This chapter is focused on a detailed examination of the sense of touch (or haptics) as a promising technology for enhancing Driver Assistance Systems, starting with an overview of the state of the art and emerging Advanced Driver Assistance Systems. Other research prospects, such as context-aware services [312] or the utilization of the two sensory modalities smell and taste are left unaccounted in this work.

Driving a vehicle has changed relatively little since the first cars appeared on the road, but with rapid advances in In-Vehicle Information Systems and Advanced Driver Assistance Systems this task will now be transformed (see Fig. 9.2 for an overview ADAS available today). One of the major reasons for the introduction of these driver-support systems is to cope with the various vehicle handling risks, originating from the larger number of cars on the streets, the complex design and layout of roads, a stressful life style, etc. (see Fig. 9.1 for a rough classification of driver risks).

Thus, ADAS have been designed to lead to a safer and stress-free driving experience (Philips [313], Hella KG [314, p. 9], Nirschl [315], Goroncy [316]). Because most of the ADAS listed in Fig. 9.2 are state of the art or well-known, replicating information regarding their functionality is omitted here (a good starting point for detailed information would be Bishop et al. [9] or Heijden and Marchau [10]).

The expected potential of Advanced Driver Assistance Systems to improve vehicle-handling performance, relieve driving persons of distraction or reduce their workload, lower traffic hazards, reduce or even eliminate the errors of the driver and enhance driving efficiency [317, p. 247] increasingly attracts the attention of car manufacturers and important decision makers to integrate new devices, or refine existing systems. For example, using an in-vehicle navigation systems reduces the driver’s attention to the task of navigating and searching for alternative routes, or automatic cruise control maintain the car’s speed and decrease the driver’s load [318].
However, there are also potential problems to be expected. With an increasing complexity of in-vehicle tasks and display systems, information overload has become a growing problem for drivers. Angelos Amditis [319], manager of the EU-funded project “Adaptive Integrated Driver-Vehicle Interface” (AIDE) warns: “There is a real risk the driver will become overwhelmed as the number of in-car systems multiply. There are so many potential demands on driver attention from these new systems that they could prove distracting.” Such information overload has the potential to result in a high cognitive workload, which subsequently reduces situational awareness and lowers driving performance [147].

A second issue is the complexity of the dashboard (or “cockpit”), which increases the likelihood of errors by the driver (either through spontaneous failure or design errors) [317, p. 249]. Tango et al. [320] presented a design method for Driver-Vehicle Interfaces, starting with a user needs analysis in order to ensure clear recognition of user and system requirements.

9.1 Alternatives Supporting the Driver

There are a number of options in order to compensate for the problems of cognitive overload and driver distraction, originating in the number and complexity of ADAS. The most powerful one would fully employ drivers’ vital context, as presented in Fig. 9.3 (boldface sensor and/or actuator labels indicate technology utilized in the scope of this work). Of course this would necessitate a brand-new design of the vehicular controls and all interaction systems available today.

In a first step and as proposed within this research work, the sense of touch as an additional sensory modality would be used in the vehicle (integrated into the seat and backrest of the driver’s seat). Vibro-tactile voice coil elements are used to generate vibrations (output channel); force sensor array mats are responsible for the acquisition of static and dynamic sitting postures of the driving person (input channel). An in-depth investigation on vibro-tactile interfaces is given in the next section.