Guest Editorial: Embedded and Networked Systems for Intelligent Vehicles and Robots

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Embedded and networked systems for intelligent vehicles and robots are expected to have a significant economic, societal and technological impact on industrial and automotive applications. Among the aspects that will benefit from these technologies the first one is safety, thanks to the reduction of accidents caused by human errors. Another positive effect is expected on sustainability, thanks to the increase in transport systems efficiency. Comfort and inclusiveness will be also improved, ensuring users' freedom for other activities and "mobility for all".

Logistics and factory automation are among the main areas that will take advantages from intelligent vehicles and robots, that are expected to play a key role in Industry 4.0 scenarios, the so-called fourth industrial revolution, where intelligent vehicles and industrial robots will move and operate autonomously and cooperatively. Such a revolution has many key enabling technologies, such as, networked sensors, actuators and embedded computing and control platforms, that will be distributed on-board the vehicle/robot. The contribution of artificial intelligence and deep learning computing platforms is also emerging to achieve full intelligent autonomous mobility of vehicles and robots.

Among the challenges that intelligent vehicles and robots have to face, functional safety and cybersecurity are for sure key aspects that need to be fully addressed to ensure the widespread adoption of autonomous vehicles in the market.

The Special Section on "Embedded and Networked Systems for Intelligent Vehicles and Robots" of the IEEE Transactions on Industrial Informatics (TII) tackles the research challenges for the successful adoption of intelligent vehicles and robots in many areas, including autonomous vehicles and Industry 4.0. The Special Section attracted over 40 submissions. After a rigorous review process, 9 high-quality contributions were selected that cover a broad spectrum of topics.

The paper "Recent Advances and Trends in On-board Embedded and Networked Automotive Systems", by Lo Bello et al. [1], provides a comprehensive overview of the current technological challenges in on-board and networked automotive systems. In particular, the paper surveys current solutions and future trends on models and languages for automotive software development, on-board high performance computing platforms and in-car communication protocols, which are moving beyond classic CAN-based vehicle networks to Time-Sensitive Ethernet-based ones. Moreover, the work describes the state of the art and novel design strategies for cybersecurity and functional safety.

The work "OptDynLim: An Optimal Algorithm for the One-Dimensional RSU Deployment Problem With Nonuniform Profit Density", by Gao et al. [2], addresses the problem of deploying road-side units in the context of vehicular ad-hoc networks (VANETs). Road-side units have a significant impact on the quality of service of VANETs. The paper proposes an optimal algorithm for the deployment of these units. The proposed algorithm significantly reduces the solution space by dynamically adjusting the limits of the space.

In the paper "A Hybrid Metaheuristic Embedded System for Intelligent Vehicles Using Hypermutated Firefly Algorithm Optimized Radial Basis Function Neural Network", by Huang et al. [3], a 4-wheeled vehicle's dynamic model is fused with a hypermutated firefly algorithm and with a radial basis function neural network to develop a real-time optimal controller. All control algorithms are implemented in real-time through a field programmable system-on-chip approach. The proposed controller ensures optimal trajectory tracking, as assessed through application on the experimental Mecanum 4-wheel vehicle.

The article "A Comparison of Partitioning Strategies for Fixed Points Based Limited Preemptive Scheduling", by Marković et al. [4], discusses hardware architectures for time-critical embedded systems. The paper proposed to integrate the fixed preemption points scheduling (LP-FPPS) and partitioned scheduling on fixed-priority multicore real-time systems to increase the overall systems schedulability. A new joint approach for task partitioning and preemption point selection is proposed, that is based on the computation of the maximum blocking tolerance upon each allocation, thus being able to quantify the schedulability of the set of tasks on each processor. Partitioning strategies based on different heuristics are also investigated.

The paper "Topology Management and TSCH Scheduling for Low-Latency Convergecast in In-Vehicle WSNs", by Tavakoli et al. [5], presents a low-latency topology management and TSCH scheduling (LLTT) technique that aims to minimize the average latency of guaranteed data convergecast in small-size and dense TSCH networks. The proposed technique is a cross-layer design, which selects a proper network topology at the network layer to maximize the TSCH schedule utilization for the MAC layer. The intended targets are industrial automation and automotive applications. The paper conducts a case study on the in-vehicle wireless networks.

The article "Security/Timing-Aware Design Space Exploration of CAN FD for Automotive Cyber-Physical Systems", by Xie et al. [6] targets the Controller Area Network with Flexible Data-rate (CAN-FD). The paper proposes a security-

and timing-aware system model that is based on CAN-FD. The proposed model is compliant with the AUTOSAR standard. Based on the proposed model, the paper presents an efficient design-space exploration method that optimizes the bandwidth utilization of CAN FD, while taking both the timing and security constraints in the application into account.

The paper "TEAM Applications for Collaborative Road Mobility", by Bellotti et al. [7], addresses collaborative road mobility, an emerging trend that encompasses system issues and human aspects. In this area, the paper presents some results from the Tomorrows Elastic Adaptive Mobility (TEAM) European project, which targets a system architecture and a set of applications of industrial interest for collaborative mobility. The paper focuses on user tests, i.e., real-world tests performed to investigate the aspects that are crucial for the adoption of novel technologies in commercial vehicles.

The work "Adaptive Scheduling for Multicluster Time-Triggered Train Communication Networks", by Wang et al. [8], targets train communication networks and presents a novel approach to schedule multicluster time-triggered networks. The algorithm includes two parts, the off-line part and the on-line one. A mixed integer linear programming (MILP) model is used to find a feasible solution for the off-line part, with three useful properties. Based on these properties, the on-line part method can fast react to changes in the system, that are very likely in the targeted scenarios, as train consist dynamically changes.

