A COMPUTATIONAL MODEL OF POWER IN COLLABORATIVE NEGOTIATION DIALOGUES

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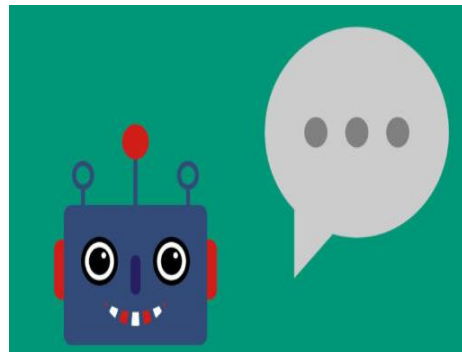Nicolas Sabouret (LIMSI-CNRS)

Charles Rich (WPI)

Plan

- Context

- Model of collaborative negotiation

- Evaluation

- Conclusion and futur work

Context: Conversational agents

- Raise of popularity in different fields.
  - Chatbots (SIRI, Google now ….)
  - Companion for the eldery *(Bickmore, 05)*
  - Tutoring agents *(Kerly et al, 08)*
  - *…*
- Collaborate with user in order to satisfy tasks.
  - Ex tutoring agents:
    - Knowledge comparison for a better learning
    - Personalized teaching to the learner.

Collaboration in dialogue

Expertise

Preferences
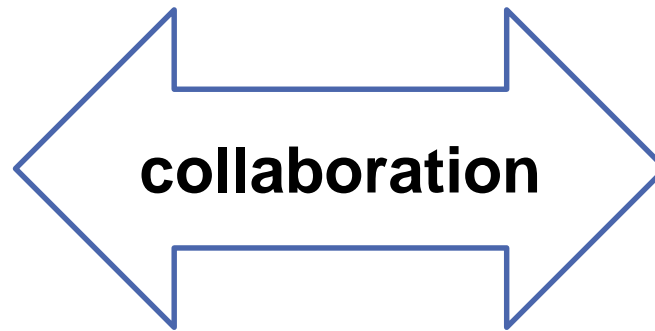
collaboration

Expertise

Preferences

Collaboration in dialogue

Collaborative Negotiation

Expertise

Preferences

Expertises

Preferences

Collaborative negotiation
trade-of which best satisfies the interests of **both participants**, instead of maximizing **one participant's interest**. (Chu-Caroll & Carberry, 95)

Social aspects in negotiation

- Negotiation involves social interaction:**(Broekens et al, 10)**
  - Affects
  - Social behaviors.

- **Dominance**:
  - Ability to express behavior of power*(Burgoon & Dunbar 98)*
  - control attempts by one individual are accepted by the interactional partner *(Burgoon & Dunbar 98)*

- **Power:** the ability to influence the behavior of another person *(Burgoon et al 98)*

Social aspects in negotiation

➤ Non-verbal behaviors:

- Body movement:
  - Posture, relaxation etc …
  - Computational model *(Mignault and chaudhuri, 03)*
- Head tilts
  - raised head is associated to a dominant behavior
  - Computational model *(Gebhard, 14)*
- Gaze
  - Computational model *(Lance and Marsella, 08)*
- …

Social aspects in negotiation

➢ Verbal behaviors➔ **3 principles**

- **Level of demand and concession***(Dedreu et al 95)*
  - Power is associated to a high level of demand and a low level of concessions
- **Self *vs* other** *(Fiske 93, DeDreu et al 95)*
  - High-power individuals are self-centered and only interested in satisfying their own preferences.

- **Lead of the negotiation** *(Dedreu and VanKleef, 04)*
  - High-power individuals tends to make the first move
  - Control of the flow of the negotiation

Objectives

- Model of *social behaviors* in the context of *collaborative negotiation*.

  - Conversational agent communicates using actes of dialogue

  - Define strategies of collaborative negotiation

  - Adapt the strategies of negotiation to the relation of **power**

Model of negotiation based on power

- Domain model
  - Goal : choose an option (ex : Restaurant).
  - Option = {Criterion_1, …, Criterion_n}
    - Ex : Restaurant = {cuisine, Price, ambiance}
  - Preferences on criteria's values $\prec$
    - Partial order.
  - Score of satisfaction based on the preferences
    - Inverse of the number of ancestors

$$sat_{self}(v, \prec_i) = 1 - \left(\frac{|\{v' : v' \neq v \ \wedge \ (v \prec_i v')\}|}{(|C_i| - 1)} \right)$$

Model of negotiation based on power

- Communication: Dialogue acts

Share preferences	Negotiation

• Share a preference
    • **State Preference(X)**
 	
• Ask for a preference
    • **Ask Preference(X)**
	• Make a proposal
	    • **Propose(X)**
	
