Autonomous Cars: What problems need to be solved to get from assisted driving to fully autonomous driving?

Tobias Wen Klingenberg

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1 Introduction

Autonomous cars, or autonomous vehicles, are one of the most researched and impactful technologies of our current century [1]. It is one of the first steps of the vision of the future of individual transportation. While there currently already exist a large number of assistance systems in modern vehicles, such as Lane Keeping Assist (LKA), Adaptive Cruise Control (ACC), or Automatic Emergency Braking (AEB), the step to actual full autonomous car driving is still significant in terms of [2].

1.1 Motivation

The development of autonomous vehicles represents a significant milestone in modern, individual transportation, promising safer road infrastructure, reduced traffic congestion, and greater mobility for users. However, despite significant advances in assisted driving systems, the step to full autonomy remains one of the more complex challenges in engineering and artificial intelligence. This paper is motivated by the need to understand what obstacles still stand in the way of achieving truly autonomous cars and vehicles. By examining the technical, ethical, legal, and infrastructural barriers that must be overcome, this work aims to explain the multidimensional nature of the problem and highlight the interconnection between technology, regulation, and public trust. Understanding these challenges is essential not only for engineers and lawyers but also for society as a whole, as the decisions made today will shape the future of transportation and urban life.

2 Current State of Autonomous Cars

The Society of Automotive Engineers (SAE) classifies the level of driving autonomy into six classes, as shown in Figure 1. Starting with Level 0, cars in this classification resemble traditional manual cars, with little to no assistance when driving, including assistance in driving off. Assistance is typically provided in the form of warnings and momentary support.

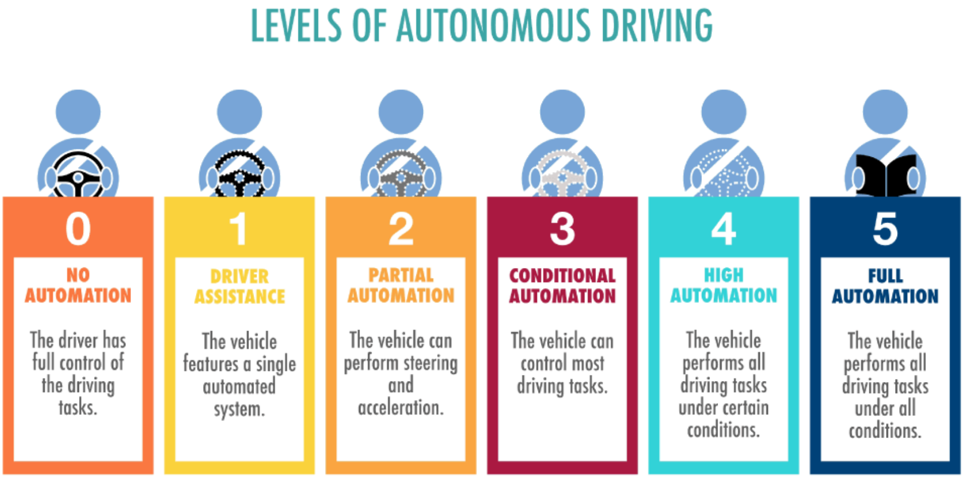

Figure 1: Levels of Autonomous Driving as considered by SAE[1]

Looking at Level 1, vehicles in this class have the possibility of support for steering, braking, and acceleration, including lane centering or adaptive cruise control (ACC). The last level, in which the human is in all cases still the driver, is level 2. At this level, the car can support steering, acceleration, and braking. Therefore, these cars often have both lane centering and ACC. From level 3 on, cars can be classified as being the primary driver, not the human. Level 3 can still require the driver to take over in specific scenarios. For level 3, for example, this would involve autonomously navigating through traffic jams, or in level 4, being a local driverless taxi for a specified region. In this level, the card would also not request assistance from a human. Reaching the last and yet unachieved level 5, it describes a car that can drive autonomously in all conditions and will never require human intervention.

2.1 Current Autonomous Driving Technologies

In this chapter, we will briefly discuss the driving technologies currently available on the market and explain how they work.

2.1.1 Adaptive Cruise Control (ACC)

Adaptive Cruise Control enables a vehicle to automatically adjust its speed to maintain a safe distance from vehicles ahead, utilizing front and rear radar and sensors to detect the distance to other cars. This is especially useful on long-distance highways, where cars often do not stop for themselves, and inadequate safety distance can lead to traffic accidents, as noted by [3].

2.1.2 Lane Keeping Assist (LKA)

Another technology that is useful in those highway, long-distance situations is the Lane Keeping Assist. Using sensors at the side and front of the vehicle, the autonomous system can detect patterns of other vehicles and road markings to determine if the vehicle is centered on the road. If not, the vehicle can autonomously relocate and steer to stay in the center [4].

2.1.3 Automatic Emergency Braking (AEB)

Using similar technologies, such as the ACC, but with a greater focus on the Ultrasonic Sensor, the Automatic Emergency Braking System enables the vehicle to detect imminent collisions and automatically brake to prevent a collision [5].

[1]https://ackodrive.com/car-guide/autonomous-cars-and-levels-of-autonomous-driving/

2.1.4 Blind Spot Detection (BSD)

The Blind Spot Detection is designed for the special Blind Spot commonly found in the structure of cars, which makes cars in the adjacent lane difficult to see for humans. Similar sensors from previous technologies allow cars to detect if a car is in the driver's blind spot and warn them using lights.

