EXTENDED-ABSTRACT

Designing Technologies for Socially and Environmentally Sustainable Mobility

SHADAN SADEGHIAN, University of Siegen, Siegen, Nordrhein-Westfalen, Germany

HATICE SAHIN IPPOLITI, University of Oldenburg, Oldenburg, Niedersachsen, Germany

DEBARGHA (DAVE) DEY, Cornell Tech, New York, NY, United States

PHILIPP WINTERSBERGER, University of Applied Sciences Upper Austria, Wels, Upper Austria, Austria

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Shadan Sadeghian
shadan.sadeghian@uni-siegen.de
University of Siegen
Siegen, Germany

Hatice Şahin Ippoliti
hatice.sahin@offis.de
OFFIS Institute for Information Technology
Oldenburg, Germany

Debargha Dey
debargha.dey@cornell.edu
Cornell Tech
New York, USA

Philipp Wintersberger
philipp.wintersberger@fh-hagenberg.at
University of Applied Sciences Upper Austria
Hagenberg, Austria

ABSTRACT

In this workshop, we aim to explore how the design of technology can encourage sustainable mobility practices and facilitate interactions that promote environmentally friendly, prosocial transportation choices. We intend to identify real-world scenarios where these interactions can be implemented, discuss the challenges and opportunities they present, and develop actionable strategies for their application. We will use speculative design methods such as design fiction and anticipatory ethnography to envision alternative future mobility practices. This holistic approach aims to create a comprehensive understanding of how technology can shape sustainable and inclusive mobility ecosystems, and critique the current practices. By bringing together researchers, practitioners, and stakeholders from various disciplines, we hope to foster a collaborative network that will drive future advancements in sustainable mobility. Our goal is to address the urgent need to reduce ecological footprints and improve social experiences through innovative technological solutions.

CCS CONCEPTS

• **Human-centered computing → Interaction design theory, concepts and paradigms**.

KEYWORDS

sustainable Mobility; social sustainability; environmental sustainability; green mobility; prosocial behavior

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1 MOTIVATION

The need for mobility is undeniable. Practices like commuting to work or visiting loved ones are integral parts of our lives. However, these mobility practices still rely heavily on private cars and pose significant environmental challenges, including greenhouse gas emissions and air pollution, as well as social costs such as aggressive road climate, noise pollution, congested roads, and physical inactivity [3, 16, 27].

Social and environmental sustainable mobility focuses on creating transportation systems that minimize ecological footprints while promoting equity, accessibility, and positive experiences for all community members. It emphasizes the development and integration of technologies that reduce carbon emissions, utilize renewable energy sources, and promote alternative transportation modes such as walking, cycling, or public transit. Social sustainability in mobility ensures that these systems are inclusive, catering to the needs of diverse populations, including the elderly, disabled, and economically disadvantaged [19, 39]. It further promotes prosocial traffic behavior, which encompasses actions that potentially protect the well-being of passengers, other drivers, and pedestrians, and foster effective cooperation within the driving environment [16].

One approach to addressing these goals, in addition to implementing regulations and legislative measures, is by designing technologies that influence and shape people's behavior and mobility practices. Recent advances in automated, or AI-driven systems offer opportunities to shift mobility practices towards more sustainable forms [33]. With their learning capabilities, as well as their agency and proactivity, these systems can serve as counterparts to humans, supporting changes in their mobility behavior [17]. They can be integrated into automated vehicles to consider carbon emissions [24] in their driving style or route planning, or to adhere to courtesy values to be prosocial towards other road users [22, 32, 35–37]. Furthermore, they can function as digital assistants or companions that provide individuals with opportunities for utilizing cross-modal or shared mobility [14] or propose alternative maneuvers to be more considerate towards vulnerable road users (VRU).

Despite many affordances, there is still a limited body of literature focusing on the social and environmental impacts of mobility practices and behaviors. Most existing research remains at a 1-to-1 human-technology interaction level, primarily addressing questions of usability and task performance (see Figure 1). Even existing work on eHMIs (external human-machine interfaces) and communication

