Probabilistic and Empirical Grounded Modeling of Agents in Partial Cooperative (Traffic) Scenarios

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Abstract: Traffic scenarios can be regarded as problem situations with one or more (partial) cooperative problem solvers. Solving such a problem successfully requires (nonverbal) communication and distributed cognition. This is especially true when traffic is deregulated as in the *shared space* concept. Each traffic agent has a set of beliefs concerning his state, his goals, and the future behavior of the other agents. Risky but fortunately rare maneuvers can occur anytime. We call these risky maneuvers *anomalies* (eg. Verletzung der Vorfahrt, riskantes Auffahren, Einscheren, Überholen, ...). An experienced car driver is able to anticipate these anomalies. Novices and handicapped persons do not. It is expected that assistance systems could enhance the situation awareness and the communication competencies of unskilled or non-cooperative drivers. The design challenge for intelligent assistance systems is to model the behavior of traffic agents and diagnose these anomalies. We propose probabilistic models for these challenges.

1 Regulated Partial Cooperative Scenarios: Driving

Crews in navigation bridges or in cockpits normally cooperate in solving the problems arising during ship or aircraft operation. This cooperation includes exchange of complex verbal messages which require a high dimensional state space for the agent models. Traffic scenarios are of a fundamental different type. Communication, cooperation and action repertoire are limited in amount and complexity. Agents do not belong to a formal cohesive group. They meet together by accident and try to maximize their personal utilities sometimes ignoring the needs of others. Internal group norms are substituted by traffic regulations which are expected to accelerate negotiations between the traffic agents in a scenario. The solution of a traffic problem is a distributed but synchronized sequence of actions (e.g. Collision-free crossing an intersection) of all scenario partners.

2 Modeling Agents in Partial Cooperative Scenarios

Skilled agents differ from novice in their competence of risk perception thus increasing their objective safety. Models have to represent these and other kinds of perceptions, be-

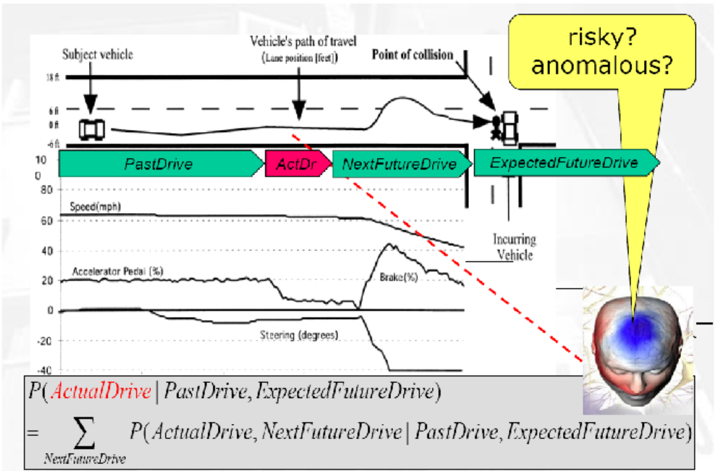

Abbildung 2: Driving control of an Alzheimer driver in a simulated intersection incursion and risk assessment by probabilistic driver models of incurring vehicle

liefs, goals and actions of the ego agent and alter agents. Driver models have to answer two kinds of research questions:

1. Represent and predict the behavior of individual drivers and groups of drivers (maybe in combination with assistance systems) with models derived directly from empirical distributions without any non testable ad hoc assumptions.

2. Diagnose and measure the riskiness or abnormality of the behavior of alter agents There are different alternatives for computational driver models. Due to various reasons we focus ourselves on probabilistic models with a special emphasis on dynamic probabilistic models.

3 Examples of Partial Cooperative Traffic Scenarios

The success of the shared space concept is mostly due to the enhancement and stimulation of the agent's situation awareness and perception of risk. Modeling selected traffic scenarios makes it necessary to model not the behavior of ensembles of *single isolated* agents but of *ensembles of coordinated* agents. As an example we present a result of [RMDA01]. They studied the behavior of drivers suffering from Alzheimer disease. At a lane crossing a car incurred from the right. Many maneuvers of Alzheimer patients ended in a collision. They suffered from the *looking without seeing syndrom*.

The first research question consists of modeling both agents and their mutual belief structure. The second research question is concerned with the risk assessment of the situation. In figure 2 we sketch the proposed risk assessment of the incurring driver model.

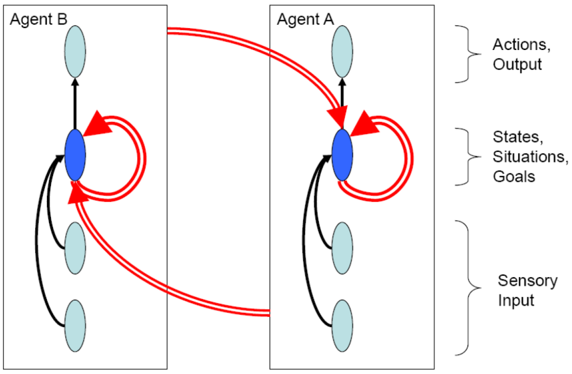

Abbildung 3: Coupled IOHMM (double spaced arrows denote dynamic links)

4 Empirical Based Static and Dynamic Probabilistic Models

Due to variability in human cognition and behavior and the uncertain identification status of cognitive mechanisms it seems rational to conceptualizes, estimate and implement probabilistic models for modeling partial coordinated traffic agents. In contrast to models embedded in cognitive architectures like ACT-R these models have to be derived directly from the empirical distributions of the variables of interest. Thus, no ex-post validation of models is necessary. At the present moment we are studying the suitability of static and dynamic Bayesian (Belief) Nets. Using the static type it is possible to generate reactive models and and inverse (naïve) models. Current own research [Eil08] is focused in using them for controlling simulated cars in real time. The dynamic type allows creating Markov Models (MM), Hidden Markov Models (HMM), Input-Output-HMM (IOHMM). With these models it is possible to introduce situation recognition, goals and intentions modeling BDI-Agents. These models can be constructed by data mining driver's behavior traces in experimental settings with experimental induced goals (Interrupted Time-Series Experiments). At the present moment no publication exists where such a model is used to control a simulated car in real time. For modeling coordinated ad hoc groups of traffic agents we propose coupled IOHMMS (Figure 3). Ego agent's goals depend on the beliefs about alter agents.

Literatur

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[RMDA01] M. Rizzo, D. V. McGehee, J. D. Dawson und S. N. Anderson. Simulated Car Crashes at Intersections in Drivers With Alzheimer Disease. *Alzheimer Disease and Associated Disorders*, 15(1):10–22, 2001.