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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 ssorasorystem 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 valuated 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 (Dunber, 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 Svennevigs relational model [9], the definition of familiarity is based on social penetration theory (Berscheid and Reis, 1998) which describe 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 topic).

Affect This dimension represent 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]. Is 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 basis structure of dialogue is a message that contain all the information that interlocutors exchange. We thus define a message as triple $M = <i \rightarrow j, s(cont), F>$, where $i, j \in$ {agent, user} are the agents participating in the dialogue,$s \in \wp$ is the utterance used to express a message. $\wp = \{\mathsf{Ask}, \mathsf{Propose}, \mathsf{Reject}, \mathsf{Accept}, \mathsf{State}\}$ represents the set of utterance types [8] that agents can express to exchange messages. $\mathsf{F} \in \mathfrak{I}$ where $\mathfrak{I} = \{\mathsf{Strongly}, \mathsf{Weakly}, \mathsf{Yelling}, \mathsf{Withhesitation}...\}$ is a set of verbal and non verbal style 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: $\mathsf{Relationship} \times \mathsf{context} \to \mathfrak{I}$, 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 $\mathsf{Relationship} = \mathsf{Dom}$ where $\mathsf{Dom} = \{+, -, =\}$ is a three values function. For example, two colleagues have a conversation, colleague A speaks *loudly with insurance*, while colleague B 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 $\mathsf{Dom}_{A,B} = +$ and $\mathsf{Dom}_{B,A} = -$)

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. Note that O is a set of instance of the same type (restaurants in our example):
  $\mathsf{O} = \{\mathsf{Ginza}, \mathsf{LeDragonD'Or}, \mathsf{Venezzia}, \ldots\}$
- Criteria C: set of criteria or features of preferences on objects. For example, we assume that we can choose a restaurant based on one or several of the following criteria $= \{\mathsf{cuisine}, \mathsf{ambiance}, \mathsf{price}, \mathsf{location}\}$. Each criterion has its domain of values that we note: $\forall c \in \mathsf{C}$, D_c is its domain. For example $\mathsf{D}_{\mathsf{cuisine}} = \{\mathsf{chineese}, \mathsf{italian}\}$.
- $\forall o \in \mathsf{O}, \forall c \in \mathsf{C}$, we define $v(c, o) \in \mathsf{D}_c$ as the objective value of the criterion c attributed to the object o. For example, Ginza is an expensive Japanese restaurant. Thus $v(\mathsf{price}, \mathsf{Ginza}) = \mathsf{expensive}$ and $(\mathsf{cuisine}, \mathsf{Ginza}) = \mathsf{japanese}$.
- Lets now define interlocutor's preferences. $\forall \mathsf{agent}_i$ that has to define its preference for an object, for example a restaurant.
  - Preferences on criteria of quality related to the object: $\mathsf{Pref}_i^C(X, Y)$ is a total ordered set of criteria. For example, $\mathsf{Pref}_i^{\mathsf{restaurant}}(\mathsf{cuisine}, \mathsf{price})$ means that the criteria of cuisine is more important for the agent_i than the price to choose a restaurant.
  - Once the criteria is defined, the agent_i defines his preferences on the domain of this criteria. Thus, $\forall v_1, v_2 \in \mathsf{D}_C$, the agent has a partially ordered preference on these values noted $\mathsf{Pref}_i^C(v_1, v_2)$ that can be represented as $v_1 >_C v_2$. For example, $\mathsf{agent}_i : \mathsf{Pref}_i^{\mathsf{cuisine}}(\mathsf{Japanese}, \mathsf{Chinese})$, means that agent_i prefers the Japanese cuisine over the Chinese. v_1 and v_2 can take other values as presented :
    - $\mathsf{Pref}_i^C(v_1, *)$ means that agent_i prefers the most v_1.
    - $\mathsf{Pref}_i^C(*, v_2)$ means that agent_i doesn't like v_2.
    - $\mathsf{Pref}_i^C(*, *)$ means that 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 Dec such that $\forall o_1, o_2 \in \mathsf{OxO}, \mathsf{Dec}$ define an order of preference on these objects where $\{o_1 \prec o_2, o_1 \succ o_2, o_1 \approx o_2\}$.

