A reasoning module to select ECA's communicative intention

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Abstract. In the context of a ECA-human interaction, we propose to create a BDI-like reasoning engine based on the agent's beliefs. This reasoning engine first aims to trigger the agent's emotions from its goals, beliefs, ideals and the notion of responsibility. Then this engine selects the agent's communicative intention from its mental states and a set of dialogue rules. The integration of "Stimulus Evaluation Checks" from Scherer's appraisal theory allows us to associate the selected communicative intention with a multimodal expression. We present a test-scenario involving an argument between the user and the ECA MARC, currently used to evaluate the perceived sincerity and believability of the ECA behaviour.

Keywords: ECA, dialogue, BDI, emotion

1 Introduction

In the field of Embodied Conversational Agents (ECA), one of the main bottlenecks can be translated into a very simple question: *how to decide what to express and how to express it?* A lot of researchers have proposed ECA's models and implementations to trigger emotions *via* appraisal and express them through multimodalities, regardless of language [1, 2]. Other researchers have chosen to achieve the ECA's communicative intention through cognitive and reactive backchannels [3], while a few researchers combine emotion and language to achieve the ECA's intention [4] but not in the context of a ECA-human dialogue. In this context, what is needed is a module that lets the agent reason on its mental states, select its communicative intention while taking its emotions into account and compute a way to achieve it (both **verbally** - using a generic language - **and non-verbally**).

In this paper, we present a BDI-like (Belief, Desire, Intention - [5]) reasoning module that selects the communicative intention of an ECA from its mental states. This reasoning module corresponds to the first module of the standard SAIBA architecture [6], the communicative intention planner. This paper is structured as follows. In a first part, we describe the underlying mechanisms of the reasoning module, its architecture and the three different ways to select the agent's communicative intention. In a second part, we present our implementation of the reasoning module in Prolog and its deployment in the MARC ECA

[2]. We also present a test-scenario involving an argument between the user and the ECA, and we conclude and outline the perspectives of our work.

2 Proposition: the reasoning module

Our reasoning module is composed of 3 sub-modules following the classical perception - decision - action loop of BDI architectures, plus an additional appraisal sub-module to trigger *complex* emotions and compute a facial expression. In the general architecture of the reasoning module (see Figure 1), the 4 sub-modules are:

1. the *perception module*: updating the agent's mental states;
2. the *appraisal module*: from agent's mental states and user's input, triggering agent's emotions and evaluating Scherer's SEC to compute facial expression;
3. the *deliberation module*: selecting the agent's communicative intention;
4. the *intention planning module*: computing and executing a plan to reach this intention.

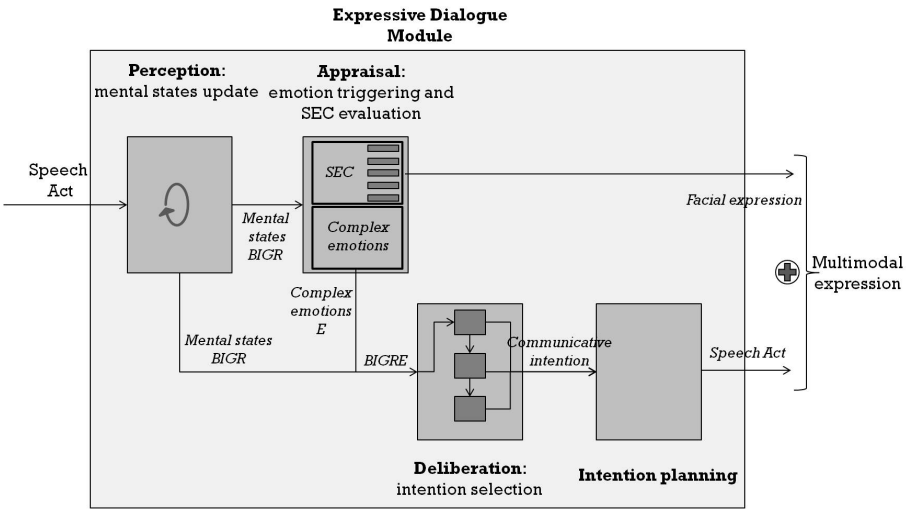

Fig. 1. General architecture of the reasoning module

We use here a specific BDI logical framework presented in [7]: *beliefs* (B), *ideals* (I), *goals* (G), *responsibility* (R) and *complex emotions* (E), forming what we call the BIGRE model. These modal operators allow us to represent utterances in terms of the mental states that they express, particularly *complex* emotions [7, 8]. *Complex* emotions are based upon the agent counterfactual reasoning and upon reasoning about responsibility, skills and social norms. The notion of responsibility is central here in order to provide an analysis of counterfactual emotions such as regret and disappointment.

