A Cognitive Model for Visual Attention and its Application (Extended Abstract)*

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1 Introduction

In the domain of naval command and control and warfare, the complex and dynamic nature of the environment makes that a warfare officer, who has to compile a tactical picture of the situation, has to deal with a large number of tasks in parallel. This study aims at investigating the use of a cognitive model of visual attention as part of the design of a software agent that supports such officers. In order to support, agents can take over part of the parallel tasks. However, a problem is how to determine an appropriate work division between agent and its user: due to the rapidly changing environment, such a work division cannot be fixed a priori [1]. This results in the need for dynamic task allocation, determined at runtime. For this purpose, two approaches exist, namely human-triggered and system-triggered dynamic task allocation [4]. In the former case, the user can decide up to what level an agent should assist him. But especially in alarming situations the user does not have the time to think about proper task allocation [5]. In these situations it would be better if the agent determines the allocation of tasks. Hence a system-triggered dynamic task allocation is desirable.

2 Agent Design

In order to obtain such a runtime system-triggered task allocation system, it is proposed to use a cognitive model of visual attention as part of its design. The idea is to estimate the user's attention in order to determine which subtasks the agent has to pay attention to. For instance, if the user has the subtask to pay attention to a certain track on the radar, no additional support for that track is needed, and the agent should rather direct its own attention to the user's unattended tracks. The assumption made here is that if a certain track is attended to, the user has also consciously committed him- or herself to dealing with it. This assumption enables the agent to adjust its support at runtime, based on the dynamics of the modeled attention.

3 Cognitive Model Formalization and Simulation

The cognitive model of visual attention is written in a mathematical format and then specified in a logical simulation language LEADSTO that is part of the agent's design. This simulation is based on data from a case study in which a user executed a task abstracted from a naval radar track identification task. Data consist of two types of information: 1) dynamics and properties of tracks on the radar and 2) the user's gaze behavior using an eye-tracker. Based on this information, the cognitive model estimates the distribution of

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attention levels over tracks on the radar. The gaze data consists of (x, y)-coordinates over time. The track data consists of the variables of moving, possibly threatening, airplanes visible on the radar: speed, distance to the center, type of plane, and status of the plane.

4 Philosophical and Logical Validation

To obtain a philosophical and logical foundation for the attention model, the notion of representational content, as known in the literature on Cognitive Science and Philosophy of Mind, is used: 'what does it mean for an agent to have a certain mental state', or 'what information does the mental state represent'? To evaluate whether the model introduced here does what is expected, this question is answered for attentional states in both a fundamental and practically useful, operational manner. This is done by identifying a representation relation that indicates in which way a mental state property p relates to properties in the external world or the agent's interaction with the external world; cf. [2]. The expressions specifying the representational content have been formalized in the predicate logical language TTL. Formal specification of representation relations for attentional states, enables verification of the attention model against the intended meaning of attentional states. Fundamental issues on representational content that were encountered in the context of this work are (1) how to handle decay of a mental state property, (2) how to handle reference to a history of inputs, and (3) how to define representational content when a behavioral choice depends on a number of mental state properties.

5 Conclusion

In short, a cognitive model has been developed as a component of a socially intelligent agent: The component allows the agent to adapt to the need for support of a warfare officer for his task to compile a tactical picture of the situation. The model was specifically tailored to domain-dependent properties retrieved from a task environment. Nevertheless, the method remains generic enough to be easily applied to other domains and task environments.

Future studies may result in the actual use of the attention estimate for dynamically allocating tasks as a means for assisting a naval warfare officer. One way is to use a threshold that facilitates a binary decision algorithm that decides whether or not a task should be supported. Open questions are for instance related to modeling both endogenous and exogenous triggers and their relation in one model. One important element missing is for example expectation as an endogenous trigger.

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