Impact of Affective Appraisal on Collaborative Goal Management: How My Robot Shares My Worries

Anonymous

***Abstract*—The abstract goes here.**

I. Introduction

Cognitive architectures involve various components and processes to provide cognitive functions to intelligent agents. All these cognitive functions ultimately serve the agents what goal to pursue next. However, there should be a process to provide dynamic adjustments in goal priority in response to internal and external changes.

Goals represent an important part of the context information during collaboration. However, not all goals are appropriate to pursue in different conditions. In fact, it can be distructive to pursue a good goal is in a wrong context.

Changes in a dynamic collaboration environment alter the balance of alternative goals. These changes can occur as the reflection of collaborators' internal changes, the influence of their actions, or the occurance of any change in the collaborative environment.

Emotions have different functions. These functions, e.g., *goal management*, help one to communicate and/or regulate their internal changes as well as changes in their environment. In a collaborative environment, emotions represent the outcome of underlying internal mental processes of the collaborators. Goal-oriented emotions such as anger, frustration and worriedness, constitute the same representation of the mental processes status specifically influenced by one's internal goals. Therefore, the reverse appraisal of the collaborator's perceived emotion can impact regulation of the robot's active goals during collaboration. Furthermore, the appraisal of the individual alternative goals provides a better context-dependant assessment of these goals. Hence, we use both appraisal and reverse appraisal in our goal management process.

Goal management provides diverse influence on an intelligent agent's behavior, such as choosing the right goal between available alternatives with respect to the collaboration status, or changing the focus of attention to a different goal at the right time. The evaluative aspect of the affective appraisal processes has a key role in differentiating between available goals.

All of the solutions for the action selection problem address the question of which action to perform at what time [1].

[2]

For an intelligent agent to convey appropriate behavior, its actions should be chosen based on an accurate evaluation of the environment [3].

II. Background

III. Contribution

In this paper, we focus on small part of a larger architecture framework built based on our *Affective Motivational Collaboration Theory* [4], [5]. First, we investigated the influence of a collaboration structure on appraisal processes [6], and now we are investigating the influence of appraisal on collaboration structure (see Figure 1).

In the first part of our work, we implemented distinct algorithms for different appraisal processes for a collaborative robot. According to the appraisal theory, the outcome of these processes are separable antecedents of emotion with which the robot evaluates the environment. Our appraisal variables included: a) *relevance* used to measure the significance of an event for the robot, b) *desirability* to characterize the value of an event to the robot in terms of whether the event facilitates or thwarts the collaboration goal, c) *expectedness* indicating the extent to which the truth value of a state could have been predicted from causal interpretation of an event, and d) *controllability* indicating the extent to which an event can be influenced, and it is associated with a robot's ability to cope with an appraised event in a collaborative environment.

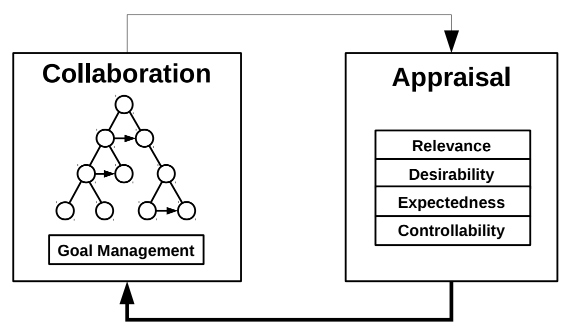

Fig. 1. Reciprocal influence of Collaboration and Appraisal mechanisms in our framework.

The outcome of each appraisal process is a specific value for the corresponding appraisal variable. The vector containing these appraisal variables can be mapped to a particular emotion instance at each point in time. For instance, a *relevant, undesirable, expected*, and *uncontrollable* event can elicit *anger* in an individual. However, it is not the actual emotion instance that is important for us. In fact, it is a) the functions of emotions in a social setting, e.g., *action selection*, and b) the meaning of the collabrator's perceived emotion that we are interested to investigate in collaboration context.

In our current work, we are investigating how appraisal can influence the *action selection* process during collaboration. The action selection process should provide the most appropriate action out of repertoire of possible actions. A collaboration structure provides a hierarchy and the constraints of the shared goals in the form of a shared plan (Figure 2). Therefore, a shared plan contains both the robot and human collaborator's goals. The robot takes actions with respect to the goals of which the robot is responsible for in the shared plan. However, there can be several goals available for the robot to pursue at each point in time during collaboration. In other words, any "live" goal can be pursued by the robot. A goal is *live* if all of its predecessors are *achieved* and all of its preconditions are *satisfied*. Therefore, a collaborative robot requires a mechanism to choose between a set of *live* goals. We believe appraisal processes can lead the robot to choose between the available *live* goals; since the appraisals are the immediate outcome of the robot's assessment of the collaboration environment.

