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## 1 Interpersonal relationship

Social relationship and its effects on behavior lies at the heart of social science. It was proved that understanding interpersonal relationship is crucial for social cognition [6]. Most of the literature that get interested in the conceptual analysis of interpersonal relationship have agreed that the essence of relationship appears in the nature of interaction that occurs between relationship partners. Moreover, social relationship is a dynamic system that may develop and change continuously over interactions [6,9]. Communication between relationship partner will grow in stages from the initial interaction where partners share superficial information to a more deeper relationship where partners can share more personal information. Therefore, the social relationship of partners affects their behavior and their strategy of dialogue.

## 2 Representation of interpersonal relationship

The aim of this section is to relate the work of N.HASLAM [3] who get interested on the mental representation of social relationship. In summary, there are three different representation in the literature.

The first is the dimensional representation. It is the most common representation that consists on represent relationships in a dimensional circle (c.f wiggins model). Therefore, any relationship can be situated and valued in this *continuous* dimensional space.

The second representation is the lawful representation. Laws are defined in the same circle's dimension of affiliation and control. The main difference with the dimensional representation is that laws try to make discrete prediction about the other behavior. For each behavior, complementarity and symmetry make discontinuous prediction about the the other interact behavior.

Finally, categorical representation make a discrete prediction on which kind of social relationship are well performed. In addition the categorical representation focus only on local prediction ( prediction in a small region within a dimensional scheme).

Dimensions	Laws	Categories
Continuous	discontinuous	discontinuous
Local	Global	Local

## 2.1 Dimensions of interpersonal relationship

The definition of dimensions was widely studied under different labels. However, we distinguish four dimensions that are always used for the representation of interpersonal relationship.

**Dominance and power** Scholars from different fields converge to define power as the ability to influence the other behavior [9]. Power may be latent (Komter, 1989), which is in contrast with the definition of dominance which is inevitably manifest (Dunbar, 2004). It is an asymmetric variable in which one interactant's assertion of control is met by acquiescence from another (Rogers-Millar & Millar, 1979).

**Familiarity** In Svennevig's relational model [9], the definition of familiarity is based on social penetration theory (Berscheid and Reis, 1998) which describes the grades of relationship evolution through mutual exchange of information both in depth (superficial information to personal and intimate information) and breadth (from narrow to a broad range of personal topics).

**Affect** This dimension represents the degree of liking that have one interact for the other. This dimension allows interactants to create personal attachment and improve the relationship of interactants [4]

**Solidarity** The solidarity dimension is in the opposite of power dimension. It is a symmetrical dimension where two individuals share equal obligations and rights [9]. It is identified as like-mindedness [1] where interactants have the same behaviors and share for example the same preferences.

## 2.2 Dialogue utterances

In this paper we are interested in modeling a collaborative negotiation on preferences in the context of social dialogue. The negotiation takes its values during the dialogue when messages are exchanged between interlocutors. In the following we present our model of dialogue.

**Structure of messages** The basic structure of dialogue is a message that contains all the information that interlocutors exchange. We thus define a message as triple  $M = \langle i \rightarrow j, s(\text{cont}), F \rangle$ , where  $i, j \in \{\text{agent, user}\}$  are the agents participating in the dialogue,  $s \in \wp$  is the utterance used to express a message.  $\wp = \{\text{Ask, Propose, Reject, Accept, State}\}$  represents the set of utterance types [8] that agents can express to exchange messages.  $F \in \mathcal{F}$  where  $\mathcal{F} = \{\text{Strongly, Weakly, Yelling, Withhesitation...}\}$  is a set of multimodal features that are applied to the utterance to express a personal linguistic style or

social move. These features affect the perception of interlocutors about their relationship. Therefore, we define a social relationship function  $SR: 2^J \times \text{context} \rightarrow \text{Relationship}$ , that tells which feature say in term of social move. The context represents all the previous knowledge of the speaker. We focus on the relation of dominance in this paper. Thus  $\text{Relationship} = \text{Dom}$  where  $\text{Dom} = \{+, -, =\}$  is a three values function. For example, two colleagues have a conversation, colleague  $A$  speaks *loudly with insurance*, while colleague  $A$  shows *hesitation* in his talking. Thus, based on the features used in their linguistic style, we can conclude that the colleague  $A$  dominates the colleague  $B$  (i.e  $\text{Dom}_{A,B} = +$  and  $\text{Dom}_{B,A} = -$ )

**Preferences** Now, that the model of communication is defined, we introduce the notion of negotiation on preferences. First, lets define the domain of preferences. We assume that the agent expresses its preferences on a defined object based on one or multiple criteria.

