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Editorial

Road Vehicles Surroundings Supervision: Onboard Sensors and Communications

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Abstract: This Special Issue covers some of the most relevant topics related to road vehicle surroundings supervision, providing an overview of technologies and algorithms that are currently under research and deployment. This supervision is essential for the new applications in current vehicles oriented to connected and autonomous driving. The first part deals with specific technologies or solutions, including onboard sensors, communications, driver supervision, and traffic analysis, and the second one presents applications or architectures for autonomous vehicles (or parts of them).

Keywords: vehicle surroundings supervision; vehicle surroundings reconstruction vehicle positioning; autonomous driving; connected vehicles; sensors; communications

1. Introduction

New assistance systems, cooperative services and autonomous driving of road vehicles imply an accurate knowledge of vehicle surroundings. This knowledge can come from different sources, such as onboard sensors, sensors in the infrastructure, and communications.

Among onboard sensors, short- and long-range sensors can be distinguished. In the first case, ultrasonic, infrared, and capacitive sensors can be cited. Among the second group, laser scanners and computer vision technologies appear to provide the best performance, although there are many others that can complement the information using data fusion processes. In any case, the goal is to have a representation of vehicle surroundings that is as complete as possible. Sensor fusion algorithms are a common solution to overcome the sensors' individual limitations.

Vehicle positioning is also essential. For this purpose, satellite positioning is commonly used, but when it is not sufficiently reliable or the signal is lost, the same technologies as those used for the recognition of the surroundings can provide an acceptable solution. In this regard, the SLAM (Simultaneous Localization and Mapping) problem should be noted, which tries to build or update the map of an environment that is not known a priori, and position the vehicle on that map simultaneously. This technique, widely used and proven in robotics, has also been implemented in the vehicular field for the perception of the environment in real time, for support and accuracy improvements in autonomous global navigation satellite systems (GNSS) navigation, and for generation of digital maps or calculation of trajectories followed when no GPS (Global Positioning System) signal is received.

Vehicle-to-vehicle (V2V) communications and vehicle-to-infrastructure (V2I) communications allow the vehicle to have greater knowledge of surroundings and to obtain information that is far away from the onboard sensors. These communications provide additional data that could be used for driver information purposes or for decision modules in autonomous driving, for example. In this sense, connected and cooperative driving appears as a catalyst of autonomous driving, because it enables real deployment under complex driving situations.

2. The Present Issue

This Special Issue consists of 11 papers covering some of the most relevant topics related to road vehicle surroundings supervision, providing an overview of technologies and algorithms that are currently under research and deployment.

These papers could be divided in two main groups. The first deals with specific technologies or solutions [1–7] and the second presents applications or architectures for complete autonomous vehicles (or parts of them) [8–11]. Furthermore, the first group presents a quite wide vision of research fields that could be involved such as onboard sensors [1–3], communications [4], driver supervision [5], and traffic analysis [6,7].

Onboard perception systems provide knowledge of the surroundings of the vehicle, and some algorithms have been proposed to detect road boundaries and lane lines. This information could be used to locate the vehicle in the lane. However, most proposed algorithms are quite partial and do not take advantage of a complete knowledge of the road section. An integrated approach to the two tasks is proposed in [1] that provides a higher level of robustness of results for road boundary detection and lane line detection. Furthermore, the algorithm is not restricted to certain scenarios such as the detection of curbs; it could be also used in off-road tracks.

The next paper [2] also considers that global navigation satellite systems (GNSS), to achieve the necessary performance, must be combined with other technologies into a common onboard sensor set that allows the cost to be kept low and which features the GNSS unit, odometry, and inertial sensors. However, odometers do not behave properly when friction conditions make the tires slide. The authors introduce a hybridization approach that takes into consideration the sliding situations by means of a multiple model particle filter (MMPF). Tests with real datasets show the goodness of the proposal.

Considering that monitoring systems for intelligent vehicles that employ remote sensors, such as cameras and radar, require the tracking of moving objects, adaptive tracking techniques are commonly used for this purpose. To this end, a gain design strategy to compose an optimal α-β-η-θ filter is proposed [3].

Vehicular communications, both between separate vehicles and between vehicles and infrastructure can be seen as an extension of the knowledge a vehicle can obtain from the surroundings. VANETs (Vehicular Ad-hoc Networks) are an emerging offshoot of MANETs (Mobile Ad-hoc Networks) with highly mobile nodes. They are envisioned to play a vital role in providing safety communications and commercial applications to the on-road public. Establishing an optimal route for vehicles to send packets to their respective destinations in VANETs is challenging because of the quick speed of vehicles, dynamic nature of the network, and intermittent connectivity among nodes. A novel position-based routing technique called Dynamic Multiple Junction Selection based Routing (DMJSR) is proposed for the city environment [4].

Even in intelligent vehicles and sometimes for the design of assistance systems, driver's intention classification and identification is identified as the key technology. To study driver's steering intention under different typical operating conditions, five driving school coaches of different ages and genders were selected as the test drivers for a real vehicle test [5].

Furthermore, the knowledge of traffic flow and its modelling is relevant information that could be taken into account for decision-making in many intelligent systems. A localized space–time autoregressive (LSTAR) model is proposed and a new parameter estimation method is formulated based on the Localized Space–Time ARIMA -autoregressive integrated moving average- (LSTARIMA) model to reduce computational complexity for real-time traffic prediction purposes [6]. A roundabout traffic model based on cellular automata for computer simulation that takes into account various sizes of roundabouts, as well as various types and maximum speeds of vehicles, is presented [7].

The four remaining papers that are included deal with autonomous vehicles. An adaptive global fast sliding mode control (AGFSMC) for Steer-by-wire system vehicles with unknown steering parameters is proposed [8]. Due to the robust nature of the proposed scheme, it can not only handle the tire–road variation, but also intelligently adapts to the different driving conditions and ensures that the tracking error and the sliding surface converge asymptotically to zero in a finite time.

A Driving Decision-making Mechanism (DDM) is formulated [9] in order to take into account the road conditions and their coupled effects on driving decisions. The results demonstrate the significant improvement in the performance of DDM with added road conditions. They also show that road conditions have the greatest influence on driving decisions at low traffic density. Among them, the most influential is road visibility, followed by adhesion coefficient, road curvature, and road slope; at high traffic density, they have almost no influence on driving decisions.

Finally, two papers include autonomous vehicle architectures. An open and modular architecture is proposed [10], capable of easily integrating a wide variety of sensors and actuators which can be used for testing algorithms and control strategies and including a reliable and complete navigation application for a commercial vehicle.

The last experimental platform [11] consists of a platform for research on the automatic control of an articulated bus, and the paper also focuses on the development of a human–machine interface to ease progress in control system evaluation.

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