Decision-making in 2apl with emotions

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Abstract

This paper is a report on an experiment where four emotions from the OCC model of emotions, namely joy, distress, hope, and fear, were used to enhance the decision-making mechanism of a BDI-based agent-oriented programming framework called 2apl. An agent was put in a grid environment and given goals to reach different destinations where he had to prioritize the goals in order to get the best result. The emotions served as a nice abstraction paradigm for implementing a mechanism that helped the agent to solve the problems given in the experiment.

1. Introduction

Emotions are a big part of being a human being and a big factor in how we make decisions. It is interesting to see how they can be used in developing intelligent agents and [Steunebrink, 3] explains how there are at least three reasons why emotions are important for them. To make virtual characters more believable to humans, to more accurately model human decision-making, e.g. in economic models, and finally, "there exists psychological and neurological evidence that emotions are not only relevant but even necessary for intelligent behavior". The last one is the reason that inspires this paper.

One of the most widely used model of emotion is the OCC model [Ortony et al., 2]. It defines the eliciting conditions of 22 emotion types and the variables that affect their intensities, but we will focus on four of them, defined in the model as such: *Joy*: (pleased about) a desirable event, *distress*: (displeased about) an undesirable event, *hope*: (pleased about) the prospect of a desirable event, and *fear*: (displeased about) the prospect of an undesirable event. We notice two key differences in these four emotions, first that joy and hope arise when the agent is pleased about the consequence of the event while distress and fear arise when the agent is displeased about the consequence of the event, and second that joy and distress arise out of an actual event happening while hope and fear arise out of the prospect of an event happening.

2apl [Dastani, 1] is a BDI-based agent-oriented programming framework where the agent has a list of planning goal rules explained by Dastani like this:

> "The specification of a planning goal rule $\langle pgrule \rangle$ consists of three entries: the head of the rule, the condition of the rule, and the body of the rule. The head and the condition of a planning goal rule are goal and belief query expressions used to check if the agent has a certain goal and belief, respectively. The body of the rule is a plan in which variables may occur. These variables should be bound by the

goal and belief expressions. A planning goal rule of an agent can be applied when the goal and belief expressions (in the head and the condition of the rule) are entailed by the agent's goal and belief bases, respectively."

In the deliberation cycle the agent applies all the planning goal rules it can, given his belief base about the world, and lacks a mechanism to choose responsibly what goals to commit to. This can be troublesome for the agent. For example, if the belief query is true for two different goals and for both it applies that pursuing it gets the agent further away from achieving the other, then the agent can get stuck and achieve neither.

Here, I propose a way to use the four aforementioned emotions to give the agent a coping mechanism to commit responsibly to goals. Instead of thinking of the overall emotional state of the agent, each goal has an emotional state. When a goal is adopted it starts out in a neutral state which means that the agent should not make plans for it, he knows he should do it in the end but he hasn't decided to do it yet. If he then decides to pursue the goal (it becomes his intention to pursue it) the emotional state changes to a mix of hope and fear since now there is both the prospective event of achieving it and of not achieving it. If the actual pleasing event of achieving the goal happens the goal becomes joyful and if the actual displeasing event of realizing that he will not achieve it happens he becomes distressed. In both cases the prospective events for the goal have disappeared. The coping mechanism is run in the beginning of the deliberation cycle and makes sure that if there is no goal in the mixed emotional state of hope and fear it takes a neutral goal, if any, and changes the emotional state to hope/fear. The goal planning rule therefore has an added condition that the goal is in the hope/fear state. This way the agent only commits to one goal at a time. The difference between a goal in the neutral state and a goal in the hope/fear state can be viewed in BDI terms as the same as the difference between desires and intentions.

To see if this approach can be useful, an agent with this mechanism was implemented using oo2apl which is an object-oriented version of 2apl, created by Bas Testerink. The agent was then tested in an environment that demanded that he committed responsibly to his goals.

2. Experimental

To incorporate the processing of emotions in a oo2apl agent some key changes were necessary and they are explained in the appendix along with a link to the whole code, including the experimental setup.