- Objects  $O$  : Set of all possible objects of negotiation. For example, negotiate to find at which restaurant have dinner.
- Criteria  $C$ : represents the criteria or features of preferences on a defined object. For example, we assume that we can choose a restaurant based on one or several of the following criteria  $= \{\text{cuisine, ambiance, quality of food, price, location}\}$ . Each criterion has its domain of values that we note:  $\forall c \in C$ ,  $D_c$  is its domain. For example  $D_{\text{cuisine}} = \{\text{chinese, italian}\}$ .
- $\forall o \in O, \forall c \in C$ , we define  $v(c, o) \in D_c$  as the objective value of preference attributed for the object  $o$  in the context of the criteria  $c$ . For example, Ginza is an expensive Japanese restaurant. Thus  $v(\text{price, Ginza}) = \text{expensive}$  and  $(\text{cuisine, Ginza}) = \text{japanese}$ .
- Lets now define interlocutor's preferences.  $\forall \text{agent}_i$  that has to define its preference for an object, for example a restaurant.
  - Preferences on criteria of quality related to the object:  $\text{Pref}_i^C(X, Y)$  is a total ordered set of criteria. For example,  $\text{Pref}_i^{\text{restaurant}}(\text{cuisine, price})$  means that the criteria of cuisine is more important for the  $\text{agent}_i$  than the price to choose a restaurant.
  - Once the criteria is defined, the  $\text{agent}_i$  defines his preferences on the domain of this criteria. Thus,  $\forall v_1, v_2 \in D_c$ , the agent has a partially ordered preference on these values noted  $\text{Pref}_i^C(v_1, v_2)$  that can be represented as  $v_1 >_C v_2$ . For example,  $\text{agent}_i : \text{Pref}_i^{\text{cuisine}}(\text{Japanese, Chinese})$ , means that  $\text{agent}_i$  prefers the Japanese cuisine over the Chinese.  $v_1$  and  $v_2$  can take other values as presented :
    - $\text{Pref}_i^C(v_1, *)$  means that  $\text{agent}_i$  prefers the most  $v_1$ .
    - $\text{Pref}_i^C(*, v_2)$  means that  $\text{agent}_i$  doesn't like  $v_2$ .
    - $\text{Pref}_i^C(*, *)$  means that  $\text{agent}_i$  has no preference on  $C$ .
  - The last step consists in defining the agent preferences on the object "restaurant". Based on what we defined above, we conclude that defining a preference on an object is a multi criteria decision [2]. We denote a

function of decision  $\text{Dec}$  such that  $\forall o_1, o_2 \in O \times O, \text{Dec}$  define an order of preference on these objects where  $\{o_1 \prec o_2, o_1 \succ o_2, o_1 \approx o_2\}$ .

**Belief base and intentions** In this section we present the agent belief on his preferences. We situate our definition in the context of social conversation between two people. Suppose  $i, j \in \{\text{Interlocutors}\}$ .

Following the BDI [5], we present the following definitions:

- $B_i \varphi$  the fact that  $\text{agent}_i$  believes that a proposition  $\varphi$  is true. For example,  $\text{Agent}_i$  likes Chinese cuisine is represented  $B_j \text{Pref}_i^{\text{cuisine}}(\text{Chinese})$ .
- $U_i \varphi = \neg B_i \varphi \wedge \neg B_i \neg \varphi$ , means that the  $\text{agent}_i$  has no belief on  $\varphi$ . For example, the fact that  $\text{agent}_j$  ignores what type of cuisine the  $\text{agent}_i$  prefers is formalized :  $U_j \text{Pref}_i^{\text{cuisine}}(*, *)$ .
- $I_i \varphi$  means that agent  $i$  has the intention to communicate  $\varphi$ . We define axioms of cooperation that allows an agent to respond to a communication. Thus,  $B_i \varphi \wedge B_i U_j \varphi \wedge B_i I_j B_j \varphi \implies I_i B_j \varphi$ . We represent messages as actions in our model. These actions are modeled using Disco [7] representation. The action selection is done reactively, where the next action is selected based on the user response on the previous action.

**Utterances semantic** Agents communicates using utterances that encapsulate the message and at each communicated utterance agents will update their beliefs about the preferences of the other agent. Therefore an utterance is communicated to a need to update a belief. In the following we suppose that  $\text{agent}_i$  is the speaker and  $\text{agent}_j$  is the hearer.

- $\text{State.Preference}(\text{Pref}_i(P_1, P_2))$  : I prefer  $P_1$  over  $P_2$ .
  - (Optional )Preconditions:  $B_i U_j \text{Pref}_i(P_1, P_2)$
  - Effects:  $B_j \text{Pref}_i(P_1, P_2)$
 We define two variant valuations on stating preferences as follows:
  - $\text{State.Preference}(P_i, *)$ : I prefer the most  $P_i$ .
  - $\text{State.Preference}(*, P_i)$ : I don't like /hate  $P_i$ .
  - Example:  $\text{State.Preference}(\text{Pref}_i^{\text{cuisine}}(\text{Japanese}, \text{Chinese}))$  : I prefer japanese cuisine over chinese.
- $\text{Ask.Preference}(\text{Pref}_j(P_1, P_2))$  : Do you prefer  $P_1$  to  $P_2$  ?.
  - Preconditions:  $U_i \text{Pref}_j(P_1, P_2)$  ,  $I_i B_i \text{Pref}_j(P_1, P_2)$
  - Effects:  $B_j U_i \text{Pref}_j(P_1, P_2)$  ,  $B_j I_i B_i$
 We define two variant valuations as follows:
  - $\text{Ask.Preference}(\text{Pref}_j(P_1, *))$ : Do you like  $P_1$ ?
  - $\text{Ask.Preference}(*)$ : What do you like ?. This case appear when the speaker has no belief on the hear preferences.
  - Example:  $\text{Ask.Preference}(\text{Pref}_i^{\text{cuisine}}(\text{Japanese}, \text{Chinese}))$  : Do you prefer japanese cuisine or chinese?
- $\text{Propose.Preference}(V(\text{criteria}, \text{value}))$ : I think that  $\text{value}$  would be great.
  - Preconditions:  $I_i \text{Pref}_j(V(\text{criteria}, \text{value}))$
  - Effects:  $B_j I_i \text{Pref}_j(V(\text{criteria}, \text{value}))$  ,  $B_j \text{Pref}_i(V(\text{criteria}, \text{value}))$
  - Example:  $\text{Propose.Preference}(V(\text{cuisine}, \text{Japanese}))$  : I want to taste japanese food.

