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Message from the Review Board Directors

Welcome to the June 2023 issue of the IEEE ComSoc MMTC Communications – Review.

This issue comprises three reviews that cover multiple facets of multimedia communication research including cooperative object classification, decompressed point cloud, and agriculture and food industry. These reviews are briefly introduced below.

The first paper, published in IEEE Internet of Things Journal and edited by Dr. Dong Li, proposes a lightweight, privacy-preserving cooperative object classification mechanism for connected autonomous vehicles.

The second paper, edited by Dr. Mengbai Xiao, was published in IEEE International Conference on Multimedia and Expo. This paper investigates deep geometry post-processing for decompressed point clouds.

The third paper, edited by Dr. Yongliang Qiao, was published in IEEE Internet of Things Journal. This paper reviews the application of IoT technologies in agriculture and the food industry, and the potential contribution of big data and AI in these sectors.

All the authors, reviewers, editors, and others who contribute to the release of this issue deserve appreciation with thanks.

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Exploring Cooperative Object Classification for Connected Autonomous Vehicles

A short review for "Toward Lightweight, Privacy-Preserving Cooperative Object Classification for Connected Autonomous Vehicles"

Edited by Dong Li

J. Xiong, R. Bi, Y. Tian, X. Liu and D. Wu, "Toward Lightweight, Privacy-Preserving Cooperative Object Classification for Connected Autonomous Vehicles," in IEEE Internet of Things Journal, vol. 9, no. 4, pp. 2787-2801, 15 Feb.15, 2022.

Recently, a connected autonomous vehicle (CAV) systems have gradually entered people's lives and play an important role due to the increasing popularity of the combination of wireless communication and autonomous vehicle technologies. CAV system is able to perceive its surrounding environment with a suite of local sensors [1-2]. The CAV system has been playing an important role in accomplishing real-time tasks, talking with the business, and working in a mobile environment [3].

However, it has been discovered that the sharing data among the autonomous vehicles and edge servers was the raw sensor data rather than the processed ones, e.g.., drivers' or pedestrians' faces captured by HD cameras [4-5], which would lead a problem of serious privacy leakage.

In order to solve this problem, this paper proposes a lightweight, privacy-preserving cooperative object classification mechanism, where the communication overhead is considered to achieve the data transmission with privacy protection. In a nutshell, the main contributions of this paper contain four aspects, which are summarized as follows:

First, the authors propose a lightweight, privacy-preserving framework, where image reencryption, privacy-preserving CNN and object decryption are aiming to achieve privacy protection and efficient cooperative object classification. The framework can be extended to other CNN-based deep learning models with computation tasks implemented by the proposed secure computing protocols.

Second, the authors design an image chaotic encryption scheme to process the raw data before uploaded to the edge server, which preventing potential adversaries from hijacking sending vehicles or simultaneous damaging both upload links.

Third, the authors propose a series of secure computing protocols in P-CNN that almost identically implement the computational operations in the original CNN and the computational efficiency is greatly improved.

Forth, the encrypted image-based processing is carried out on edge servers, which significantly reduced the computational cost of individual vehicles. The security and correctness of the proposed protocols and framework have been proved in the theoretical analysis.

For the performance evaluation, extensive simulation results are conducted to compare the proposed scheme with the existing schemes in terms of accuracy, computational cost, and communication overhead. Undoubtedly, the proposed scheme results are significantly better than those of the comparable schemes. Besides, to further prove the effectiveness of the proposed scheme, some benchmarks are compared to show its superiority.

In summary, this paper presents a novel framework and solid theoretical contributions for privacy protection in cooperative object classification for CAVs.

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Refining Visual Quality of Point Clouds After Lossy Compression

A short review for "Deep Geometry Post-Processing for Decompressed Point Clouds"

Edited by Mengbai Xiao

X. Fan, G. Li, D. Li, Y. Ren, G. Wei, and T. Li, "Deep Geometry Post-Processing for Decompressed Point Clouds," 2022 IEEE International Conference on Multimedia and Expo, Jul. 18-22, 2022, Taipei, Taiwan.

As a widely adopted 3D representation, point clouds describe objects and scenes vividly and stereoscopically, and have been increasingly deployed in multimedia industries. A point cloud is merely a collection of orderless points, and each point is associated with its 3D coordinates and other attributes like its color in RGB channels. Though its strong expressive capability, the point cloud demands high volume to store or to stream it. A number of compression techniques [1-2] have been developed to reduce the bitrate required for serving point cloud data. However, in the compression techniques, a quantization step is essential to improve the compression ratio, which would merge spatially adjacent points into one, leading to a decompressed point cloud with lower level-of-detail (LoD).

To solve this problem, a feasible method is to refine the decompressed point cloud in a post-processing step. In this study, the authors propose a learning-based model that refines the decompressed point cloud. Specifically, the input of the model is the decompressed point cloud and the output is a probability map at the same size, predicting if the points should be added back or be removed. The structure of the model generates the output in a coarse-to-fine manner, and two strategies are used to determine the existence of refined points.

The post-processing method consists of three modules: *a point cloud partition module*, *a 3D convolutional prediction module*, and *a point cloud combination module*.