	• Reject a proposal
	    • **Reject(X)**
	
	• Accept a proposal
	    • **Accept(X)**

Model of negotiation based on power

- ## Dialogue model

Shared knowledge during the negotiation:

Proposals

P : Open, **T :** Accepted, **R** : Rejeted

Shared preferences

Other preferences

$$sat_{other}(v) = \begin{cases} 1 & \text{if } c \in A_i \\ 0 & \text{if } c \in U_i \\ 0.5 & \text{otherwise} \end{cases}$$

Model of negotiation based on power

- Dialogue model

    Shared knowledge during the negotiation:

Proposals

> **P : Open**, **T :** Accepted, **R** : Rejeted

Shared preferences

> Other preferences

$$\text{sat}_{other}(v) = \begin{cases} 1 & \text{if } c \in A_i \\ 0 & \text{if } c \in U_i \\ 0.5 \text{ otherwise} \end{cases}$$

I like v

I don't like v

Model of negotiation based on power

- Decision based on power
  - Implementation of the three principles
  - Agent is initiated with a value of power
  - **pow ∈ [0,1]**

Submissive   **Powerful**

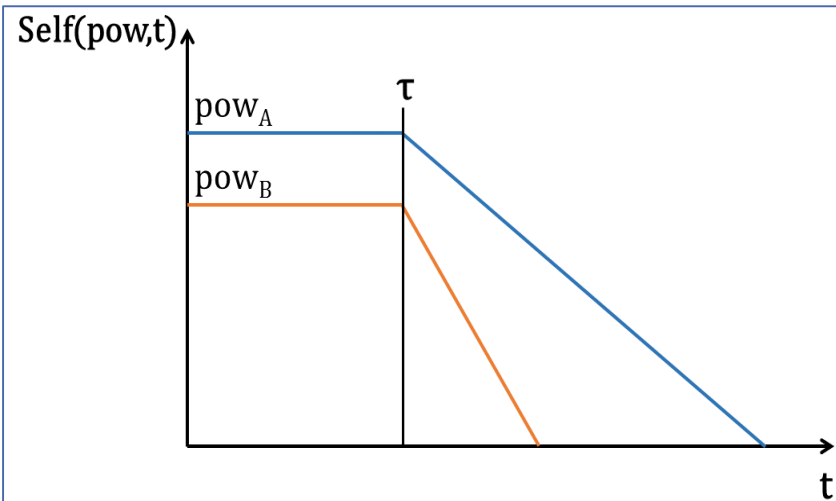0   1

Model of negotiation based on power

• Decision based on power

> ➤ Principle 1

High power agent makes
less concessions

Self : Function
representing the value of
pow over time

$$self(pow, t) = \begin{cases} pow & \text{if } (t \leqslant \tau) \\ max(0, pow - (\frac{\delta}{pow} \cdot (t - \tau))) & \text{otherwise} \end{cases}$$

Model of negotiation based on power

• Decision based on power

> ➤ Principle 1

- • High-power agent is more demanding
- • Acc: Define if a value is acceptable for the agent
  - • *Ex: Accept(Chinese) / Condition : acc(Chinese) = True*
- • The acceptability of a value depends on the agent's level of demand

$$acc(pow, v, t) = sat_{self}(v, \prec_i) \geqslant (\beta \cdot self(pow, t))$$

Model of negotiation based on power

- Decision based on power

> ➢ Principle 2

- High-power agent gives more weight to its own satisfaction.

- **Tolerability**:
    - *Let V_i* be the set of acceptable values
    - Compute the acceptability of a proposal by taking into account **self preference** and **other preferences**

$$\text{tol}(v) = \text{self}(\text{pow}, t) \cdot \text{sat}_{self}(v, \prec_i) + (1 - \text{self}(\text{pow}, t)) \cdot \text{sat}_{other}(v)$$

Model of negotiation based on power

- Decision based on power

  > Principe 2

  - High-power agent gives more weight to its own satisfaction.

  - **Tolerability***:* Compute the acceptability of a proposal by considering both interlocutors preferences
  - The agent proposes the most « **tolerable** » value

$$propose(V_i, \prec_i, pow) = \arg\max_{v \in V_i}(\mathbf{tol}(v))$$

Model of negotiation based on power

- Decision based on power

> Principle 3

Mental state
- Preferences
- Pow (Power)

Negotiation context
- Proposalss (P,T,R)
- Other (A,U)
- History of utterances

Decision based on power

- Decision on preferences. **(P1, P2)**
- Decision on the choice of an utterance **(P3)**

Model of negotiation based on power

- Decision based on power

> ➢ Principle 3

- high-power agent tends to **lead** the negotiation

- Decision rules
- Define a priority in the choice of the utterance
- **High-power:** Negotiation acts
  (Propose, Reject, Accept).
- **Low-power:** Statement acts
  (StatePreference, AskPreference)

Example of dialogue

Pow(Agent1) = 0.9, Pow(Agent2) = 0.4

A: "Let's go to a Chinese restaurant."

