9 Self-Driving Cars: The Digitization of Mobility. The Technology Behind it and the Impact on our Society

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9.1 Abstract

This paper discusses the implementation of autonomous vehicles with the aim of providing an overview of this current topic and to present hurdles and forecasts from a technological and sociological point of view.
Keywords: self-driving cars, social impact

9.2 Introduction

The automotive industry continues to invest heavily in intelligent vehicle technology, from driver assistance systems to fully autonomous vehicles that no longer require human intervention. This trend towards the introduction of "robots on four wheels" is bringing newcomers from the IT industry into the scene and is making significant changes to the nature of mobility and many aspects of everyday life. It seems certain that autonomous vehicles will increase road safety and efficiency as they mature. At this stage, it also seems certain that the future of autonomous vehicles is imminent and that any remaining issues and concerns will not constitute insurmountable obstacles. It is therefore only a matter of time before the first market-ready self-propelled cars come onto the market.

9.3 Levels of Automation

The automation of vehicles can be divided into five levels ranging from driver assistance to full self-driving [1] (see Fig. 1).

Level 1. Most cars are already there today. Current driver assistance systems support the driver during the driving task and thus ensure greater safety and comfort. This includes the active cruise control with stop & go function, which regulates the distance to the vehicle in front independently, or the collision avoidance and passenger warning with city brake function, which is designed to prevent collisions by an automatic braking process.

Level 2. Semi-automated driving is already a reality in most high-end cars, with its driver assistance systems including steering, guidance and traffic jam assistants. The car can automatically brake and accelerate and, unlike Level 1, also semi-automatically take control of the vehicle. The remote-controlled parking function allows cars—for the first time—to park in driverless mode in narrow parking bays. As with Level 1, however, the driver is always responsible for driving and cannot turn attention away from traffic.

Level 3. Today we are approaching level 3. At that level, the driver gains more and more freedom from the driving task and is able to permanently turn away from the traffic under certain conditions and completely delegate the driving task to the vehicle. By means of highly automated systems, the vehicle can operate completely

independently over long distances and in certain traffic situations, e.g. highway driving. However, the driver must be ready to take control of the vehicle at any time.

Level 4. Level 4 is the precursor to autonomous driving, whereby the vehicle navigates most of its journey independently. Level 4 automated driving technology has evolved to the point where the self-driving car can handle even highly complex urban traffic situations, for example, mastering an unexpected construction site without the intervention of the driver. As with level 3, the driver must still be able to take over the driving task, if necessary, with the car signaling the driver to take control. If the driver ignores the car's warnings to take control, the system has the authority to transfer the car to a safe condition, such as stopping. However, it is conceivable that the driver could go to sleep temporarily.

Level 5. While level 4 still requires a driver, level 5 is autonomous driving, whereby the vehicle is completely driverless. In contrast to levels 3 and 4, driving or a driver is not required in completely autonomous driving - the steering wheel and pedals therefore become unnecessary. The vehicle takes over all driving functions. All persons in the car thus become passengers. One of the social benefits is that this will create new mobility options for people with disabilities. The complexity, or the requirement for technical solutions, is extremely high. Therefore, completely self-driving vehicles will initially only be traveling at relatively low speeds in city traffic.