2.1 Perception sub-module

During an agent-human dialogue, human utterances are translated into speech acts[1] whose perception triggers an update of the agent's mental states and knowledge base (KB) *via* inference rules. The agent's KB is divided into static domain knowledge (library of domain plans, ontology and specific knowledge, *e.g.* about politics) and dynamic knowledge (the agent's mental states and its beliefs on the user's ones, deduced from interactions with them). The agent also updates its KB after itself performing a speech act.

2.2 Appraisal sub-module

The appraisal sub-module aims at, first, triggering the *complex* emotions from their logical definition in terms of the agent's BIGR mental states, and second, computing a dynamic facial expression to accompagny the speech act achieving the communicative intention selected by the reasoning module. Its inputs are the agent's BIGR mental states and the performed speech act.

So on one hand, the agent's *complex* emotions E are triggered from the BIGR. For example, the emotion of gratitude is triggered when the agent i's BIGR contain $Goal_i\varphi \wedge Bel_i Resp_j\varphi$ [7]; its intensity is derived from the priority of the goal. This triggering depends on one aspect of the agent's personality, its emotionalism[2]. On the other hand, this sub-module appraises each speech act *w.r.t.* 5 "Stimulus Evaluation Checks" (SEC) introduced by Scherer's appraisal theory [9, 10] and that we adapted to the speech act theory:

1. novelty of the speech act (was it expected in the dialogue scheme?);
2. intrinsic pleasantness (depending on the type of act, *e.g.* `Refuse` *vs.* `Accept`, and the propositional content);
3. congruence with the agent's goals and attribution of responsibility;
4. coping potential (can the agent influence the speech act's consequences?);
5. compatibility with the agent's ideals.

This appraisal process consists of this sequence of SEC, evaluated in turn. A dynamic facial expression can be computed from this appraisal, since Scherer showed that each SEC can be linked to a temporal sequence of Action Units (AU) [11]. So for each assessed event, the facial expression of each evaluated SEC is computed, combined with the previous one and expressed by the ECA; the global expression lasts while the ECA answers to the user (for a concrete example, see Figure 2).

Within Scherer's theory, we can identify some SEC that are part of our *complex* emotions definition: the goal congruence is represented by the *goal* operator, the attribution of responsibility by the *responsibility* operator, and norms can be assimilated with the *ideals*. Thus we can say that *complex* emotions form a subset of the emotions triggered by the SEC evaluation process.

[1] For now we only have a very limited grammar of human inputs that was designed *ad hoc* for the demo scenario.

[2] How much it is easy (or difficult) for the agent to feel an emotion

2.3 Deliberation sub-module

The communicative intention of the ECA is selected from its mental states (BIGR+E) *via* practical reasoning. We define three kinds of communicative intentions to differentiate between the intentions useful to dialogue regulation at the local level, and the intentions at the global level [12]:

The "emotional" intention is the intention to express an emotion. During each dialogue turn, the agent's emotions are triggered from its B, I, G, and R mental states as updated by the perception sub-module. Then the "emotional" intentions are selected from the triggered emotions depending on the agent's expressiveness (a very expressive agent will intend to express all its emotions while a less expressive agent will only intend to express the most intense ones). The achievement of an "emotional" intention is possible *via* the appropriate expressive speech act (the speech act library is described in Section 2.4). These intentions have *the highest priority*: an agent will first try to achieve its stronger "emotional" intention (*i.e.* express its most intense emotion) before considering other intentions. They participate in the local regulation of dialogue by enabling a more natural interaction [13] between the ECA and the human user.