  B: "I don't like Chinese restaurants, let's choose something else."

A: "Let's go to the Shanghai. It's a quiet, cheap Chinese restaurant on the south side."

  B: "Do you like Italian restaurants?"

A: "I don't like Italian restaurants."

  B: "Do you like French restaurants?"

A: "Let's go to the Shanghai. It's a quiet, cheap Chinese restaurant on the south side."

B: "Do you like French restaurants?"

A: "I don't like French restaurants."

  B: "Do you like Korean restaurants?"

A: "Let's go to a cheap restaurant."

  B: "Okay, let's go to a cheap restaurant."

A: "Let's go to a restaurant on the south side."

  B: "Okay, let's go to a restaurant on the south side."

A: "Let's go to the Shanghai. It's a quiet, cheap Chinese restaurant on the south side."

  B: "Okay, let's go to the Shanghai restaurant."

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Evaluation of the model

- Evaluate the perception of the implemented behaviors

- Conditions
  - Agent preferences.
    - **Similar** preferences
    - **Different** preferences
  - Init of power.
    - Pow(Agent1) = 0.9, Pow(Agent2) = 0.4
    - Pow(Agent1) = 0.7, Pow(Agent2) = 0.4
    - Pow(Agent1) = 0.7, Pow(Agent2) = 0.2

Evaluation of the model

- Hypotheses
  - H1 The higher-power agent will more strongly be perceived as self-centered than the lower-power agent

  - H2 The lower-power agent will be more strongly perceived as making larger concessions than the higher-power agent

 - H3 The higher-power agent will more strongly be perceived as demanding than the lower-power agent

  - H4 he higher-power agent will more strongly be perceived as taking the lead in the negotiation than the lower-power agent

Evaluation of the model

- Procedure

- a between-subject study on the online site CrowdFlower.com.

- Agents described as two friends trying to negotiate a restaurant to have dinner.
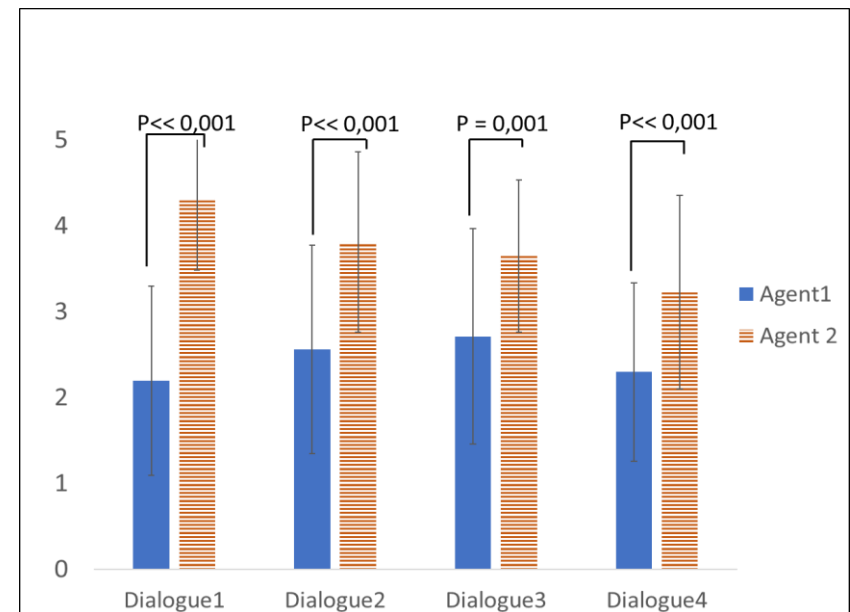
- Total participants: 120

