Guest Editorial >>>

Special Topic on 3D Point Cloud Processing and Applications

Guest Editors


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3D point cloud processing has redefined the way we perceive and interact with digital spatial data. By translating physical entities into a collection of 3D points, it offers an accurate digital model of our surroundings. This emerging field of 3D point-based representation has piqued interest significantly over recent years, owing to its capacity to depict detailed spatial environments, thereby bridging the gap between virtual and real dimensions. Numerous applications, including virtual reality, augmented reality, and advanced mapping, have greatly benefited from this technology, allowing for immersive experiences and accurate spatial analysis. However, the journey from raw spatial data to refined point cloud representations is fraught with challenges, including storage and computational demands, noise handling and the quest for efficient compression techniques.

In this special issue on 3D point cloud processing and applications, we present a curated series of articles that dive deep into these challenges, suggesting innovative strategies and methodologies tailored to address them. The selected contributions touch upon a diverse spectrum of topics within the realm of point cloud processing. They discuss novel compression algorithms, delve into quality assessment metrics, elucidate advanced rendering techniques, and highlight the nuances of feature extraction, among other pivotal areas. The call for papers for this special issue attracted excellent submissions, indicating the growing significance of this field. Following rigorous reviews, we are proud to present six standout papers that not only showcase cutting-edge research but also set the direction for future endeavors in this domain.

The first paper titled "Perceptual Quality Assessment for Point Clouds: A Survey" delivers a comprehensive overview of how the visual quality of point clouds is gauged. Traditional quality assessment methods fall short when applied to point cloud data. This survey presents the significance of point cloud quality assessment, discussing common distortions, experimental setups, and subjective databases. It contrasts model-based and projection-based objective methods, and the performance of these methods across various databases is analyzed. Experimental insights underline the utility and efficacy of the presented methods.

The second paper titled "Spatio-Temporal Context-Guided Algorithm for Lossless Point Cloud Geometry Compression" addresses the challenges faced during the compression of point cloud data. Traditional compression techniques struggle with the irregular distribution of point cloud data in space and time. This paper introduces an innovative context-guided algorithm that slices point clouds and employs the travelling salesman algorithm to predict compression. Testing results emphasize its robustness, presenting a feasible avenue for efficient 3D point cloud compression (PCC).

The third paper titled "Lossy Point Cloud Attribute Compression with Subnode-Based Prediction" shines light on the advances in 3D point cloud compression. With the Moving Picture Expert Group (MPEG) working towards a standard for PCC, the paper highlights the challenges in current attribute compression techniques. It introduces a subnode-based prediction method, leveraging spatial relationships for improved

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precision. Experimental results showcase its superior performance over existing MPEG standards.

The fourth paper titled "Point Cloud Processing Methods for 3D Point Cloud Detection Tasks" revolves around the pivotal role of 3D point cloud processing in object detection. Given the complexity of data acquired from LiDAR sensors, the paper offers a review of point cloud processing methods and how they influence detection outcomes. The discussion underscores the evolution of voxelization and sampling strategies, emphasizing their implications for feature extraction and final detection performance.

The fifth paper titled "Perceptual Optimization for Point-Based Point Cloud Rendering" delves into the challenges in point-based rendering for point clouds. The established method of determining rendering radius using neighboring points' distances is problematic. The paper introduces an outlier detection mechanism that optimizes the perceptual quality of rendering, using local and global geometric features to detect outliers. Results confirm the significant improvements in rendering quality with this approach.

The sixth paper titled "Local Scenario Perception and Web AR Navigation" explores the exciting convergence of web technologies and augmented reality (Web AR). As Web AR grapples with computational demands, the paper introduces an indoor navigation system based on local point cloud map positioning. This novel approach minimizes the need for external sensors, highlighting a promising avenue for precise and widespread application of Web AR navigation.

To conclude, this special issue aims to be an indispensable guide for researchers, industry experts, and students delving into 3D point cloud processing and its varied applications. We anticipate that the content will spur more research and advancements, shaping the future trajectory of digital spatial data analysis. Our deepest gratitude extends to all the authors, reviewers, and editorial staff for their invaluable contributions that have made this issue a success. We earnestly hope that the articles in this special issue offer both clarity and insight to all readers in this emerging domain.