The "global" intention corresponds to the global level of dialogue: it is the intention that gives the direction of dialogue and defines its type ([14], *e.g.* deliberation, persuasion). The agent adopts the global intention to pursue a certain goal when it is committed to achieve this goal. Such a commitment can be *public*, *via* commissive acts such as `Promise`, `Accept` etc., or *private*, as the agent can commit on one of its goals after practical reasoning on its knowledge *w.r.t.* the domain plans it knows. These types of commitment are consistent with Cohen and Levesque's definition [15]: our public commitment matches their social commitment and our private commitment matches their internal commitment. An exemple of *private* commitment can be that the agent has the goal to make up with the user and knows the plan to do it: in the appropriate context (*e.g.* if the agent does not have other incompatible "global" intentions and commitment), it adopts this intention.

The "obligation-based" intention. The major drawback of most dialogue engines is that they are unable to regulate dialogue at a "local" level because they favour the agent's global intention. For example, an agent which has the intention to know something will keep asking the same question while ignoring user's input that does not answer it, including possible user's questions. Traum and Allen [16] have introduced the concept of discourse obligation to compensate this drawback: each act sent or received by the agent corresponds with a number of discourse obligations the agent has to follow. The obligations thus represent social norms guiding the agent's behaviour and making it reactive at the discourse level. We have integrated in our module a number of obligation rules that allow the regulation of the dialogue at the "local" level. For example, when the user `Asks`

for something (or `Offers` something), the agent has to either `Accept` or `Refuse`, depending on its goals and plans. The third and last type of communicative intentions are these "obligation-based" intentions that are selected from the obligation rules. They have *priority over* the "global" intentions, but are only selected if the agent has no "emotional" intention.

2.4 Intention planning sub-module

The way to achieve the selected communicative intention is planned by the intention planning sub-module according to a plan-based approach of dialogue [17, 18]. We provide in our reasoning module a library of Multimodal Conversation Acts (MCA) based on the Speech Acts theory [19, 20]. These MCA are the plans' operators (actions): they are described in terms of preconditions and effects to enable backward-chaining planning. The agent looks for all the sub-actions which satisfy a given intention; then looks for all the false preconditions of these sub-actions; actions establishing these false preconditions are added to the plan; and so on.

Our library of MCA constitutes an extension of our previous work on Expressive MCA [8], since we provide here 38 MCA from four categories, namely assertives (`Affirm`, `Deny`...), directives (`Ask`, `Suggest`...), commissives (`Promise`, `Accept`...) and expressives (`Apologize`, `Satisfy`...). We identify different effects upon receiving or upon sending each MCA. For example, the definition of the `Rejoice` MCA from the point of view of the agent a in a dialogue with the human h is:

To `Rejoice`:
Preconditions: $Goal_a\varphi \wedge Bel_a Resp_a\varphi \stackrel{déf}{=} Rejoicing_a\varphi$
The agent a "feels" the emotion of rejoicing; it is responsible for having achieved its goal φ.
Effects upon sending: $Bel_a Bel_h Rejoicing_a\varphi$
The agent a believes that human h believes that a feels rejoicing about φ.
Effects upon receiving: $Bel_a Goal_h\varphi \wedge Bel_a Bel_h Resp_h\varphi$
The human h has just expressed rejoicing to agent a about φ, so a believes that h has achieved its goal φ and that h feels responsible for this.

When the agent receives a MCA performed by the human, it deduces from this MCA the human's mental states (including emotions in the case of Expressive MCA). This kind of "reverse appraisal" has been discussed in psychology [21] and tackled in the virtual agent field [22, 23].

In the case of "emotional" and "obligation-based" intentions, the built plan usually includes only one MCA. For example, if the agent's "emotional" intention is to express gratitude, the plan will include the MCA `Thank` or `Congratulate` depending on the emotion's intensity. In the case of "global" intentions, the domain plans in the agent's KB may be necessary. These domain-dependent

actions are also described in terms of preconditions and effects. For instance, if the agent intends to book a train for the user, it has to know that to book a train it needs information about the time and date of departure and destination. Then it can use the same planning mechanisms to decide what are the appropriates MCA (e.g. `Ask`) to get this information.

If a plan is already known (because it was computed earlier), this plan is updated from the last performed action and the actions which cannot be done (for example, if the user refused to give an answer, the agent has to find another plan to get the desired information).

