Wizards of WoZ: Using Controlled and Field Studies to Evaluate AV-pedestrian Interactions

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Abstract
Interactions between autonomous vehicles (AV) and pedestrians remain an ongoing area of research within the AutoUI community and beyond. Given the challenge of conducting studies to understand and prototype these interactions, we propose a combined full-day workshop and tutorial on how to conduct field experiments and controlled experiments using Wizard-of-Oz (WoZ) protocols. We will discuss strengths and weaknesses of these approaches based on practical experiences and describe challenges we have faced. After diving into the intricacies of different experiment designs, we will encourage participants to engage in hands-on exercises that will explore new ways to answer future research questions.

Author Keywords
Automated driving; eHMI; external communication; interaction; metrics; research methodology; Wizard-of-Oz

CCS Concepts
•**Human-centered computing** → **Interaction design theory, concepts and paradigms; Empirical studies in interaction design;** *Interface design prototyping;*

Introduction
How autonomous vehicles (AVs) will interact with pedestrians, in particular when the operator is absent or dis-

tracted, remains an open question in the AutoUI community. Assuming there will be a communication gap from a lack of driver-generated explicit and implicit cues, many have worked towards designing and testing explicit external human-machine interfaces (eHMI), while others suggest that the motion of the car could be a sufficient eHMI.

To explore this area and test designs, researchers conduct both controlled and uncontrolled (field) studies. Methods and metrics for studying interactions between automated vehicles and pedestrians in their vicinity are, however, not fully established yet. Every experimental method has benefits and limitations, and the community has used a wide range of on-road, simulator, and virtual reality experiments to aim at designing ideal interactions between AVs and pedestrians.

One of the major challenges is that automated vehicles are currently not available for the general public and independent researchers. At the same time, it is still an open research question how to evaluate the new functionality with respect to various human-factor issues, and what methods to use.

Many research questions call for realistic evaluation of pedestrian interactions with automated vehicles. However limited access to real AVs has stimulated the development of Wizard-of-Oz (WoZ) techniques that enable researchers to prototype interactions between AVs and pedestrians using conventional vehicles with minor aesthetic modifications making them appear automated. Some methods include Ghostdriver (with a driver underneath a costume) and right hand drive vehicles with fake steering wheels. These methods, while simple in principle, bring many challenges to experiment design and execution.

We believe the AutoUI community would benefit from a workshop on how to implement WoZ techniques, as well as a discussion of pros and cons of using controlled and field studies, and when to use each. This would help novice researchers understand the tools available to them as well as deepen the discussion among more expert researchers on the ongoing challenges and opportunities of using different methods.

Topics

- Introduction to field and controlled studies: when one might choose one type or another, how we have implemented them in the past, what has worked well, and what has *not* worked well. We will compare WoZ approaches to other methods to study pedestrian interactions such as VR and simulation.
- Discuss different WoZ approaches: Ghostdriver, fake steering wheels, and the benefits of using these approaches in the field and in controlled settings. We will also discuss ways to ensure safety of all involved entities, and how to address ethical concerns, including concerns of ethical/institutional review boards.
- Data collection and analysis: What are the different data streams available (e.g., interviews, questionnaires, video coding, car motion data, eye tracking, physiological measurements, motion tracking), and what can you measure in different types of experiments?

Previous Workshops

Interactions between AV and pedestrians is a topic that has been addressed at previous AutoUI workshops (e.g., [1, 2, 3]) as well as other venues (e.g., ISO Workshop in Gothenburg 2017, Workshop at AVS 2017 and 2018, interACT Workshop in Vienna 2018, Breakout session at AVS

2019). In particular, [1] addressed methodologies for evaluating such interactions. While many different methodological aspects were covered there, we learned that a further discussion and sharing of practical knowledge is needed in the AutoUI community. We also learned that (independent) researchers rarely have access to AVs and that they have a common interest in using WoZ techniques. To support sound research using WoZ techniques, this tutorial and workshop will make an effort to highlight the strengths and weaknesses of such techniques based on practical experiences and identify how to apply them in practice.

Goals

Following on last year's successful workshops on methodology for AV-pedestrian interaction and WoZ experiments, the goals of this full-day workshop are as follows:

- Empower the AutoUI community to use and apply WoZ methods to their own research questions.
- Underline the strengths and weaknesses of controlled and field studies using WoZ.
- Understand how to effectively implement and conduct controlled and field experiments through hands-on prototyping activities.
- Invite discussion on ongoing methodological challenges and issues we can seek to address as a community.
- Engage the broader community to identify the most pressing research questions that can be potentially answered using these approaches.
- Community build among researchers with similar interests and goals.

