Guest Editorial
Special Issue on 3D Sensing in Intelligent Transportation

HIGH-ACCURACY and high-efficiency 3-D sensing and associated data processing techniques are urgently needed for today's roadway inventory, infrastructure health monitoring, autonomous driving, connected vehicles, urban modeling, and smart cities. 3D geospatial data acquired by digital photogrammetry or laser scanning or LiDAR systems have become one of the most critical data sources to support the above-mentioned applications. While progress has been made to applying 3D sensory data to those applications related to intelligent transportation systems (ITS), such as road network extraction, platform localization, obstacle avoidance, high-definition map generation, and transportation infrastructure inventory, many essential questions remain regarding the processing and understanding such massive 3D datasets in ITS-related applications. The authors have selected four articles for review in this Special issue. A summary of these articles is outlined below.

The article entitled "Moving object detection by 3D flow field analysis," by Jiang *et al.*, presents a complete framework to detect and extract moving objects, such as walking pedestrians or moving trucks, from a sequence of unordered and texture-less point clouds. The authors propose a novel 3D Flow Field Analysis approach to accurately detect the moving objects from data acquired with a possibly fast-moving platform. The proposed algorithm elegantly models the temporal and spatial displacement of the moving objects. The authors proposed a Sparse Flow Clustering algorithm to group the 3D motion by incorporating sparse subspace clustering framework flows to achieve 3D reconstructions. Experiments on the KITTI dataset proved that the proposed methods are highly effective for motion detection and segmentation and yield high-quality reconstructed static maps and rigidly moving objects.

The article entitled "Automatic extraction of roadside traffic facilities from mobile laser scanning point clouds based on deep belief network," by Fang *et al.*, extracts the traffic facilities (trees, cars, and traffic poles) beside the road to provide richer information to the intelligent transportation system, infrastructure inventory and city management related applications. This study separates the raw off-ground point clouds into individual segments and designs an object-based Deep Belief Network (DBN) architecture to detect roadside traffic facilities with limited labeled samples. One of their contributions is the development of a general and straightforward multi-view feature descriptor to characterize the global feature of individual objects and extend the training samples' quantity. Accuracy evaluations and comparative studies on trees, cars, and traffic poles prove that the proposed method can achieve promising performance of roadside traffic facilities detection in complex urban scenes.

The article entitled "Capsule-based networks for road marking extraction and classification from mobile LiDAR point clouds," by Ma *et al.*, proposes a method to accurately extract and categorize road pavement markings to build a high-definition map. The authors designed a capsule-based deep learning framework to extract and classify road markings from MLS point clouds to deal with the variations of point density and intensity from mobile laser scanning (MLS) systems. The network segments, extracts, and classifies road marking in stages. The article built a dataset containing both 3D point clouds and labels from three road scenes, including urban roads, highways, and underground garages. The proposed method was accordingly evaluated by estimating robustness and efficiency using this dataset. Quantitative evaluations indicate the proposed extraction method can deliver 94.1% in precision 90.5% in recall, and 92.4% in F1-score, respectively, while the classification network achieves an average of 3.4% misclassification rate in different road scenes.

The article entitled "Three-dimensional object co-localization from mobile LiDAR point clouds," by Guo *et al.*, proposed a framework to locate 3D objects without any help of supervised training data to avoid the expense of manual annotation. The framework can automatically extract objects of the same category from different point cloud scenes by formulating a 3D object co-localization problem as a maximal subgraph matching problem. To handle the inconsistent representation of objects in various scenes, the authors propose a multi-scale clustering method to represent objects by a pyramid structure. Extensive experiments on the point cloud data collected by the Reigl VMX450 mobile LiDAR system demonstrate the promising performance of the proposed framework.

The Guest Editors would like to express their deep gratitude to all the authors who have submitted their valuable contributions and to the numerous and highly qualified anonymous reviewers. The selected contributions, which represent the current state of the art in the field, will be of great interest to the ITS community. The Guest Editors would also like to thank the IEEE publication staff members for their continuous support and dedication.

CHENGLU WEN, *Guest Editor*
School of Informatics
Xiamen University
Xiamen 361005, China
e-mail: clwen@xmu.edu.cn

Digital Object Identifier 10.1109/TITS.2021.3067396

AYMAN F. HABIB, *Guest Editor*
School of Civil Engineering
Purdue University
West Lafayette, IN 47907 USA
e-mail: ahabib@purdue.edu

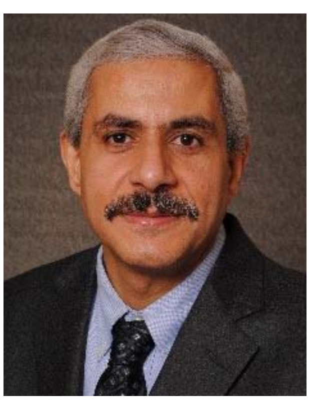
CHARLES K. TOTH, *Guest Editor*
Department of Civil, Environmental, and Geodetic Engineering
The Ohio State University
Columbus, OH 43210 USA
e-mail: toth.2@osu.edu