In the end, the agents try to negotiate a choice about an object. The final decision is to select an object (*e.g.* let's go to Ginza), but during the negotiation, agents can also propose values for criteria (*e.g.* let's go to a Japanese restaurant). To represent these elements of decision, we will use the following notation:

− Propose an object:
  − Let R be the set of rejected objects $o \in \mathsf{O}$ such as $\mathsf{Rej}(o)$ means that the o has been rejected during the dialogue.
  − $\mathsf{O/R}$ is the set of objects that don't have been rejected yet, and $o = \max_i(\mathsf{O/R})$ is the most preferred object of agent_i that has not been reject.Thus, $\mathsf{choice}_i = o$.
− Propose a criterion:
  − Let C be the set of criteria $c \in \mathsf{C}$ where $\mathsf{FDec}(c, *)$ (*i.e* c has no defined value).
− $\mathsf{Dec}(o)$ represents the fact that the final decision is to choose object o (eg: the Ginza restaurant)
− $\mathsf{Dec}(c, v)$ represents the fact that the final decision must choose an object that has value v for criteria c (eg: a silent restaurant)

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 $i, j \in \{\mathsf{Interolocutors}\}$.

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

− $\mathsf{B}_i\varphi$ the fact that agent_i believes that a proposition φ is true. For example, Agent_j believes that Agent_i likes Chinese cuisine is represented $\mathsf{B}_j\mathsf{Pref}_i^{cuisine}(\mathsf{Chinese})$.
− $\mathsf{U}_i\varphi = \neg\mathsf{B}_i\varphi \wedge \neg\mathsf{B}_i\neg\varphi$, means that the agent_i has no belief on φ. For example, the fact that agent_j ignores what type of cuisine the agent_i prefers is formalized : $\mathsf{U}_j\mathsf{Pref}_i^{cuisine}(*, *)$.
− $\mathsf{I}_i\varphi$ means that agent_i has the intention that φ is true.
  In our work, we focus on communication of preferences. Therefore, $\varphi = \mathsf{Pref}_i^c(x, y)$. we will be considering formulas of the form: $\mathsf{B}_j\mathsf{Pref}_i^c(x, y)$ (possibly, $i = j$ if we represent an agent belief about its own preferences, and $i \neq j$ when it represents the beliefs about the interlocutor's preferences).
  The dialogue is a negotiation about preferences. Therefore, we do not modify the preferences of the other (to be discussed with Chuck). We only have intentions of the form $\mathsf{I}_i\mathsf{B}_j\mathsf{Pref}_i^c(x, y)$: the agent has the intention to change a belief about a preference, with $i \neq j$, or $\mathsf{I}_i\mathsf{B}_i\mathsf{Pref}_j^c(x, y)$, with $i \neq j$.
  In our model, these $\mathsf{I}_i\mathsf{B}_j\varphi$ or $\mathsf{I}_i\mathsf{B}_i\varphi$ correspond to communications: the agent i has the intention to communicate a preference ($\mathsf{I}_i\mathsf{B}_j\varphi$) or to obtain the information about the interlocutor's preference ($\mathsf{I}_i\mathsf{B}_i\varphi$).
  Thus, we can write that $\mathsf{I}_i\varphi$ means that agent_i has the intention to communicate about φ (in one way or the other: obtain or transmit a preference).

We define axioms of cooperation that allows an agent to respond to a communication. Thus, $B_i \varphi \wedge B_i U_j \varphi \wedge B_i I_j B_j \varphi \implies I_i B_j \varphi$.

In our model, actions are not built automatically by a planer: the plan is described in an HTN following the Disco [7] paradigm. Actions are represented hierarchically where complex actions are decomposed to more simpler ones. The action selection is done reactively, where the next action to be executed is selected based on the user response on the previous action.

Utterances semantic Agents communicates using utterances that encapsulate the message. After 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 agent_i is the speaker and agent_j is the hearer. As messages are actions, they are defined with precondition and effects on the belief. The preconditions are all optional, because the message selection depends first on the agent strategy of conversation. However, defining preconditions allow us to do inferences in order to know the reasons that make the agent choose this action. For example, if the agent changes the subject of discussion and talks about Chinese food, then we can conclude that the agent is dominant enough to lead the dialogue and change the subject of discussion. In addition, the effects are symmetric, we only represent the agent's belief about its preferences and user preferences. We cannot represent the user belief, we can only represent the agent perception of the user belief. For example, we situate our perception form the agent point of view. Suppose that the agent states that he likes Chinese food. We can imagine that the reasons (precondition) that lead him to state its preferences was that the agent believed that the user didn't know the agent preference and the agent also had the intention to inform the user about its preferences. The effect of the statement is that now the agent believes that the user knows that he likes Chinese food.

