Validating Task and Domain Models for Traffic Situations

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Tasks and Domains: Key to Understanding Behavior

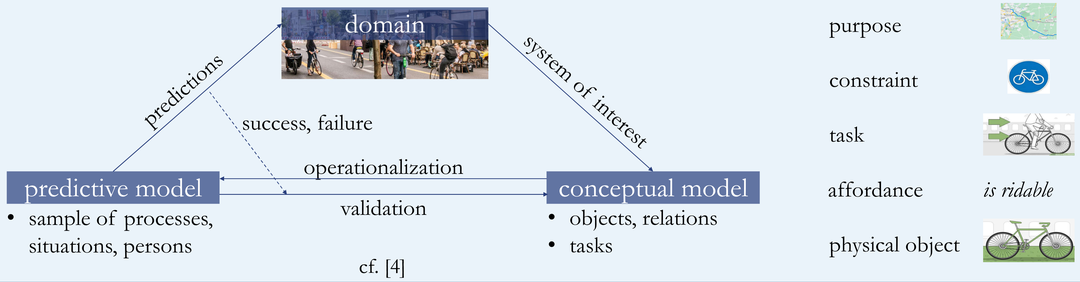
"In order to ensure that something goes well, it is necessary to understand what goes on." [1]

- task: what is to be done to reach an objective, often as interactions within systems
- domain: subset of the world where task is executed, provides resources and constraints
- task analysis: modelling task related objectives, required actions, situational dynamics, cognitive processes

Unvalidated Models are Problematic

- validation of task & domain models rarely done [2], perhaps because "model validation is an extremely complicated subject" [3]
- problematic: using unvalidated models as norm for task execution; making broad statements about the traffic system

Conceptual Approach



cf. [4]

Abstraction Hierarchy as Conceptual Model

	road traffic system	...	human car driver
purpose	transport of people and goods		individual motorized mobility
constraints	• rate of crashes / injuries / fatalities • traffic flow		• risk minimization • travel time minimization
tasks	• carry moving objects • direct and separate moving objects • convert stored energy to kinetic energy		• navigation • maneuvering • control
affordances	• driveable surface • highly visible symbols • controlled locomotion		• perception • cognition • motor functions
objects	• static (roads, signs, markings) • dynamic (people, vehicles)		body with eyes, brain, hands, feet

cf. [5, 6, 7]

Operationalization: Risk Minimization

"To minimize the risk of colliding with a car in front of you, do not approach too fast when close."

	specification conceptual model
objects	• human car driver / ego vehicle (same position and speed) • foreign vehicle
relations	• spatial: relative positions • speed: positional changes over time • driver actions: longitudinal and lateral control ego vehicle
task	approach vehicle in front

operationalization

$S(p) \rightarrow [Rmin(p): \leftrightarrow (B(p) > c)]$ cf. [8]

- p: person with a driver's license,
- S: study,
- $Rmin$: risk minimization,
- B: observed time-to-collision (TTC)
- c: critical TTC threshold := 3.5 s [9]

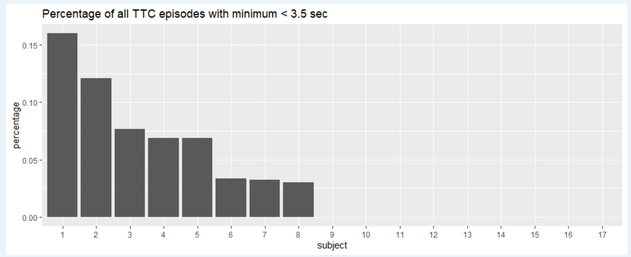
Prediction

- A human driver minimizing risks when approaching a vehicle in front will avoid TTCs ≤ 3.5 s (e.g. [5]).
- All drivers want to minimize risks (from conceptual model).
- Therefore, when observing a sample of human drivers in the given situation, no TTCs ≤ 3.5 s will be recorded.

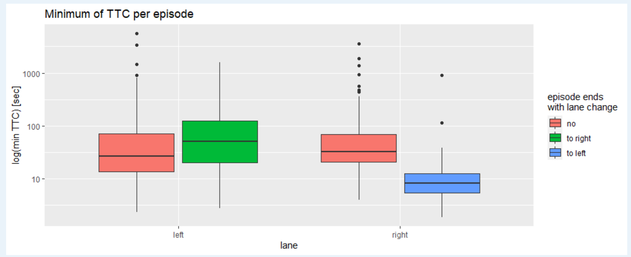
Simulator Experiment

- 360° fixed base simulator with passenger car mockup
- 17 subjects drove manually on a two-lane motorway with medium-dense traffic
- instructions: keep speed between 120 km/h and 150 km/h; comply with traffic rules

Results



- TTC episode := period of ego vehicle approaching lead vehicle
- 96 % of all episodes were not critical
- 8 of 17 subjects had at least one such episode
- worst offender: 16% of subject's episodes were critical



- low TTC-episodes are part of overtaking maneuvers (right-to-left)

lane at time of min TTC	ends with lane change	mean TTC [s]	SD TTC [s]
right	to left	18.0	82.5
right	no	124.3	386.0
left	to right	169.1	324.6
left	no	130.6	476.7

Conclusions

- Empirical results: Prediction failed because of deterministic standards and not relating risks to subtasks.
- Validation approach: Explicit operationalization of conceptual models makes communication about a model's scope and intent easier, yields interesting results even when failing, and ties in well with established methodology.

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[2] Annett, J. (2002). A note on the validity and reliability of ergonomics methods. Theoretical Issues in Ergonomics Science, 3(2), 228–232.
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[5] Rasmussen, J., Pejtersen, A. M., & Goodstein, L. P. (1994). Cognitive systems engineering. New York, NY: John Wiley & Sons.
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