ANR project CoPains: Key Challenges and Some Ideas

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General information

- Project title: Cognitive Planning in Persuasive Multimodal Communication
- Acronym: CoPains
- Duration: 3 years
- Project website: https://www.irit.fr/%7EEmiliano.Lorini/Copains.htm
- Official starting date: 1^{st} February 2019
- Consortium:
  - Institut de Recherche en Informatique de Toulouse (IRIT), Toulouse University
  - Laboratoire d'Informatique pour la Mécanique et les Sciences de l'Ingénieur (LIMSI), Paris
  - Laboratoire d'Informatique & Systèmes (LIS), Université d'Aix-Marseille
  - Laboratoire Parole & Langage (LPL), Aix-en-Provence
  - DAVI-The Humanizers
  - INSERM, Université Bourgogne Franche-Comté (subcontractor)

Project objective

To develop an artificial agent with the following capacities:

- **Mental state recognition**: to infer the cognitive attitudes (e.g., beliefs, desires, preferences, intentions) and affective states (e.g., emotions, moods) of the human user from her observable behaviors
- **Cognitive planning**: to influence and persuade the human user to believe something and/or to behave in a certain way
- **Multimodal expressive behavior for persuasion**: to interact with the human user through multimodal communication including textual expressions and facial expressions

Scenarios: persuasive technology for healthcare and assistance

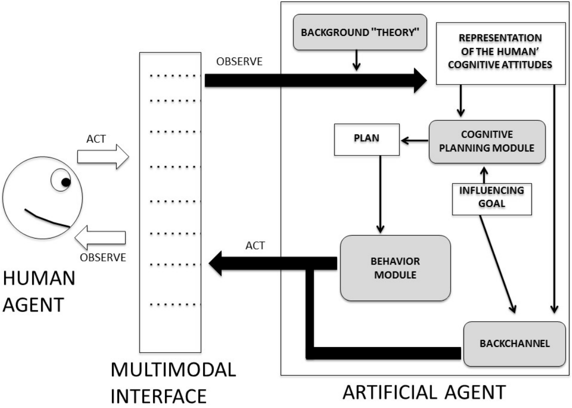
Scenario 1

R2-D2 is an artificial companion which takes care of an elderly person called Bob and keeps him company. Bob has to do regular physical activity to be in good health. In this situation, R2-D2 has to play a tutor role: it has to ensure that Bob will do regular physical activity in his interest. To this aim, R2-D2 needs to use its persuasive capabilities in order to induce Bob to adopt a healthy lifestyle.

Scenario 2

A virtual assistant providing useful advices about nutrition.

General architecture



Workpackages

- WP0: Coordination and project management (IRIT)
- WP1: Collection, annotation and analysis of a corpus of human-human interaction in the context of a persuasive task (LPL)
- WP2: Cognitive planning module (IRIT)
- WP3: Computational model of verbal and nonverbal behavior (LIS)
- WP4: Integration (DAVI)
- WP5: Evaluation of the persuasive artificial agent (LIMSI)

Example of dialogue

- Thanks to its previous interactions with Bob, R2-D2 has learnt that:
  - *Bob is willing to go out for a walk if and only if:*
    - *he is not tired,*
    - *he believes that it is a sunny day, and*
    - *he believes that the outside temperature is above 10° C;*
  - *Bob trusts R2-D2's judgment about weather conditions.*

- R2-D2 knows that Bob has done no physical activity in the last two days. Thus, it deduces that Bob is not tired. R2-D2's goal is to motivate Bob to go out for a walk. Thus, it plans the execution of the following utterance and performs it:

  "Hey Bob! It is a great sunny day. You should take advantage of it and go out for a walk before the end of the day".

- Bob expresses dislikes about R2-D2's suggestion: 

- From Bob's facial expression and its prior beliefs, R2-D2 deduces that Bob does not believe that the outside temperature is above 10° C. Then, R2-D2 plans the execution of the following new utterance and performs it:

  "Bob, you shouldn't worry so much. If you go out, you won't feel cold: the outside temperature is above 10° C."

