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MODELING DRIVER COGNITION

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Summary: A discussion of driver modeling is presented along with the design of the PADRIC (**PATH DRIVER** Cognitive) model, and more specifically the perceptive module and its control by a tactical module.

INTRODUCTION

Modeling driver's cognition is a challenging endeavor undertaken by psychologists and human factors researchers. The motivations underlying this enterprise range from safety concerns to improvement of traffic conditions. This approach is the next step after the production of risk models that explain drivers' behavior. Before the advent of ITS, psychology applied to driving sought to understand and explain why accidents happen (risk management issues) and design countermeasures to prevent them. It turned out that many countermeasures did not meet the expected gain, so the appreciation of risks taken by the driver started to be explored by psychologists. This exploration led to another dimension of driving and the focus on "what does a driver understand of a given driving situation?" opened the door to the production of cognitive models. In this type of approach, the goal is not to explain why a driver takes a risk, but explain how a driver understands and processes a driving situation, propose how to assist drivers in their driving activity, and eventually design systems that will support them in their driving decisions and actions. The other well known challenge for these systems is to integrate the users characteristics, i.e. in order to improve the control of one driving task, the system should not degrade the other driving tasks that are carried out at the same time.

This paper will focus on the design and implementation of the PADRIC (PATH DRIVER Cognitive) model and on the module in charge of reproducing part of the perceptive processing of the model. This model is integrated within a micro-simulation tool, SmartAHS¹, for supporting the development and assessment of driver assistance systems.

MODEL DEVELOPMENT

The departure point for PADRIC² design is COSMODRIVE (COgnitive Simulation Model of the DRIVER; Tattegrain-Veste et al. (1996)). COSMODRIVE interest relies on the fusing of concepts from cognitive psychology with the classical models describing the driving activity in three levels: strategic, tactical, and operational. The most interesting aspect of COSMODRIVE for our model is the description of the tactical level via cognitive structures (Long Term Memory

¹ See <http://path.berkeley.edu/SMART-AHS/index.html>

² See Delorme and Song 2001 for a description of the model

and Working Memory) and processes (e.g. categorization, decision making) and its modular structure.

PADRIC implementation focuses on the aspects most relevant for highway driving simulation, and more specifically, highway cruising. This focus influences the contents of the original model. The processing associated with cruising on a highway is distributed among three modules: perception, tactical and operational. The influence of a strategic module is implicitly represented in the form of “goals ” integrated within the tactical module.

PERCEPTION MODULE

The perception module is in charge of providing information relative to the road environment, traffic, controls (heater, ventilation, etc.) and in-vehicle displays, such as navigation systems to the cognitive system. From a cognitive standpoint, the control of visual attention functions in two modes. On the one hand, there is an exogenous (bottom-up) control, where conspicuous objects automatically attract driver's attention. In the other hand, the control is endogenous, which means that the driver's attention is deliberately directed toward his/her environment, for the search of expected properties of the relevant objects for the task, (e.g. location, color, shape). Exogenous and endogenous control alternate as a function of the driving search demands. This demand is continually changing and there are no external cues about when a driver is in an exogenous or endogenous control, which might explain the problem encountered for defining visual patterns (Theeuwes, 1991).

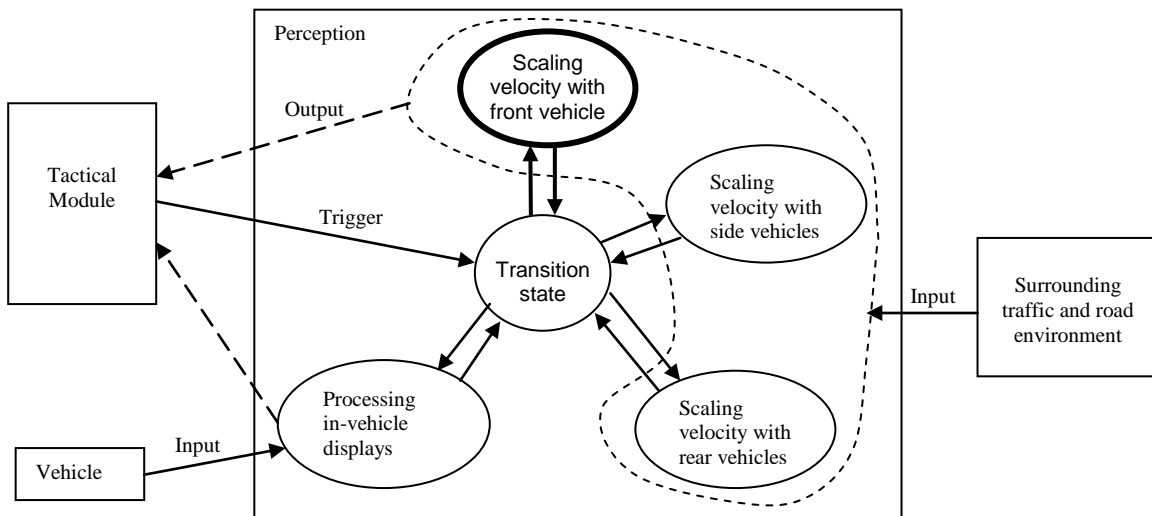


Figure 1: Visual Allocation

The first step in the implementation of this module addresses the endogenous control of the visual attention. In PADRIC, this control is coming from the tactical module, as it hosts the cognitive processing of the model. The visual allocation is implemented via a final state machine, including a transition state and four “processing” states: Scaling the relative velocity with the leading vehicle, scaling the relative velocity with side vehicles, scaling the relative velocity with rear vehicles and processing in-vehicle displays. This last state represents the

processing of information inside the vehicle on the dashboard, odometer, and controls, such as heat, ventilation, and radio. (see Figure 1).

Three dimensions influenced the implementation of the perception module: 1) the way to allocate visual attention among the different states, 2) the type of processing realized once in one state and 3) the time spent while on one state. Multiple sources show that visual searching while driving is not based on a cycle but on the need for information, what Theeuwes (1991) calls “uncertainty reduction”. Therefore, visual attention is by default allocated to the road in front, for scaling the relative velocity of the leading vehicle, by the perception of range and range-rate with this vehicle; as well as the information necessary for keeping the vehicle within the lane. While in this state, the relative velocity with the leading vehicle is scaled base on Hoffman and Mortimer model (1996). The tactical module triggers the transition state, which will then select the state corresponding to the necessary information. Finally, we used data from the literature for the description of the duration of a glance while in a state and the number of glances necessary for obtaining the information the driver is seeking. For example, Bhises et al. (1986) described that in-vehicle displays need between 7 and 15 glances for extracting the information.

This modeling tool has already generated interesting simulations. For example, the model was used for the simulation of an emergency caused by visual distraction. A worst-case scenario was created with two cars on a highway, where the second vehicle followed the first with a time-gap of just under 2-sec. A distraction was then introduced by way of a visual attention allocation for tuning the radio. At the same time, the lead vehicle executed a hard braking action. Depending of the length of the distraction with the radio, the driver of the following car also exhibited a hard braking and sometimes crashed.

CONCLUSION

The above case study and other simulations show that the model, even in the first stage of development, is already an interesting tool. The next steps are oriented towards the inclusion of additional cognitive processes in order to increase the variety of behavior that can be simulated and the introduction of new knowledge bases for applying the model to traffic situations other than highways (e.g. rural or urban).

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