In the following, we will be presenting the utterances of dialogue and their effects on the agent belief in the case where the agent is either the hearer (*i.e* Agent = agent_i) or the listener(*i.e* Agent = agent_j). We specify that the effects of the speaker (i) are always of the form $B_i \mathsf{Effects}(j)$, but in some situation this does not bring any useful knowledge for the reactive planer so we ignore it. In addition, utterances update only the belief of the agent about preferences but at any case utterances change the values of preferences in the dialogue (no action can have any effect on the preferences of the interlocutor).

- State.Preference(P_1, P_2) : I prefer P_1 over P_2.
  - Preconditions(i): $B_i U_j \mathsf{Pref}_i(P_1, P_2), I_i B_j \mathsf{Pref}_i(P_1, P_2)$
  - Effects(j): $B_j \mathsf{Pref}_i(P_1, P_2)$
  - Effects(i): $B_i \mathsf{Effect}(j)$ (not really useful for the agent to know that the user knows its preferences ?)
  We define two variant valuations on stating preferences as follows:
  - State.Preference($P_i, *$): I prefer the most P_i.
  - State.Preference($*, P_i$): I don't like /hate P_i.

- Example: State.Preference($\text{Pref}_i^{cuisine}(\text{Japanese}, \text{Chinese})$) : I prefer japanese cuisine over chinese.
- Ask.Preference(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 (j): $B_j U_i \text{Pref}_j(P_1, P_2)$, $B_j I_i B_i \text{Pref}_j(P_1, P_2)$
  - Effects(i): $B_i \text{Effect}(j)$ (not really useful for the agent to know that the user knows that the agent wants to know, imho)
  We define two variant valuations as follows:
  - Ask.Preference($\text{Pref}_j(P_1, *)$): Do you like P_1?
  - Ask.Preference($*$): What do you like ?. This case appear when the speaker has no belief on the hear preferences.
  - Example: Ask.Preference$^{cuisine}(\text{Japanese}, \text{Chinese})$: Do you prefer japanese cuisine or chinese?
- Ask.Object(): Which "Object" do you want to choose ? For example we consider Object = Restaurant. Note that Ask.Object has no content. Since we consider a single-object negotiation, the participants have to choose one single element in O. The semantic of the utterance Ask.Object means that the sender asks the hearer to propose an instance $o \in O$.
  - Preconditions: $U_i \text{Pref}_j(*, *)$, $I_i B_i \text{Pref}_j(*, *)$
  - Effects (j): $B_j U_i \text{Pref}_j(*, *)$, $B_j I_i B_i \text{Pref}_j(*, *)$
- Propose.Criteria(*V(criteria, value)*): I think that *value* would be great.
  - Preconditions: $I_i \text{Dec}(\text{criteria}, \text{value})$
  - Effects: $B_j I_i \text{Dec}(\text{criteria}, \text{value})$
  - Example: Propose.Preference($V(\text{cuisine}, \text{Japanese})$) : I want to taste japanese food.
- Accept.Criteria(*V(criteria, value)*): Okay, let's choose *value*. After receiving a propose utterance from the agent_j, agent_i might accept the proposal.
  - Effects: $B_{i,j} \text{Pref}_{i,j}(V(\text{criteria}, \text{value}))$
- Reject.Criteria(*V(criteria, value)*): Sorry, I would choice something else.
  - Effects: $B_i \neg \text{Pref}_j(V(\text{criteria}, \text{value}))$
- Propose.Object(*object*): I think that *object* would be great.
  - Preconditions: $I_i \text{Pref}_j(\text{object})$
  - Effects: $B_j I_i \text{Pref}_j(\text{object})$, $B_j \text{Pref}_i(\text{object})$
- Accept.Object(*object*): Okay, let's choose *value*.
  - Effects: $B_{i,j} \text{Pref}_{i,j}(\text{object})$
- Reject.Object(*object*): Sorry, I would choice something else.
  - Effects: $B_i \neg \text{Pref}_j(\text{object})$

2.3 Synthetic dialogue with utterances

In this section, I present a synthetic dialogue to illustrate the language definition.Yhe 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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