Chapter 28
Self-Driving Robotic Cars:
Cyber Security Developments

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ABSTRACT

Even the behavior of a single driver can have a dramatic impact on hundreds of cars, making it more difficult to manage traffic. While the attempts to analyze and correct the traffic patterns that lead to congestion began as early in the 1930s, it wasn't until recently that scientists developed simulation techniques and advanced algorithms to create more realistic visualizations of traffic flow. In experiments conducted by Alexandre Bayen and the Liao-Cho, which included several dozen cars in a small-scale closed circuit, a single autonomous vehicle could eliminate traffic jams by moderating the speed of every car on the road. In larger simulations, the research showed that once their number rises to 5-10% of all cars in the traffic, they can manage localized traffic even in complex environments, such as merging multiple lanes of traffic into two or navigating extremely busy sections.

INTRODUCTION

Challenges of fully-automated driving require vehicles that are able to recognize the limitations of their machine perception, as well as the functional limitations of their processing modules, since with fully-automated driving mode, a human is not expected to give any backup. To achieve this level of autonomy, the autonomous vehicle needs to perceive its surroundings, interpret them accurately, and be able to execute relevant decisions over and over again. This is achieved by individual processing modules that are both dependent on and upgrade each other (Figure 1).

The machine perception is achieved by various sensors, like cameras and radars which are part of the vehicle systems, but also by information from highly accurate digital maps. If a vehicle knows its position, it is able to self-localize while the environmental model displays the vehicle and other road

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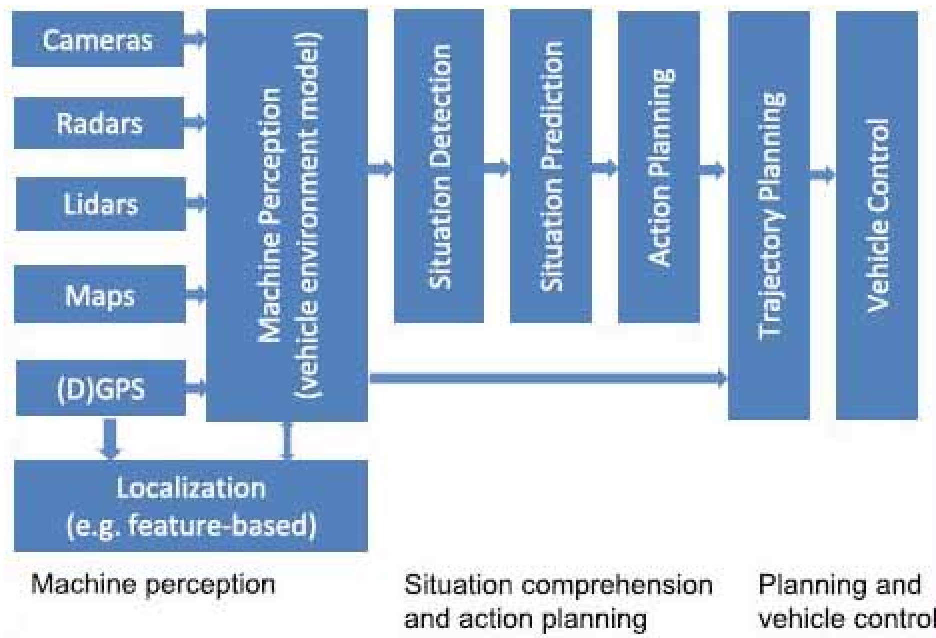
Figure 1. Structure of the information processing for automated vehicle driving



users as individual dynamic motion models. This representation also contains the elements of road infrastructure, such as traffic signs, traffic lights, curb stones, traffic islands, and road markings. Using this vehicle environmental model, all the individual elements are in relation to each other while the vehicle processors generate a machine interpretation of the scene. Different possible developments on the road are called episodes and are continually calculated in advance and evaluated on the basis of probability. For example, the module can execute driving around an obstacle or overtaking a slower vehicle, calculating the optimal trajectory, the time horizon of 3-5 seconds, and the passengers' safety and comfort (Rodic, Mester, & Xu, 2019).

However, if the machine perception fails, uncertainties in the situation evaluation might make it impossible for the vehicle to safely plan and execute actions. The question remains whether limitations in the machine perception operation can be detected or predicted, and if so, how early. The following section will discuss the technological possibilities and known methodical approaches that may provide the answer.

SCOPE AND CHARACTERISTICS OF THE MACHINE PERCEPTION

Machine perception uses cameras and radar/lidar technology. Cameras provide a 2D interpretation of a 3D scene as a high-resolution grayscale or colored images, from which processing modules can extract individual objects based on the contrast or differentiation in the texture. However, determining distance with cameras alone often leads to errors, based on the assumption that all objects are flat. Although stereo cameras can theoretically calculate the object distance, their accuracy decreases with the distance.