(O_2) \\ P(O_2, O_1) \; \textit{if} \; U(O_2) > U(O_1) \\ \textit{Neither is preferred if} \; U(O_2) = U(O_1) \end{cases}$$

Example of decision Suppose that an interlocutor intents to calculate a relation of preference P(Clementine, Mogoroko), such that {Mogoroko, Clementine} $\in$ Restaurant. Theses restaurants are described as follow:

- Clementine=(Cuisine =*French*, Cost=*Expensive*, Location=*Paris02*, Ambiance=*Calm*).
- Mogoroko=(Cuisine=*Japanese*, Cost=*Cheap*, Location=*Paris09*, Ambiance=*Calm*).

Thus the utility of each restaurant is calculated as described bellow:

- U(Clementine)=rank(Cuisine)×score(*French*)+rank(Cost)×score(*Expensive*) +rank(Location)×score(*Paris02*) +rank(Ambiance)×score(*Calm*).
- U (Mogoroko)= rank(Cuisine)×score*Japanese*+rank(Cost)×score(*Cheap*) +rank(Location)×score(*Paris09*) + rank(Ambiance)×score(*Calm*)..

After calculating both restaurants utilities: U(Clementine)=-3 and U(Mogoroko)=5. We conclude that $P(\text{Mogoroko}, \text{Clementine})$ is true. (i.e Mogoroko is more preferred to Clementine).

2.3 Mental model of interlocutors

To be able to negotiate in dialogue, the agent needs a formal representation of its environment namely, its preferences, user preferences. In addition, the agent has to take into account the current context of the dialogue with all the information shared during the conversation (i.e both interlocutors preferences).

In the following, we present the formal representation of an interlocutor mental model for dialogue.

Preferences model

- agent preference model is defined with the notation $\mathcal{P}_{self}$.
- User preference model as perceived by the agent during the dialogue is defined with the notation $\mathcal{P}_{other}$.
- In addition, the agent has to model the user knowledge about him based on the interaction (i.e Theory of mind; what the user knows about me). We note it $\mathcal{P}_{other-about-self}$.

Dialogue context During dialogue, interlocutors negotiate about a topic and its criteria. The final decision is to select an option (*e.g.* let's go to Ginza restaurant). Therefore, interlocutors share information about their preferences and propose decisions to their negotiation (*e.g.* let's go to a Japanese restaurant, we can't afford expensive restaurant, or let's go to Ginza). To represent these elements of negotiation, we use the following notations to define the status of proposals.

We first define a proposal as a tuple $\mathsf{Proposal(Type, Value)}$ where Type is either the the topic (for example Restaurants) or a criterion $\mathsf{c} \in \mathcal{C}$ and value is:

- an option $\mathsf{O} \in\in \mathcal{O}$ if $\mathsf{Type} \in \mathsf{Topic}$
- a value $\mathsf{v} \in D_{\mathsf{c}}$ if $\mathsf{Type} \in \mathcal{C}$

In order to keep track of all the proposals made during the dialogue, we define the following structures that defines the different status of a proposal can take during a negotiation:

- $\mathsf{Proposed}$ is the set of all the open proposals made during the dialogue.
- $\mathsf{Rejected}$ is the set of rejected proposals.
- $\mathsf{Accepted}$ is the set of accepted proposals.

Utterances semantic Agents communicate using utterances that encapsulate the message. In dialogue, messages are represented as actions, they are defined with precondition, postconditions and effects that update both interlocutors mental states. The preconditions are all optional, because the message selection depends first on the interlocutor dialogue strategy. For utterance effects, we only represent the agent's perception of its environment (i.e. his preferences and user preferences). We cannot represent the user belief, we only represent the agent perception of the user belief. For example, suppose that the agent states that he prefers Japanese cuisine over Chinese. By consequence, the agent adds this preference to its $\mathcal{P}_{\mathsf{o-a-s}}$ model, but we don't have no certainty that the user adds this preference to its $\mathcal{P}_{\mathsf{other}}$ model.

Note that the effect of an utterance updates only the belief of the agent about a preference, but in any case it can update the values of the preference model.

