Simulator Showdown - Pitch your Virtual Ride

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AutomotiveUI '19 Adjunct, 11th Intl Conference on Automotive User Interfaces and Interactive Vehicular Applications, September 21–25, 2019, Utrecht, Netherlands
ACM 978-1-4503-6920-6/19/0920.
10.1145/3349263.3349600

Abstract
With autonomous driving on the horizon, new research challenges appeared and subsequently, new methods and research instruments became necessary. To adapt to these emerging research questions, driving simulators, the cornerstone of automotive human factors research, have been tweaked, modified or developed from scratch. This one-day workshop invites academics and practitioners to report, demo or discuss their solutions for simulating the next wave of automotive interaction research. The goal of this workshop is two fold: (1) we provide a forum for researchers focusing on simulator software and discuss opportunities for a future collaboration platform for sharing and co-develop simulator software. (2) We collect and discus the needs, expectations and solutions of the automotive UI community to articulate a road map for developing future driving simulators setups.

Author Keywords
Driving Simulator; Research Methods; Autonomous Driving

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Figure 1: Skyline Simulator

Figure 2: CARLA Simulator

Figure 3: miniSim Simulator

Background

Driving simulators play a critical role in investigating driver behavior in a safe and controlled environment. Without doubt, driving simulators are one of the most important instruments for human factor research in the automotive domain ranging from simple desktop simulators to complex, highly-immerse simulator environments. However, with recent advancements in autonomous driving the research questions and subsequently the requirements of an suitable driving simulator are changing rapidly. To adapt to the challenges and needs, researchers in academia and industry are required to develop new simulation environments or hack existing solution to guide their research.

In the following we introduce a few of the organizers' developments on driving simulator technologies.

VR-OOM - a hybrid simulation system
Similar to the fused reality simulator from NASA's Armstrong Flight Research Center [3] this project enable the experience of realistic felt motion inside of a simulated environment [5]. By using a real vehicle driving on an virtual course (in a empty parking lot), we can generate a wide variety of scenarios. The motion and sound perceived by the participants are real and just the visual modality is replaced by an off-the-shelf VR headset. This realistic motion is especially useful for to simulate subtle scenarios (e.g. driving style preference, motion cues) or emergency scenarios (e.g. take over and crash avoidance).

Skyline
Developed to enable rapid prototyping of vehicle cockpit configurations [1] facilitating the integration of multi-modal sensors with Web-based User Interfaces to create event-reactive UIs [6]. Skyline has been also applied to induce and study passenger emotional reactions under automated driving conditions [2]. See Figure 1.

Nervtech
Small compact and motion based simulation system, ideal to perform user studies on human behavior and driver performance in different traffic conditions [7]. The simulation environment enables fast creation of different scenarios including different types of vehicles, motorbikes, bicycles and pedestrians. It supports data acquisition from multiple biometrical sensors and eye trackers. With proprietary camera-based head tracking system, it enables automatic mapping of gaze position to screen coordinate system and consequentially automatic gaze analysis.

miniSim
The miniSim driving simulator has powerful scenario control and data acquisition capabilities based on 20 years of research and development at the University of Iowa's National Advanced Driving Simulator (NADS). The miniSim team currently provides user support for over 60 sites, some with multiple simulators. Typical applications include human factors, driver state modeling, distraction, and impairment research. It has also been utilized in clinical applications. The miniSim's modular architecture simplifies integration with external systems such as eye-tracking, EEG, haptics, motion bases, distraction and workload (eg PDT) tasks, infotainment, video capture, and a user's own automation or ADAS algorithms. The miniSim has ACC, Lane Follow, and Lane Keeping Assist systems. Advanced automation allows emulation of up to Level 4 under scenario or external control. The software is used by NADS staff on a daily basis to fulfill research contracts on our NADS-1, NADS-2, and miniSim simulators, ensuring our users receive the most up-to-date capabilities. The miniSim supports multiple display and cab configurations. See Figure 3

CARLA
was developed to study End to End development of Automated Driving algorithms from Perception to Actuation in realistic Urban Scenarios [4]. CARLA has become a standard tool for Automated Driving curriculums in Computer Science and Automotive Engineering schools. It provides multi-sensor input and flexible scenario creation. Also recently we added pedestrian control and safety restrictions for AV planning. See Figure 2.

Maps and data integration
To study new ways of interaction with the physical world surrounding the car and to conduct research in autonomous driving scenarios, the use of High Definition maps and the integration of geo-referenced data coming from the real world (POIs, Venues, etc) into simulators are key elements. By matching the virtual simulation with ground-truth data and integrating multimodal sensors in the simulation environment, it is possible to develop context-aware UIs, end-to-end simulations, and to test natural user interfaces against realistic conditions. We present the challenge to integrate such data sources into a simulation environment and discuss how much case-by-case hacking is required to get things to working.

