Chapter XI
The Localisation Problem in Cooperative Vehicle Applications

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ABSTRACT

The next paradigm towards enhancing vehicle safety and road transportation represent cooperative systems. Advances in computer and communications technologies are facilitating the establishment of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications links. This enables the sharing and aggregation of information which results in an extension of the driver awareness horizon in an electronic manner. In this chapter, V2V and V2I applications are considered as a spatio-temporal problem. The tenet is that sharing information can be made only if this is time stamped and related to a spatial description of the information sources. The chapter formulates the spatio-temporal problem having as constraint the precision of the pose estimates of the vehicles involved. It regards the localisation problem and accuracy of digital road maps as a combined issue that needs to be addressed for the successful deployment of cooperative vehicle applications. Two case studies, intersection safely and an overtaking manoeuvre are included. Recommendations on the precision limits of the vehicle pose estimations and the potential uncertainties that need to be considered when designing V2V and V2I applications complete the chapter.

INTRODUCTION

Over the years motor vehicles have provided a rapid means of transportation, they are today part of our daily lives. These have evolved from simple thermo mechanical devices to complex mechatronics systems where networks of microcomputers plus a plethora of proprioceptive and exteroceptive sensors control multiple functions. The dependency on motor transport has resulted in...
traffic congestions, pollution and an unacceptable level of accidents (Broughton & Walter, 2007). Whilst in countries with advanced economies, the number of accidents has decreased, in countries with emerging economies accident tendencies are on the increase, in most cases with disastrous consequences.

Since the late seventies, the number of safety features in all types of vehicles has increased. These are known as passive safety systems like seat belts, deformable chassis, etc. At the same time legislation has hardened and road infrastructure has improved. Currently the number of accidents and road fatalities has decreased particularly in Europe, Japan and the USA; however over the past years a plateau is being reached and further reductions are difficult. At the same time congestion and pollution continues to increase whilst society is becoming more concerned on the costs of pollution to global warming and health under an uncontrollable raise in fuel costs. In the past years, the trend has been to develop active safety systems as part of advanced driving assistance systems (ADAS) like the use of video cameras for obstacle detection, Radar or Ladars (Laser detection and ranging sensors) for vehicle following, etc. In other words, through the use of exteroceptive and proprioceptive sensors, it is feasible to estimate the vehicle ego-state and perceive its immediate surrounding environment. The combination of the captured data results in digital models that represent the vehicle immediate surrounding environment and is enabling the development of advanced safety systems as it is possible to inform and warn drivers of potential risks or even act on the subject vehicle in the case of pre-crash braking systems (Laugier C., Vasquez D., Yguel M., Fraichard Th. & Aycard O., 2008, Wang H., Xu Jian, Ibañez-Guzmán, J, Jarvis, R., Goh, T. & Chang C.W., 2000). Whilst this represents a major progress and should yield to better safety, there are two major constraints: Sensors: these have limited capabilities and only a combination of several of them could warrant limited safety; Cost: prices are high and only a limited number of vehicles would be equipped with full safety features. Further, vehicle onboard sensors due to their physics and the limits in their layout on the vehicles, means that the perception horizons are limited which reduces the effectiveness of several active safety applications.

Advances in computer and communications technologies are facilitating the establishment of vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) wireless communications links (Cook J.A., Kolmanovsky I.V., McNamara D., & Prasad K.V., 2007, Srini V.P., 2006). This enables the sharing and aggregation of information and hence to extend the driver awareness horizon. Within this context, it is feasible to share information between vehicles and infrastructure, to combine this information and allow for a better machine and driver understanding of its situation and thus to extend electronically the driving horizon (Cook J.A., Kolmanovsky I.V., McNamara D., & Prasad K.V., 2007, Srini V.P., 2006). A typical example could be cooperative adaptive cruise control (CACC), an extension of ACC, where in addition to measuring the distance to the leader, a vehicle can exchange information with the leader by wireless communications to improve performance (Arem B.van., Driel C. van., and Visser R., 2006). At present multiple worldwide efforts exist in this domain like the SKY project on intersection safety by NISSAN Corp., which is already in its field operational test phase involving hundreds of passenger cars. In Europe there are two major large scale demonstrators’ projects under the 6th research framework of the European Community, namely the co-operative vehicle infrastructure systems (CVIS) and the Cooperative vehicles and road infrastructure for road safety (SAFESPOT) projects, (CVIS Project Partners, 2008 & SAFESPOT Project Partners, 2008).

V2V and V2I applications result from the sharing of information between the various entities involved. The purpose is to extend the driver awareness horizon by associating the information
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