Chapter 15
Surround Sensing for Automotive Driver Assistance Systems

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ABSTRACT

In recent years, driver assistance systems have become a strong trend in automotive engineering. Such systems increase safety and comfort by supporting the driver in critical or stressful traffic situations. A great variety of surround sensors with different fields of view include radar, ultrasonic, laser, and vision systems. These sensors are based on different technologies and measurement principles. They all have their specific advantages and disadvantages and range from low-cost to high-end systems. They also differ in size, mounting position, maintenance, and weather compatibility. Hence, such sensors are used in various configurations to explore the surroundings ahead, sideways, and behind a vehicle. In addition, vehicle dynamics information from speed, steering angle, yaw rate, and acceleration sensors is available. Data fusion algorithms on raw data, feature, or object levels are used to collect all this information and set up vehicle surround models. An important issue in this context is the question of data accuracy and reliability. Situation interpretation of the traffic scene is based on these surround models. Any situation interpretation has to be performed in real-time, independent of the situation complexity. Typically, the prediction horizon is a couple of seconds. Depending on the results of the driving environment analysis critical situations can be identified. In consequence, the driver can be informed or warned. Some driver assistance systems already perform driving tasks like following, lane changing, or parking autonomously. The art of designing new, valuable driver assistance systems includes many factors and aspects and is still an engineering challenge in automotive research.

INTRODUCTION

In recent years driver assistance systems have moved into the focus of intensive research activities in the automotive sector. This contribution tries to give an overview on the many topics of sensors and surround models for automotive driver assistance systems. Safety and comfort systems shall disburden the driver from many driving tasks in both critical situations and routine jobs. Safety systems cover all aspects of save driving: They inform, warn, and intervene. Such systems all have in common, that they predict the traffic situation only for a very short period of at most a few seconds. Comfort systems disburden the driver and make driving less stressful. All assistance systems are based on information about the vehicle and the vehicle surroundings. A comprehensive presentation of many topics related to automotive assistance systems can be found in Winner (Winner 2009).

SURROUND SENSORS

Machine Perception

Surround sensors are among the key innovations that have made driver assistance systems possible at all. Most assistance systems need information not only about the vehicle itself but also about the vehicle environment. Surround sensors are no traditional automotive sensors. They have been developed intensively in the last two decades. Many different physical measurement principles including electromagnetic waves, ultrasonic waves, image perception, and laser have been considered and tested. The general key questions in the context of machine perception are:

- Where is something?
- Where is nothing?
- What is the dynamics of the something?
- What kind of thing is detected?

At first glance, these questions look quite general and simple. Especially the second question sounds superfluous. Emergency evading systems need reliable information of sufficient free evading space. This issue is addressed by the second question. Although much research on automotive surround sensors has been carried out giving answers to these questions completely and precisely still is an engineering challenge. Assistance systems requirements can be conflicting. Safety systems need reliable and stable data with little preprocessing whereas comfort systems prefer current data that is prepared in an appropriate way. Model assumptions on the dynamics of a detected object can be generated by classifying the object and by tracking the object over several system cycles. Objects in standstill cannot achieve high velocity in the following time cycle.

Radar Sensors

A radar sensor emits electromagnetic waves via an antenna. Such waves are reflected by an object and are received again by the sensor. Radar echoes are created by electrically conductive material. Most vehicles today are at least partly built of such conductive material. The time delay Δt between sending and receiving directly yields to (twice) the distance d:

$$d = \frac{c\,\Delta t}{2},$$

where c denotes the speed of light. One big advantage of radar sensors is the ability to directly measure distance as well as velocity. Distance can be computed by the time delay between sending and receiving. Based on the Doppler effect velocity measurements result from a frequency shift:

$$v_{rel} = -\frac{c}{2}\frac{f_D}{f_C}$$

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