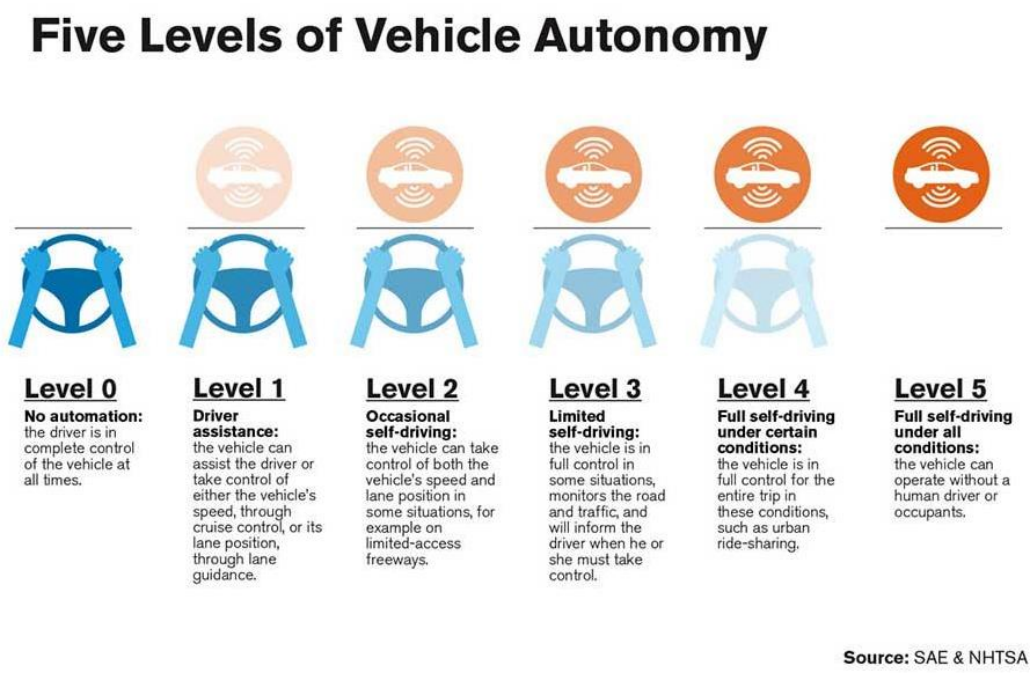

Figure 1: *Five levels of vehicle autonomy.*
Source: https://www.automotivelectronics.com/sae-levels-cars/

9.4 Technology and Sensors

Driverless cars are powered by technology [2] (see Fig. 2), which includes sensors and communication devices.

- Sensors:

  Lidar-based laser range finder
  Front camera for near vision
  Front and rear radar
  GPS navigation

Ultrasonic sensors
Altimeters, gyroscopes, and tachymeters inside the car

- Communication devices:
  Vehicle to roadside V2R
  Vehicle to infrastructure V2I
  Vehicle to vehicle V2V
  Vehicle to everything V2X

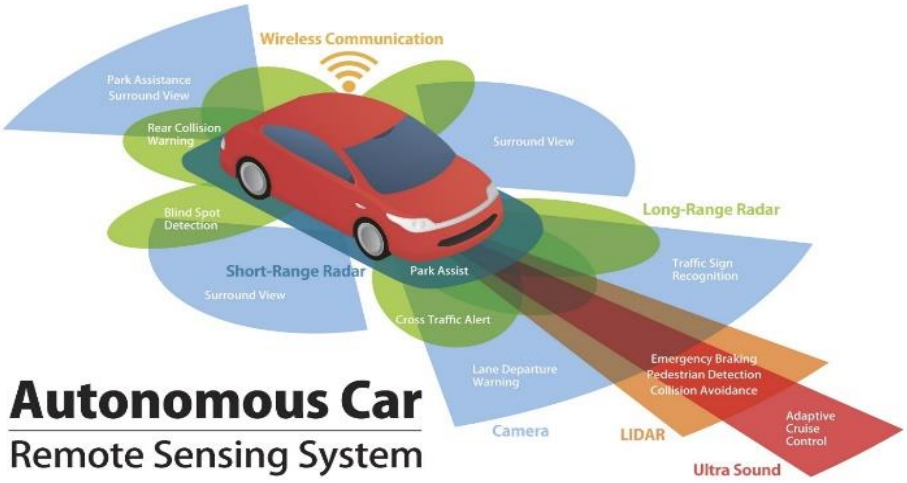

Figure 2: *Autonomous car remote sensing system. Source: https://innovation-destination.com*

9.5 Safety and Social Benefits of Self-Driving Cars

About 99.9% of all accidents are caused by humans. In EU 28 there were around 25,300 fatalities and 135,000 serious injuries in road accidents reported in 2017 [3]. An ambitious goal is aimed by “EU Vision Zero”, striving for zero fatalities by 2050, reducing fatalities and serious injuries by half by 2030 [4]. This can only be achieved by automated driving in addition to significantly increasing safety.

