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SELECTED SAFETY PROBLEMS OF AUTONOMOUS VEHICLES

Abstract

Autonomous cars are a fast-growing technology that was considered science fiction a few years ago. Particularly in such a dynamic context of changes, some ideas about this technology may be wrong, and concerns related to its development, impact on the environment and the nature of the innovation process are misleading. The article criticizes the view that autonomous vehicles must overcome hundreds of millions of kilometers so that they can be considered safe enough to allow them to move on public roads. The doubts discussed concern the highest, fifth stage of automation of autonomous vehicles.
Keywords: autonomous vehicle, mobility, automation

Introduction

An autonomous transport system can be defined as a system in which the driver of the means of transport – by plane, by train, by ship, by bus or by car – is replaced by a technologically advanced control system consisting of software, computers, sensors, communication devices etc., located in the vehicle itself, as well as in the infrastructure used by the vehicle, enabling safe and efficient movement of vehicles on particular routes[1]. Currently operating transport systems differ in the degree of automation. Automation of transport entails changes in many areas beyond the transport system, causing the development of physical and digital business environment, involvement and education of users, challenging many existing aspects of the functioning of modern societies, ranging from cultural behavior

[1] B. Grucza, *Wizje i scenariusze rozwoju autonomicznych systemów transportowych* [in:] *E-mobilność: wizje i scenariusze rozwoju*, eds. J. Gajewski, W. Paprocki, J. Pieriegud, Publication of the European Financial Congress, Sopot 2017, p. 63.

patterns of drivers and passengers to redefining the concept of ownership of vehicles. Among the existing branches of transport, a particularly dynamic development of these systems can be observed in relation to road transport, including in particular individual motorization. Autonomous cars are a fast-growing technology that was considered science fiction a few years ago. Particularly in such a dynamic context of changes, some ideas about this technology may be wrong, and concerns related to its development, impact on the environment and the nature of the innovation process are misleading. On the basis of literature research, an attempt was made to identify the key problems related to vehicle safety of the fifth level of automation and to verify some of the concerns raised related to their admission to traffic on public roads.

1. Degrees of vehicle automation

The Society of Automotive Engineers (SAE) distinguishes five levels of vehicle automation[2]. At levels 1 and 2, the vehicle is still man-driven and solutions such as adaptive cruise control, responsive braking and a parking assistant help him. At level 3, the car is on an "autopilot", but a person can take over if necessary. Level 4 requires the driver even less, allowing him to even take a nap, while at level 5, where the car is fully automated, the vehicle may not even be a driver's seat or controls.

An inspiring analysis of the most common misunderstandings regarding autonomous vehicles was made in the article by A. Hars[3] from the German technology company Inventivio, focusing on a fully automated driving method (L5).

2. Impact of the distance covered on the safety of autonomous vehicles

The issue of the safety of autonomous vehicles is often reduced to the simple use of statistics and leads to the conclusion that "fully autonomous vehicles must travel hundreds of thousands of kilometers and sometimes hundreds of millions of kilometers to demonstrate their reliability[4]". According to A. Hars[5], similar conclusions are in the long run unsustainable because the statistical argument is often based on false assumptions. The basic problem concerns the estimation of the accident rate, where the identified accidents involving autonomous cars are compared directly with accident rates involving drivers – people. The probability of failure, i.e. the estimate that the fatal accident will occur at a certain distance is very low, and the reverse the success rate, the probability that no death toll

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2 *Connected and Autonomous Vehicles – The UK Economic Opportunity*, KPMG and SMMT, March 2015, p. 5.

3 A. Hars, *Top misconceptions of autonomous cars and self-driving vehicles*, Thinking outside the box: Inventivio Innovation Briefs Issue 2016-09 (Version 1.3).

4 J.M. Anderson, N. Kalra, K.D. Stanley, P. Sorensen, C. Samaras, O.A. Oluwatola, *Autonomous Vehicle Technology. A Guide for Policymakers*, RAND Corporation, Santa Monica, Calif 2016.

