Special Issue on Perception and Navigation for Autonomous Vehicles

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This special issue of *IEEE Robotics and Automation Magazine (RAM)* has been prepared in the scope of the activities of the Technical Committee on Autonomous Ground Vehicle and Intelligent Transportation Systems (AGV-ITS) (http://www.ieee-ras.org/autonomous-ground-vehicles-and-intelligent-transportation-systems) of the IEEE Robotics and Automation Society (RAS).

The purpose of this special issue is to address topics related to the challenging problems of autonomous navigation and driving assistance in open and dynamic environments. Technologies related to application fields, such as unmanned outdoor vehicles or intelligent road vehicles, are considered from both the theoretical and technological points of view. Several research questions located on the cutting edge of the state of the art are addressed. Among the many application areas that robotics addresses, individual mobility and mass transportation seem to be the domains that will most dramatically benefit from intelligent automation. Autonomous driving is emerging as the solution for dramatically improving efficiency while, at the same time, leading to the ultimate goal of zero fatalities. Clearly, robotics technologies are at the very core of this major shift in the automobile paradigm (Figure 1).

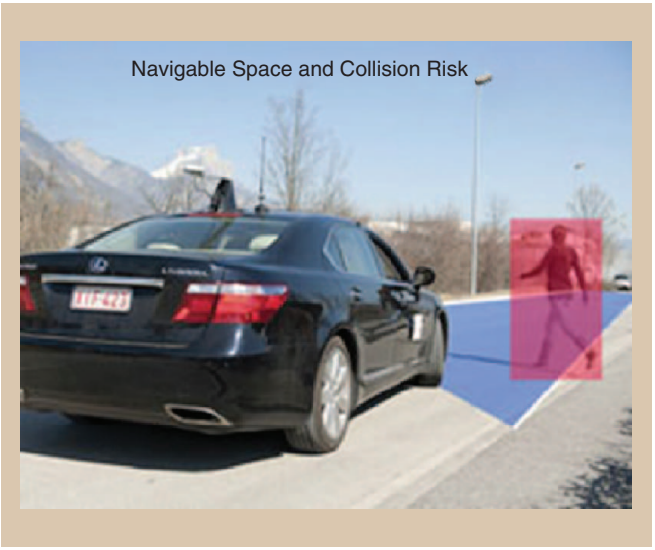

Figure 1. The problems of autonomous navigation and collision risk.

Most of the 15 articles that have been submitted for this *RAM* special issue are from speakers or active participants of the series of workshops organized by the IEEE RAS Technical Committee on AGV-ITS on the hot topic of "Planning, Perception, and Navigation for Intelligent Vehicles." Among these submitted articles, only five have been accepted for publication in this special issue after a two-round review process.

The first edition of this series of workshops, the 2007 Workshop on Planning, Perception, and Navigation for Intelligent Vehicles (PPNIV'07), was held in Rome, Italy, during the 2007 IEEE International Conference on Robotics and Automation (ICRA) and had around 60 attendees. The second, PPNIV'08, was in Nice, France, during the IEEE/RSJ 2008 International Conference on Intelligent Robots and Systems (IROS'08) and had more than 90 registered attendees. The third, PPNIV'09, was in St. Louis, Missouri, during IROS '09 and had around 70 attendees. The fourth edition, PPNIV'12, was in Vilamoura, Portugal, during IROS'12 and had more than 95 attendees. The fifth edition, PPNIV'13, was in Tokyo during IROS'13 (more than 135 attendees) where two best papers were awarded. In parallel, several workshops closer to some other robotics issues have been organized such as SNODE'07 in San Diego, California, during IROS'07 (around 80 attendees), SNODE'09 in Kobe during ICRA'09 (around 70 attendees), and RITS'10 in Anchorage, Alaska, during ICRA'10 (around 35 attendees), and PNAVHE'11 in San Francisco during IROS'11 (around 50 attendees).

The subject of this special issue has been motivated by both the unprecedented technical advances obtained in the field of intelligent vehicles over the last decade and the currently favorable socioeconomic context. After the success of the DARPA Urban Challenge in 2007, the Google Car Project has shown the potential feasibility of the driverless

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car concept in real traffic conditions; it has also pushed some state governmental authorities in the United States to modify the legislation to make it possible to experiment with such vehicles on normal roads. Several other challenges in the world, such as the Grand Cooperative Driving Challenge (GCDC) in 2011 and the VisLab Intercontinental Autonomous Challenge (VIAC) in 2010, have also contributed to the dissemination of the autonomous driving concept and its experimental validation in realistic traffic conditions. For instance, the four driverless vehicles of the VIAC covered almost 16,000 km from Parma, Italy, to Shanghai, China, on various roads by moving autonomously in a platoon during a three-month race (http://viac.vislab.it/).

