Automotive Emoticons: Augmenting Vehicle Space and Morphology

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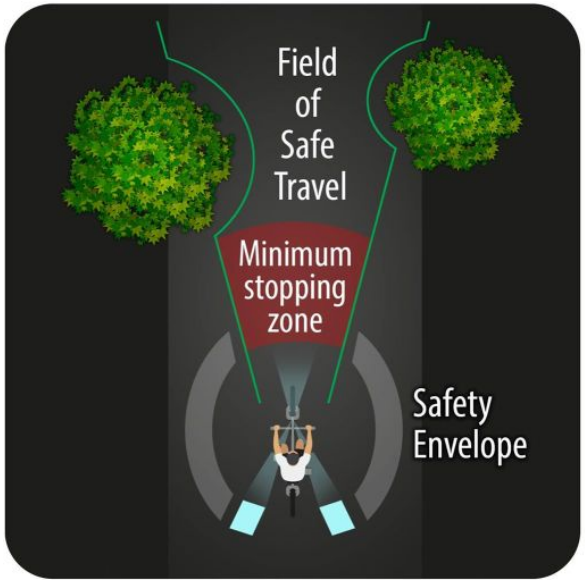

Figure 1: Augmenting the space around vehicles; concepts proposed in our previous work [3]

Abstract
In this position paper, we identify intuitive communication methods between autonomous vehicles, pedestrians, and cyclists. Based on recent industry use cases and findings from our published work, we suggest how they could be developed as part of an exterior autonomous vehicle interface. We end with a brief history of our research and experience as related to the autonomous vehicles and mobility space.

Author Keywords
Communicating intent of autonomous vehicle; Vehicle morphology; Projection; Augmentation; Emotion

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
The world's population living in cities is increasing, from 53% currently living in urban areas to 67% by 2050, while "the total amount of urban kilometers travelled is expected to triple by 2050" [1]. New transportation technologies are being developed, and a wide range of battery-powered locomotion devices has already come to market, such as electric skateboards, unicycles, self balancing scooters and dual wheels. Autonomous vehicles will be widely available by 2025 [2], with companies such as Tesla demonstrating

this function already [5], automotive visual interfaces will look different in the future.

Communication in Traffic

Communicating with pedestrians and participants in traffic will become important issues since the human driver will disappear. The interactions in traffic will change since autonomous vehicles will be able to communicate with other vehicles and city infrastructure. In this paper, we focus on visual communication that takes place while the vehicle is moving or standing (e.g at a crossing). Other vehicles could be also autonomous or have human drivers (e.g. cyclists, car and battery-powered devices drivers). Pedestrians at a crossing create a use-case that requires negotiation of intent between the autonomous car and the human.

Figure 2: Vehicle prototypes communicating information through light embedded in the vehicle body. Frankfurt Motor Show, IAA'15. Taken by authors. http://trive.me

The Mercedes autonomous vehicle prototype completed successfully the 103km historic route resolving complex traffic situations. The researchers noted that improvements are necessary in "the ability to interpret a given traffic scenario and to obtain a meaningful behavior prediction of other traffic participants" [8]. One way to resolve these complex situations would be to communicate intention of the autonomous vehicle to the other participants in traffic. Nissan showcased their concept car in 2015 [6] introducing a system called *Intention Indicator* that communicates with pedestrians (Figure 3).

The trive.me vehicle concepts (Figure 2) cover the body of the car with configurable lighting panels, which can be modified remotely via a smart-phone app. The Nissan IDS Concept car incorporates a screen on the front windshiled displaying text and symbols to signal the car's intent to passing pedestrians.

Signalling Methods

Before the widespread use of light based turn signals, the primary signalling method involved using symbolic arm gestures. Today, these gestures are used predominantly by cyclists and occasionally by drivers in heavy traffic.

An important consideration when designing communication interfaces around the vehicle is their connection to natural and intuitive signalling systems that are easy to understand. For example, pedestrians may use natural body language such as posture and facial expressions to signal intent, whereas cars are limited to specific sets of light patterns. Thus, in pedestrian-meets-vehicle scenarios, augmenting the signalling systems of autonomous cars to be more expressive or "human-like" could provide a smoother communication interface.

Don Norman's book entitled *Turn Signals Are the Facial Expressions of Automobiles*, emphasizes the importance of communicating the internal states and intent of automobiles via emotional expressions [7]. One way to model these expressions is to use vehicle morphology and the space around it in order to communicate the autonomous car's intent.

Design Space

The technical solutions of trive.me and Nissan prototypes are examples of new ways of communicating information in traffic. They provide opportunities for HCI researchers and designers to explore the design space of future vehicle interfaces.

We propose two methods of expanding the communication of autonomous vehicles by using morphology and by augmenting physical space nearby.

Figure 3: Nissan's autonomous vehicle interface communicating intent to pedestrians https://youtu.be/h-TLo86K7Ck

Vehicle Morphology
The internal state of the system, and the intent of the autonomous vehicle could be communicated through vehicle morphology. For instance, by changing their shape and lighting configurations, headlights could express concern, surprise, or other emotional states of the autonomous vehicle. In a more advanced scenario, headlights of an autonomous vehicle can be used to establish eye-contact with pedestrians, letting them know that the system is aware of them while simultaneously raising awareness of the traffic participants around them. Hence, the eye contact of the human driver is replaced with the eyes of the machine. In mobile communication, the use of emoticons is used to express emotional states. Similarly, we can model expressive headlight stances by using iconic representations of the desired emotional state.

Space around Vehicle
As projectors are getting cheaper and widely available, augmenting the physical space around vehicles has the potential of improving safety and the interaction between participants in traffic. Headlights could be replaced with projectors displaying the minimum stopping distance and the zone of safe travel [4]. Gesture Bike [3] implements this concept and augments the space around vehicles with information. Our proof-of-concept experiments employed bicycle-mounted projectors. The online visibility study from the perspective of pedestrians, cyclists, and vehicles found that gesture-projection shows the cyclist's intention more clearly, creates better situational awareness, and is easier to understand [3]. This type of projections around autonomous vehicles has the potential to improve situational awareness for other traffic participants.

The two approaches of augmenting the space around the vehicle and the emotional design expressed through vehicle morphology complement each other and could improve the communication of participants in traffic.

Author Background and Motivation

Alexandru Dancu is currently a PhD student at Chalmer's University with a background in mid-air displays and projection technology. **Velko Vechev** is an interaction design master's student at the same institution with experience in interaction in motion and augmented reality. In 2015, Alex and Velko developed the 'Gesture Bike' [3] at Chalmers which makes use of cyclist gestures to communicate intent to other traffic participants. In September of 2015, both authors attended a week long IDEA League workshop on connected mobility and autonomous driving at Aachen / RWTH. Alex's design team received top prize for their innovative design on social networking opportunities in autonomous driving scenarios. As part of his thesis work, Velko is currently contributing towards the AIMMIT project (Automotive Integration of Multi-Modal Technologies) in collaboration with Semcon and Volvo.

During the workshop, the authors intend to visit Google Partnerplex and Stanford University to gain first hand experience in how autonomous vehicle behave with the overall goal of designing for increased urban mobility and safety in traffic.

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