5 A. Hars, *Top misconceptions…*, p. 6.

will occur at a certain distance is very high. When observing autonomous cars, you can get estimates of the probability of failure. The belief that such estimates reflect the real accident rate increases with the number of kilometers traveled by these vehicles. However, the change in the assumed level of confidence causes that the number of kilometers traveled allows to recognize that self-driving cars are as safe as vehicles with drivers ranges from several dozen million kilometers to even several billion kilometers driven.

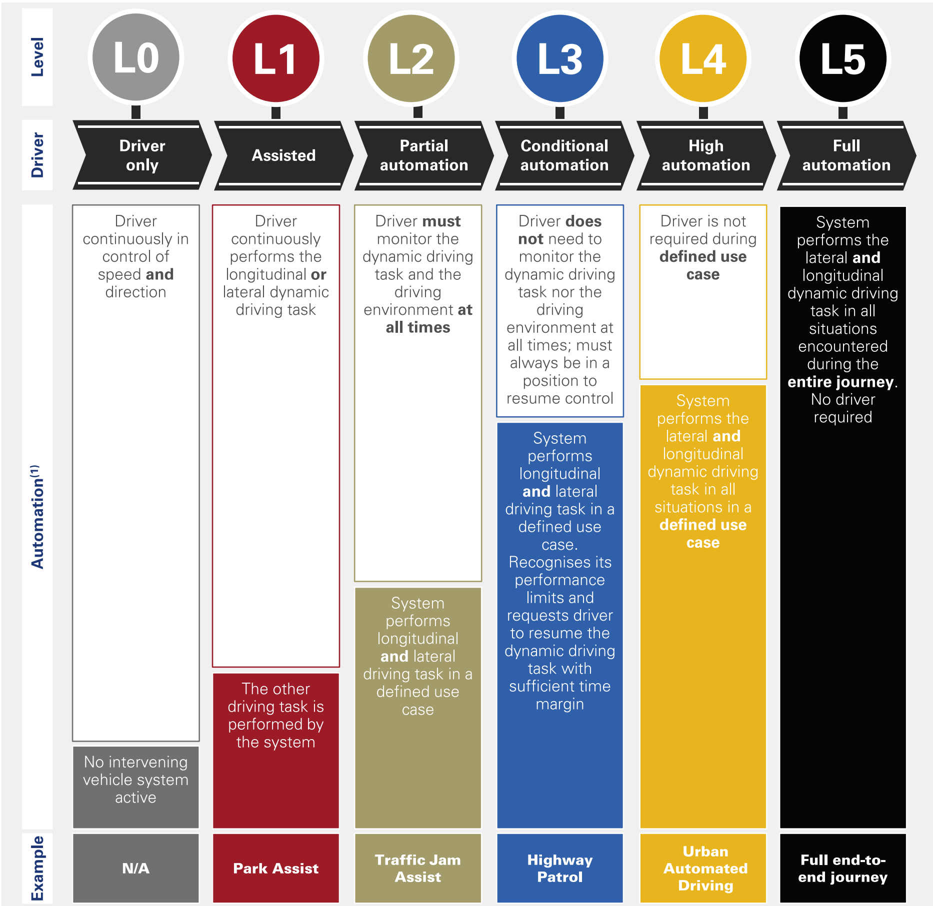

Figure 1. Degrees of vehicle automation
Source: *Connected and Autonomous Vehicles – The UK Economic Opportunity*, KPMG and SMMT, March 2015, p. 6

3. The rate of fatal accidents and the safety of autonomous vehicles

To obtain a safety index of autonomous vehicles, the number of fatalities is often divided by the number of miles traveled, which increases the death rate because a single accident can lead to many fatalities and the number of fatal accidents may depend on many factors other than driver reliability. The RAND report indicates that many accidents that do not involve fatalities are not recorded. The ratio of the actual number of accidents to the number reported is not clear. Some studies suggest that it may be as low as 2–4 to 1. If you take into account different types of accidents, and not only accidents with fatalities, then the number of kilometers that must be overcome by autonomous vehicles to be considered safe, falls significantly. The probability distributions of fatalities, accidents with injuries and other accidents are in fact correlated. A car that is much better at avoiding fatal accidents than a human driver is probably also better at avoiding other accidents.

