A Design Space for External Displays on Cars

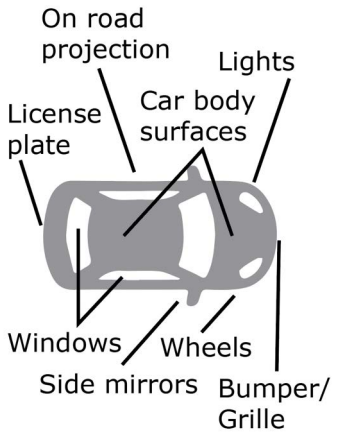

Figure 1: Example potential areas for external displays on cars.

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Abstract
The exterior surfaces of cars provide so far unutilized opportunities for information display. The exploitation of this space is enabled by current advances in display technologies combined with increased sensor integration, computing power, and connectivity in vehicles. With this motivation, we present a framework, mapping the design space for *external vehicle displays*. The audience for the displayed information may be other road users, pedestrians, or autonomous systems. This design direction is particularly interesting in the future, as the current direction towards driverless vehicles may be an enabler for increased separation, redesign, and repurposing of vehicle interior and exterior surfaces.

Author Keywords
Automotive UI; cars; public displays; interactive surfaces; design space.

CCS Concepts
• Human-centered computing → Human computer interaction (HCI)

Introduction
Cars inhabit urban environments, and are today platforms for many different kinds of interactive technologies. Research on interaction design related to cars is flourishing with more and more sensors,

Figure 2: Adjacent cars providing parking guidance (green and orange lights) when reversing into a parking space.

Figure 3: A dynamic air pollution display included in the license plate, to raise social awareness of fuel economy and air pollution issues. In the case of shared (electric) vehicles, the same area could be utilized to display battery charge status or fuel level.

displays, and other ubiquitous computing systems being integrated in cars. In the area of human-computer interaction (HCI), research has addressed topics such as car dashboard design [1], different input methods for in-car touch screens [2], persuasive UI design for more economic driving behavior [11], and haptic feedback for interaction [6,14], to name a few. Despite the vast amount of car related interaction research, current HCI design scarcely considers cars in senses other than as transport. In this paper, we approach cars from the viewpoint of their outward appearance, and consider the possibilities to use them as platforms for external displays. With display technologies developing towards arbitrary shapes, and different forms of public displays integrating in the urban spaces [8], it is timely to consider car surfaces also from this aspect (see Figure 1). As examples, the following use cases introduce potential applications within the scope of the car external display space

Example Applications for Car External Displays

Parked cars providing information to pedestrians and other drivers. In typical urban environments, the entire edge of the sidewalk is walled by parked cars. The outer surfaces of these vehicles could be used to enhance pedestrian safety, by visually informing drivers and pedestrians of each other. Alternatively, as part of a pedestrian navigation system, the surface of parked cars could display guidance arrows and beacons towards which the pedestrian navigates, for example, see Millonig and Schechtner [12].

Providing information to other car drivers. In contrast to the well-researched approach of augmented virtual information as see-through augmented reality on one's own car windows, there is potential to display this information physically on other vehicles visible through the car windows. Examples of suitable information could be navigation guidance, warnings, availability of parking spaces etc. When reversing into a parking space the cars parked in the neighboring spaces could visually indicate the proximity of the reversing vehicle (Figure 2).

Vehicle performance and status display. As a behavior change tool, cars could externally display their actual fuel economy and environmental footprint. This could potentially impact driving styles as well as vehicle purchase decisions. In the case of shared or electric cars, displaying the current fuel or battery status externally, would be beneficial knowledge before entering the vehicle. For such detailed information, the area surrounding the car license plate provides a potential location (Figure 3).

Autonomous vehicles. For vehicles lacking an active driver to communicate with the surroundings, this essential communication channel must be replaced with external vehicle display. This has been explored in the Mercedes F105 concept (Figure 4) and the Semcon 'smiling car' concept (Figure 5), which include displays to communicate with pedestrians.

Contribution Statement

We present a design space for external displays in cars. Our research contributes towards a wider perspective of cars as interactive systems, where they are not considered only from the drivers' and passengers' viewpoint, but also from the view of their surroundings.

Figure 4: The Mercedes F105 concept vehicle includes illuminated and projected displays for pedestrians. [17]

Figure 5: The Semcon smiling car concept. [16]

Related Work

Research on displays in cars has so far focused much on the driver, considering e.g. how to improve dashboard display design [1,7] or the driving task [9]. Different types of in-car display solutions have been investigated, including 3D displays [1] or head-mounted, heads-up and head-down displays, for example, Jose et al. [4]. Earlier, Haeuslschmid et al. [3] have presented a design space for windshield displays, and our work seeks to extend their work by considering also other surfaces of the car, while explicitly focusing on the exterior of the vehicle.

