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Editorial

Editorial for Special Issue on Three-dimensional Point Cloud Data Modeling, Processing, and Analysis

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The rapid development of three-dimensional (3D) sensing technologies has led to an exponential growth in the availability of 3D point cloud data, consisting of a set of 3D coordinates indicating the spatial locations of points to explicitly represent the geometric structures of objects/scenes, associated with additional attribute information, e.g., color and normal. 3D point clouds are widely used in various fields, such as immersive telepresence, virtual/augmented reality, geographic mapping, and autonomous driving. This special issue focuses on all aspects of 3D point cloud data modeling, processing, and analysis. This special issue has collected 8 excellent articles reviewed and highly recommended by the editors and reviewers.

The 1st paper is titled "Quantization Parameter Cascading for Lossy Point Cloud Attribute Compression in G-PCC", authored by Lei Wei, Zhiwei Zhu, Zhecheng Wang, and Shuai Wan. In this paper, quantization parameter cascading (QPC) is designed based on rate-distortion modelling. Firstly, the single-layer rate-quantization and distortion-quantization models are built by investigating the distribution of residuals. Later, the dependency of adjacent layers is studied to establish the rate-distortion model with dependency. Based on the proposed model, a rate-distortion optimization (RDO) guided QPC (O-QPC) and a fast implementation (F-QPC) are proposed. The experimental results verify the efficiency of the proposed methods.

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The 2nd paper is titled "OSC-Net: Object Semantic-aware Compression Network for 3D Point Cloud", authored by Kangrui Luo, Donghan Bu, Anhong Wang, Junhui Hou, and Yakun Yang. This paper proposes an object semantic-aware compression network for 3D point cloud data, namely OSC-Net. Firstly, a ground points removal module based on the elevation difference is designed, enabling the network to pay more attention to the semantic information of objects. Secondly, a 3D voxel attention module is proposed to extract multiple priors in deep entropy model that can predict the probability distribution of occupied symbols in voxel space. Experimental results show that our proposed network gains a notable bitrate saving of 16.71% compared to the baseline on the KITTI 3D object detection dataset, while maintaining a comparable detection accuracy.

The 3rd paper is titled "Enhanced MPEG G-PCC: Addressing Challenges in the OBUF Entropy Coding Framework", authored by Xiao Huo, Shidi Hao, Wei Zhang, and Fuzheng Yang. The paper proposes an initialization strategy for both fine-grained context states (Fine-CtxS) and coarse-grained context states (Coarse-CtxS) in the Optimal Binarization with Update On-the-Fly (OBUF) scheme, alongside an adaptive probability bound determination method for each Coarse-CtxS to confine probability estimation. Furthermore, the paper delves into improvements for inter-frame geometry coding, including the construction of Fine-CtxS, and reducing memory consumption of Fine-CtxS in OBUF. The proposed methods have been adopted in recent G-PCC Edition 2 standardization activities, demonstrating enhanced performance.

The 4th paper is titled "Overview and Comparison of AVS Point Cloud Compression Standard", authored by Wei Gao, Wenxu Gao, Xingming Mu, Changhao Peng, and Ge Li. This paper reviews the point cloud compression standard by the Audio Video coding Standard (AVS) Workgroup of China, namely AVS PCC, from two perspectives, i.e., the related technologies and performance comparisons.

The 5th paper is titled "JointFormer: Joint-Enhanced 3D Human Point Cloud Completion Based on Transformer", authored by Min Zhou, Jieyu Chen, Xinpeng Huang, and Ping An. This paper proposes a new network with an encoder-decoder framework, named JointFormer, to address human point cloud completion. Firstly, a joint-enhanced encoder that provides more prior guidance on the overall structure of the partial input is designed. Then, a generator is employed to generate sparse but complete point clouds. Finally, a decoder refines the rough point clouds into complete and dense human body point clouds in a coarse-to-fine manner. Moreover, by combining transformer with the convolutional block attention module, a channel-spatial attention transformer is designed to better capture point cloud spatial relationships. Quantitative and qualitative evaluations demonstrate that JointFormer outperforms the state-of-the-art completion method on our two human body point cloud datasets.

The 6^{th} paper is titled "LPSR: Lightweight Point Cloud Surface Reconstruction", authored by Qingyang Zhou, Chee-An Yu, Xuechun Hua, Shan Liu, and C.-C. Jay Kuo. This work proposes a computationally efficient and mathematically transparent Green Learning solution to achieved surface reconstruction from point cloud scans, named lightweight point-cloud surface reconstruction (LPSR). LPSR reconstructs surfaces in two steps. First, it progressively generates a sparse voxel representation using a feedforward approach. Second, it decodes the representation into unsigned distance functions based on anisotropic heat diffusion. Experimental results show that LPSR offers competitive performance against state-of-the-art surface reconstruction methods on the FAMOUS, ABC, and Thingi10K datasets at modest model complexity.

The 7^{th} paper is titled "Efficient Multi-stage Context Based Entropy Model for Learned Lossy Point Cloud Attribute Compression", authored by Kai Wang, Pingping Zhang, Shengjie Jiao, Hui Yuan, Shiqi Wang, and Xu Wang. This paper proposes ParaPCAC, a lossy Parallel Point Cloud Attribute Compression scheme, designed to optimize the efficiency of the autoregressive entropy model. ParaPCAC focuses on two main components: a parallel decoding strategy and a multi-stage context-based entropy model. Through these two techniques, ParaPCAC achieves significant decoding speed enhancements, with an acceleration of up to $160\times$ and a 24.15% BD-Rate reduction compared to serial autoregressive entropy models.

The 8^{th} paper is titled "Molecular Representation Learning via Hierarchical Graph Transformer", authored by Zehua Wang, Yang Liu, and Wei Hu. This paper proposes Hierarchical Graph Transformer (HieGT), integrating atom-level and motif-level representations to capture local-global characteristics of molecules over a hierarchical graph. Leveraging atom-wise graph attention and motif-wise graph attention, HieGT enhances intrinsic representation understanding of molecules. The proposed method achieves state-of-the-art performance over the molecular property prediction benchmark PCBA, and competitive results on PCQM4Mv2 with better interpretability.

This issue brings together the latest advancements in 3D point cloud data modeling, processing, and analysis, as presented in the published papers. It is expected that it will help readers gain a deeper understanding of developments in this field and potentially inspire new ideas.

Guest Editors
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