Universität für Bodenkultur Wien (BOKU)
University of Natural Resources and Life Sciences, Vienna

Institut für Rechtswissenschaften
Institute of Law

Report:
Autonomous Cars – A technical Introduction

Professor Hermann Winner
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One of the most discussed topics in the automotive sector is currently autonomous driving. Almost all major car manufacturers are investing high capacities and are trying to take a pioneering role. Even society is increasingly aware of autonomous driving and is discussing it more and more intensely. Here, the recent accidents involving autonomous cars from Uber and Tesla have played a major role, as a person was killed. For this reason, safety issues have arisen in connection with the autonomous vehicles.

Prof. Dr. Hermann Winner from the Technical University of Darmstadt, who has himself filed over 100 patents in the field of automotive engineering, introduced the technology of "autonomous driving" in the context of the LunchTimeSeries on Law, Technology, and Society (LTS) on 5 June 2018. First, he pointed out that autonomous driving is not a brand-new phenomenon. In the mid-1990s, successful tests with automated vehicles took place, for example, as part of Daimler's "Prometheus" project. Apart from brief interventions by the control driver, the car was already driving autonomously on the motorway from Munich to the Danish city Odense.

But what exactly is meant by the term "autonomous driving"? The SAE International divides the autonomy of the car into six levels. The higher the level, the more the driving of the car and the responsibility for it shifts from the human to the machine. The biggest cut is from level 2 to level 3. Until level 2, the driver must be able to intervene immediately in difficult situations. From level 3, the machine retains control for a few seconds in the event of a sudden new situation, until the control driver takes over.

Commenting on the current situation on the road, Winner has pointed out that autonomous vehicles already have been tested in the public sector, travelling at low speeds and with a control driver in selected cities.

Winner divides autonomous vehicle scenarios into four categories: 1. The freeway pilot driving from ramp to ramp; 2. the parking assistant, who is looking for a parking space without the presence of the driver; 3. the machine travelling on all roads, and 4. the "vehicle-on-demand", e.g., whether it can be used as a taxi or as a delivery service. The latter could, like the railway system, be sent from a control centre, thereby increasing the importance of car sharing.

Coping with all these situations is only possible if the car can "see". To make this possible, different sensors are necessary, e.g., *Lidar*, which can cover large distances, but fog weakens the measurement; ultrasonic sensors with an accuracy of 5-10 millimeters, but these have only a small field of view; or radar, which is hardly limited by fog, but has problems because of the low angular resolution in the detection of external dimensions. Despite the individual deficiencies, these technologies allow an accurate analysis of the environment when used together. Nevertheless, uncertainties, e.g., when the car detects an obstacle where there is none or does not recognise the obstacle and crashes into it without doing anything. Recognition alone is not enough if the vehicle draws the wrong conclusions at the end.

How safe is autonomous driving in the end? As an argument for the need of autonomous cars, the developers argue that the mechanised driver is safer than the human driver. According to Winner, this cannot yet be proven because the autonomous vehicles have not been placed on the market so far. Additionally, it should be remembered that people drive very safely. Statistically speaking, every human causes only 1.4 accidents in his or her entire life. Vehicles cover 210 million kilometers on German roads before a deadly accident happens. On the highway, this value increases to 660 million kilometers. With these impressive numbers, the autonomous vehicle has to be compared with, and even surpass, these values to confirm the safety argument. However, a meaningful judgment on the susceptibility of autonomous vehicles to error can only be made after billions of kilometers are travelled on public roads.
Regardless of the technical design and the application possibilities of autonomous vehicles, it is unclear how the society reacts to autonomous vehicles. Are the investments of the automobile industry and the individual countries worthwhile in the first place? Do road users change to autonomous driving? It is also unpredictable whether the legal framework covers all aspects of autonomous driving or whether adjustments are necessary, in particular,

because the machine will assume more responsibility in the future. Although the rules of civil and criminal law are merely reactive, Winner sees at least a sufficient framework for testing and exploring autonomous vehicles.

In the subsequent discussion Winner answered countless questions from the interested audience and pointed out the dangers of hacking systems. Especially vulnerable are control centres, in which hundreds of vehicles would be brought under control at the same time, if these centres would get hacked.

Winner is sure that autonomous vehicles will soon be present on the streets and will change society and mobility. In any case he advises caution, because in the field of technology there are many things that are based on assumptions and beliefs, but not on knowledge. So, it is important to observe the technical innovations skeptically and to try to expect the unexpected with the basis of our little knowledge.

Martin Weinmann, Juni 2018