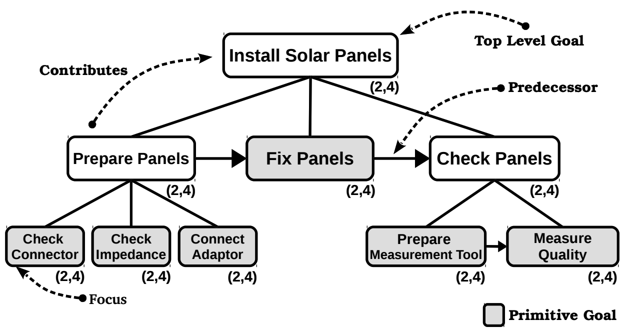

Fig. 2. Astronaut-robot collaboraiton structure (shared plan).

For instance, Figure 2 shows a nonprimitive "Prepare Panels" goal which contains three primitive goals. These primitive goals do not have any temporal constraint between them. Therefore, if the "Prepare Panels" is *live*, its primitive goals can be pursued by the responsible agent. In this example, the robot is responsible for all of these three primiitive goals. According to the collaboration mechanism in our overall framework, the "Check Connector" primitive is in focus (top of the discourse segment stack), therefore it is the most expected goal to be pursued by the robot. However, there are two other primitive *live* goals that the robot can pursue them. If everything goes based on the plan, the robot will pursue the "Check Connector" goal as the most expected one, but what if the astronaut asks the robot to skip cheking the connector, since she wants to do it? Now, the robot requires to choose between the other two goals. And, what if the astronaut fails to check the connector and becomes furstrated while the robot has already achieved the other two goals? How does the robot need to respond to the astronaut's negative emotion? or any emotion?

Equation 1 shows our general cost function we use to calculate the cost of each individual potential goal. The base in the equation is considered to calculate the cost of pursuing any given goal. There are three different functions used to calculate the cost, including *proximity* of a goal $P(g)$, *difficulty* of a goal $D(g)$, and *specificity* of a goal $S(g)$. The details about these functions are provided in equations 2 to 4. The exponent part of our cost function is considered to capture a) influence of human's emotional instance on the cost, and b) the influece of self appraisal of any given goal. The $R_h \in [0,1]$ and $D_h \in [-1,1]$ are the *relevance* and *desirability* values respectively, which will be attained based on the reverse appraisal of the human's perceived emotion. For instance, if the astronaut is frustrated the D_h obtains a negative value (depending on how undesirable is the event according to reverse appraisal), and R_h will be 1 for the active goal and its value descends to 0 for other live goals depending on their distance to the active goal in the shared plan. The $R_r \in [0,1]$ and $D_r \in [-1,1]$ are also the *relevance* and *desirability* values. However, the self appraisal functions provide these values for all of the live goals. For instance, for the active goal that the astronuat was frustrated for, the D_r can be a positive value (depending on the self's desirability appraisal function), and R_r can be 1, since the active goal is *relevant* for the robot. These values will change for the other live goals.

$$Cost(g) = \left(\frac{P(g) \times D(g)}{S(g)+1}\right)^{-C[(R_r+1)D_r+(R_h+1)D_h]} \tag{1}$$

$$P(g) = distance(g_{act}, g) \tag{2}$$

$$D(g) = [H(g)+1] \times \left[\sum_{m=0}^{M} pred_e(g) + \sum_{n=0}^{N} desc_e(g)\right] \tag{3}$$

$$S(g) = \frac{depth(g)}{degree(g)+1} \tag{4}$$

IV. Conclusion

References

[1] T. Tyrrell, "Computational mechanisms for action selection," Ph.D. dissertation, University of Edinburgh, 1993.

[2] M. Scheutz and V. Andronache, "Architectural mechanisms for dynamic changes of behavior selection strategies in behavior-based systems," *IEEE Transactions on Systems, Man, and Cybernetics, Part B*, vol. 34, no. 6, pp. 2377–2395, 2004.

[3] S. Franklin, *Artificial Minds*, ser. A Bradford book. MIT Press, 1997.

[4] M. Shayganfar, C. Rich, and C. L. Sidner, "Human-robot collaboration: Affect-driven functional coexistence," in *In Proceedings of Symbiotic Cognitive Systems Workshop at the 13th AAAI Conference on Artificial Intelligence*, 2016.

[5] M. Shayganfar, C. Rich, and C. Sidner, "Toward improving human-robot collaboration with emotional awareness," *Under Review*, 2015.

[6] M. Shayganfar, C. Rich, and C. L. Sidner, "Appraisal in human-robot collaboration," in *Under Review*, 2016.