After the workshop, we hope the attendees gain greater confidence with being able to use various WoZ techniques such as Ghostdriver protocol in studies of eHMI and other questions around interactions between pedestrians and AVs.

We will encourage participation from both researchers who have never done WoZ studies, as well as those who have experience with these methods and can share their experience.

Schedule

The full day workshop will focus on an exchange of ideas and identification of solutions:

- Welcome and introductions (30 minutes)
- Tutorial: Wizard-of-Oz protocols, controlled and field experiments based on organizers' experiences (60 minutes)
- Coffee break (30 minutes)
- Panel discussion with experts in the field (both workshop organizers and invited guests, to be determined): Ongoing challenges in controlled and uncontrolled studies; active questions from attendees (60 minutes)
- Lunch (60 minutes)
- Introduction to hands-on activities: divide into small groups (30 minutes)
- Hands on activities (2 hours)
  - Scenario planning: Identify possible design futures, future needs, and future studies

  - Study prototyping: Design a study using a full size vehicle and WoZ setup.
  - Coffee break as people need while working
  - Prepare presentation of the study: What did we learn? What did we unlearn?
- Wrap up: Next steps using WoZ in controlled and field studies (30 minutes)

We hope that this will inspire a scientific publication targeting AutoUI 2020 summarizing ongoing challenges and opportunities regarding WoZ methodology, as the discussion allows.

We will advertise the workshop and post a short summary of findings after the workshop at the following link: https://ixd.stanford.edu/autoui19wizardsofwoz.

Organizer Biographies

Dylan Moore is a Ph.D. candidate in Mechanical Engineering (Design) at Stanford University's Center for Design Research. He received dual bachelor's degrees in Engineering Physics and Music from UC Berkeley in 2013, and received a master's in Mechanical Engineering from the University of Southern California in 2015 as a Rose Hills fellow. He studies interactions between autonomous vehicles and pedestrians, and is particularly interested in studying influence of sound on interactions with technology.

Rebecca Currano is a Post-Doctoral Scholar at the Center for Design Research at Stanford University. Her research focuses primarily on human-machine interactions in a cross-cultural context. Her work includes studies of pedestrians and autonomous vehicle interactions; measurements of driver attention and situation awareness in both manual and automated driving contexts; and communication and signaling in human-robot and human-vehicle interactions. Her experience includes teaching several courses in design methodology at the senior undergraduate level, and coaching design teams in both industry and graduate level academia. Rebecca received her Ph.D. and M.S. in Mechanical Engineering from Stanford University and her B.S. in Mechanical Engineering from the University of Maryland at College Park.

David Sirkin is Executive Director of Interaction Design Research at the Center for Design Research at Stanford University. His research on the design of physical interactions between humans and robots, telepresence robotics, and autonomous vehicles and their interfaces, has been covered by the Associated Press, the Economist, New Scientist and the Washington Post. His teaching includes courses in user-centered design methods and interactive device design. David received his Ph.D. from Stanford in Mechanical Engineering (Design), and master's degrees from MIT in Electrical Engineering and Computer Science and in Management.

Azra Habibovic is senior researcher at Research Institutes of Sweden (RISE). She holds a PhD in Vehicle Safety Systems (2012) and an MSc in Electrical and Electronics Engineering (2006), both from Chalmers University of Technology, Sweden. Her research focuses on improving traffic safety and user experience by means of automation and connectivity.

Victor Malmsten Lundgren is a researcher at Research Institutes of Sweden (RISE). He has a MSc in Industrial design engineering (2015) from Chalmers University of Technology, Sweden. His research focuses on the human factors of AVs, with especial emphasis on interactions with other road users.

Debargha Dey is a researcher and PhD candidate in the department of Industrial Design at Eindhoven University of Technology, Netherlands. He holds a master's degree in Computer Science and a doctorate degree in Human-Computer Interaction. His research focuses on the human factors of automated vehicles (AV), particularly the interaction of AVs with vulnerable road users.

Kai Holländer is a researcher and second year PhD candidate in the department of media informatics at LMU Munich, Germany. He holds a master's degree in Human-Computer Interaction. His research focuses on communication between vulnerable road users with automated vehicles.

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