Meaningful Human Control over Automated Driving Systems

THIS ISSUE'S TOPICS

THE OPINION

How would SAE Level 4 work out on open roads? General Motors offers a meaningful and realistic perspective on SAE Level 4

by *Bart Van Arem*

THE INTERVIEW

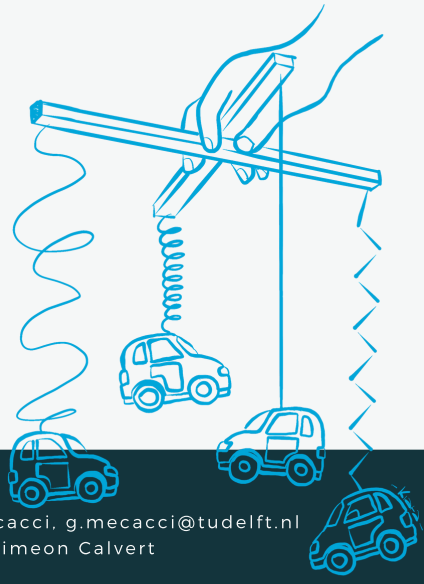
Giulio Mecacci went to RDW to interview Pieter Striekwold, special advisor to the director, and Arjan Van Vliet, senior advisor for strategy and external developments. They shared a great deal of meaningful insights on present and future of automated transportation.

NEWS FROM OUR PROJECT

Our updates on research and things we do in our daily life of hard working researchers.

PUBLICATIONS AND DISSEMINATION

A short list of our most recent publications, the events we attended, and those we are planning to attend



COLOPHON

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Interior view of General Motor level 4 vehicle (source: GM)

THE OPINION

by *Bart Van Arem*

Wouldn't it be great? The car does the driving, while you take a nap, watch your favourite episode of Friends or solve a crossword puzzle. It'll be soon on roads on your route! Will it? Visionaries, futurologists, engineers, marketers are suggesting a wide range of deployment time horizons. They are projecting widely different images of how highly automated driving (yes, we're talking SAE Level 4 here) could actually work. And of course, we all know that SAE level 4 has been operational since the late nineties on a dedicated protected road. Indeed, it's the Parkshuttle near Rotterdam, the Netherlands, completely driverless and supervised from a control centre. So how would SAE Level 4 work out on open roads?

GM discussed their take on making SAE level 4 work during the 2018 Transportation Research Board Annual Meeting in Washington DC. They are planning to operate a fleet of driverless SAE level 4 vehicles on open roads in several cities in the USA. Their approaches bear remarkable similarities. The fleet of vehicles will be owned by GM. The fleet will operate in specific conditions (in SAE terms: the operational design domain): low to moderate speed, limited interaction with other traffic, good roadway and weather conditions and an adequately 3D mapped area. Travellers can request a vehicle to drive them to their destination in the area. Contrary to earlier experiments, the professional back up driver will not be behind the wheel, not in the passenger seat, nor back seat. GM aims to implement a Level 4 vehicle where the vehicle itself is responsible for the entire driving task including obtaining a minimal risk condition when required to so. GM announced that remote support personnel will be available to communicate with passengers and address concerns that may arise. In addition, in very rare circumstances (and increasingly rare as the vehicles are exposed to and learn from more edge cases and gain driving experience), if the vehicle encounters a situation that is not within its immediate capabilities it can contact a center for help in navigating.

Yes, this could work! It certainly takes us beyond the dream (nightmare to some) of an automated vehicle making lane changes at high speed on busy motorways without any human supervision. It also busts the myth that an automated vehicle could just find its way in complex urban traffic surrounded by pedestrians, cyclists and constantly varying conditions. GM is showing through their pilot deployment, that they are carefully and safely operating within a specific Operational Design Domain. They are building up experience that will also lead to understanding how to expand the Operational Design Domain. Moreover, their vehicles aim to plan and execute their movements autonomously, while still being connected to remote support personnel. They will be collecting invaluable experiences from early users.

Could we classify the GM fleet as being under "Meaningful Human Control"? Beyond doubt, values at stake are trust and safety. But to which extent are humans involved in the settings and operations of the system. What responsibilities and tasks reside at developers, support personnel and the passenger, and which skills are required from them? And ultimately: will they indeed prove the potential of better mobility and accessibility? Pilot deployments as done by GM will help understanding the ethical, psychological and engineering issues that lie ahead on the road to responsible deployment of automated vehicles.

