Prototyping HMI for Autonomous Vehicles:
A Human Centered Design Approach

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ABSTRACT

Autonomous vehicles present Human Machine Interaction (HMI) designers and researchers with new challenges. While design decisions are typically based on financial, technical, political and personal reasons, central to novel interfaces for cars of the future is the user. Users are motivated by needs that are rooted in that which gives them meaning. Hence good design results from a process that centers on understanding users and their concerns.

Over the course of a tutorial, our team will guide participants on a four-hour crash-course in human-centered design, focusing on HMI for future autonomous vehicles. To encourage interaction, the tutorial is structured around a design thinking lens, where attendees interact through a human-centered design exercise.

Author Keywords

Autonomous Vehicles; Human Machine Interaction; Human Centered Design; Research Methods; Human Factors.

ACM Classification Keywords

Design; Experimentation; Human Factors

INTRODUCTION

In fully autonomous vehicles (NHTSA Level 4 [1]) steering, acceleration and deceleration are completely controlled by the intelligence built into the system. The technologies that determine this intelligence are highly complex, so that drivers are likely to find it difficult to establish clear mental models. The resulting uncertainty suggests major changes in user experience, as drivers will need different kinds of information when their vehicles are in manual versus autonomous driving modes, as well as during transitions between them.

Research shows that autonomous vehicle drivers expect their car to explain its behavior [2]. These researchers envision that future vehicles would also need to communicate the system's current status, its intent to take action [3], the driver's status, navigation, entertainment and critical messages through this same HMI. In addition to the *what* information that aids situation awareness, messages should also communicate *why* information to help build trust and reduce anxiety [4].

As an example, we can imagine an autonomous vehicle driver engaging in a secondary activity such as reading a text or email. Any visual messages that appear on the instrument cluster, even if they express both *what* and *why* information, can only communicate with the driver if he or she seeks this information. Audio tones can direct the driver's attention to the display, and, the design, location and recurrence of such tones also impact user experience.

There are hence many decisions that designers must make to develop systems that drivers will actually use, and that will make travel safer, more efficient and enjoyable. These decisions are typically based on financial, technical, political and personal reasons. However, drivers' needs are often lost in the process, or not evaluated in the first place. This circumstance is where *human-centered* design can be of great value. Human-centered design is an approach, and a set of techniques, used to identify needs and create new solutions for people in the world. The process centers on understanding product or service users and their concerns, developing quick physical prototypes, obtaining feedback on prototypes from both users and experts, and iterating over the entire process [5].

We envision HMI design that addresses user needs and employs familiar models and metaphors to present intuitive interactions between user and car. We believe that the

unique sales proposition for automakers and suppliers will be expressed through user experience.

OBJECTIVES

Over the course of the tutorial, our team will guide participants on a four-hour crash-course in human-centered design, focusing on HMI for future autonomous vehicles. To encourage interaction, the tutorial is structured around a *design thinking* [6] lens, where attendees interact through a human-centered design exercise. Although not exhaustive by any means, it will highlight the key steps for uncovering insights and building designs that address users' needs. We hope that participants will take away a new confidence in fast-paced ideation and hands-on, rapid prototyping.

The tutorial's goal is to bring together people who are active in HMI design, research and development on topics relevant to partially and fully autonomous vehicles of the future. Through an interactive session we encourage both young and experienced automotive HMI researchers and professionals to discuss and share experiences, settings and best practices for conducting lab or field experiments. This gathering includes building (serendipitous) connections for meaningful conversations during lunch, post tutorial and beyond. Through activity-based interaction, we hope that conversations will turn to deeper research topics, such as improving user studies, exploring which sensors and recording platforms are best suited for particular studies or settings, understanding the generalizability of results, or transferring lab results to real-world settings. In particular, we hope that these discussions inform younger researchers, who are just entering automotive UI, to learn from the experiences of others.

AUDIENCE

Invitations are open to anyone who desires to understand and involve the user's perspective as part of their design process. Understanding users is not solely the responsibility of UX designers or researchers: it is important for all members of an organization, especially management and engineers, to empathize with users. This tutorial will bring together 12–16 attendees from disciplines such as anthropology, business, government, computer science, design, engineering, human factors, human-computer interaction, management, marketing, sales and safety.

Position papers will be accepted, but are not required, to participate in the tutorial. Presenters will be selected from those who submit papers, and will be invited to share their real-world case studies on applying UX and user-centered design in the automotive context.

All attendees are requested to submit a brief paragraph of their backgrounds, topics of interest, and current areas of focus.

We will host a website for the tutorial that includes detailed attendee information (if desired), notes and material, and results and impressions from the day's activities. Website URL – www.DesignImprovWizard.com

SCHEDULE

Following a quick introductory session, the tutorial will feature a quick presentation session, during which paper submitters will present a brief summary of their research.

Next, a 15 minute lecture will introduce human-centered design fundamentals and techniques, followed by a crash course on conducting user interviews. Another lecture will summarize *needfinding* and understand *frames*, followed by a team exercise assuming the role of design and project leads in a fictitious company that makes autonomous vehicles.

The process starts with a *discovery* phase of unmet needs to frame the design question before the *imagine* phase, where we think about creative solutions to meet the needs of the end user. To help with discovery and framing, we will introduce attendees to *design sketching* (including tools and materials) of people and their interaction over time through *storyboards*. Design sketching is a way to develop ideas with oneself, and quickly build upon, and communicate, ideas with colleagues.

Over the next two hours, attendees will practice these skills organically, while developing tangible prototypes. We will explore *improvisation* techniques, such as puppeteering and embodied improvisation, as a way to prototype motion, action and interaction. Finally, focusing on lightweight paper prototypes, we demonstrate *rapid prototyping* as a way to explore alternatives prior to developing expensive or time-consuming technologies. The session will end with five-minute presentation by each team.

Table 1. Preliminary tutorial schedule

08:30–09:15	Introduction and Paper Presentations
09:15–09:30	Lecture 1: User needs and frames
09:30–10:30	Design sprint: Discover, frame imagine
10:30–10:45	Lecture 2: Design improvisation
10:45–12:00	Prototyping
12:00–12:30	Five-minute presentations

ORGANIZERS

Nikhil Gowda is an Autonomous Vehicle HMI Researcher at Renault Innovation Silicon Valley. With a background in automotive engineering and an MBA in Design Strategy, he has been a preacher and practitioner of human centered design and has co-organized many such tutorials/workshops.

David Sirkin is a Lecturer in EE and Research Associate in ME at Stanford. He teaches interactive device design and human-centered design methods, and conducts research on autonomous vehicle interfaces, and the role of movement in interactions with expressive everyday (robotic) objects.

Wendy Ju is Executive Director for Interaction Design Research at Stanford's Center for Design Research, and an Associate Professor in the Graduate Design Program at the California College of the Arts in San Francisco. Her research is primarily focused on the design of human interaction with automation, particularly autonomous car interfaces and human-robot interaction.

Marcel Baltzer is research group manager for cooperative guidance and control at Fraunhofer FKIE in Wachtberg, Germany. His research focus is interaction design for highly automated vehicles that are guided cooperatively by a human and an automation with changing assistance and automation modes.

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