Inherently, cars already employ numerous means to visually signal to their surroundings. Vehicle lights inform others of intentions of turning or overtaking, and brake and reversing lights provide critical information about the car movements. These mechanisms are safety critical, and display information that is essential for traffic to progress smoothly and safely. In addition, there are other visual indicators that are used for information delivery. As fixed information displays, car license plates are used for vehicle identification, but they can also be used as platforms for advertising the garage or car dealer. They can also express the owner's identity or interests, e.g. the state of origin, often embedding artistic visual designs. In addition, temporary or removable information displays are often visible from the exterior of cars. A utilitarian example here is parking time clocks displayed in windows in some countries. Considering more hedonic practices, personalized windscreen sun shade strips displaying, e.g., the driver's and passenger's names, have been common in earlier decades.

In addition to explicit visual communication, ambient displays have been so far little used in the domain of external automotive displays. Ambient information displays, which operate in the periphery of user's attention [10], have been demonstrated in various domains to display, e.g., energy consumption, navigation cues, or social network activity [13]. In a world exhibiting ever more information through various channels, ambient design approaches for information presentation are becoming increasingly popular.

Like for previous examples of design spaces presented in research on automotive user interfaces [3, 5], the objective of our work is to equally inspire and sketch interesting directions for future research.

Design Space

We present a design space for external car displays, consisting of the following dimensions: display areas, interaction methods and contextual factors (Figure 6). The design space can be used to mapping different use cases and designs, and covers e.g. the examples provided earlier. The presented design space is a result of use case analysis and a brainstorming session among four researchers active in the automotive user interfaces and public displays.

The inclusion of outwards display of information as a design driver for vehicle design may result in fundamental design changes, e.g. when parked, side mirrors including display technology could turn such that the mirror display surface faces outwards, rather than inwards as currently. Where cars are in personal ownership, interaction by touching the vehicle may not be preferred. However, for short-term rental cars, such solutions may be more acceptable.

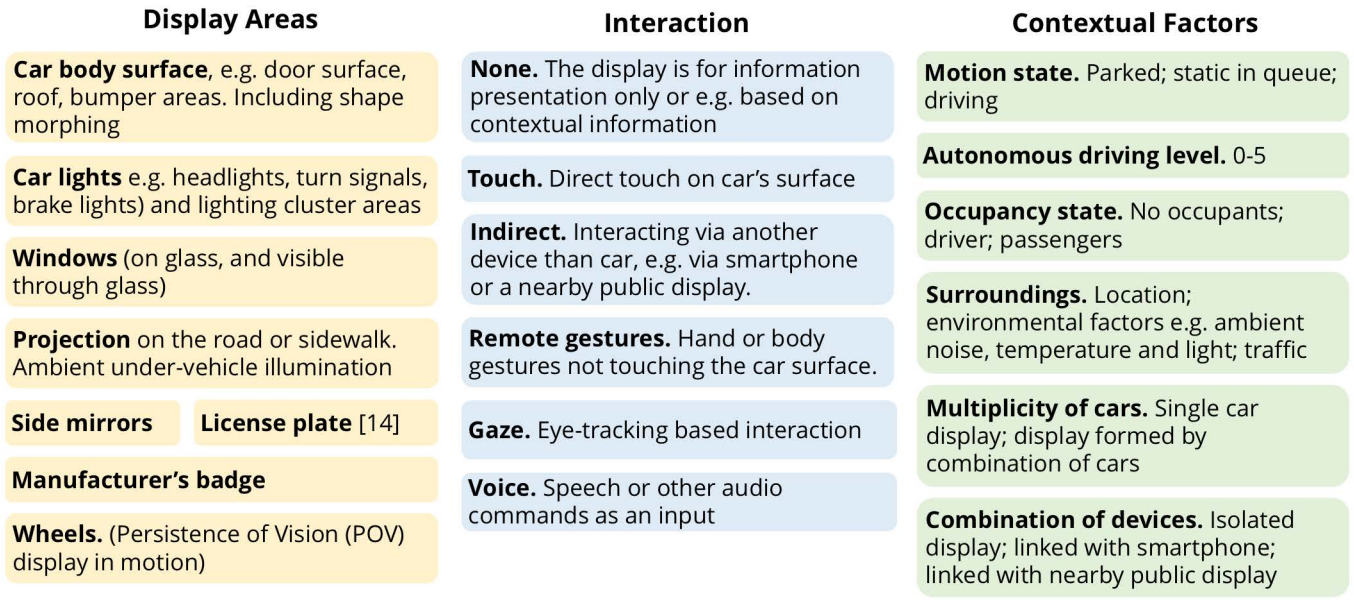

Figure 6: Design space for external car displays

Discussion

The design space presented in this paper seeks to open discussion on considering car outer surfaces as a platform for public displays, and to reach beyond thinking the car as only a means of transport. The design space is hoped to inspire researchers and designers, and to pave way for new designs and applications for external car displays. We believe this topic is especially relevant in light of current trends towards self-driving and short-term rental cars, which will create a disruption in the interior and exterior design of cars.