The agent is positioned in an 8x8 grid environment with four moving capabilities up, down, right, and left. A block in the grid can be a wall which means that an agent cannot move there but he is blind so he only knows about a wall if he walks into it. The agent is given a list of goals which are simply to move to a given destination. The agent knows where in the grid he is positioned and where the goal is and he can make a plan to move horizontally or vertically towards the goal. To make the movements more interesting, if this plan results in him hitting a wall he has a secondary plan which is to try to move in a random direction. If the primary plan has failed 10 times for the same goal he officially loses hope for the goal and it becomes sad.

Two experiments were run, twice each, once with the emotional mechanism active and once where it was deactivated. Experiment 1 was run to see if the agent could commit to a goal to achieve it instead of being torn between two goals and never achieving either, and experiment 2 to see if the agent could give up an impossible goal and move on to another one. The setup for experiment 1 can be seen in figure 1 where the agent is the blue circle and the Xs are the goal destinations. The

setup for experiment 2 was the same as in the first experiment except now the first goal is surrounded with walls so the agent cannot reach the destination, see figure 2.
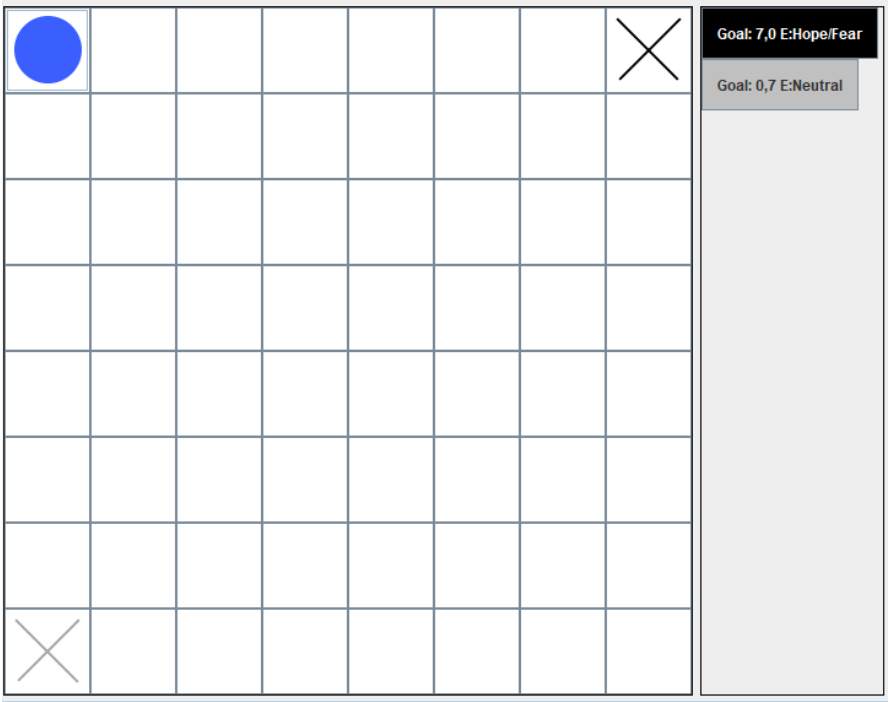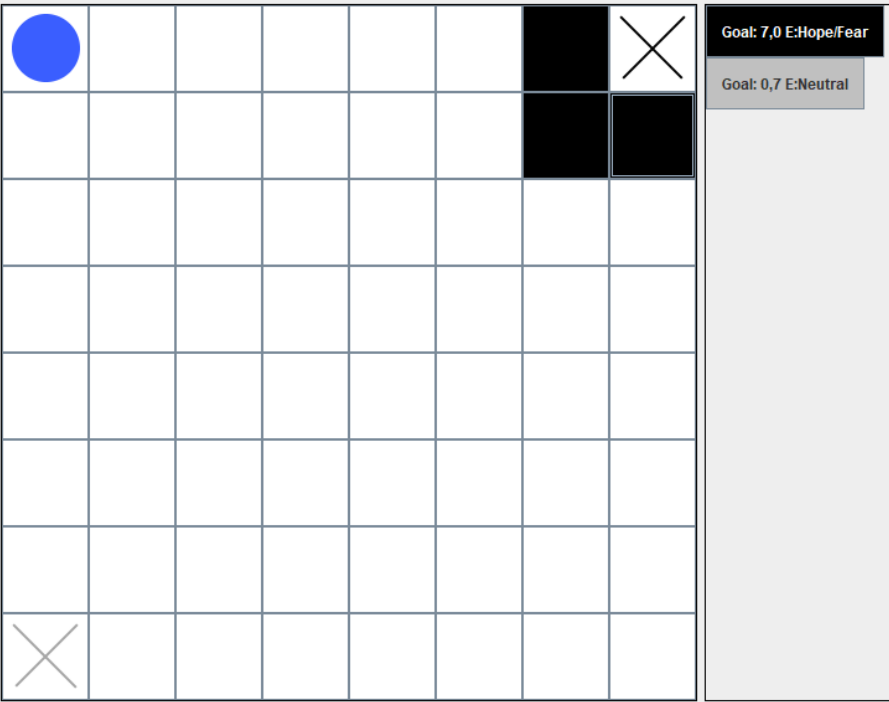