2.1.5 Traffic Sign Recognition (TSR)

Special cameras at the front of the vehicle, trained for object recognition, especially traffic sign recognition, serve the purpose of allowing the driver to see the current traffic signs if they have missed them. Furthermore, in coordination with more autonomous vehicles, traffic signs are essential for a fully autonomous vehicle to act independently, adjusting its speed and following traffic rules [6].

3 Problems in Current Technologies

In this chapter, we will discuss the actual challenges of creating and developing autonomous vehicles, as well as potential ethical considerations.

3.1 Technological Challenges

The following technical challenges are currently discussed when developing a fully autonomous system.

3.1.1 Reliable Perception in all Conditions

One of the significant problems is the use of current sensor systems, which struggle with diverse weather conditions and poor lighting, such as rain, fog, snow, and glare. To overcome this problem, we need to develop robust perception systems that can accurately detect and classify objects in every environment and lighting condition.

A special focus would be on developing more resilient camera and LiDAR systems, improving radar resolution, and implementing even more advanced sensor fusion algorithms [1].

3.1.2 Scene Understanding and Context Awareness

Another important factor is predicting behaviour. Current systems focus on recognizing the participants in road environments and how they move. More importantly, these systems must be able to understand intent and context, for example, predicting whether a pedestrian will cross a street or not.

To achieve development in this area, research needs to focus on deep learning models capable of intent prediction with the help of large and diverse datasets for training rare or unusual driving scenarios [7].

3.1.3 Scalability and Computational Efficiency

Lastly, we would like to examine the issue of software required to control autonomous systems. Regarding Abschnitt 3.1.2, we also need computational resources to enable perception and planning. Therefore, there is a need to optimize algorithms and hardware for real-time operation within the power and thermal limits of a vehicle. Advances in Edge AI accelerators, such as NVIDIA DRIVE or other efficient neural network architectures, are needed.

Alternatively, the use of AI Cloud could be possible, thereby reducing the need for on-site computational resources. However, this would come with new challenges, such as possible outages in data centers and broken connections in harsh environments.

3.2 Ethical Considerations

As we discuss autonomous, non-human decision-making, we also need to address the potential ethical considerations that accompany it.

One of those would be considering the scenario of an unavoidable accident, where an autonomous vehicle may need to decide how to minimize harm. How can the machine determine who to protect in these scenarios and establish moral priorities? As the ethical principles for human interaction scenarios are not yet fully established, applying them to machines is even more challenging.

Furthermore, the question of liability and responsibility comes into frame. When an autonomous vehicle is involved in an accident, it is unclear who should be held responsible. We need to develop a clear legal and ethical frameworks for responsibility that reflect both human and machine involvement.

It is also important to consider the impact on the job market and other humans. Entirely autonomous vehicles could disrupt industries such as trucking, taxi services, and delivery. We need to develop transition policies that support affected workers and encourage new forms of employment.

4 Conclusion

The journey from assisted driving to full autonomy represents one of the most complex technological transformations of this century. While assisted systems such as adaptive cruise control, lane keeping, and automated braking have already improved road safety and convenience, achieving full autonomy requires solving deeply interrelated technical, ethical, and societal challenges. Vehicles must be able to perceive their surroundings reliably in all conditions, make safe and context-aware decisions, and operate autonomously while ensuring security and accountability.

Bibliography

[1] R. Hussain und S. Zeadally, „Autonomous Cars: Research Results, Issues, and Future Challenges“, *IEEE Communications Surveys & Tutorials*, Bd. 21, Nr. 2, S. 1275–1313, 2019, doi: 10.1109/COMST.2018.2869360.

[2] F. Arena, G. Pau, und A. Severino, „An Overview on the Current Status and Future Perspectives of Smart Cars“, *Infrastructures*, Bd. 5, Nr. 7, 2020, doi: 10.3390/infrastructures5070053.

[3] L. Xiao und F. Gao, „A comprehensive review of the development of adaptive cruise control systems“, *Vehicle System Dynamics*, Bd. 48, Nr. 10, S. 1167–1192, 2010, doi: 10.1080/00423110903365910.

[4] S. Ishida und J. Gayko, „Development, evaluation and introduction of a lane keeping assistance system“, in *IEEE Intelligent Vehicles Symposium, 2004*, 2004, S. 943–944. doi: 10.1109/IVS.2004.1336512.

[5] E. Coelingh, A. Eidehall, und M. Bengtsson, „Collision Warning with Full Auto Brake and Pedestrian Detection - a practical example of Automatic Emergency Braking“, in *13th International IEEE Conference on Intelligent Transportation Systems*, 2010, S. 155–160. doi: 10.1109/ITSC.2010.5625077.

[6] M. Mathias, R. Timofte, R. Benenson, und L. Van Gool, „Traffic sign recognition — How far are we from the solution?“, in *The 2013 International Joint Conference on Neural Networks (IJCNN)*, 2013, S. 1–8. doi: 10.1109/IJCNN.2013.6707049.

[7] S. Li, L. Zhang, und X. Diao, „Deep-Learning-Based Human Intention Prediction Using RGB Images and Optical Flow“, *Journal of Intelligent and Robotic Systems*, Bd. 97, S. 95–107, 2020, doi: 10.1007/s10846-019-01049-3.