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Automated driving:
Optical and/or audible signals in DAS and ADS vehicles

Submitted by the WP.1 Chair

The WP.1 Chair has requested professor B. Mehler of MIT to offer first insights on the issue of optical and/or audible signals in DAS and ADS vehicles in order to facilitate WP.1 discussion on this subject. WP.1 will be invited to discuss this informal document.

Brief Comments on Requiring Automated Vehicles to Communicate a Mode of Operation: The Importance of Avoiding Unintended Consequences

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1. I should make it clear at the start of this brief comment that I am not firmly opposed to the idea of requiring an automated vehicle to signal in some manner it's mode of operation. At first consideration, I expect that many people see this as a very reasonable and desirable proposal. However, as we look at research data, particularly considering pedestrian interactions with "automated" vehicles, there are both data and antidotal evidence that suggest that attempts to communicate the status of a vehicle and its "intended" behavior can cause confusion and may have unintended negative consequences when vehicles are in mixed traffic situations where both automated and manually controlled vehicles are present. I will return to this concern in a moment.

2. One additional consideration that is also worth taking into account is that some humans have shown aggression or other abuse against automated vehicles. At one extreme there have been cases in the US where Google automated vehicles designed for transporting passengers have been physically attacked by human drivers, including being run off the roadway. Some of these cases may have involved drivers who take passengers for a living and felt their livelihood was threatened by the technology. In other instances, pedestrians have been observed deliberately stepping in front of automated vehicles and deliberately preventing them from advancing.

3. Again, what I see as the key issue is whether other road users will expect vehicles in automated vs. manual mode to behave differently – and whether they may make assumptions about vehicle behavior that could have negative safety implications. This might occur either because their assumptions about the behavior are wrong or because they misunderstand whether the vehicle is running in automated mode or not.

4. Some of this concern comes from research that looks at attempts to use visual or audio communication from a vehicle to a pedestrian to inform them whether it is safe or not safe for them to cross in front of the vehicle (for example, at an intersection). Several studies have found that humans often are unable to interpret the attempted communication or misunderstand the attempted communication. This could result in pedestrians walking in front of a vehicle when they should not.

5. Some of the motivation for creating new external signaling for automated vehicles comes from many pedestrians' belief that they generally take their cues as to whether to walk or not walk in front of a car based on eye-contact with the driver. Some research indicates that this is much less frequently the case than most people think. Often it is not actually possible to make eye contact with a driver. Some data suggests that most of the time that we actually take our cues as to whether to cross or not based on the dynamics of how the vehicle is approaching the intersection long before a driver's face may or may not become visible.

6. One active line of research is focused on understanding these dynamics so that automated vehicles are programed to most effectively communicate whether they intend to slow down and stop at intersection or proceed through the intersection when they have the right of way. One line of argument is that safest operation in mixed vehicle state environments will come from both automated and manual vehicles showing similar behavior patterns so that historically learned "communication" patterns are consistent.

7. There is also experience that most of the "crashes" that have occurred in the US between manually driven vehicles and automated vehicles has come from the automated vehicles being overly conservative in their driving behavior that has resulted in human drivers rear-ending the automated vehicle because it behaved differently than how most human drivers would drive. In these instances, it is important for designers of automated systems to find a better balance between conservative driving and more "natural" human like driving patterns to actually maximize safety.

8. Again, this is, indeed, a complex topic as there may be good reasons for some knowability as to whether a vehicle is currently in automated or manual control. For example, this may be important when the police or other safety or management related officials need to understand the status of a vehicle. However, as outlined above, there can be unintended consequences and overall safety may be better served by proceeding very cautiously before requiring overt distinction between automated and manually driven vehicles. In particular, it will be important to carefully test specific signaling methods to ensure they do not increase confusion or have unacceptable levels of misinterpretation. Simply specifying that a visual and/or auditory method of signaling status be employed runs the risk of unintended, negative consequences.

Selected References

The following is a selected list of research relevant to the points raised in these comments. It is by no means exhaustive, likely does not include some highly relevant work, and should ideally be expanded to provide a more complete background on these issues.

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