Biographies

SUN Huifang graduated from Harbin Engineering University, China, and received his PhD degree from University of Ottawa, Canada. He was an associate professor in Fairleigh Dickinson University in 1990. He joined Sarnoff Corporation in 1990 as a member of technical staff and was promoted to a technology leader for digital video communication. In 1995, he joined Mitsubishi Electric Research Laboratories (MERL) and was promoted as Vice President and Deputy Director in 2003 and currently is a retired Fellow of MERL. He has co-authored two books and published more than 160 journal and conference papers. He holds 64 US patents. He won the Technical Achievement Award for optimization and specification of the Grand Alliance HDTV video compression algorithm in 1994 at Sarnoff Lab. He received the best paper award of 1992 *IEEE Transaction on Consumer Electronics*, the best paper award of 1996 *ICCE* and the best paper award of 2003 *IEEE Transaction on CSVT*. He was an associate editor for *IEEE Transaction on Circuits and Systems for Video Technology* and was the Chair of Visual Processing Technical Committee of IEEE Circuits and System Society. He is an IEEE life fellow.

LI Ge is currently a full professor at the School of Electronic and Computer Engineering, Peking University, China. He received his PhD degree from the Department of Electrical Engineering, Auburn University, USA in 1999. He has several years of research work experience in industry. His research interests include point cloud compression and its standardization, image/video processing and analysis, machine learning, and signal processing. He has published over 100 high quality papers and holds lots of granted US and global patents. He actively submitted many technical proposals to MPEG PCC and is also currently the Lead Chair for the standardization of point cloud compression in the Audio Video Coding Standard (AVS) Workgroup of China. He served as the Panel Chair of IEEE ICME 2021, the International Liaison Chair of PCS 2022, etc.

CHEN Siheng is a tenure-track associate professor of Shanghai Jiao Tong University, China. Before joining Shanghai Jiao Tong University, he was a research scientist at Mitsubishi Electric Research Laboratories (MERL) and an autonomy engineer at Uber Advanced Technologies Group (ATG), working on the perception and prediction systems of self-driving cars. Before joining industry, Dr. CHEN was a postdoctoral research associate at Carnegie Mellon University, USA. He received his doctorate in electrical and computer engineering from Carnegie Mellon University. He has published over 80 papers on prestigious venues, including *Nature Computational Science*, *Nature Scientific Data*, *IEEE Signal Processing Magazine*, *IEEE Transactions on Signal Processing*, *IEEE Transactions on Image Processing*, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, ICASSP, NeurIPS, ICML, ICLR and CVPR. His work on sampling theory of graph data received the 2018 IEEE Signal Processing Society Young Author Best Paper Award. His co-authored paper on structural health monitoring received ASME SHM/NDE 2020 Best Journal Paper Runner-Up Award and another paper on 3D point cloud processing received the Best Student Paper Award at 2018 IEEE Global Conference on Signal and Information Processing. Dr. CHEN contributed to the project of scene-aware interaction, winning MERL President's Award. He serves as the associate editor for *IEEE Transactions on Signal and Information Processing over Networks*. His research interests include collaborative AI and 3D scene understanding.

LI Li received his BS and PhD degrees in electronic engineering from University of Science and Technology of China (USTC), China in 2011 and 2016, respectively. He was a visiting assistant professor in University of Missouri-Kansas City, USA from 2016 to 2020. He joined the Department of Electronic Engineering and Information Science of USTC as a research fellow in 2020 and became a professor in 2022. His research interests include image/video/point cloud coding and processing. He received the Best 10% Paper Award at the 2016 IEEE Visual Communications and Image Processing (VCIP) and the 2019 IEEE International Conference on Image Processing (ICIP).

GAO Wei is an assistant professor at the School of Electronic and Computer Engineering, Peking University, Shenzhen, China. His research has been focused on perception-inspired multimedia coding and processing, including both efficient algorithms and systems. He won the 2021 IEEE Multimedia Rising Star Runner Up Award for Outstanding Early-stage Career Achievements in the area of 3D Immersive media research. He is currently serving or has served as the associate editor for several international journals on multimedia computing and machine leaning, including *Signal Processing*, etc. He is also an Elected Member of IEEE CASS VSPC-TC, and APSIPA IVM-TC. He has organized workshops and special sessions at ICME 2023, ACM MM 2022, VCIP 2022, and ICME 2021. He is a tutorial speaker for point cloud related topics at ICME 2023 and ICIP 2023. He is also the leader to establish several open source projects, including OpenPointCloud, OpenAICoding, etc. He is a senior member of IEEE.