As a next step, we plan to conduct design- and prototyping-oriented research that takes the advantage of the proposed design space, focusing e.g. on usability and acceptability considerations. Another interesting area for future research is an investigation of the owners' view.

Being a safety critical domain, automotive UIs must take into account the possible risks of distracting car drivers and other road users. Thus, the applications and designs for external displays in this context will surely differ from those for public displays in general.

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References

1. Nora Broy, Mengbing Guo, Stefan Schneegass, Bastian Pfleging, and Florian Alt. 2015. Introducing novel technologies in the car: conducting a real-world study to test 3D dashboards. In *Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (AutomotiveUI '15). ACM, New York, NY, USA, 179-186. DOI=http://dx.doi.org/10.1145/2799250.2799280
2. Ashley Colley, Jani Väyrynen, and Jonna Häkkilä. 2015. In-Car Touch Screen Interaction: Comparing Standard, Finger-Specific and Multi-Finger Interaction. In *Proceedings of the 4th International Symposium on Pervasive Displays* (PerDis '15). ACM, New York, NY, USA, 131-137. DOI=http://dx.doi.org/10.1145/2757710.2757724
3. Renate Haeuslschmid, Bastian Pfleging, and Florian Alt. 2016. A Design Space to Support the Development of Windshield Applications for the Car. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16). ACM, New York, NY, USA, 5076-5091. DOI: https://doi.org/10.1145/2858036.2858336
4. Richie Jose, Gun A. Lee, and Mark Billinghurst. 2016. A comparative study of simulated augmented reality displays for vehicle navigation. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction* (OzCHI '16). ACM, New York, NY, USA, 40-48. DOI: https://doi.org/10.1145/3010915.3010918
5. Dagmar Kern and Albrecht Schmidt. 2009. Design space for driver-based automotive user interfaces. In Proceedings of the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '09). ACM, New York, NY, USA, 3-10. DOI=10.1145/1620509.1620511
6. Dagmar Kern and Bastian Pfleging. 2013. Supporting interaction through haptic feedback in automotive user interfaces. *interactions* 20, 2 (March 2013), 16-21. http://dx.doi.org/10.1145/2427076.2427081
7. SeungJun Kim, Anind K. Dey, Joonhwan Lee, and Jodi Forlizzi. 2011. Usability of car dashboard displays for elder drivers. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, New York, NY, USA, 493-502. DOI: https://doi.org/10.1145/1978942.1979011
8. Vassilis Kostakos and Timo Ojala. 2013. Public Displays Invade Urban Spaces. *IEEE Pervasive Computing* 12(1): 8-13 (2013). DOI: 10.1109/MPRV.2013.15
9. Andrew L. Kun, Tim Paek, Željko Medenica, Nemanja Memarović, and Oskar Palinko. 2009. Glancing at personal navigation devices can affect driving: experimental results and design implications. In *Proceedings of the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (AutomotiveUI '09). ACM, New York, NY, USA, 129-136. DOI=10.1145/1620509.1620534 http://doi.acm.org/10.1145/1620509.1620534
10. Jennifer Mankoff, Anind K. Dey, Gary Hsieh, Julie Kientz, Scott Lederer, and Morgan Ames. 2003. Heuristic evaluation of ambient displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '03). ACM, New York, NY, USA, 169-176. DOI=http://dx.doi.org/10.1145/642611.642642
11. Alexander Meschtscherjakov, David Wilfinger, Thomas Scherndl, and Manfred Tscheligi. 2009. Acceptance of future persuasive in-car interfaces towards a more economic driving behaviour. In *Proceedings of the 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (AutomotiveUI '09). ACM, New York, NY, USA, 81-88. DOI=http://dx.doi.org/10.1145/1620509.1620526

12. Alexandra Millonig and Katja Schechtner. 2007. Developing landmark-based pedestrian-navigation systems. *IEEE Transactions on Intelligent Transportation Systems 8*.1 (2007), 43-49.
13. Heiko Müller, Jutta Fortmann, Martin Pielot, Tobias Hesselmann, Benjamin Poppinga, Wilko Heuten, Niels Henze, and Susanne Boll. 2012. AmbiX: Designing Ambient Light Information Displays. In *Proceedings of Designing Interactive Lighting workshop at DIS 2012*.
14. Kaisa Väänänen-Vainio-Mattila, Jani Heikkinen, Ahmed Farooq, Grigori Evreinov, Erno Mäkinen, and Roope Raisamo. 2014. User experience and expectations of haptic feedback in in-car interaction. In *Proceedings of the 13th International Conference on Mobile and Ubiquitous Multimedia* (MUM '14). ACM, New York, NY, USA, 248-251. DOI=http://dx.doi.org/10.1145/2677972.2677996
15. http://www.reviver.io/ last accessed 2nd August 2017
16. https://semcon.com/smilingcar/ last accessed 2nd August 2017
17. https://www.mercedes-benz.com/en/mercedes-benz/innovation/research-vehicle-f-015-luxury-in-motion/ last accessed 2nd August 2017