CHENG WANG, *Guest Editor*
School of Informatics
Xiamen University
Xiamen 361005, China
e-mail: cwang@xmu.edu.cn

JONATHAN LI, *Guest Editor*
Department of Geography and Environmental Management
University of Waterloo
Waterloo, ON N2L 3G1, Canada
Department of Systems Design Engineering
University of Waterloo
Waterloo, ON N2L 3G1, Canada
e-mail: junli@uwaterloo.ca

HONGCHAO FAN, *Guest Editor*
Department of Civil and Environmental Engineering
Norwegian University of Science and Technology
7491 Trondheim, Norway
e-mail: hongchao.fan@ntnu.no

Chenglu Wen (Senior Member, IEEE) received the Ph.D. degree from China Agricultural University, in 2009. From 2007 to 2009, she did a joint Ph.D. program at Michigan State University. From 2018 to 2019, she was a Visiting Researcher with Purdue University. She is currently an Associate Professor with the School of Informatics, Xiamen University, and the Associate Head of the Department of Cognitive Science. She is the author or coauthor of more than 70 papers. Her research interests include LIDAR remote sensing, 3-D point cloud processing, high-definition map for autonomous driving, and multi-sensor calibration and fusion. She serves as an Associate Editor for IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS and IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, and a Guest Editor for *Sensors journal*.



Ayman F. Habib received the B.Sc. degree from Cairo University in 1986, and the master's and Ph.D. degrees from The Ohio State University, in 1993 and 1994, respectively. He is currently the Thomas A. Page Professor of Civil Engineering with Purdue University and the Co-Director of the Civil Engineering Center for Applications of UAS for a Sustainable Environment (CE-CAUSE). He is also the Associate Director of Purdue University's Joint Transportation Research Program (JTRP). His research interests include terrestrial and aerial mobile mapping systems, modeling the perspective geometry of non-traditional imaging scanners, automatic matching and change detection, automatic calibration of low-cost digital cameras, object recognition in imagery and point cloud data, LiDAR mapping, and integrating photogrammetric data with other sensors/datasets. He is the author or coauthor of one book, two edited books, 15 book chapters, 30 technical reports, 100 peer-reviewed journal articles, 13 invited editorials, 61 peer-reviewed conference proceedings, and 164 abstract-reviewed conference proceedings.

Jonathan Li (Senior Member, IEEE) received the Ph.D. degree in geomatics engineering from the University of Cape Town, South Africa, in 2000. He is currently a Professor of Geomatics and Systems Design Engineering with the University of Waterloo, and the Director of the Waterloo Lab for Mobile Sensing and Geodata Science. His research interests include mobile mapping, point cloud processing, 3-D object detection, HD maps for autonomous driving, roadway inventory, and transportation infrastructure modeling. He is the author or coauthor of eight books, more than ten patents, and more than 400 research papers. He was a recipient of more than dozens of prestigious awards.

Charles K. Toth (Senior Member, IEEE) received the M.Sc. degree in electrical engineering and the Ph.D. degree in electrical engineering and geo-information sciences from the Technical University of Budapest, Hungary, in 1977 and 1980, respectively. He is currently a Research Professor with the Department of Civil, Environmental, and Geodetic Engineering, The Ohio State University. He has published more than 400 peer-reviewed journals and proceedings papers. His research interest and expertise include spatial information sciences and systems, including photogrammetry, multi-sensor geospatial data acquisition systems, LiDAR, high-resolution imaging, surface extraction, modeling, integrating, and calibrating multi-sensor systems, geo-referencing and navigation, 2-D/3-D signal processing, and mobile mapping technologies. He was a recipient of numerous awards, including the 2009 APSRS Photogrammetric Award, the United States Geospatial Intelligence Foundation (USGIF) Academic Achievement Award, in 2015, the ISPRS Schwidefsky Medal Winner 2016, several Lumley Research awards from OSU, and various best papers awards.

Cheng Wang (Senior Member, IEEE) received the Ph.D. degree in information and communication engineering from the National University of Defense Technology, China, in 2002. He is currently a Professor with the Fujian Key Laboratory of Sensing and Computing for Smart Cities and the Associate Dean of the School of Informatics, Xiamen University, China. His current research interests include remote sensing image processing, mobile LiDAR data analysis, and multi-sensor fusion. He has coauthored about 150 papers published in refereed journals, such as the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, and *ISPRS Journal of Photogrammetry and Remote Sensing*, and conferences, such as IGARSS and ISPRS. He is the Chair of the ISPRS Working Group I/6 on Multi-Sensor Integration and Fusion (2016C2020). He is a Council Member of the Chinese Society of Image and Graphics.

Hongchao Fan received the master's degree from the University of Stuttgart, in 2006, and the Ph.D. degree from the Technical University of Munich, in 2010. He is currently a Professor of Geomatics with the Department of Civil and Environmental Engineering, Norwegian University of Science and Technology. He is the author or coauthor of seven book chapters and more than 80 papers. His research interests include 3-D point clouds processing, modeling and reconstruction of 3-D cities, spatial data mining, and HD maps.