# Tracking Driver Intentions with the ACT-R Driver Model

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Driving is a complex dynamic task that offers both serious theoretical challenges and practical applications to ACT-R, cognitive architectures, and cognitive modeling as a whole. In several studies, we have successfully applied ACT-R in predicting driver behavior and especially distraction from secondary tasks — for instance, distraction from cell-phone dialing (Salvucci, 2001; Salvucci & Macuga, 2002) and from primarily cognitive tasks (Salvucci, 2002). As a complement to this predictive work, we are beginning to explore possibilities for recognizing and tracking driver behavior and intentions using ACT-R models. The core idea in this work is closely related to model tracing algorithms used in existing intelligent tutoring systems (e.g., Anderson et al., 1995). However, these tutoring systems make at least two assumptions that hinder easy generalization to the problem of tracking driver intentions: they assume that all behavioral events/actions are discrete events without noise, and they assume that each action corresponds one-to-one with a skill-related rule without ambiguity and limited backtracking. In contrast, drivers' behavioral data, like behavioral data for many real-world tasks, are multimodal, continuous, and noisy. We are working to create a general framework for tracking intentions that can handle noisy, continuous signals and successfully map observed behavior to cognitive processes.

Our current framework, which we call the *mind-tracking architecture,* centers on a cyclic process with four key steps as shown in Figure 1. (1) We observe the driver's behavior and maintain a moving window the entire multimodal stream. (2) Given the same environmental variables available to the human driver, we generate a set of predicted thought and action sequences by running multiple copies of the ACT-R driver model (Salvucci, Boer, & Liu, 2001) in simulation; as a set, the models cover the range of strategies that we expect drivers to execute from the given point in time. (3) The architecture finds the best match between the predicted action sequences and the actual observed sequence using a predetermined similarity metric (e.g., RMSE across features, probabilistic computation, etc.). (4) By finding the best-matching model given predicted and observed actions, we thus infer the most likely cognitive processes that generated the observed actions — namely, the cognitive processes embodied by the best-matching model. Thus, the mind-tracking architecture "thinks" along with people as they behave, mirroring their thoughts and actions and providing a continual estimation of the person's current cognitive state, including intentions, goals, knowledge, etc. In doing so, the architecture provides a unified framework for relating observable, lower-level actions to higher-level cognitive processes.

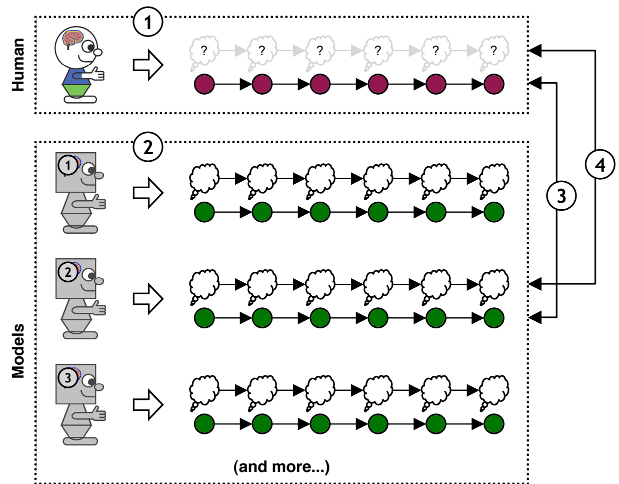


Figure 1: Overview of the mind-tracking architecture.

Thus far, we have successfully applied this architecture to the problem of detecting driver lane changes using data from a driving simulator and real-world instrumented vehicle (e.g., Salvucci & Siedlecki, 2003). We are currently exploring applications to a larger set of driver intentions as well as other domains including tracking user intentions in the context of an intelligent user interface.

## References

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