In the workshop we deep dive into the organizers' project (presented above) but also create a forum for researchers and practitioners concerned with building, extending or hacking driving simulators. Therefore, we invite our participants to present and pitch their simulators and best practices. Based on the collected approaches we discuss, how to integrate the individual approaches and simulation technologies. Furthermore, we discuss how to establish a closer exchange about simulator-based researchers, foster collaborations and the discussion of standards and metrics to simulate the autonomous world.

Motivation

Roughly half of all accepted full-papers of the last conferences (AutoUI '16 '17 '18) explicitly mentioned to conduct a simulator study in their abstracts. Despite trending towards autonomous driving topics, simulation technologies are and will be a critical component of any automotive-related interaction research. However, researchers often struggle to adapt their simulator software to the emerging themes such as autonomous driving, passenger entertainment or interaction with multiple road users. These modifications can be simple changes of code but also substantial technically advanced extensions that are worthy to be shared with a broader community.

Furthermore, for automotive UI researchers, there is little opportunity to share and collaborate on their simulator systems. The systems are often outdated, not properly maintained or simply technical incompatible to be productively shared and supported by a broader community. With this workshop we want to provide a first overview of approaches and tool-kits used in automotive UI research, reveal tools and hacks dedicated to facilitate novel research questions and finally aim to discuss the relevancy of a mutual platform for a closer collaboration.

Objectives

The workshop's central objective is to gain an overview of simulation approaches and technologies used in current automotive UI research. As an interactive workshop, participants and organizers are asked to pitch or demo one of their simulation solutions.

Topics and questions of potential interests include:

- What simulator platforms are out there? What are the pros and cons?

- Which simulator platforms or modifications are best suited for addressing research questions in the autonomous driving context?
- What is the role hybrid simulators and what can we learn from them?
- Show us how you changed, modified or hacked an simulator platform to make it ready for autonomous driving research?
- Design for immersion: How to transform simulation technology into a realistic scenario?
- How to make systems modular, shareable, accessible and reusable for the entire research community?
- What extensions and standards should be developed?
- Present your "tiny-tool" that make life easy: from data collection to analysis and system development!

To sum up, this workshop provides a forum of all researchers and practitioners to share their tricks, hacks and modifications to make their system ready for the autonomous world. We aim to consolidate ongoing approaches to conceptualize an open platform for sharing and co-developing content, modules and procedures. As such, this workshop is relevant for everyone confronted or concerned with simulator studies. By matching research challenges, the needs and system designs we aim to articulate a road map for future simulator developments.

Outcome

We aim for two tangible outcomes. By connecting researchers and collecting simulator projects and toolkits, we articulate a road map for developing a platform that allows automotive UI researchers to share and collaborate on simulator projects. Secondly, we plan a mutual publication as a special issue on simulators for the autonomous world. This publication contains not only the organizers' simulator approaches but also invite the participant to contribute with their system. Besides a detailed overview of relevant simulator project, we discuss a taxonomy for simulator technologies and how their address the emerging research questions of autonomous driving.

Both outcomes are intended to establish a closer collaboration among automotive UI researchers and their simulation approaches and promote an open research and development culture that benefit the next wave of simulator technologies.

Workshop Organization

The full-day workshop (8 hours) consists of two parts. In the first part i.e. 'the pitching sessions' (morning), the organizers and participants are presenting their simulator environment, tools or approaches. The second part (afternoon) we split into groups of interests to discuss extension and collaboration of simulator setups presented by organizers or participants. We discuss how simulation technology can address the emerging research questions, the technical and conceptual extendablity of the systems, as well as the systems' integration opportunities to make it accessible and modular.

This workshop hopes to attract about 25 researchers and practitioners with technical experience in driving simulator setups for interaction and human factors research. We accept position papers from researchers of divers backgrounds. We welcome researchers who are currently conducting simulator-based study and are facing similar chal-

Duration	Activity
30 mins	Introduction
60 mins	Pitch I: Organizers' Sims
30 mins	Sim Demos
60 mins	Pitch II: Participants' Sims
60 mins	Matchmaking: Sims & RQs
	Lunch Break
60 mins	Intro & group building
60 mins	Group work on "Pimp my Sim"
60 mins	Presentations & discussion
60 mins	Discussion on integration and next steps

Table 1: Suggested Schedule.

lenges. We also aim to appeal to experts from industry who are concerned with simulator technology on a professional day-to-day basis and are interested in promoting open source solutions that fulfill the needs of the automotive UI community.

Before the workshop
A dedicated Call-for-Participation (CfP) will be distributed through various academic mailing-lists and social media channels. In the CfP potential participants are invited to submit a 2-4 pages position paper (ACM SIGCHI Extended Abstract template) that specifies one or all of the following aspects:

- Tell us what you have, use or build and show us what it can do!
- Share what tools or modifications you developed that makes your system special!
- What research questions do you address with your simulator and what are the expected challenges in term of technologies or content?
- Tell us where and what we need to download to demo your system!