Our aim was to define utterances with semantic that allows interlocutors to handle cooperative negotiation in dialogue. The proposed utterances are summarized in the table 1. We define in details the semantic of each utterance.

1. State.Preference utterance allows the agent to express his preference. For example: State.Preference$_{\mathsf{cuisine}}$(*Japanese , Chinese*) : "I prefer japanese cuisine over Chinese".
   The sender of the utterance (speaker) has to belief the preference statement (i.e it has to be defined in his preference model). Note that effect of the state utterance is different whether the agent is the speaker or the hearer. Thus, the speaker updates its mental state about the hearer's knowledge about him. In addition, $(\mathsf{a}, \mathsf{b}) \in \mathcal{P}_{\mathsf{other-about-self}}$ does not prevent from sending redundant information (I can try to insist on an already stated preferences):

Table 1: dialogue utterances semantic

N	Utterance	Preconditions	Effects	
			(hearer case)	*(speaker case)*
1	State.Preference(a, b): "I prefer a over b"	$(a, b) \in \mathcal{P}_{self}$ $(a, b) \notin \mathcal{P}_{o-a-s}$	$\mathrm{add}((a, b), \mathcal{P}_{other})$	$\mathrm{add}((a, b), \mathcal{P}_{o-a-s})$
2	Ask.Preference(a, b): "Do you prefer a to b" ?	$(a, b) \notin \mathcal{P}_{other}$	None	
3	Propose$(Proposal(T,V))$: "Let's choose V"	$\mathrm{Proposal}(T, V) \notin \mathrm{Proposed}$	$\mathrm{add}(\mathrm{Proposal}(T, V), \mathrm{Proposed})$	
4	Accept$(Proposal(T,V))$: "Okay, let's choose V for T"	$\mathrm{Proposal}(T, V) \in \mathrm{Proposed}$ $\mathrm{Proposal}(T, V) \notin \mathrm{Accepted}$	$\mathrm{add}(\mathrm{Proposal}(T, V), \mathrm{Accepted})$ $\mathrm{remove}(\mathrm{Value}, \mathrm{Proposed})$	
5	Reject$(Proposal(T,V))$: " Sorry, I would choice something else."	$\mathrm{Proposal}(T, V) \in \mathrm{Proposed}$ $\mathrm{Proposal}(T, V) \notin \mathrm{Rejected}$	$\mathrm{add}(\mathrm{Proposal}(T, V), \mathrm{Rejected})$ $\mathrm{remove}(\mathrm{Proposal}(T, V), \mathrm{Proposed})$	

this depends on the dialogue strategy (see section X below). In parallel, The hearer updates its mental state about the speaker preferences.
We define two variant valuations on stating preferences:
– State.Preference$(a, *)$: "I prefer the most a".
– State.Preference$(*, a)$: "I don't like /hate a".
– In this model, we cannot express indifference about preferences.

2. Ask.utterance is defined to enrich speaker knowledge about the hearer preferences. For example: Ask.Preference$_{cuisine}$(Japanese, Chinese) : Do you prefer japanese cuisine or chinese?, is sent because the speaker has no belief about the hear preference on those elements.
We define two variant valuations as follows:
– Ask.Preference$(\mathrm{Pref}_j(a, *))$: "Do you like a?"
– Ask.Preference$(*)$: "What do you like ?." This case appear when the speaker has any belief on the hear preferences on the current topic$\mathcal{P} = \emptyset$.

3. Propose (Proposal(T,V)) allows the speaker to make a proposal. The effect of this utterance is to update interlocutors shared information about the negotiation.
For example: Propose.Preference(cuisine, Japanese) : "Let's choose japanese cuisine", will update both interlocutor information about the dialogue context, in the way that *Japanese* is added to *Proposed*.

4. Accept (Proposal(T,V)), indicates to the hearer that the speaker accepts the proposal V for T which has been the subject of a previous proposal. We belief that there is no update of the belief on preference model because the speaker accepts a proposal if it is consistent with its strategy of dialogue and not necessarily with its preferences. For example :

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– Other: Propose.Criterion (Proposal(Cuisine, Indian)):" Let's choose Indian cuisine."

