Robotics and Autonomous Systems 144 (2021) 103832

Contents lists available at ScienceDirect

Robotics and Autonomous Systems

journal homepage: www.elsevier.com/locate/robot

Editorial

Editorial: Special issue on Autonomous Driving and Driver Assistance Systems — Some main trends

1. Introduction

This special issue covers several topics associated to the main point of Autonomous Driving and Driving Assistance Systems, and most papers span a wide range of concerns. Therefore, there is not a single set of categories where papers can be associated to. So, in order to simplify the overview, a simple clustering was done. Clearly, perception is the most common theme. A relevant focus is also the learning based techniques, especially the Deep Learning front, which serves mainly as a tool for several fields of the entire robotics research domain, sometimes to solve new problems and some other times to tackle classical issues of perception and navigation that still remain challenging. A third large scope of the papers cover topics like planning and control up to full systems management; that covers higher levels of software organization and the integration of complete or very large systems covering many fronts from perception, to data fusion and process and task management at the level of the Intelligent Transportation Systems (ITS) realm.

So, the 13 papers of this special issue are divided primarily into these three groups:

1. Perception [1] [2] [3] [4] [5]
2. Deep Learning [6] [7] [8] [9]
3. Planing, control and management [10] [11] [12] [13]

As mentioned, this categorization is not very strict since topics overlap and in some cases more than one of these topics is covered in the paper. The intended idea is mainly to mark some major trends observed in the Autonomous Driving community.

2. Trends in this special issue

Next sections provide a further insight of each paper within its major category but where their remainder components are also addressed.

Perception

In this section, there is one paper that focuses on the classical problem of Simultaneous Localization and Mapping (SLAM) [3]. Other papers include the detection or tracking of vehicles, obstacles or the road [2,4] [1]. Perception is carried out using several different sensors, from RGB sensors [3,4] to LiDAR [1] and RaDAR [2]. The fusion of information from these sensors requires accurate estimations of the geometric transformations between them. This problem of the calibration of the sensors in intelligent vehicles is addressed in [5].

Rato and Santos propose a new methodology for the detection of road curbs based on the density of the accumulated point cloud generated by the motion of the vehicle equipped with a 4-Layer LiDAR. Results from the algorithm are compared with data annotated on top of satellite images, which show that the detection is accurate [1]. Khalkhali et al. [4] propose a method that combines Situation Assessment (SA) information extracted from surveillance cameras in a driving environment with Kalman Filter (KF) equations. The resulting modified model is able to track objects in different situation scenarios based on SA information and state estimation from KF. Results in video sequences from different datasets show an average 25 percent performance improvement in vehicle tracking [4]. Zhao et al. [3] address the problem of SLAM from a perspective of enhancing the robustness of the method to challenging situations such as large-baseline motion, textureless environments, and great illumination changes. Several improvements are proposed across the pipeline, including the usage of more robust visual features, online photometric calibration, and a multi-scale analysis. Results indicate that the system improves both the accuracy and robustness of localization. Bersani et al. [2] present an integrated algorithm for the estimation of ego-vehicle and obstacles' positioning and motion along a given road, modeled in curvilinear coordinates. Data from RaDARs and a LiDAR is fused in order to identify and track obstacles. The algorithm is tested and validated in a prototype intelligent vehicle. Oliveira et al. [5] propose a novel framework for the calibration of multi-sensor and multi-modal intelligent vehicle platforms. The proposed methodology is general and can be used for any intelligent vehicle. Results include a case study where the calibration of the four sensors of and intelligent vehicle is carried out.

Deep learning

The usage of machine learning based solutions is growing in most of computer vision applications, in the current special issue four papers are deep learning-based approaches, which represent about the 30% of publications. Two of these papers are focused on road and objects detection through deep learning models while the remaining papers are focused on the driving topic as detailed next.

Regarding the publications focused on road and objects detection both of them target the lane detection problem under different schemes. Almeida et al. [8] propose a new representation

https://doi.org/10.1016/j.robot.2021.103832

based on the usage of two simultaneous deep learning techniques for road and lane detection in the context of mixed scenarios (i.e., structured, unstructured, lane based, curb based limits, etc.). The proposed approach has been evaluated in five different road scenarios (e.g., roundabout entrance, highway scenario, road occlusion, etc.) achieving a better overall performance than each algorithm individually applied. The proposed approach allows to change the number of simultaneous algorithms used in the detection, each of the used algorithms can be updated or replaced by another with more confidence. In contrast to the approach presented above, Lo Bianco et al. [7] propose a single architecture for detecting both road lane and road participants (e.g., pedestrian, vehicles). The proposed multi-task approach takes advantage of detected features to reduce computational requirements, hence a real time performance is reached even in configurations with limited hardware. The proposed approach is validated through a newly generated public dataset that contains about 20K images of different real scenarios. Obtained results show both the validity of the proposed multi-task model for road applications as well as the good overall performance in a real-time computation, which make it suitable for on-board operations.

