Which Methodology? A Proposed Comparison of Studies in Real-Life, Video, and VR

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ABSTRACT

Research in context of Autonomous Vehicle (AV) and pedestrian interaction includes difficult challenges. For example, AVs are not yet publicly available. Therefore, meaningful research is mainly performed in controlled environments e.g., closed test tracks or laboratory settings. Such studies represent only an approximation of reality. It cannot be assumed that participants behave in the same way as in the real world. The validity of results from such studies might be limited, since consequences of misbehavior (e.g., collisions) do not imply physical damage. We will uncover to what extend pedestrian behaviour differs in context of three discriminative methodological approaches: (1) a real world study, (2) a video-based setting and (3) an investigation in Virtual Reality (VR). The study scenario will focus on pedestrians' willingness to cross a street with an autonomous vehicle present. We expect to get valuable insights for the research community by uncovering differences in results regarding each study modality.

CCS CONCEPTS

• **Human-centered computing** → **HCI design and evaluation methods**; *HCI theory, concepts and models*.

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KEYWORDS

Methodology Comparison, Car-Pedestrian Interaction, Position Paper

INTRODUCTION

Current developments in the automotive domain tend towards increasing automation of the driving task. In this context we want to investigate the communication between highly automated vehicles (AVs) and pedestrians. The safety of pedestrians in road traffic is critical, as they remain almost unprotected in the event of a collision with motorized vehicles. It is therefore necessary to take pedestrian safety into account when developing new interface concepts for AVs. In particular, communication of AVs with pedestrians and other vulnerable road users is a vital HCI challenge. Several concepts of interfaces exist that offer solutions to the challenge of communication between AVs and pedestrians, and ongoing research is trying to validate and substantiate the efficacy of such interfaces.

However, there are two difficulties that challenge such investigation. Since AVs are not openly available, research cannot be conducted in the wild yet. Consequently, investigations on AV-pedestrian interaction are often limited to lab studies. To that end, many studies rely on Wizard of Oz implementations [4, 6], video content [3, 7] or Virtual Reality (VR) [2, 5] approaches. As of now, there is no benchmark on the relative responses of pedestrians across these different methodologies of evaluation, and thus statements of ecological validity are difficult to substantiate. Furthermore there is no "toolkit" suggesting which method is best suited for which research question.

In this context a comparison of the three methods is proposed: (1) a real outdoor environment, (2) a video-based environment and (3) a VR-based pedestrian simulation. The specific scenario we want to consider includes the willingness of pedestrians to cross a road in front of an autonomous vehicle. Given this background, our research questions are:

(1) Is there a substantial difference between pedestrians' willingness to cross across different mediums of testing interactions (real-life/video/VR), given that the vehicle exhibits identical behavior in all cases?
(2) How to transform results into methodological recommendations for the design of pedestrian-AV interaction studies?

Our research questions do not have a theoretically motivated hypothesis, and are exploratory in nature. The results will illuminate whether statistically significant differences exist between the different mediums of interaction. The outcome of the second research question is highly dependent on results of the first questions.

We expect to gain valuable insights for the research community. Our overall goal is to identify differences for each study modality. Finally, we want to present insights about each approach, its

advantages and drawbacks. In specific, we aim to contribute guidelines with study design recommendations for each condition. Our insights and contributions could shape the methodology of many future pedestrian-vehicle interaction studies.

RELATED WORK

Previous research has suggested that time-to-arrival estimates for manually-driven vehicles do not differ substantially between real-life and video [1]. However, arrival time estimates are different from a subjective experience of the feeling of safety and consequently a willingness to cross the road in the presence of the vehicle. Our study therefore particularly focuses on pedestrians' willingness to cross across three modalities of testing: real-life, video, and VR.

Lagström and Lundgren conducted a real-life study including observations, interviews and a Wizard of Oz approach [4]. For the Wizard of Oz setup they used a right-steered car and covered the steering wheel with tinted windows and a piece of dark clothing. They state that changes in the driving mode (human driver or automated) of a vehicle influence pedestrians' willingness to cross. Rothenbücher et al. observed pedestrian responses when an AV is present [6]. In order to create a situation where pedestrian interact with an autonomous car they also set up a Wizard of Oz study design. A seat costume disguised the actual driver making the driver seat of the car appear empty.

Ismail et al. developed a video based system which detects and tracks traffic [3]. The system is capable of automatically extracting information on the interplay of pedestrians and vehicles. Besides distinguishing motorized vehicles and pedestrians it is also able to recognize critical situations e.g., collisions. Song et al. implemented an online survey with embedded videos [7]. These Videos showed an approaching vehicle in the ego-perspective of a pedestrian. When the video paused participants where asked to state if they would cross the road considering the displayed situation.

Virtual Reality approaches were employed to validate external human-machine interfaces [2] or to analyze pedestrians' attitudes towards autonomous vehicles [5].

The mentioned publications drawn from related work show clearly that each of the three study design approaches can lead to valuable insights. However, to our knowledge there has not been a direct comparison of one scenario with all three conditions (real-life, video, and VR) yet.

RESEARCH METHOD

In its simplest form, the study task expects participant to assume the role of a pedestrian intending to cross the road in the presence of an approaching vehicle. As the vehicle approaches, the pedestrian will perform the task of indicating their willingness to cross the road in real time.

The materials needed in this experiment are: a vehicle, an input device, access to a long stretch of road without traffic, a video camera, a laboratory setup with monitor and a VR setup reassembling

the scenario. Hardware used might vary within the methodological approaches. For example, the vehicle in VR might turn out to be slightly different to the one in our real-life setup.

Participants should have normal, or corrected-to-normal vision and be in a clear state of mind. They will experience an approaching vehicle at different speeds. In order to avoid learning effects and transferring experiences between each modality a between-setup will be implemented.

In the case of the real-life study, participants will be asked to stand on the edge of a sidewalk equipped with tracking modules, and the input device in their hands. Videos will be taken of the scenario from the perspective of a pedestrian - to be used for the video-based study. For the VR setup, the scenario will be replicated, and participants will be asked to put on head-mounted VR glasses and stand while holding the input device in their hands.

In the experiment, the participants are not actually asked to cross the road, but merely asked to indicate their willingness to cross via the input device. There are no obvious harmful effects of taking part in this experiment. Afterwards all participants get invited to an interview about their experiences throughout the study.

EXPECTED OUTCOME

We are interested in the interplay of pedestrians and AVs and we expect to identify patterns in pedestrians' behavior when interacting with autonomous vehicles. Additionally, we expect to contribute valuable insights about resulting changes of the outcome of (1) real-life, (2) video, and (3) VR studies for a specific scenario. Hence, the main contribution for the research community will be profound and justified statements regarding the validity of outcomes of each approach. Additionally, we will transfer our insights into a set of guidelines suggesting which method matches best to different kinds of research questions.

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