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Integrating Planning, Creativity and Exploration in Motivational Agents

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Abstract

Although, planning and exploration of unknown environments has been previously addressed in multi-agent environments, we believe that in addition to these activities, agents may also benefit from exhibiting creativity so that they are able to imagine or invent new things (objects) that may be helpful or simply pleasant for the agents that inhabit the environment. Psychological and neuroscience research (e.g.: Damásio, 1994) over the past decades suggests that motivations (emotions, drives and other motivations) play a critical role in these activities that involve decision-making, and action, by influencing a variety of cognitive processes (e.g., attention, perception, planning, etc.).

We have developed a multi-agent environment (Macedo & Cardoso, 2004) in which, in addition to inanimate agents (objects), there are two main kinds of animate agents interacting in a simple way: the creators, whose main function is to create things (objects, events), and the explorers whose goal is to explore the environment, analyzing, studding and evaluating it. In spite of this classification, there are agents that may exhibit the two activities, exploration and creation. In addition to these two activities, animate agents are able to generate plans. Planning plays a central role in the reasoning/decision-making by supporting the other two activities: exploration and creativity. Actually, in our approach, creativity and exploration involve planning: when exploring the environment an agent has to plan a sequence of actions required to visit an unknown region or entity; when creating, an agent has to plan the sequence of actions required to come up with an original and valuable object.

The architecture of an agent includes the following modules: memory (for entities, plans, and maps of the environment), goals/intentions, desires, motivations (emotions, drives and other motivations), and reasoning/decision-making. The planner is the core of the deliberative reasoning/decision-making module. The agent uses a planner that combines the technique of decision-theoretic planning with the metholody of HTN planning in order to deal with uncertain, dynamic large-scale real-world domains. Unlike in regular HTN planning, the planner can generate plans in domains where there is no complete domain theory by using cases of previously successful plans instead of methods for task decomposition. It generates a variant of a HTN - a kind of AND/OR tree of probabilistic conditional tasks - that expresses all the possible ways to

decompose an initial task network. The expected utility of alternative plans is computed beforehand at the time of building the HTN and it is based on the expected positive and negative feelings that the agent feels if the plan is executed. Plans that are expected to elicit more positive feelings (happiness, surprise, etc.) and less negative feelings (e.g.: hunger) are assigned a higher expected utility.

When performing exploration, the aim of an agent is twofold: (i) acquisition of maps of the environment – metric maps – to be stored in memory and where the cells occupied by the entities that populate that environment are represented; (ii) construction of models of those entities. Exploration may be performed by single or multiple agents. Each agent autonomously generates goals for visiting unknown entities or regions of the environment (goals of kind *visitEntity* or *visitLoc*) and builds a HTN plan for each one. Goals and plans that are expected to cause more positive feelings and less negative feelings are preferred. Thus, each agent performs directed exploration using an action selection method based on the maximization of the intensity of positive feelings and minimization of negative ones. Relevant motivations for directing exploration are for instance curiosity, surprise and hunger. The exploration strategy for multiple agents relies on considering a team leader that, based on the information provided to it by the members of the team as they perform their single exploration, builds a joint metric map, a joint episodic memory and a joint plan in order to be shared by all the members of the team.

When performing creativity, an agent generates goals for the creation of novel, original and valuable entities (goals of kind *createObj*) and builds a plan for each one. Like in exploration, goals and plans that are expected to cause more positive feelings and less negative feelings are preferred. Motivations such as surprise and curiosity that capture variables such as novelty or unexpectedness, respectively, are hence important for creativity.

Main References

Damásio, A. (1994). Descartes'error, Emotion Reason and the Human Brain. New York: Grosset/Putnam Books.

Macedo, L., & Cardoso, A. (2004). Exploration of Unknown Environments with Motivational Agents, Proceedings of the International Joint Conference on Autonomous Agents and Multi-Agent Systems.: ACM.