3 Implementation in MARC

MARC [2] is an ECA following the SAIBA framework and able to communicate *via* several modalities (including facial expressions incoded by Action Units). We have implemented the reasoning module in Prolog and deployed it in MARC in order to evaluate it within a test-scenario. This scenario is within the context of a dialogue between a companion ECA (acted out by MARC) and the user. The scene takes place after an argument between MARC and the user. MARC first `Regrets` the fight (the plan to achieve its "emotional" intention) and `Asks` for forgiveness (start of the plan to achieve its "global" intention). The user then has 3 choices: he can `Accept` to forgive MARC ("forget about it"), `Refuse` ("you cannot be my personal agent anymore!", see Figure 2), or `Ask` for some time to think about it.

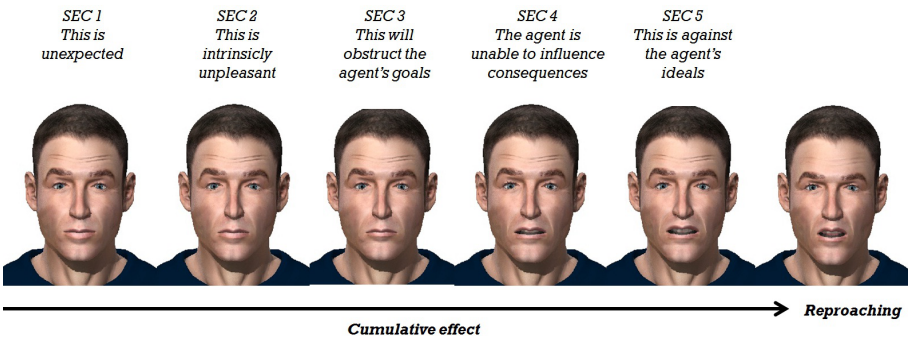

Fig. 2. The user just `Refused` to forgive MARC. From left to right, the expression of the evaluation of each SEC and its cumulative effect. The total expression lasts while MARC `Reproaches` the user for his refusal.

The point here is to observe the agent's reaction following the user's answer. In the case where the user `Asks` for some time to think about it, 4 communicative intentions are selected in sequence:

1. "emotional" intention: MARC expresses its disappointment (`Complain`) because the user does not want to grant its request;

2. "obligation" intention: MARC has to answer the user's request; since its goal is to have an answer to its own request, MARC `Refuses` to wait.
3. "emotional" intention: MARC `Apologises` because it believes that the user expected an acceptance and it is responsible for not having accepted his request.
4. "global" intention: MARC keeps following its current "global" intention to make up with the user and `Asks` again for forgiveness.

This scenario is currently used to evaluate the sincerity and believability of the agent behaviour perceived by users. The first evaluation's results are promising.

4 Conclusions and Perspectives

In this paper we have introduced a BDI-like reasoning module that aims to select and plan the ECA's communicative intention. The intention is selected from the agent's emotions (triggered from its beliefs, goals, ideals and the notion of responsibility - the BIGRE model), the user's speech acts and our set of dialogue rules. A plan consisting of a sequence of MCA is then computed to achieve this intention. To compute a multimodal expression to accompagny the MCA, we have implemented 5 of Scherer's SEC linked to facial expressions. We have implementated this reasoning module in Prolog and integrated in the MARC ECA. A user evaluation using MARC is currently in progress to prove that both the communicative intention selected by our reasoning module and the multimodal expression computed from events appraisal have a positive influence on the perceived believability and sincerity of ECA.

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References

1. Marsella S. C., Gratch J.: EMA: A process model of appraisal dynamics. Cognitive Systems Research 10, 70–90 (2009).
2. Courgeon, M., Martin, J-C., Jacquemin, C.: MARC: a Multimodal Affective and Reactive Character. In: 1st workshop on Affective Interaction in Natural Environments (AFFINE 2008), Chania, Crete, 2008.
3. Bevacqua E., Mancini M., Pelachaud, C. : A Listening Agent Exhibiting Variable Behaviour. In : 8th international conference on Intelligent Virtual Agents (IVA'08), pp. 262–269. Springer-Verlag, Berlin, Heidelberg, 2008.
4. Aylett, R., Dias, J., Paiva, A.: An affectively driven planner for synthetic characters. In: International Conference on Automated Planning and Scheduling (ICAPS), pp. 2–10. AAAI press, 2006.
5. Rao, A. S., Georgeff, M. P.: Modeling Rational Agents within a BDI-Architecture. In: 2nd International Conference on Principles of Knowledge Representation and Reasoning (KR'91), pp. 473–484. Morgan Kaufmann publishers Inc., San Mateo, CA, USA, 1991.