– Self: Accept.Criterion (Proposal(Cuisine, Indian)): "Okay, lets choose Indian cuisine."

The agent accepts this proposal while Indian$\notin \mathcal{P}_{self_{Cuisine}}$ because in its strategy of dialogue, he prioritizes the other preferences (submissive interlocutor).

5. Reject (Proposal(T,V)): this utterance has the same semantic of an Accept utterance, it occurs after a proposal and the proposed value doesn't respect the speaker goals. For example:

– Other: Propose.Criterion (Proposal(Cuisine, Indian)): "Let's choose Indian cuisine."

– Self: Accept.Criterion (Proposal(Cuisine, Indian)):" Sorry, I would choose something else."

3 Dominance in dialogue

Despite the various definitions of dominance available in the fields of interpersonal communication and psychology, scholars are converging to a general definition of dominance as the power to produce intended effects, and the ability to influence the behavior of other person in the conversation. (Bachrach & Lawler, 1981; Berger, 1994; Burgoon et al., 1998; Foa& Foa, 1974; French & Raven, 1959; Gray-Little & Burks, 1983; Henley, 1995; Olson & Cromwell, 1975; Rollins & Bahr, 1976). Dominance is generally viewed as a personality trait, or to describe the social role of an individual inside a group. However, in the context of communication, dominance is a dyadic variable where one individual's attempt of control is necessarily acquainted by the partner in the interaction.(Rogers-Millar and Millar, 1979,Dunba and Burgoon, 2005).

Dominant behaviors in a conversation can contribute either positively or negatively to the discussion. For example, positive contributions include actions such as keeping the conversation going, orient the task decision, by making quick decisions and conclusions etc. Negative contribution may include not considering the partner in the conversation, for example, not giving the occasion to express his opinion, not open to criticism. In addition, expressing verbally the dominance can be viewed as offensive and unjustified (K,Zablotskaya). Giving these contributions to the conversation, several researches get interested to detect behaviors related to the dominance during the conversation. We focus essentially on the context of conversation of negotiation, where several researches already proved the impact of dominance on the negotiation(VAN KLEEF, 2005)

3.1 Behaviors of dominance in dialogue

Several scholars studied behaviors related to the dominance in order to gain a better understanding to social relations. During a conversation, dominance

can be perceived through verbal and nonverbal behaviors. We present in this section behaviors related to dominance that can be perceived in a conversation of cooperative negotiation.

Non-verbal behavior At the non-verbal level, a wide range of behaviors have been associated with dominance. (Dunbar & Burgoon) divide non-verbal behaviors into classes such (kinesics, vocalic,). First, kinesics behaviors are considered as the richest of all the codes that includes facial expression, body movements, gestures. Indeed, dominant individuals are related with high visual ratio (high looking while speaking / listening)(burgoon). Furthermore, (Dunbar, Burgoon 2005) found that the more body control a woman had the more observers perceived her as dominant. In addition, dominant individual are more susceptible to use gesture when they talk.

Second, voice cues of dominance manifest by speaking duration, speaking intensity, voice control and pitch. Dominant individuals speak loudly and more frequently and might cause interruption while other are talking (Dunbar, Burgoon 2005).

Verbal behavior verbal behavior of dominance in the dialogue is related to the type of *strategies* that individuals choose in order to take control of the other especially during a negotiation. Therefore, dominant negotiators tend to end up with the larger share of the pie (Giebels, De Dreu, & Van de Vliert, 2000).

A considerable body of research has documented the effects of power on negotiation behaviors and outcomes. First, Dominant negotiator have higher aspirations, demands more and concede less(De Dreu, 1995). Second, dominant negotiator control the flow of the negotiation. Indeed, dominant behavior increase task orientation and goal-directed behaviour (Galinsky,Gruenfeld, & Magee, 2003). Finally, dominant negotiator tend to not pay attention to less dominant negotiators Fiske (1993). The idea is that high-power individuals have many resources and can often act at will without serious consequences, while submissive individuals, have to be more careful because they are more dependent on other people. In addition, they are motivated to gain or regain control over their outcomes by paying close attention to the people on whom they depend.

Dominance behaviors implemented

References

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