TACOP: A COGNITIVE AGENT FOR A NAVAL TRAINING SIMULATION ENVIRONMENT

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Decision-making in complex and dynamic multi-agent environments (e.g., military missions) requires a significant effort and has proven difficult to train. Moreover, such trainings are expensive, since for training one person multiple persons are needed to play the various other roles in the training scenario. Replacing these human agents by software agents would reduce the costs substantially. Such agents should be capable of showing human-like behavior. Therefore, they should incorporate – next to expert knowledge – cognitive characteristics that can be utilized using cognitive modeling techniques [1].

Recently, the Royal NetherLands Navy (RNLN) recognized the potential of software agents for training (future) naval officers in decision making. The RNLN is interested in the development of a multi-agent system that can train a student, where cognitive agents (instead of other persons) play the roles of team member, instructor, and enemy. This research presents TACOP: a TActical Cognitive OPponent.

A training scenario was developed in close cooperation with a RNLN instructor, who then provided a set of plausible goals, strategies, and actions for an enemy in that scenario. This set was used to model TACOP. The environment in which the student interacts with the TACOP was created with VR-Forces [3].

We decided to model TACOP as a BDI-agent, since the Beliefs-Desires-Intentions architecture is known to be suitable for the generation of autonomous reactive and proactive behavior [2]. TACOP's beliefs define his knowledge and reasoning. Two kinds of beliefs can be distinguished; (i) simple beliefs, formed passively through sensor perceptions and (ii) complex beliefs, actively formed when the agent is in a certain state of mind (represented by its beliefs, desires, and intentions) and reasons about it. In addition, beliefs are constantly updated and deleted when necessary.

The desires of the agent are formed by the agent's goals. Two types of desires can be distinguished: static desires (i.e., always activated, primary goals; e.g., self defense) and dynamic desires (i.e., emerging with a belief; e.g., fire, which is only activated when the belief is present that the target is within range).

When a desire of an agent is in focus, intentions (determined by beliefs and other intentions) will be generated. An intention is planned to enable the agent to fulfill its goal and is executed as soon as possible. Subsequently, observations or actions can be generated. Moreover, a link can be made between the actions of an agent and the external (real) world.

The cognitive agent model was implemented using the COGNET architecture and the iGEN Toolset [4], which is based on computational models of human cognitive processes. Its main components are a blackboard, which stores the agent's declarative information, and tasks, which represent its procedural knowledge.

Beliefs are stored on the blackboard, as well as the static desires (as primary goals). The dynamic desires of an agent are represented by tasks and composed of two parts: the head, which specifies the circumstances under which the task should be triggered and the body, which contains the steps to be executed when the task is activated.

Intention generation emerges when a task is on the blackboard (i.e., triggered) and receives attention. In the body of every task, various sub goals (intentions) are defined. Some of them will only be activated when certain specifics (simple or actively generated complex beliefs) are met.

In the implementation of the cognitive model, tasks are the central components since they generate intentions (activated sub goals), complex beliefs (through determinations initiated by intentions), and actions. In addition, task bodies can post, delete, and prioritize tasks from the blackboard and subsequently determine the current active desires.

TACOP was evaluated in three separate successive phases. The evaluation focused on two properties of the cognitive agent's behavior during the training exercise: its tactical representativity and its contribution to the didactic quality of the training.

First, the global system was tested by two instructors of the RNLN Operational School. They did not find irregularities while using it. However, only one instructor managed to fulfill the specified task.

Second, a questionnaire, formed by a pre-defined hierarchical structured list (or binary tree) of questions was conducted. This assured that a standardized question was present for each training situation of interest. Since the instructors went through the training in various ways, most questions were only asked to one instructor. The answers show a disagreement between the instructors; one evaluated both the training and TACOP's behavior very positive, the other (unable to fulfill the task) slightly negative.

In the third phase, both participants were interviewed separately. The participants mentioned a variety of comments. However, only some of them involved TACOP's behavior. Most of the comments referred to the system's parameters. These comments were processed in the further development of the system.

In this paper, we described a cognitive agent that can support naval training sessions. Although in general the agent functioned excellent, some comments can be placed concerning the development of the conceptual model.

Although the knowledge used to develop TACOP was of a high expert level, it was the opinion of one single person. The divergence in the evaluation was caused by a different opinion of the instructors concerning the correct tactical behavior of both the trainee and TACOP. When the trainee interpreted the scenario as expected, TACOP demonstrated tactical sound behavior that supported the specified training goals. However, the simulation did not reach its didactic goal when the scenario was interpreted differently, as one of the evaluators did. To ensure that future cognitive models and scenarios do not suffer from the differences in expert opinions, they should be developed in cooperation with multiple experts.

Furthermore, in the future the agent should become capable of showing tactical sound behavior that supports the didactic quality of the simulation, independent of the interpretation of the scenario. Hence, more tactical knowledge and functions should be incorporated to determine the trainee's interpretation of the scenario.

Supported by the success of this research a follow up project was initiated. In time, we expect to develop an entire, formally specified, real-world multi-agent system for naval training purposes, including all possible complex interactions between artificial and human agents.

References

[1] R. W. Few and A. S. Mavor. *Modeling Human and Organizational Behavior.* Washington DC: National Academy Press, 1998.

[2] G. E. Phillips-Wren and N. Ichalkaranje. *Innovations in Intelligent Agents and Applications*, volume 3213, pages 71–73. Springer Verlag, 2004.

[3] MÄK Technologies. VR-Forces. `http://www.mak.com` [Last accessed on September 09, 2005], 2005.

[4] W. Zachary, J.-C. Le Mentec, and J. Ryder. *Interface agents in complex systems.* Norwell, MA: Kluwer Academic Publishers, 1996.