Because of the recent technical advances and mediatized events, the automotive industry is more and more interested in these new technologies, and several commercial announcements have recently been made (e.g., by Nissan, Toyota, and Tesla). Also, several governments in the world (including Japan, Korea, the United States, and France) are now pushing for the industrial development of such technologies.

However, social acceptance and legislation still remain as barriers to the deployment of such a new technology, even if several thousands of kilometers in autonomous driving mode have been already been demonstrated all over the world.

This special issue includes five articles addressing five complementary topics in the field of multivehicle control, dynamic environment perception, vision under bad weather conditions, global navigation satellite systems (GNSS)-based localization, and motion planning, respectively.

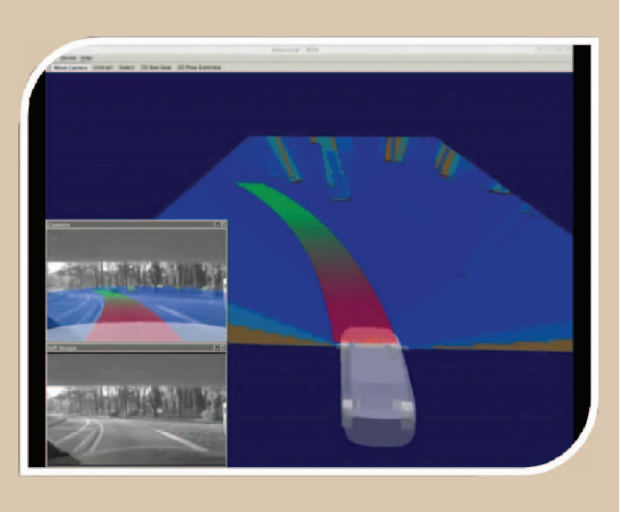

Figure 2. A method of obstacle detection to avoid collision.

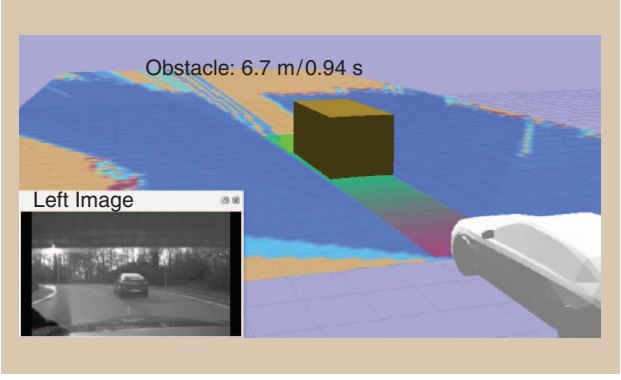

Figure 3. A method of lane detection and risk avoidance.

The first article, "Adaptable Robot Formation Control," deals with the modeling and control of a fleet of mobile robots operating in formation using adaptive and predictive control to account for the influence of several phenomena, including dynamic perturbations and bad grip conditions.

The second article, "A Robust Motion Detection Technique for Dynamic Environment Monitoring" reports the recent advances in the Bayesian occupancy filter paradigm, which provides a framework for robust grid-based monitoring of dynamic environments. This approach allows the perception system to estimate dynamic grids containing probabilistic information of both occupancy and velocity. The article shows that many false detections can be avoided by first classifying the grid cells as probabilistically static or probabilistically dynamic. The clustering step then provides, in a more robust way, the detected moving objects of the observed scene (Figure 2).

The third article, "Detecting Unfocused Raindrops," shows one example of solving important issues when visual perception is impaired during rainy conditions. Obviously, this article may extend the working conditions of conventional advanced driver assistance systems (Figure 3).

The fourth article, "GNSS Autonomous Localization," focuses on GNSS autonomous localization. It is well known that such systems do not work well when used in inner cities. The main problem is to be able to analyze online the reliability of the system by using the knowledge of three-dimensional maps when receiving the satellite signals.

The final article, "Model-Predictive Motion Planning," proposes recent advances in motion planning using model-predictive motion planning techniques.