Participants who submit a position paper that introduces their simulator setup have the opportunity to present and/or demo their system during the 2nd Pitch session (see table 2).

Furthermore, we setup a dedicated workshop website. The website contains the workshop program and position papers and serves as a repository with links to all simulator systems discussed in the workshop.

Workshop schedule
Table 1 shows the suggested schedule for the workshop. The workshop's program points consist of two central parts: the presentation, pitch or demo of simulators in the morning and the discussion and integration challenge in the afternoon.

In the morning, organizers and participants present their driving simulators. After that we start categorizing the systems based on research questions and simulation approaches (motion platforms, VR, hybrid, photo realistic, video-based etc.).

In the afternoon, we break into groups of interests to discuss the presented system and identify opportunities for collaborations and extensions. The groups are asked to document their discussion and present their findings to the other groups. Following that, we reserve an hour to articulate a road map that facilitates integration and collaboration.

After the workshop
A detailed documentation of the workshop will be shared with the participants and published on the workshop's website. In addition to this, we invite interested participants to contribute to a special issue on driving simulators for the autonomous world. As future work, we aim to extend the workshop's website into a repository for exchanging and developing driving simulators for human factors and experience researchers.

Organizers' Bios

Sven Krome
Sven is Sr. UX Researcher at Uber ATG and fmr. postdoctoral researcher in Information Science at Cornell Tech. His research interests are design-based explorations of experiential factors of future technologies, in particular of autonomous driving and intelligent infrastructure. Conducting

research in academia and industry, he focuses on strategies to design interactions with safety-critical, future technologies in simulations and real-world scenarios. His current research investigates safety perceptions of advanced traffic models for autonomous driving from a first-person perspective.

Eric Deng
Eric is a Product Manager at Uber Advanced Technologies Group (ATG) working on designing and building next-generation self-driving vehicles with a human-centered approach. His background is in human-robot interaction and has worked on a variety of interactive robots in both industry and academia.

David Goedicke
David is a Ph.D. student advised by Dr. Wendy Ju at Cornell Tech in New York City. For his Master thesis, he developed the VR-OOM simulator (see above). David's work mostly focuses on developing prototype solutions that incorporate natural user responses and user interaction patterns to enable the design of novel interactions.

Wendy Ju
Wendy Ju is an Assistant Professor of Information Science with the Jacobs Technion-Cornell Institute at Cornell Tech in NYC. She received her PhD from Stanford and a Masters degree from the MIT Media Lab, and is the author of *The Design of Implicit Interactions*, available from Morgan and Claypool. Wendy's research group has pioneered numerous methods for simulating autonomous driving for the purposes of understanding AV interaction with pedestrians, in-vehicle drivers, and other drivers. This work spans the gamut from on-line studies to laboratory studies to VR studies to on-road field studies.

Ignacio Alvarez
Ignacio is Senior Research Scientist at the Autonomous Driving Research Lab in Intel Labs, USA. He obtained his PhD in Computer Science at University of the Basque Country, Spain and Clemson University, USA. His primary contributions are focused on automated driving systems, driving simulation tools and HCI. His research interest focuses on the development of intelligent cooperative automated vehicles to empower human potential for safer and more enjoyable driving experiences.

Jaka Sodnik
Jaka is Professor at the Faculty of Electrical Engineering, University of Ljubljana. His research focuses on human factor and human-machine interaction in vehicles. He coordinates several national and international research projects focusing on methods for driver evaluation and profiling as well as mechanisms for assessing performance and safety of autonomous vehicles. He also advises R&D department of Nervtech, a Slovenian company developing state-of-the-art motion driving simulators and providing simulation technologies for AV testing and validation.

Andrew Veit
Andrew is the miniSim Program Director at the National Advanced Driving Simulator (NADS) at the University of Iowa, and has managed over 115 miniSim projects. Beyond the miniSim product, he has designed custom simulators for multi-site clinical data collections, including for the evaluation of intraocular lens implants and pharmaceuticals. Mr. Veit was also integral to numerous upgrades and repairs to the NADS-1 simulator. Prior to joining the NADS in 2005, Mr. Veit was engaged in the design of physical test and simulation systems, precision motion control, instrumentation, and consulting. Mr. Veit earned his B.S. and M.S. degrees in Mechanical Engineering at the University of Iowa.

He is a Professional Engineer licensed in North Carolina.

Francesco Grani
Francesco is Lead Researcher in the Automotive UX Design team at HERE Technologies. His research focuses on Human-Machine Interaction, autonomous systems, and multimodal perception with a particular focus on sound and spatial audio. He has a long track record as an academic researcher and lecturer and has coordinated national and European research projects within the field of multimodal interaction. He has been one of the initiators of the SIVE chapter (Sound Interaction in Virtual Environments) at IEEE-VR and is a regular contributor to the Sound and Music Computing community.

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