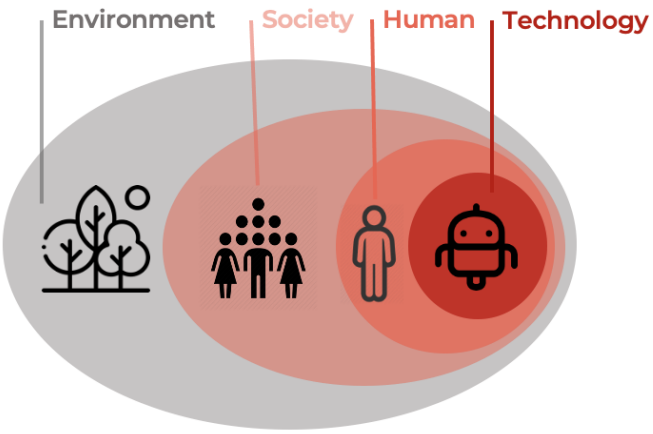

Figure 1: Impact of interacting with technology in individual, social, and environmental levels

between AVs (automated vehicles) and VRUs largely focuses on the effectiveness of such communications in fulfilling requirements related to safety or traffic flow [9]. Studies have shown that eHMIs can improve the understanding of AVs' intentions by pedestrians and cyclists, thus potentially reducing accidents and improving safety [30]. However, these investigations often overlook broader social dynamics and environmental contexts that shape and are shaped by mobility behaviors. There is a need for a more comprehensive approach that includes not only the technical efficiency of eHMIs but also their societal and ecological implications [4, 5]. Current research on eHMIs typically emphasizes their visual and auditory signals designed to communicate AVs' intentions to VRUs, such as yielding or crossing [1, 2, 6, 8, 10, 15, 25, 38]. These studies suggest that well-designed eHMIs can enhance trust and predictability in AV-VRU interactions, yet they often fail to consider the diverse and dynamic nature of urban environments where such interactions occur. For example, studies suggested that the behavior of vehicles (i.e., braking, accelerating) allows VRUs to make decisions. However, each braking or acceleration maneuver requires resources and leads to additional power consumption. Thus, there is a need to integrate insights from urban planning, sociology, and environmental psychology to develop eHMI systems that not only enhance safety and usability but also contribute to sustainable and inclusive mobility ecosystems.

In this workshop, we explore how the design of technology could offer opportunities for sustainable mobility. Through applying speculative design methods such as design fiction [7] and anticipatory ethnography[23] we will collect potentially utopian and dystopian narratives of future mobility practices and develop interaction concepts for future technologies designed to enhance sustainable mobility.

Based on previous work [29], we assume the following broad categories of "persuasive" interaction strategies:

Inform: Persuasive systems use collected data to make user behavior (e.g., energy use) more transparent. For example, it shows the fuel consumption relative to speed control, or the number of people with wheelchairs or baby strollers that could not pass if the driver parked in front of pavement ramps, providing a sense of consequence of actions. This feedback strategy is the most widely used in HCI (e.g., [14]).

Argue: Persuasive systems need to judge user behavior against external or self-set goals. For example, by setting a monthly goal for CO2 emissions. The moment this goal becomes violated, the system needs to respond by pointing out the violation and providing persuasive arguments to influence the behavior, which produced the violation.

Intervene: In contrast to top-down rhetoric strategies (i.e., arguments), behavioral change can be instilled bottom-up through the direct shaping of behavior [26]. Typically, in this strategy, a system creates friction to disrupt routines and provides a materialized suggestion of how to behave "better". In daily mobility practices, for instance, the flexible barrier creates friction when taking a private car for distances of less than a kilometer. The explicit connection of short trips with private cars makes a "behavioral suggestion" by linking going on a short trip with using other forms of transport, such as cycling. This is an example of a bottom-up behavioral strategy.

Reward: Behavior in line with the set goals can be externally rewarded. Originally, Persuasive Design [13] and its industry-led variations, such as "Gamification," heavily relied on extrinsic rewards. However, in our sustainable mobility system, we avoid explicitly rewarding users, as we aim to foster intrinsic motivation to care about the environment and society. Extrinsic rewards, such as badges and saved money, can undermine long-term motivation [12, 21]. Nevertheless, despite the criticism, praise and other forms of rewards for desired behavior are important elements of instilling change that we will explore.

Time	Phases
09:00 - 09:30	Welcome and introduction
9:30- 10:15	Brainstorming on Challenges
10:15 - 10:30	Coffee break
10:30 - 11:00	Design fiction prototyping session
11:00 - 11:30	Presentation of results
11:30 - 12:00	discussion and wrap-up & Exploration of future work
later	Joint workshop dinner (optional)

Table 1: Workshop schedule

Disclose: Unlike purely task-oriented systems, persuasive mobility systems come with a set of assumptions and norms, such as considering walking to work as "normal" or defining appropriate ways of driving. Ideally, these norms are based on neutral, widely accepted, and preferably scientific knowledge. However, this may not always be possible or desirable. Many seemingly "obvious" goals can be legitimately questioned. For instance, in the realm of health tracking, devices have been criticized for promoting "healthism," which imposes unfair beliefs that individuals are primarily responsible for their own health (and failures to achieve it) and can even lead to alienation from one's body [18]. Consequently, we advocate for a standard interaction element that discloses the system's overall goal (e.g., saving energy, being prosocial), all implemented rules (e.g., walking as default), and the underlying user background knowledge.