6. Vilhjalmsson, H., Cantelmo, N., Cassell, J., Chafai, N. E., Kipp, M., Kopp, S., Mancini, M., Marsella, S., Marshall, A. N., Pelachaud, C., Ruttkay, Z., Thórisson, K. R., Van Welbergen, H., Van Der Werf, R. J.: The behaviour markup language: recent developments and challenges. Lecture notes in artificial intelligence 4722, 99–111 (2007).
7. Guiraud, N., Longin, D., Lorini, E., Pesty, S., Riviere, J.: The face of emotions: a logical formalization of expressive speech acts. In: 10th International Conference on Autonomous Agents and Multiagent Systems (AAMAS'11), pp. 1031–1038. International Foundation for AAMAS, 2011.
8. Riviere, J., Adam, C., Pesty, S., Pelachaud, C., Guiraud, N., Longin, D., Lorini, E.: Expressive Multimodal Conversational Acts for SAIBA Agents. In: 11th International Conference on Intelligent Virtual Agents (IVA'11), pp. 316–323. Springer-Verlag, Berlin, Heidelberg, 2011.
9. Scherer, K. R.: Emotion. In: Introduction to Social Psychology, pp. 151–195. Wiley-Blackwell, 2001.
10. Scherer, K. R.: Appraisal considered as a process of multi-level sequential checking. In Appraisal processes in emotion: Theory, Methods, Research, pp. 92120. New York and Oxford: Oxford University Press, 2001.
11. Scherer, K. R., Ellring, H. : Are facial expressions of emotion produced by categorical affect programs or dynamically driven by appraisal? Emotion, 7(1), 113-130 (2007).
12. Baker, M.J.: A Model for Negotiation in Teaching-Learning Dialogues. Journal of Artificial Intelligence in Education 5(2), 199–254 (1994).
13. Bates, J.: The role of emotion in believable agents. In: Communication of ACM 37(7), 122–125 (1994).
14. Walton, D. and Krabbe, E.: Commitment in Dialogue: Basic concept of interpersonal reasoning. State University of New York Press, Albany NY, 1995.
15. Cohen, P. R. and Levesque, H. J.: Intention is choice with commitment. In: Artificial Intelligence 42(2-3), 213–261 (1990).
16. Traum, D. R., Allen, J. F.: Discourse Obligations in Dialogue Processing. In: 32nd annual meeting on Association for Computational Linguistics (ACL '94), pp. 1–8. Association for Computational Linguistics, Stroudsburg, PA, USA, 1994.
17. Perrault, C. R., Allen, J. F.: A Plan-based Analysis of Indirect Speech Acts. Computational Linguistics 6, 167–182 (1980).
18. Allen, J. F., Perrault, C. R.: Analyzing Intention in Utterances. Artificial Intelligence 15(3), 143–178 (1980).
19. Searle, J. R.: Speech acts : an essay in the philosophy of language. Cambridge University Press, New York, USA, 1969.
20. Searle, J. R., Vanderveken, D.: Foundations of illocutionary logic. Cambridge University Press, New York, USA, 1985.
21. Hareli, S., Hess, U.: What emotional reactions can tell us about the nature of others: An appraisal perspective on person perception. Cognition and Emotion 24(1), 128–140 (2009).
22. de Melo, C., L. Zheng, Gratch, J.: Expression of Moral Emotions in Cooperating Agents. In: 9th International Conference on Intelligent Virtual Agents (IVA'09), pp. 301–307. Springer-Verlag, Berlin, Heidelberg, 2009.
23. de Melo, C., Gratch, J., Carnevale, P.: Reverse Appraisal: Inferring from Emotion Displays who is the Cooperator and the Competitor in a Social Dilemma. In: The 33rd Annual Meeting of the Cognitive Science Society (CogSci 2011), Boston, 2011.