Finally, the paper "Distributed Real-Time IoT for Autonomous Vehicles", by Philip et al. [9], takes on the challenges related to distributed real-time Internet of Things (IoT) applications in autonomous vehicles. In this context, the paper proposes a smart algorithm and implements a smart traffic intersection management system for automated vehicles, which enables the vehicles to independently update their lanes with near-optimal velocities. The proposed solution is simulated using an open-source road traffic simulator, namely Simulation of Urban Mobility (SUMO).

Summarizing, the selected nine papers address several important challenges and novel areas for intelligent vehicles and robots, providing both useful solutions and hints for future work. The Guest Editors are grateful to the Authors who submitted their manuscripts, the Reviewers who provided comprehensive reviews and comments, to the Editor-in-Chief, Prof. Ren Luo, for the valuable guidance, and to the TII staff, for the professional support provided.

Acknowledgement

The editorial work leading to this Special Section is supported by the Swedish Knowledge Foundation (KKS) via the projects HERO and DPAC, the Swedish Governmental Agency for Innovation Systems (VINNOVA) via the project DESTINE, University of Catania via the project CHANCE and Piano per la Ricerca 2016-2018 - Linea di intervento 2, University of Pisa via the grant PRA2017 and EPI H2020 programs.

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Authors' Biography

Lucia Lo Bello (M'02) is an Associate Professor at the University of Catania, Italy. She received the M.S. degree in Electronic Engineering and the Ph.D. degree in Computer Engineering in 1994 and 1998, respectively. She was also Guest Professor at Mälardalen University, Sweden (2014) and a Visiting Researcher with the Department of Computer Engineering, Seoul National University, Korea (2000-2001). She authored or coauthored more than 150 technical papers in the area of real-time embedded systems, automotive communications, industrial wireless sensor networks. In 2008 she was the recipient of the IEEE Industrial Electronics Society Early Career Award. She is a member of IEC, CENELEC and CEI and actively participates to standardization activities in the area of industrial communication. She was the Scientific Responsible for the University of Catania for several international research projects in the areas of the factory automation and real-time embedded systems and networks. She is Senior Member of the IEEE and Associate Editor of several journals, including the IEEE Transactions on Industrial Informatics and the Springer Real-Time Systems journal.

Saad Mubeen (SM'16) is an Associate Professor at Mälardalen University, Sweden. He received his Ph.D. degree in computer science and engineering from Mälardalen University in 2014. He has previously worked in the vehicle industry as a software engineer and a consultant. He has authored or coauthored more than 100 peer-reviewed research publications in the area of model-based development of vehicular embedded systems with a focus on timing models, end-to-end timing analysis, and multi-core platforms. He has received several awards, including the IEEE Software Best Paper Award in 2017. He is a Senior Member of the IEEE. He has co-organized several Special Sessions at the international conferences such as IEEE IECON, ICIT, and Springer ITNG. He is a member of the program committee of several international conferences. He is a guest editor of ACM SIGBED Review and IEEE Transactions on Industrial Informatics.

Sergio Saponara (SM'12) is Full Professor of Electronics at University of Pisa (UNIPI) and IEEE DL. He co-authored about 300 scientific publications and is AE or GE of many journals, including IEEE TII, IEEE VTM IET EL, and IEEE CEMAG. He is director of the school "Enabling Technologies for Industrial IoT", VP of Bachelor and Master Electronic Engineering degrees, and responsible of the CrossLab Industrial IOT and I-CAS lab and leader of UNIPI in the European Processor Initiative (EPI) H2020 project.

Riccardo Mariani (M'05) received a Laurea Degree in Electronic Engineering, and a Ph.D. degree in Microelectronics, both from the University of Pisa, Italy. He won the SGS-Thomson and Enrico Denoth best engineering awards. Before founding the company YOGITECH, in San Martino Ulmiano, Italy, he was Technical Director in former Aurelia Microelettronica company in Viareggio, Italy. Yogitech was acquired in 2016 by Intel and Riccardo now holds the role of Intel Fellow Functional Safety. Riccardo has worked for many years on the specification and design of Integrated Circuits and Intellectual Property cores for safety critical systems in automotive, industrial, medical and railway applications. He is an active member of international committees for functional safety: in ISO 26262, he is leading the chapter about "ISO 26262 and microcontrollers". He will be the IEEE CS Standardization VP for 2019. Riccardo is a member of the IEEE. He has authored many papers related to High-Reliability Circuits, Design for Testability and Asynchronous Circuits. He has been also an invited speaker at many ISO and IEEE conferences and he has been a moderator of round tables at IEEE conferences.

Unmesh Dutta Bordoloi is a Compute Platform Architect/Senior Researcher for Autonomous Vehicles at General Motors. He obtained his PhD from the National University of Singapore where he graduated with President's Graduate Fellowship and Sun Microsystems Fellowship. After obtaining his PhD, Dr. Bordoloi spent one year as a post-doctoral researcher at Verimag Lab in France. Thereafter, he joined Linköping University, Sweden where he spent almost 6 years before leaving as a tenured faculty member. His primary research interest lies in deep learning for in-vehicle systems. Dr. Bordoloi has published several papers on design and analysis of real-time embedded systems, reliability (fault-tolerance) of automotive systems, real-time automotive networks, and GPU-based heterogeneous systems. He has served as a program committee member of several international conferences.