2 WORKSHOP OBJECTIVES AND STRUCTURE

This workshop will serve as a platform for discussing and developing interaction strategies that can positively influence individual and collective transportation choices, ultimately contributing to social and environmental well-being. The concrete objectives of the workshop are listed below:

- *Develop Concrete Persuasive Interactions:* The design of a variety of concrete persuasive interactions between humans and technology for socially and environmentally sustainable mobility, based on five different interaction strategies for persuasive technologies (to inform, to argue, to intervene, to reward, to disclose)
- *Identify and Collect Useful Scenarios:* Revealing and collecting scenarios where such persuasive interactions could be useful to better understand the contexts in which technology can drive sustainable mobility.
- *Discuss Challenges and Opportunities:* We aim to facilitate in-depth discussions about the challenges and opportunities that arise from implementing persuasive interactions where participants examine the ethical, technical, and social implications of these technologies.
- *Foster Collaboration and Networking:* Another key objective is to bring together researchers, practitioners, and stakeholders who are interested or actively working in the sustainable mobility domain, establish networks, share knowledge, and collaborate on future projects.
- *Generate Actionable Insights and Strategies:* By the end of the workshop, our goal is to produce a set of actionable insights and strategies that can form the foundation of future research in the design and implementation of persuasive technologies for sustainable mobility. These insights will be documented and shared with the broader research and practitioner community.

2.1 Workshop Structure

This is a half-day workshop with presentations, discussions, and hands-on sessions. We expect approximately 20 participants excluding the organizers. Table 1 shows an overview of the workshop schedule.

We will begin the workshop with self-introductions from both the organizers and participants, followed by a brief overview of the workshop objectives and agenda. Next, we will hold a brainstorming session focused on interaction concepts and technologies that promote actions and behaviors supporting social and environmental sustainability. This session is designed to encourage out-of-the-box thinking and spark thought-provoking ideas and transdisciplinary discussions.

We will begin the second half of the workshop with a speculative design [11] and prototyping session using methods such as design fiction [7, 31] and anticipatory ethnography [20, 23]. As this is the first AutomotiveUI workshop focusing on socially and environmentally sustainable mobility, we have included this session to create new interaction concepts by integrating knowledge from both sustainability and HCI disciplines. Participants will be divided into four teams and invited to explore and visualize novel concepts for future interactions based on the results of the brainstorming session. We will encourage them to ideate possible scenarios and provide sustainable prototyping materials (i.e., no plastic waste, degradable) for implementing their concepts. Each group will be asked to enact [28] their concept/prototype and present it to the other groups. We will close the workshop with a discussion of the results and possible future collaborations such as joint publications and follow-up workshops.

3 ORGANIZERS

Shadan Sadeghian is an Assistant Professor leading the Interactive Autonomous Systems group at the University of Siegen, Germany. Her research focuses on designing user experiences and interactions with automated systems, including robots, AI-driven systems, and automated vehicles. She explores approaches that balance pragmatic (performance-oriented) and hedonic (experience-oriented) qualities in interacting with automation. Since 2016, she has served

in several chairing roles (e.g., general chair in 2021), and as a steering committee member in Automotive UI.

Hatice Şahin Ippoliti is a senior researcher at OFFIS Institute for Information Technology in Oldenburg, Germany. Her research focuses on social interaction between humans and automated vehicles in mixed traffic where they coexist [34–37].

Debargha Dey is a postdoctoral researcher at Cornell Tech, USA, with a research focus on human-automation interaction. He received his PhD in Industrial Design from TU Eindhoven and has 8+ years of experience in the domain of human factors for automated driving and traffic behavior. His current work focuses on the cross-cultural aspects of traffic interactions and their implications in the deployments of automated driving systems.

Philipp Wintersberger is a Professor of Interactive Systems at the University of Applied Sciences Upper Austria. He researches and designs systems to strengthen the cooperation between humans and machines, emphasizing safety-critical systems such as automated vehicles. His research fields include trust in automation, operator AR/VR support, Attention Management, and UX.

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