Task and domain modelling and validation for dynamic situations

Background and methodological issues

Task and work domain analysis are widely used methodologies to model the domain of traffic systems. However, their validation beyond expert judgement has received little attention. The problem is exacerbated by traffic systems being complex and dynamic environments where discrete task execution stages are difficult to model. We argue that model validation should follow a template linking conceptual task models with operationalised task models, which in turn are used to make quantitative predictions about the domain. Successful predictions will increase a model's claim to validty whereas failed predictions question that claim. Further, it is important to address those variables relevant to a domain. For human behavior in traffic systems, these variables are represented by the TASC conceptual framework presented here. TASC splits human behavior into the Task under consideration, Actions taken, the Situation, and the human embodied Cognition.

Aim and method

The validation approach to is demonstrated using a lightweight work domain analysis of the driving task. An abstraction hierarchy of the traffic system was constructed with special focus on values and priority measures. For selected values and priority measures, testable predictions were made regarding human drivers assuming the abstraction hierarchy to be valid. Subsequently, data were gathered in a driving simulator. Twenty-one participants drove on a two-lane motorway in two scenarios in random order. The “controlled” scenario consisted of vehicles showing very predictable behavior; the “realistic” scenario had medium-dense traffic behaving similarly to everyday traffic. The participants were instructed to drive according to traffic rules. Eye-tracking data were recorded. Nine participants drove the two scenarios again while being instructed to think aloud focusing on perceptions and goals.

Results

Based on the data, we produced separate graphical representations for the TASC levels of action, situation, and cognition representing the time course of the drive for each subject. The cognition-level was split into perception (eye tracking) and goals (thinking aloud). Behavior on right lane differed markedly from behavior on left lane. Values appeared clearly in driving actions, gaze behavior, and thinking aloud utterances. Predictions from the abstraction hierarchy were statistically evaluated using linear mixed models. Generally, observed data followed the predictions.

Conclusions

The template for task and domain model validation could be effectively used to address questions of validity regarding the abstraction hierarchy. Turning values into predictions regarding defined measures also helped to sharpen the Abstraction hierarchy on a conceptual level. The TASC-framework proved very useful to analyse dynamic situations. However, it also became clear that values had been underspecified in their original formulation. Additionally, it the linkage of values and actual measures for the values was identified as a potential issue complication questions of validity.

More effort should be directed towards validation of task models. We recommend making operationalisation of task models standard practice when conducting task analysis to help planning of evaluation studies and assessment of generalizability of results beyond the task environment studied. To gain a better understanding of the cognition of task execution, more research into setting of multiple goals, action selection, and situation representation in dynamic environments is highly desirable.