Requirements

- Theory of Mind (ToM)
- Learning capabilities
- Deductive capabilities
- Planning capabilities

Formalization of the dialogue

- Logic of explicit and implicit beliefs
- Operators:
  - $\mathtt{E}_i\alpha$: agent *i* explicitly believes that α
    $\Rightarrow$ Information in *i*'s belief base
  - $\mathtt{I}_i\alpha$: agent *i* implicitly believes that α
    $\Rightarrow$ Information deducible from *i*'s belief base
  - $+_i\alpha$: agent *i*'s belief base is expanded/revised by α
  - $[inform(i,j,\alpha)]\varphi$: φ holds, after agent *i* has informed *j* that α

$$inform(i,j,\alpha) \stackrel{\text{def}}{=} +_i\mathtt{E}_j\mathtt{E}_i\alpha$$

Lorini, E., Romero, F. (2019). Decision Procedures for Epistemic Logic Exploiting Belief Bases. *Proceedings of AAMAS 2019*, ACM, forthcoming.

Lorini, E. (2018). In praise of belief bases: doing epistemic logic without possible worlds. *Proceedings of AAAI-18*, AAAI press, pp. 1915-1922.

Formalization of the dialogue (cont.)

R2-D2's prior beliefs:

$$\mathtt{E}_{R2-D2}\big(willing_{Bob,goOut} \leftrightarrow (\neg tired_{Bob} \wedge \mathtt{E}_{Bob} temp_{>10} \wedge \mathtt{E}_{Bob} sunny)\big) \quad (1)$$

$$\mathtt{E}_{R2-D2}(\mathtt{E}_{Bob}\mathtt{E}_{R2-D2} sunny \rightarrow \mathtt{E}_{Bob} sunny) \quad (2)$$

$$\mathtt{E}_{R2-D2}(\mathtt{E}_{Bob}\mathtt{E}_{R2-D2} temp_{>10} \rightarrow \mathtt{E}_{Bob} temp_{>10}) \quad (3)$$

$$\mathtt{E}_{R2-D2} \neg tired_{Bob} \quad (4)$$

$$\sigma_1 \stackrel{\text{def}}{=} inform(R2-D2, Bob, sunny) \quad (5)$$

$$\sigma_2 \stackrel{\text{def}}{=} inform(Bob, R2-D2, \neg willing_{Bob,goOut}) \quad (6)$$

$$\sigma_2 \stackrel{\text{def}}{=} inform(R2-D2, Bob, temp_{>10}) \quad (7)$$

Effect of R2-D2's first utterance:

$$[\sigma_1]\mathtt{I}_{R2-D2}\mathtt{E}_{Bob} sunny \quad (8)$$

Effect of R2-D2's first utterance followed by Bob's expression:

$$[\sigma_1]\ [\sigma_2]\mathtt{I}_{R2-D2}\neg\mathtt{E}_{Bob} temp_{>10} \quad (9)$$

Effect of R2-D2's first utterance followed by Bob's expression and R2-D2's second utterance:

$$[\sigma_1]\ [\sigma_2]\ [\sigma_3]\mathtt{I}_{R2-D2} willing_{Bob,goOut} \quad (10)$$

Agent's reasoning module

- Sound and complete tableau-based satisfiability checking procedure
- Implemented at `https://lea.tableaux.live`
- The following can be automatically checked:

$$B_{R2-D2} \models_{?} [\sigma_1]\ [\sigma_2]\ [\sigma_3]\mathtt{I}_{R2-D2} willing_{Bob,goOut}$$

where B_{R2-D2} is R2-D2's belief base

Challenges

- Cognitive planning algorithm:
  - INPUT: Agent i's "cognitive" goal γ about j's cognitive state.
  - INPUT: Agent i's prior belief base B_i.
  - OUTPUT: a sequence of speech acts $\mathit{inform}(i, j, \alpha_1), \ldots, \mathit{inform}(i, j, \alpha_n)$ such that

$$B_i \models [\mathit{inform}(i, j, \alpha_1)] \ldots [\mathit{inform}(i, j, \alpha_n)]\mathtt{I}_i\gamma.$$

- ToM learning algorithm: building agent i's prior belief base about agent j's dispositions through learning. Solutions:
  - Inductive logic programming (ILP)
  - Belief base extraction from neural networks

Levels of integration