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# Adaptive Decision Making in Microsimulations of Urban Traffic in Virtual Environments

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**Abstract.** To improve the plausibility of driving and interaction as well as the perceived realism of agents in interactive media, we extend cognitive traffic agents based on personality profiles with emotions. As proof of concept a scenario with a narrowing road was evaluated. To enable agents to handle these scenarios, an existing lane change model was adapted to model the required decision processes and incorporate the driving style defined by static and dynamic aspects of the agents.

**Keywords:** adaptive agents, serious games, virtual environments

## 1 Introduction

The credibility of NPCs in current entertainment software, called agents in the following, often suffers from unrealistic and incomprehensible behavior. Especially in serious games, where individual agents are often closely observed by a player, displayed behavior must be plausible to enhance immersion. By adding personality profiles to agents, observed decisions become more consistent and may increase realism. However, in deterministic systems, the profiles cause identical reactions in identical situations. Such predictable behavior may become implausible if the agent does not adapt to its surroundings or to the player. This contribution will outline how psychological profiles of agents are extended with a model of emotion to dynamically adapt their behavior. The model is applied to a specific road traffic scenario demonstrating the benefits of such an approach.

## 2 Modeling Adaptive Decisions

Our approach for adaptive decision making is based on two elements: (1) a static foundation, based on the Five Factor Model (FFM) as presented in [1], to achieve consistent behavior patterns for individual agents and (2) a dynamic model to allow influencing these patterns. A personality profile representing the five personality traits of the FFM is part of each simulated agent. To increase

credibility, we proposed a general model for mapping real personality profiles and studies to a consistent form and number range in [2]. This model was used to map findings from a study in [3], which linked personalities to general driving behavior, to our agent profiles. To integrate a mapping into an application, task dependent parameters are derived from the personality to influence the agents' decisions. This will yield consistent individual behavior patterns for each agent.

Although, this recurring consistent behavior is desirable, it becomes implausible if an agent is stuck in a certain situation due to its personality derived behavior. Therefore, it is necessary that agents are able to adapt. Thus, the static personality-based model is extended with a dynamic emotional state.<sup>5</sup> Emotions are integrated into the agent architectures in three parts: experiencing, influencing, and fading. Experiencing has been modeled through predefined incidents. When an agent experiences an incident, the negative and positive emotion of its emotional state are adjusted according to the type of incident. Studies (e.g., [4]) have shown correlations between personality of subjects and their perception of emotions. Thus, the perception depends on the emotional state and personality of an agent. In our case, high neuroticism will intensify negative emotions and high extraversion or conscientiousness will intensify positive emotions [2]. The influence of the emotional state is modeled as a temporary modification of personality profiles [2]. In general, the personality of a person is a constant attribute over extended periods of time. However, by modeling the influence of emotions as a change of the personality, it can be added or removed without having to change the existing system. Exponential and linear functions control how the influence of each emotion dimension fades over time. For details see [2].

### 3 Results

As a proof of concept the presented agent model was applied to a specific traffic scenario in which the lane of an agent is blocked by an obstacle (e.g., a delivery truck). To clear it, the agent needs to change onto an adjacent opposing lane with dense traffic. The agent could pass the obstacle by waiting for an appropriate gap to not influence oncoming traffic (1), by forcing oncoming traffic to slow down or stop (2), or by waiting for an oncoming agent to slow down for it (3). In reality, most drivers would choose case (1). However, with increasing waiting time, drivers will accept increasingly smaller gaps and at some point may choose option (2). To simulate this behavior, the lane change (LC) model MOBIL [5] was added to our agents. It includes a politeness factor to control the aggressiveness of agents in LC decisions, which is derived from an agent's personality in our case. We adapted MOBIL to include changes to opposing lanes by weighting the advantage which agents gain from a LC with their complementary politeness.

The test scenario was simulated with static personality-based drivers (PB) and dynamic emotion-based drivers (EB). In a first step, traffic flows were measured for the free and the blocked lane to measure the emergent traffic behavior.

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<sup>5</sup> Mood is not considered here, because it persists for prolonged time periods and agents in our application are only observable for a limited time.

The flow on the blocked lane was low for PB agents since polite drivers would weigh the disadvantage for oncoming agents higher than their own advantage. As a result they get stuck behind the obstacle until a polite agent on the free lane allows the waiting agent to pass. EB agents achieved higher flows on the blocked lane indicating that they will not wait until allowed to pass, but force their way around the obstacle if they have been waiting too long. This effectively models drivers whose patience is limited, just as is the case in real life. The resulting shorter waiting times are more plausible to an observer. Additionally, the model is able to emulate behavior that is frequently observable in real traffic: If a queue had formed behind the waiting agent, several enqueued agents will tailgate the first agent as soon as it starts to pass the obstacle.

## 4 Conclusions and Future Work

We proposed a model that uses personality profiles to generate consistent behavior patterns for individual agents, improving their credibility. A proof of concept was evaluated in a specific traffic scenario. Static personality-based drivers produced implausible behavior in certain situations (e.g., unrealistic waiting times). Adding an emotion model for adaptive behavior did not only improve plausibility of directly observable agent behavior, but also improved traffic flow, resulting in more plausibility on a macroscopic scale.

In future work it needs to be investigated whether the proposed agent model is able to generate plausible behavior for other (general) scenarios. Additionally, it remains to be evaluated whether players really perceive the proposed agents as more realistic. This could be evaluated by integrating them into an existing application, like the FIVIS project ([vc.h-brs.de/fivis](http://vc.h-brs.de/fivis)), for a detailed user study.

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