Communication of Intention in autonomous vehicles

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Abstract

This position paper serves as a personal introduction and a description of my work and ideas in the field of autonomous passenger vehicles. The paper briefly explores a concept for communication of intention between a passenger and an autonomous vehicle, and

also with other road users in the outside world as potential topics for discussion in the workshop HCI and Autonomous Vehicles: Contextual Experience Informs Design in CHI 2016.

Author Keywords

Autonomous vehicles; in-car infotainment; interaction design

ACM Classification Keywords

H.5.2 Information interfaces and presentation: user interfaces (D.2.2, H.1.2, I.3.6) Subjects: Interaction Styles; H.1.2 User/Machine Systems: Human Factors

Introduction

While most people are willing to be driven to their destination under the right circumstances by a fully autonomous (NHTSA Level 4) vehicle, lack of trust in the car is one of the major factors in people's hesitance towards acceptance of this technology [1, 5, 6]. In this context, it is important for the car to give the passengers the sense that they are aware of the car's intentions, and are able to take control at any time, or even tell it "how" to drive within their comfort zone. This paper outlines a concept in which an autonomous vehicle can communicate subtle behavioral aspects in driving such as intent, which is above and beyond the communication of simple navigational directions.

Car-Human Communication

Different automakers have different ideas when it comes to self-driving cars. While Google's design concept for an autonomous vehicle completely does away with the steering wheel and aims for complete autonomy, most automobile manufacturers retain the ability to drive the car manually, and maintain that autonomous driving for passenger cars will be relevant for driving in adverse or tedious conditions, or otherwise when the driver is willing to delegate the task to the car because they prefer to use their time in another way. Additionally, as autonomous passenger vehicle technologies become more common, they will be capable of autonomous driving only under certain conditions and in certain stretches of road, necessitating the driver to take manual control of the car at certain times. This calls for a very effective communication between the car and the driver, especially during the handoff of driving responsibility.

There can be several situations when expression of intent is crucial for the car in attaining the passenger's trust or confidence. An example might be a scenario when the car would attempt an overtaking maneuver in a narrow two-lane road next to a semi-trailer truck. Even if the car might have deemed it a safe maneuver, the passenger might feel uncomfortable and might choose to wait until the road widens. Another scenario is when the car has chosen a "shortest-route" path to a destination which takes it through a neighborhood or a part of town which the passenger would like to avoid.

In such situations, the passenger needs to be able to "tell" the car effectively how they want to be driven in order to maintain a high level of trust and comfort in the car. This communication can be established in three ways: visual, auditory, and haptic. The nuances of the many possible scenarios and the action the car intends to take can be too detailed and information-heavy to adequately express via visual aids. While auditory communication in such situations can augment the feedback, care must be taken that this doesn't lead to information overload, and that the passenger is not overwhelmed, as it takes away from the conveniences of autonomous driving.

Car to human communication
 A simple form of informing the passenger of the car's intention is to just show the car's navigation path well in advance, so that the passenger can take adequate actions if they disagree. This can also be portrayed in the form of an advanced heads up display (HUD), which unlike traditional HUD systems can adjust for parallax effect based on the driver's head position and movement, and project intended directions on the windshield, 3D-mapped to the road ahead, instead of showing a static direction with the usual countdown to the next significant maneuver. I have already conceptualized this form of a navigation system as a part of a former project. A screenshot of a video prototype I built for this is shown in Figure 1. Notice the translucent green arrow mapped to the road in front of the driver in the picture.

In a non-autonomous vehicle, this can act as an augmented navigation system which portrays directions and turns mapped to the road based on the driver's perspective. In a fully autonomous car, this system can be adapted to communicate any future action the car may be taking. In the case of an overtaking maneuver, the arrow may change color and animate forward to indicate this. This is of particular relevance as the directional indicators and arrows mapped to the real world in context in a natural way will aid perception of intent. This can be adapted further for more complicated forms of communication with the passenger. Suitable topic for exploration and discussion in the workshop might be which conditions are crucial for the car to communicate its intent, and how can it be done most effectively.