4. Time of moving autonomous vehicles as an indicator of safety

The most effective way to obtain a large number of "test" kilometers in autonomous traffic is driving on closed test tracks under controlled conditions and moving on highways. Driving a car on the highway is generally safer than driving on many other types of roads. Since the average vehicle speed varies depending on the type of road, the total autonomous vehicle movement time may be a better basis for measuring the accident rate than the distance covered. The autonomous urban environment, with a large share of pedestrians and cyclists, may cause particular difficulties[6]. This can be more evident in the statistics of accidents than in the mortality reports, because the average speeds are lower. Time devoted to the movement of autonomous vehicles in urban conditions could be a more accurate indicator of their safety level than the number of kilometers driven[7].

5. Comparing the algorithms of autonomous vehicles to human behavior

The problem of measuring the safety of autonomous vehicles is often related to the adoption of an appropriate reference point and defining detailed ranges of constituent elements understood as safety to be monitored[8]. In the case of self-driving cars, there is no standard developed in this respect[9]. The reference of accident statistics of autonomous vehicles to data concerning people-drivers should not be used as a basis for assessing their safety. These cars, which never tire, do not drink, do not divert attention from the road[10] – they would have to commit other serious errors on a much larger scale than people to get similar levels of accident. Of course, this is unacceptable. Rather, the expectations and requirements

[6] *Driving to the future. The development of connected cars*, The Economist Intelligence Unit Limited 2016, p. 18.

[7] A. Hars, *Top misconceptions…*, p. 7.

[8] D.A. Brown, G. Cooper, I. Gilvarry, A. Rajan, A. Tatourian, R. Venugopalan, D. Wheeler, M. Zhao, *Automotive Security Best Practices*, Intel Security, Santa Clara 2016, p. 4.

[9] E. Heymann, J. Meister, *The digital car More revenue, more competition, more cooperation*, Deutsche Bank Research, 03.07.2017, p. 20.

[10] *Driving to the future. The development…*, p. 7.

regarding the level of safety that autonomous cars should present based on what is known about the problems and risks of driving vehicles in general and not only about the specificity of running them by people should rather be specified. The need to develop detailed risk models for driving vehicles that use accident statistics and determine the impact of road structure, load levels, weather, and many other factors affecting the driving risk that could be used to create reference data for the preservation of autonomous vehicles. These can be, for example, mileage divided by road type. According to A. Hars[11], it is possible to publish a complexity indicator that points the average complexity of the environment in which the vehicles moved or the overall distribution of the complexity of environments encountered during testing.

6. Increasing reliability of autonomous vehicles and its impact on safety

In contrast to the error rate of drivers of classic cars, the reliability of an autonomous vehicle cannot be considered constant. It improves over time, because due to the "cross-linking" of autonomous cars, a possible software error occurring in all copies of a given car model can, after being detected in one of them, be removed from all cars. The future mobile system will require the creation of an IT system to manage vehicle traffic and network. Such a system will help in the management and control of the movement of autonomous vehicles and fleets intended for the provision of shared mobile services[12], thus it will create completely different possibilities of caring for the safety of individual vehicles and their users. In contrast to the production of goods in which batches are tested to detect design and production problems, it is possible to remove the defect not only in products passing through the production process in the future, but also in batches that have already been released to the market. Developers will improve their algorithms to solve the problem in all cars on the road: the accident rate of a given car model will no longer be the same. The simple statistical model does not take into account the feedback loop, which tends to reduce the accident rate at each incident encountered. On the other hand, when an accident occurs, it may increase the estimated accident rate above the accepted level and determine that the car model is not suitable for public use. All cars can be immediately withdrawn and thus prevent further accidents. This is a completely different approach than in the case of other physical products, in which the detected defect after passing such products to the consumer may be difficult to remove. Since people driving cars also cause accidents, it is worth avoiding two cases: recognizing cars as safe and allowing them to move, although they are not yet safe enough and recognizing cars as dangerous and preventing them from moving despite being safe. In the first case, self-propelled vehicles will cause damage because people using them will use them. In the second case, the damage will be suffered because people who could use an autonomous

[11] A. Hars, *Top misconceptions…*, p. 8.