- Accept.Preference( $V(criteria, value)$ ): Okay, let's choose *value*. After receiving a propose utterance from the  $agent_j$ ,  $agent_i$  might accept the proposal.
  - Effects:  $B_{i,j}Pref_{i,j}(V(criteria, value))$
- Reject.Preference( $V(criteria, value)$ ): Sorry, I would choice something else.
  - Effects:  $B_i \neg Pref_j(V(criteria, value))$
- Propose.Object( $V(object, value)$ ): I think that *object value* would be great.
  - Preconditions:  $I_i Pref_j(V(object, value))$
  - Effects:  $B_j I_i Pref_j(V(object, value))$  ,  $B_j Pref_i(V(object, value))$
- Accept.Object( $V(object, value)$ ): Okay, let's choose *value*.
  - Effects:  $B_{i,j}Pref_{i,j}(V(object, value))$
- Reject.Object( $V(object, value)$ ): Sorry, I would choice something else.
  - Effects:  $B_i \neg Pref_j(V(object, value))$

### 2.3 Find utterances in dialogs

In the following I represented the utterances in the hand made dialogues. When analyzing the recorded dialogues, the utterances appears in a more implicit manner. For example, when Lauriane says: " Sinon j'aime bien japonais". here its a State.preference(Lauriane, leonor,japonais).Loenor perceives it as a propose and make a reject by saying : "Je n'aime pas du tout le japonais." Dialogue Utterance

### 2.4 Synthetic dialogue with utterances

In this section, I present a synthetic dialogue to illustrate the language definition. The goal of the agent is to invite the user to a restaurant. The Agent has a predefined list of preferences of types of food (AgentPreferences = { +Indian, +Italian, -Japanese}) and the agent has no information on user preferences (UserPreferences = {}). In this example the Agent is peer with the user.

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|--|---|
| 1. A: Would like to have dinner with me ?            | 1. Propose.Preference(A,U,dinner).          |
| 2. U: Yes, that would be great.                      | 2. Accept.Preference(U,A,dinner).           |
| 3. A: What kind of food do you prefer ?              | 3. Ask.Preferences(A,U,UserPreferences)     |
| 4. U: I like Japanese food                           | 4. State.Preference(U,Japanese)             |
| 5. A: Oh, I really don't like japanese food.         | 5. RejectStrongly.Preference(A,U,Japaneese) |
| 6. U: Ok. What do you prefer ?                       | 6. Ask.Preferences(U,A,AgentPreferences)    |
| 7. A: I like italian food                            | 7. State.Preference(A,italian).             |
| 8. U: Yeah, I like italian food too.                 | 8. State.Preference(U,italian).             |
| 9. A: So let's have dinner at an italian restaurant. | 9. Propose.Preference(A,U,Italian).         |
| 10. U: perfect for me!                               | 10. Accept.Preference(U,A,Italian).         |

## References

1. Timothy W Bickmore and Rosalind W Picard. Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 12(2):293–327, 2005.
2. José Figueira, Salvatore Greco, and Matthias Ehrgott. *Multiple criteria decision analysis: state of the art surveys*, volume 78. Springer Science & Business Media, 2005.
3. Nick Haslam. Mental representation of social relationships: Dimensions, laws, or categories? *Journal of Personality and Social Psychology*, 67(4):575, 1994.
4. Carolyn Y Nicholson, Larry D Compeau, and Rajesh Sethi. The role of interpersonal liking in building trust in long-term channel relationships. *Journal of the Academy of Marketing Science*, 29(1):3–15, 2001.
5. Anand S Rao and Michael P Georgeff. Modeling rational agents within a bdi-architecture. *KR*, 91:473–484, 1991.
6. Harry T Reis, W Andrew Collins, and Ellen Berscheid. The relationship context of human behavior and development. *Psychological bulletin*, 126(6):844, 2000.
7. Charles Rich. Building task-based user interfaces with ansi/cea-2018. *Computer*, (8):20–27, 2009.
8. John R Searle. *Speech acts: An essay in the philosophy of language*, volume 626. Cambridge university press, 1969.
9. Jan Svennevig. *Getting acquainted in conversation: a study of initial interactions*, volume 64. John Benjamins Publishing, 2000.