Disclaimer: this opinion article is based on a personal interpretation of the author. It is intended to stimulate discussion and has not been the result of a systematic scientific study. The feedback by GM on an earlier version of the article has been greatly appreciated. More information about the GM project can be found at the official website.

THE INTERVIEW

by *Giulio Mecacci*

A few weeks ago, I went on a journey. Destination: Zoetermeer, RDW. My scope was to get some insights on the current state of things in The Netherlands and in Europe for what regards vehicle automation. I ended up having a great discussion with my two hosts, Pieter Striekwold, special advisor to the director, and Arjan van Vliet, senior advisor for strategy and external development. I briefly report here some fascinating bits and pieces of our long conversation, that provided our interdisciplinary research team with invaluable technical and societal perspectives on vehicle automation.

Striekwold is one the Dutch representatives in Geneva for what concerns vehicle technology standardization. One of the most debated topics at an international level, he says, is how to deal with transition of control.

"We are frantically discussing how to deal with the different situations automation presents, the takeover ones being the most difficult. If you know at what level of automation your car is operating, you may also know, to a certain extent, what you are and are not supposed to do. This is already challenging, but It is when that level changes, and a driver is requested to take over, that things become even more complicated. There are situations that a level 3 automated car cannot deal with, and you have to take over. However, it is not easy for the system to realize when a human intervention is needed and the control has to be given back to the driver. It can take up to 30 seconds to a driver to recover full awareness of the surroundings".

I was glad to know that human control was in bold on Geneva's agenda, after all it is what our team is trying to investigate. However, I was wondering what solutions, if any, could have been proposed at a policy making level. Striekwold's answer was surprisingly straightforward.

"Dutch representatives in this discussion are trying to stimulate as much as possible the adoption of fully automated systems, level 4 and 5. We are not very in favor of level 3 systems. If possible, we want to skip level 3 and go straight to level 4 or even better level 5. Level 3 creates too many troubles with transition of control between drivers and vehicles."

I understood at that point that safety was a central value in the idea of promoting higher levels of automation. After all one of the big issues with transition of control is exactly that it can turn out to create unwanted risks, at least if not properly designed. Safety is indeed central, but I was curious to know whether accountability could also be helped by promoting such transition. In fact, one of the biggest issues our team is investigating, is how to solidly link a human, responsible agent, and the (mis)behavior of her automated car. Striekwold and Van Vliet were confident on that regard.

Arjan Van Vliet & Peter Striekwold

"If you go to level 5 of automation, it becomes clear that it is the manufacturer to be responsible of anything that could happen. In that case, it is clear that there is no responsibility for drivers, unless they push a button or perform actions that have been specifically forbidden. The fact that the car is driving on autopilot means in itself that the responsibility goes all with the car manufacturer".

"There is of course still some responsibility on the passenger", Van Vliet pointed out, *"and that is to provide the vehicle with adequate updates and maintenance. The manufacturer should on the other hand prevent situations were the vehicle drives with, for instance, an outdated software."*

I concluded my interview by asking the question that had been pressing during our whole conversation. I really wanted to know what all of us, science as well as society, could do to get safely and responsibly to a fully automated future.

Van Vliet hastily shot some answers, eager to also reveal an exciting plan. "*Infrastructures will need to change in these next few years, or at least we have to find a way to optimize how we use the ones we have. Automated cars, unlike drivers, will keep the safety distance, and that takes a lot of space. We will need connectivity to understand what all the other cars are doing. Also, and in the meantime, we have to be sure of what automated vehicles can and cannot do. Together with CBR, we are currently setting up a driving exam for self-driving vehicles. Next year we will have the first of them to give an exam."*

"From your research, though", concluded Striekwold, *"we could really use some insights on the different ways of transferring control back and forth between driver and vehicle. If you could find the best one, all on the basis of hard evidence, and while striving for safety and environmental friendliness, that would help a lot in developing standards and, of course, in designing technology."*

NEWS FROM OUR TEAM

Dr. Simeon Calvert, traffic engineer

The past months have involved three main areas of work from the engineering track of the project. The first is the performance of interviews with various experts involved in vehicle automation research in the broadest sense. The goal of this is to seek out possible collaboration and synergy possibilities and avoid repetitive work where others are already working. This resulted in useful insights and access to data and experimental results.
The second area of work is the construction of a framework of core components of the automated driving system (ADS) as a function of MHC, which includes consideration of the chain of MHC in ADS. This work has been written as a scientific paper and in nearing completion in February and should be submitted soon.
Finally, work has started on defining the constraints and conditions for a conceptual simulation framework to model MHC ADS. This is the first step towards the development of a simulation model to actually perform impact analysis. Part of this is also the identification of gaps in knowledge which can lead to intermittent experiments (e.g. FOT or driving simulator). Meanwhile, fundamental work in this regard on including human factors in modelling is on-going parallel to the MHC-ADS project together with Hans van Lint. This is not part of the project, but will feed directly into the project.