Evaluation of the model
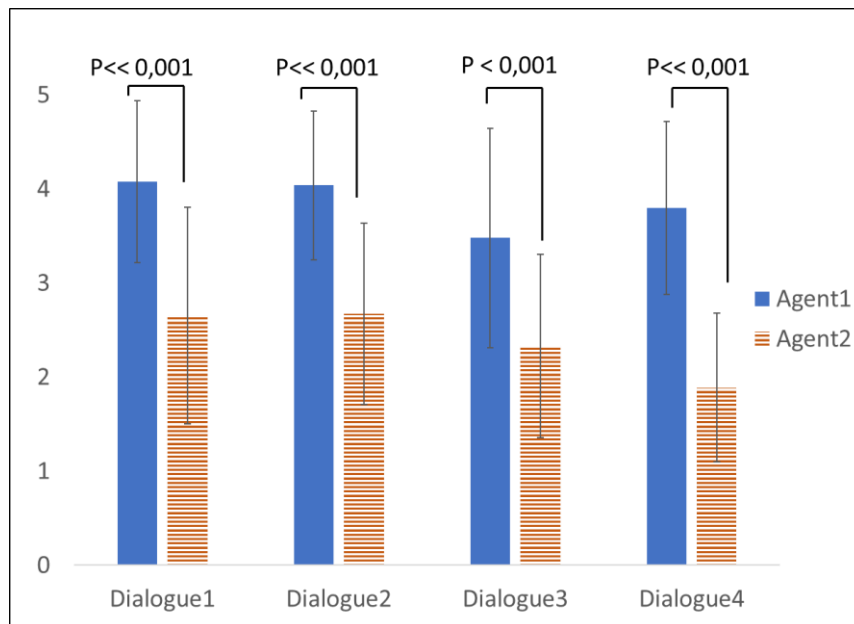
- Results

H1
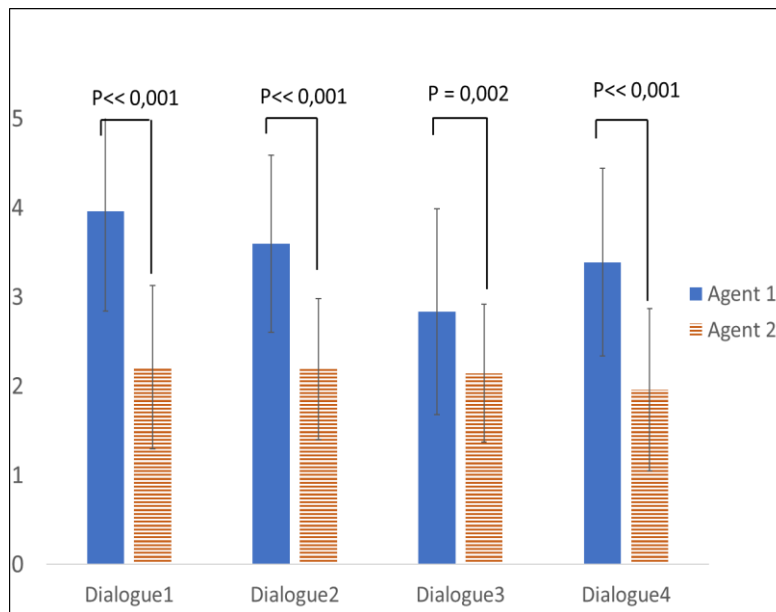
H2

- Agent 1 is more self-centered and do not make concessions.
- Agent 2 tries to find the best trade-off for both parties, and is able to make larger concessions.
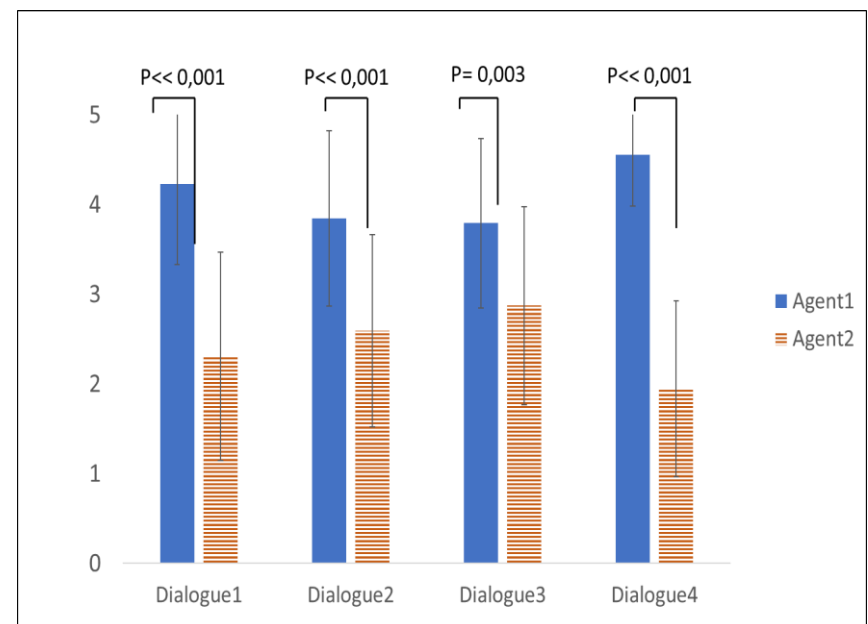
Evaluation of the model

- Results

H3

H4

- Agent 1 is more demanding than agent 2.

- Agent 1 is the one who leads the dialogue.

Conclusion & futur work

1. Impact of power on the negotiation strategies
   - Identify 3 principles of behaviors related to power
   - Define a computational model of collaborative negotiation

2. Validation of the computation model: Perception of behaviors by external observers

3. Validate the model in a human machine interaction

4. Define the relation of dominance:
   - Add a model of ToM
   - Test the model in a human machine interaction

Thank you for your attention