On the other hand, the publications tackling the driving action propose deep learning based approaches for driver identification [6] and a decision-making strategy for autonomous driving [9]. In Abdennour et al. [6] the authors propose to identify driver by means of a lighweight deep learning model that is trained with just the CAN-Bus vehicle data. The proposed method requires less than two hours of training to achieve an accuracy higher than the 99%. The driving problem is also tackled in Likmeta et al. [9], but in this case for autonomous vehicles by proposing a high-level decision-making system. The authors propose a combination of traditional rule-based strategies together with a reinforcement learning (RL) model. The usage of hand-crafted rule-based controllers allows to always determine why a given decision was made; on the other hand the RL architecture enable to deal with complex scenarios, which are usually difficult to interpret. The best features of each approach are combined by designing parametric rule-based controllers, where rules can be provided by domain experts and their parameters are learned via RL. The manuscript presents an extensive numerical simulation in both highways and urban scenarios showing the validity of proposed approach.

Planing, control and management

There are two papers concerning issues related to parking systems: [10][13], one for abnormality detection based on Self-awareness [11], and the last one shows how to use a cognitive multi-layer map to develop collaborative human–machine systems [12].

Lucet et al. [10] present an autonomous bus navigation and parking system in a bus depot. Several peculiarities make this case harder than cars: the environment is a confined area, dimensions and weight higher and the need of a better accuracy. The authors use a predictive controller, based on its model linearized around the changing path curvature value, to perform accurate curved paths tracking. The controller has been implemented in an industrial vehicle and tested under realistic conditions. Quin et al. [13] present an Automated Valet Parking system. The methodology is based on the directional graph search and it is divided into three parts: global path planning, path coordination strategy and parking path planning. The global path planning uses a directional Hybrid A* algorithm. The path coordination strategy gives a transitional path to connect the end node of the global path to the parking planning start node. The parking path planning generates a parking path to guide the vehicle using a modified C-type vertical parking path planning algorithm. The system is validated using simulations on Matlab and PreScan. Kanaram et al. [11] use self-awareness for the detection of abnormalities instead of a manually programmed set of nested conditions checking for their presence. Multi-sensory time-series data are used to develop Dynamic Bayesian Network models used for state prediction and the detection of abnormalities. Real experiments of autonomous vehicles performing various tasks under real conditions are used to develop and test the algorithm. Fernandez et al. [12] introduce a cognitive layer called Associated Reality to enhance the information, knowledge and communication processes needed for Advanced Driver Assistance Systems (ADAS) and Automated and Autonomous Vehicles. The proposed architecture includes an augmented Local Dynamic Map and an augmented Graph Database. They show its use for vehicle localization and mapping in road tunnels.

3. Conclusions

For some time now, it is clear that the Autonomous Driving challenges and the Driver Assistance Systems share similar tools to a common purpose, which is essentially to ensure the safety of drivers, passengers and all agents in the road.

Perception continues to be the most common topic, which is clear from the proportion of papers in this special issue which are devoted to this topic. Multi-modality seems to be a trend too, and issues of calibration in multi-sensorial and multi-modality setups are also found as relevant concerns by authors.

After perception, authors address the problem of modeling and controlling vehicles and related systems, both on board or on the road. The classical approaches, especially in planning and controlling are still exploited and improved by authors, but it is undeniable that learning techniques, mainly Deep Learning, seem to have established as critical tools, mainly in perception for classification, with very good results in semantic segmentation of images, which used to be a huge challenge some years ago.

As a final corollary, and to bring the challenge to higher levels, we also find works, usually based on large projects, that combine many of the tools described an others to propose entire setups and demonstrators, ready to merge in full featured Intelligent Transportation Systems.

We have not yet observed abundant full end-to-end systems, but there is a feeling that the path is being left open to that, perhaps to be covered in future versions of these special issues in ADDAS.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work has been supported by: the Spanish Government under Project TIN2017-89723-P, the "CERCA Programme/ Generalitat de Catalunya", the ESPOL projects CIDIS-205-2020 and FIEC-16-2018, FCT — Foundation for Science and Technology, in the context of project UID/CEC/00127/2020. The authors gratefully acknowledge the support of the CYTED Network: "Ibero-American Thematic Network on ICT Applications for Smart Cities" (REF-518RT0559).

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Available online 12 June 2021

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