Dr. Daniel Heikoop, behavioral scientist

From the start of the project, my work entailed the determination, classification, and quantification of human control over (automated) vehicles. This meant identifying a foundational framework of human behaviour related to control, after which each component could be assessed separately. Herewith, three main components were identified, namely "skill", "rule", and "knowledge"-based behaviour, after Rasmussen (1973). Hereafter a quantification process took place, classifying several hundreds of behaviours that are applicable within the driving domain. The next steps will be assessing the reduction and/or addition of these types of behaviour within various levels of automated vehicles. The final product is then planned to be discussed with Human Factors experts and driver instructors, with the aim of developing a framework for "meaningful" human control over automated driving systems.
Next to my own work, active collaboration has been taken place on several grounds, resulting in a publishable article, and a submitted research proposal that progresses from our current project. Also several conferences have been and will be attended.
Future steps will entail empirical assessment of both the found and proposed frameworks.

Dr. Giulio Mecacci, philosopher

It's been around six months since I started working at this project. As a philosopher, my first priority was to take care of the conceptual challenges. I decided to start from finding a solid ground to devise a notion of meaningful human control applicable to the empirical science and usable in an informed societal debate. Luckily enough, a recently published work by Santoni de Sio and Van Den Hoven, gave me a head start. There, a general definition of meaningful human control is given for any automated system. I decided to see whether and to what extent the concept was applicable to different kinds of automated vehicles. The conceptual framework that I devised identifies different types of controllers and different types of controllers' intentions. It frames in an encompassing picture the core components identified by Calvert et al., and the cognitive elements isolated by Heikoop.
Besides my armchair philosophical activity, I released an interview for VOX Nijmegen, to be published, I attended the NWO-MVI conference in Utrecht, and I'll be hosted at the Radboud Science Festival in April, talking about meaningful human control.

PUBLICATIONS AND DISSEMINATION


Lindenholmen, Gothenburg

- S. C. Calvert, D. D. Heikoop, and B. v. Arem, "Core components of automated driving for meaningful traffic flow and safety," (to be submitted): available on request.
- S. C. Calvert, and D. D. Heikoop, (submitted abstract). "Vehicle Automation Design to Maintain Meaningful Human Control for Driver Inattention", *6th International Conference on Driver distraction and Inattention*, October 15-17, 2018, Gothenburg, Sweden.
- D. D. Heikoop., & M. Hagenzieker, (submitted abstract). "Working Towards a Meaningful Transition of Human Control over Automated Driving Systems", *6th International Conference on Driver Distraction and Inattention*, October 15-17, 2018, Gothenburg, Sweden.
- D. D. Heikoop et al. (in progress). "A Quantified Framework of Human Control over Automated Driving Systems".
- G. Mecacci & F. Santoni de Sio (in progress). "Human Intentions and the Tracking of Automated Behavior".
- F. Santoni de Sio & J. v. d. Hoven. (2018) "Meaningful Human Control Over Autonomous Systems: A Philosophical Account", *Frontiers in Robotics and AI*.
- D. D. Heikoop, S. C. Calvert, G. Mecacci, M. Hagenzieker, F. Santoni de Sio, & B. van Arem (submitted abstract). "Meaningful Human Control over Automated Driving Systems", 6th HUMANIST Conference, June 13-14, The Hague, The Netherlands.

- Attendance at the Kennisagenda @ Connekt, September 5, 2017, Delft, The Netherlands.
- Attendance at the RSS2017 - Road Safety & Simulation International Conference in The Hague, October 2017.
- Attendance at the NWO-MVI conference, January 19, 2018, Muntgebouw Utrecht, The Netherlands.
- Invited lecture at Politecnico Milano, "Ethics in the Age of Autonomous Transportation".
- Co-organized workshop on "Social and Ethical Implications of Autonomous Vehicles" at University of Vienna
- Co-organizing a panel session on MHC within the ethics breakout of the Automated Vehicles Symposium (AVS) July 9-12, 2018, San Francisco, US.


Muntgebouw, Utrecht