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Cognitive Agents for Multimodal Traffic Simulations in Virtual Environments

Introduction

The objective of this doctoral thesis is to develop a realistic traffic simulation. The simulation should consist of multi-modal traffic participants (agents) whose observable behavior closely resembles that of their real-world counterparts. Such behavior needs to include risky maneuvers and most importantly violations of traffic rules, since these are common elements of every-day road traffic.

Requirements

Realistic traffic agents need to:

- Generally follow traffic rules
- Show individual behavior
- Take risks and break traffic rules in appropriate situations
- Include various types (e.g., cars, bikes, pedestrians)
- Be simulated in real-time

Methods

- Construction of a virtual simulation environment based on the city of Siegburg (Fig. 1a)
- Definition of a semantic road traffic network description
- Modeling of cognitive processes (e.g., perception, memory, learning) to achieve realistic agent behavior (see Fig. 1c)
- Addition of individual agent behavior through psychological personality profiles based on the “Five Factor Model” (FFM)
- Derivation of FFM profile prototypes and task specific decision parameters from psychological personality studies
- Simulation of agents with different levels of detail to decrease computational demand

Results

- Simulation of visual perception using a perception framework and different visual sensor approaches (ray cast-based and depth buffer-based (see Fig. 2a))
- Addition of personality-based behavior patterns to resolve traffic deadlocks and to improve traffic flow (see Fig. 2b)
- Combination of static profiles and dynamic influence of emotion-inducing events to achieve more realistic behavior (see Fig. 2c)
- Mesoscopic simulation layer capable of simulating 100 000 agents in a network consisting of 625 intersections and 2400 roads while maintaining frame rates above 60 fps (see Fig. 2d)
- Automatic extraction of personality profiles from subject data recorded in a driving simulator (see Fig. 2e)

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Figure 1: (a) Screenshot of the virtual Siegburg simulation environment. (b) Evaluation scenario where the agent’s driving lane is blocked by an obstacle. To pass the delivery truck, the agent needs to change to the opposing lane with constant flow of dense traffic. An observer would expect a human driver to alter his/her behavior after prolonged waiting time (e.g., to accept smaller gaps in oncoming traffic). (c) Applied lightweight cognitive architecture for traffic agents. Cognitive processes are influenced by an underlying FFM personality profile.

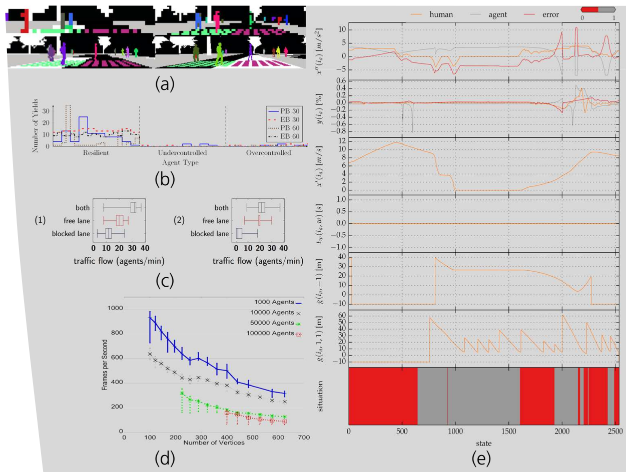

Figure 2: (a) Agent perception using depth buffer-based vision. Different sensor resolutions represent a trade-off between accuracy and precision. (b) Yield distributions between agents from different personality classes. For emotion-based (EB) agents, deadlock resolving yields at an intersection are distributed more realistically than for static personality-based (PB) agents. (c) Traffic flows in the blocked lane scenario (see Fig. 1 (b)) are more plausible for EB agents (1) than for PB agents (2). (d) Frame rate development for different numbers of mesoscopic agents simulated on road networks of different sizes. (e) Comparison of a human driver with the simulated driver that was automatically configured from the subject's data.

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