[12] S. Corwin, J. Vitale, E. Kelly, E. Cathles, *The future of mobility. W jaki sposób techniki transportowe i trendy społeczne tworzą nowe ekosystemy gospodarcze*, Deloitte University Press, 2015, p. 16.

vehicle run alone. This seems particularly important when we take into account the observed increase in the developed countries, the number of accidents caused by the deconcentration of drivers using smartphones while driving[13].

7. Luck and critical situations

Luck can play a huge role in human driving and have a significant impact on the perception of the safety of autonomous cars. The fact that the accident does not happen to the driver, may not have much to do with his high skills, but a lot with the relatively low frequency of difficult, unexpected situations on the road. From the perspective of autonomous vehicles, this means the need for more sophisticated driving risk models[14]. Accidents form the basis of official statistics, but accidents are only the tip of an iceberg, they are the result of critical situations in terms of security that have not been avoided. Driving behaviors combined with external factors such as poor road conditions, technical defects, obstacles etc. lead to critical situations for safety. Fortunately, most of these critical security situations do not lead to accidents. In more than 93% of accidents, driver behavior is the leading factor in mortality. But this also highlights the important difference between drivers and autonomous vehicles. Based on human behavior, we focus on accidents. Thanks to autonomous vehicles, attention is focused on critical situations for safety. Every small mistake of an autonomous car is cataloged and evaluated long before any accident. When the driver moves slightly off the road, no one is interested unless an accident occurs. However, when the self-propelled car improperly sticks to the traffic lane, it is rightly regarded as its significant drawback. The same happens when the autonomous car does not give way to other vehicles etc. Therefore, you should not use accident statistics to compare the reliability of drivers and autonomous vehicles, it is worth comparing the behavior of the driver and the impact on the frequency of inducing critical situations. It is easy to measure in a stand-alone car, but it requires more effort for the driver. Although no system is fully reliable, an autonomous vehicle can potentially provide unprecedented levels of transparency in the event of accidents[15]. Rather than relying on the testimony of the driver or eyewitnesses of the incident, the autonomous vehicle will have a wide range of data on conditions before, during and after the accident, which can be used for evidential purposes, but also for teaching other autonomous vehicles, identifying what went wrong and giving a chance to avoid similar situations in the future.

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[13] *Future of the vehicle*, BlackRock Investment Institute 2017, p. 5.

[14] A. Hars, *Top misconceptions…*, p. 9.

[15] *The Autonomous Vehicle Revolution: Fostering Innovation With Smart Regulation*, Center for the Study of the Presidency and Congress, Washington, March 2017, p. 4.

Conclusions

The view that autonomous cars must travel hundreds of millions of kilometers to be considered safe seems unjustified. It is misleading to focus only on death rates as a result of moving autonomous vehicles, while many other correlated reliability measures are available that are more adequate and easier to measure. It seems inappropriate to focus primarily on accidents – you should focus on avoiding situations critical to security. The human intuition associated with the driver's own abilities and behaviors can be misleading. Luck may be more important in the safety balance than it often seems. It is also worth realizing that the reliability of an autonomous car changes over time and that the potential of accidents and damage resulting from the functioning of autonomous vehicles after their introduction for public use may turn out to be much smaller than in the case of defects of other traditional products and devices. It is worth paying attention to two sides of the coin – it is necessary to avoid not only moving a vehicle that has been allowed to move on public roads too early, but because an alternative human ride is not safe at all, there is a real risk that autonomous cars will be too late admitted to public traffic, which will also lead to many road accidents that could be avoided.

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