# Human-Robot Collaboration: How Emotions Help to Do the Right Thing?

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***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 to do next. Therefore, the underlying processes of an intelligent agent is in the service of action selection procedure. Hence, any intelligent agent must continually answer the question "What do I do next?", since action is the real measure of intelligence.

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 2).

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.

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 1). 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.

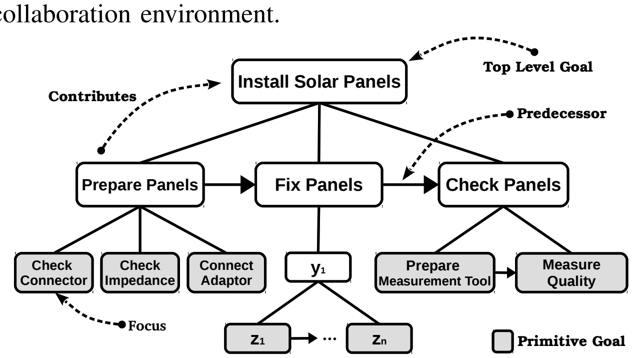


Fig. 1. Astronaut-robot collaboraiton structure (shared plan).

For instance, Figure 1 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?

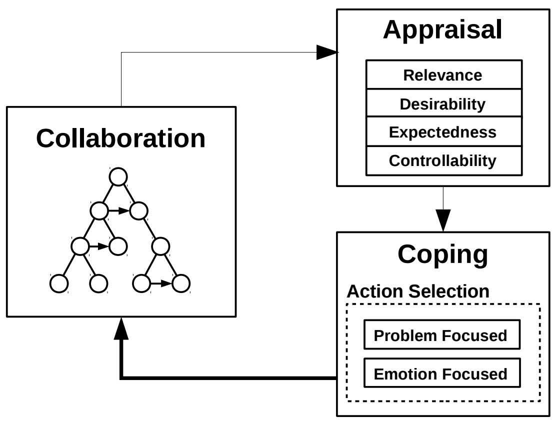


Fig. 2. Using coping strategies (action selection schemas) to select appropriate goal.

## IV. Conclusion

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