Important social benefits can be accomplished by improving access to transportation. Independence and quality of life for the entire population, particularly for those of advanced age, illness or disability.

Urban and rural areas require different considerations. Individual car ownership has a disproportionately high importance in the countryside. This must also be taken into account from the point of view of the ageing rural population. For many older people, “life” in the city is no longer affordable. Individual mobility has a high impact on the “older” generation. Also, the costs for traffic services like meals on wheels, caretaking and school buses are high.

At Seestadt Vienna, which is an urban development area of Vienna, self-driving buses (see Fig. 3) will go into service by 2019 [5]. Physical infrastructure of the test track includes the following features:

- 2.2 km (each direction)
- Maximum allowable speed is 30 km/h
- Passengers and one operator
- Adaptations: bus stop bays, GNSS reference station via 3G/4G and WLAN
- Digital infrastructure, digital map, prerecorded and manually edited
- Mobile data connection 3G/4G

Figure 3: *Self-driving bus at Seestadt Vienna. Source: https://www.mobillab.wien/autobus/. Johannes Liebermann, Wiener Linien*

9.6 Future Scenarios

We are approaching the end of the traditional automotive era. Travel will be in standardized modules. Fully autonomous modules with no capability for the driver to exercise command. Modules will be owned by mobility service providers like Uber [14] or Ly[15]ft. Human-driven vehicles will be legislated off the highways. Tipping point: when 20 to 30 % of vehicles are fully autonomous.

It will be figured out that human drivers are causing 99.9 % of accidents. This will result in questioning the existance of large vehicle fleets, the future of car manufacturers and car dealers. (*Source: Bob Lutz, former vice chairman and head of product development at General Motors. He also has held senior executive positions with Ford, Chrysler, BMW and Opel).*

9.7 Impact on Society

In addition to increasing security and social benefits, as with any new technology, there will be far-reaching social consequences. Fewer truckers means fewer motel stays, means fewer rest stops, means less services personnel. Conforming to traffic laws means less traffic policing, means fewer traffic tickets, means less revenue for municipalities. With 135,000 seriously injured by car accidents every year in the EU, a decline to almost zero will have a huge impact on the insurance and health care system. The full scale of these economic shifts will be impossible to realize until they are upon us, but the one thing we can know for sure is that they will influence almost every aspect of society.

9.8 Conclusion

From the first automobile in 1889 to about 1.2 billion worldwide in 2019, we have experienced 130 years of automotive history. But the next 10 years will change our life and our mobility like never before. (*Source: Helmut Klaus Schimany Bundesinitiative eMobility Austria).*

[14] https://www.uber.com/
[15] https://www.lyft.com/

9.9 References

[1] Chatterjee, V. (2018), Society of Automotive Engineers (SAE) Automation Levels for cars. A detailed explanation of all the defined levels. http://www.automotivelectronics.com/sae-levels-cars/

[2] Yaakub S. Hayyan, Alsiba M (2018), A Review on Autonomous Driving Systems. International Journal of Engineering Technology and Sciences (IJETS). http://journal.ump.edu.my/ijets/article/download/2800/451

[3] EU Press release (2017), Road Safety: Data show improvements in 2017 but renewed efforts are needed for further substantial progress. https://ec.europa.eu/commission/presscorner/detail/en/IP_18_2761

[4] EC (2019), EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero". https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/move-2019-01178-01-00-en-tra-00_3.pdf

[5] Wiener Linien (2018), Wiener Linien: Fahrerlose Busse in Seestadt unterwegs. https://www.vienna.at/wiener-linien-fahrerlose-busse-in-seestadt-unterwegs/5868598