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学位(専攻分野) 博士(情報学)

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学位授与の要件 複合科学研究科 情報学専攻
学位規則第6条第1項該当

学位論文題目 An Experimental Space for Conducting Driving Behavior
Studies Based on a Multiuser Networked 3D Virtual
Environment and the Scenario Markup Language

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論文内容の要旨

Summary of thesis contents

This thesis describes a new framework for conducting controlled driving behavior studies based on multiuser networked three-dimensional (3D) virtual environments. The framework supports (a) the simulation of multiuser immersive driving, (b) the visualization of interactive surrounding traffic, (c) the specification and creation of reproducible traffic scenarios, and (d) the collection of meaningful driving behavior data. Thus the framework allows traffic engineers to investigate complex traffic situations that depend on the interaction between multiple drivers. The framework is used to investigate the ‘rubbernecking’ phenomenon, which refers to the slowing down of a driver due to an accident on the opposite side of the road, and its effect on the following drivers. The main contribution of the thesis is two-fold. First, we developed the Scenario Markup Language (SML) as a practical tool to specify dynamic traffic situations (e.g. an accident). Second, we designed the SML Framework to simulate interactive ambient vehicles in a multiuser driving simulator and to ensure the reproducibility of particular traffic situations, so that traffic engineers can obtain comparable data and draw valid conclusions. To demonstrate the effectiveness of our framework, we collaborated with traffic engineers to specify the traffic accident scenario in SML and to conduct a study on the rubbernecking phenomenon.

In Chapter 1, main stream of alternative approaches for driver behavior experiments are introduced, and their relative pros and cons are discussed. Then, the importance of multiuser driving simulators and of simulating realistic traffic scenarios to create predictable experiences for human participants in driver experiments, are discussed. Next, the challenges in simulating realistic traffic scenarios in driving simulators are introduced.

In Chapter 2, related works are introduced in various areas related to this research. We specifically review the techniques used for simulating ambient traffic in driving simulator environment, scenario authoring as high level specification, scenario control system implementation, and intermediate mapping representations that maps high level specification to scenario implementation.

Chapter 3 describes the motivating traffic phenomenon called ‘rubbernecking’ and the tagging structures of the Scenario Markup Language (SML) by walking through an example from our target traffic situation, the specification of an accident using the Scenario Markup Language.

Chapter 4 covers a description of the SML Framework. Here we show how the framework has been designed on top of our in-house three dimensional (3D) virtual environment technologies. It presents the approaches utilized for a) simulating multiuser immersive driving in 3D virtual environment, b) simulating ambient traffic in a multiuser driving simulator, and c) implementing the intermediate representation mapping and scenario control scheme. In

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addition, we provide the details of how research and technical challenges are addressed.

Chapter 5 demonstrates the effectiveness of the framework, with a multiuser driving behavior experiment on the rubbernecking effect, using SML Framework. It reports on the results of our study from two viewpoints: (a) the reproducibility of the traffic accident situation (i.e. state variables of interest are recreated successfully in 78% of the cases), and (b) the interactive car-following behavior of human subjects embedded in the traffic situation of the virtual environment. Chapter 6 summarizes the research work and concludes the thesis.

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博士論文の審査結果の要旨

Summary of the results of the doctoral thesis screening

(論文審査結果) [2013年 7月 8日実施]

Mr. Gajan presented his main result and answered questions accordingly.

The committee agreed that he can receive his doctoral degree.

Core reference:

Kugamoorthy Gajananan, Alfredo Nantes, Marc Miska, Arturo Nakasone, and Helmut Prendinger. An experimental space for conducting controlled driving behavior studies based on a multiuser networked 3D virtual environment and the Scenario Markup Language. IEEE Transactions on Human-Machine Systems, Vol. 43, Issue 4, 2013.5, pp 345-358. [DOI: 10.1109/TSMC.2013.2265876]

The paper was recommended for publication in the former IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans (2011 Impact Factor: 2.123)