Figure 1: The navigation directions are projected on a HUD mapped directly to road and the horizon from the perspective of the driver.

Surveys and research have shown that visual and auditory feedback are the most preferred ways that humans would like to receive communication from self-driving cars. [2, 4] However, haptic feedback as a means of communication has not been explored extensively, and the ways to achieve this end with modalities other than various form of vibration is an interesting area to be investigated.

Human to car communication
The other side of this coin is the investigation regarding how a passenger can convey his intentions to the car. This is comparatively more complicated. One of the ways this can be accomplished is with control surfaces that allow communication to the car regarding discrete direction and motion preferences (e.g. joystick, as opposed to a steering wheel and accelerator/ brake pedals). When the passenger is presented with a specific number of options regarding possibilities, they can notify the car of their preference using such a medium. However, the effectiveness of such devices for this purpose remains to be investigated. This can be yet another topic for discussion in the workshop.

"When a human is rarely required to respond, he will rarely respond when required". [3] Keeping this in mind, it is important to strike the balance between keeping the passenger engaged, and relieving them of driving duties to do other things. This factor will become less important as cars reliably move toward full autonomy without requiring human assistance; however at present, this is of considerable importance as partially autonomous vehicles that depend on human intervention are likely to be widely available in the near future.

Car-Road User Communication
Communication to the outside world
As autonomy becomes more common and such vehicles share the road with other vehicles, pedestrians, or cyclists, it will become important to convey intent with the outside world. In slow speed situations, drivers often rely on eye contact and gestures with each other to communicate. In a non-fully-autonomous, non-connected-car environment autonomous vehicles will need to achieve this communication by other explicit means.

Some auto manufacturers like Audi, Mercedes-Benz, BMW, and Nissan have already explored this kind of communication via laser and LED lights, and projections on the road. However, road surfaces can be unpredictable, and often poorly suited for such important communication. An alternative idea is to display communication information on the windscreen of the autonomous vehicle itself. Investigation needs to be conducted regarding a comprehensive research on what kind of information an autonomous vehicle might need to communicate with the outside world, and what standardized way of doing that might be best suited from a Human-Computer-Interaction perspective.

Personal Introduction and Motivation
With a background in Computer Science and Software Engineering, I have gradually shifted my focus to human computer interaction and user experience over the last few years. I am currently a Professional Doctorate candidate in User System Interaction (USI) at the Eindhoven University of Technology. My specific interest lies in the field of Automotive UI, particularly in the field of autonomous driving. In the USI program, I have been working with other candidates and have experience with interaction design and prototyping. I believe that this workshop is in direct alignment with my interests and goals, and will be an invaluable addition to my experience. I would also like to participate in the pre-workshop program by visiting the Google Partnerplex and the Stanford University.

Experience

Over the last few months, I have been working under the advisorship of Dr. Jacques Terken of TU/e in a research regarding anthropomorphism in autonomous vehicles. The goal of this research is to find if cars that can communicate with its passengers in a "human" way have an effect in how the passengers relate to the car; and if this in turn leads to an increase in trust on the car for the passenger. Additionally, I have also conceptualized a method of displaying navigation directions in a vehicle in 3D projection mapped to the world around the driver, as mentioned briefly earlier. Other than the specific experience in the field of in-vehicle interactions, I have successfully concluded numerous projects in the field of interaction design, evaluation, and analysis.

Conclusion

Although the potential for passenger vehicle autonomy is real and likely not too far into the future, it is challenging to put forward ideas in this field without adequate elaboration and explanation. A conversation or an engaged discussion, perhaps with sketches and prototypes are much better suited mediums of communication in contrary to a short summary. I would welcome the opportunity to attend the workshop and exchange ideas, concepts, and thoughts with other researchers and experts in this field.

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