Figure 1 - Initial setup for experiment 1.

Figure 2 - The initial setup for experiment 2.

3. Results

Experiment 1:
With emotions: The agent started by changing the emotional state of the goal he was given first, the one in the upper-right corner, to *hope/fear* and moved until he achieved it and then changed the emotional state of it to *joy* and the other one to *hope/fear*. He then continued until he had achieved the second goal as well, changed its emotional state to *joy* and stopped.

Without emotions: The agent alternates between moving one step towards the first goal and one step towards the second goal and never achieves either.

Experiment 2:
With emotions: The agent started the same way as in the first experiment by changing the emotional state of the first goal to *hope/fear* and pursued it until it gave up and changed its emotional state to *distress*. Then he changed the emotional state of the second goal to *hope/fear* and pursued it until he achieved it, changed its emotional state to *joy*, and stopped.

Without emotions: The agent, again, alternates between moving one step towards the first goal and one step towards the second goal and never achieves either.

4. Discussion

When the emotional mechanism was activated the agent easily solved the problems in the experiments, but without it he achieved nothing. This shows that the emotional structure serves the intended purposes of committing responsibly to goals, at least in these simple experiments. This mechanism can undoubtedly be implemented without the explicit use of emotions but this experiment hopefully shows that they can serve as a nice abstraction and/or inspiration for implementing the decision-making process that will surely be useful in larger and more complicated projects.

5. Conclusion

The inspiration was that emotions are not only relevant but even necessary for intelligent behavior. This project used four emotions from the OCC model, namely joy, distress, hope, and fear, to enhance the decision-making process of the 2apl framework and showed that they can be helpful. This was a very simple exercise but does show that emotions can serve as a nice abstraction and/or inspiration for implementing the decision-making process.

An interesting next step would be to create a more complex mechanism for the agent to use to decide when to give up on goals. [Steunbrink, 3] offers quantitative measures in emotion regulation that could prove helpful for this purpose. This could lead to a scenario where an agent temporarily gives up hope for a goal and takes it up again if his hope for the other goals have diminished below his hope for the first one.

References

1. M.M. Dastani, 2APL: a practical agent programming language. *Autonomous Agents and Multi-Agent Systems* 16, no. 3 (2008): 214-248.
2. A. Ortony, G.L. Clore, and A. Collins. *The Cognitive Structure of Emotions.* Cambridge: Cambridge University Press, 1988.

3. B.R. Steunebrink. *The Logical Structure of Emotions*. PhD diss., Utrecht University, 2010.

Appendix

Here the code that implements the emotional behavior of the agent is explained. The whole code can be found at https://github.com/sasiggi/EmotionalAgents.

A new class `EGoal extends oo2apl.agent.Goal` was created which has an `EState` object that describes the emotional state of the goal.

In `oo2apl.defaults.deliberationsteps.ApplyGoalPlanSchemes.execute()` a part was added for the coping strategy of keeping at least one `EGoal` in the emotional state *hope/fear*. This method also runs the code that clears achieved goals by running their `Goal.isAchieved()` function which is where `DestinationGoal extends EGoal` realizes that it has been achieved and changes its emotional state to *happy*. `DestinationGoal` also has a method `onFailed()` which changes the emotional state to *sad* when it has been called to often.

In `oo2apl.defaults.deliberationsteps.DefaultDeliberationStep.applyPlanSchemes(…)` plans are now only made for goals that have the emotional state *hope/fear*.