In the point cloud partition module, a complete point cloud is voxelized, and the voxels are binarized to 1 or 0. The voxelized point cloud is subdivided into $l \times w \times h$ non-overlapping cubes. These cubes are voxelized point clouds as well, and are compatible with the following 3D convolutional neural networks.

The 3D convolutional prediction module is designed to add back the points lost in the quantization and correct the positions of existing points. To achieve arbitrary up-sampling ratios, a 3D convolutional neural network is used to generate the occupancy probability of each voxel in the $l \times w \times h$ input cube. The network uses a U-Net structure, where the input is down-sampled by a series of 3D convolutional blocks with a factor of 2 at the encoder side. The down-sampling blocks are followed by the up-sampling counterparts at the decoder side. The up-sampling blocks are transposed convolutional layers with a stride of two, and skip connections are used to concatenate the feature maps between blocks before sending the intermediate results to the next up-sampling block. At each layer, an activation function of sigmoid function is installed to regularize outputs between 0 and 1, reflecting the probability desired.

The output of the last layer is not directly used as the final results. The final occupancy probability is generated in a coarse-to-fine manner. Specifically, the layers of decoder generate the probability maps at various scales. These probability maps are up-sampled with the nearest neighbor interpolation. Then, the final prediction is the weighted sum of these up-sampled probability maps.

To generate the refined point cloud, a threshold should be selected to determine that a voxel with a probability could be turned into an actual point. One could either set the threshold to a unifying constant for all input point clouds or set an adaptive value according to the point number of the ground-truth point cloud. For the first strategy, 0.98 is a proper value, which means in a probability occupancy map, if the probability of a voxel is greater than 0.98, we generate a point at the corresponding position in the refined point cloud, otherwise no points are generated. On the other hand, the probability threshold could be an adaptive value. If there are k points in the ground-truth point cloud, k points are generated in the refined point cloud by selecting the k voxels with the highest probabilities. But the second strategy comes at a cost of that the point number of the ground truth point cloud should also be kept during the compression.

Until now, the refined point clouds in cubes have been generated, and these cube-wise point clouds should be combined to form the complete point cloud in the point cloud combination module. The coordinates of points in the cubes are only relative ones, and they are added to the offset of the cubes. Once the coordinates of all cubes have been processed and concatenated, the complete refined point cloud is generated.

The proposed method is compared with several state-of-the-art methods, i.e., the nearest-neighbor interpolation (NNI), the sparse convolutional network (SCN) [3], and lookup table (LUT) [4]. Among them, SCN is a learning-based solution, and the others are not. G-PCC is also used as the baseline. From the RD-curves reported, the proposed method outperforms other solutions on various videos in terms of the distortion of decompressed video. Especially at low bit rates, the proposed method could reach much higher visual quality. The qualitative results are also presented, where the errors of the proposed method are the least while G-PCC and NNI has the highest distortion. The experiment also tests different strategies that select the threshold used to determine the voxel occupancy. The adaptive strategy achieves better visual quality than the one using a fixed value, though the adaptive strategy requires additional bitrate to deliver the point number information. Such additional information is compressed with lossless methods and incurs extra overhead less than 0.01 bits per point (bbp)

Ablation studies that verify the effectiveness of the multi-scale probability prediction operation are also carried out. In the experiment, the coarse-to-fine structure is removed from the U-Net structure and the model is trained as the complete one. It shows that by removing more probability prediction layers, the output result regresses to coarser point clouds, which verifies the hypothesis in the design.

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IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry

A short review for "IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry"

Edited by Yongliang Qiao

N. N. Misra , Yash Dixit , Ahmad Al-Mallahi , Manreet Singh Bhullar, Rohit Upadhyay , and Alex Martynenko, " IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry" IEEE Internet of Things Journal, vol. 9, no. 9, May 1, 2022.

Agricultural yields and food security have long been an issue throughout history [1]. As the globe's population grows, agriculture will need to increase production to guarantee a sufficient food supply. However, the current agricultural production level is far below what is expected to meet the world's food needs [2]. Furthermore, food safety, encompassing quality, hygiene, and traceability, emerges as a critical concern for public health and wellbeing. In recent years, a number of food safety incidents have caused widespread concern and anxiety, making the assurance of food quality and safety an important issue on a global scale [3].

The application of new technologies such as the Internet of Things (IoT), Big Data and Artificial Intelligence (AI) has become particularly important in responding to the challenges of agricultural production and agri-food safety. These technologies can help improve agricultural productivity, reduce waste of resources, enable precision agriculture management, reduce the incidence of pests and diseases, and ensure food quality and safety. The application of these technologies can make a greater contribution to global food security [4-5].

This paper reviews the application of IoT technologies in agriculture and the food industry, and the potential contribution of big data and AI in these sectors. By introducing IoT technologies such as sensors, wireless communication and cloud technologies, the authors show how they can help farmers monitor soil moisture and temperature status and detect crop growth anomalies promptly, improving food production and crop quality. In addition, IoT technologies play an important role in agricultural supply chain management, logistics monitoring and product tracking. Meanwhile, applications of big data and AI technologies were also mentioned, including agricultural production monitoring, product tracking, food safety and marketing. With big data technologies, farmers and researchers can quickly process and analyze large amounts of production data to optimize decision-making and improve production and marketing processes.

On the other hand, AI technologies can automate agricultural production, such as using machine vision to detect crop growth and self-driving tractors and drones for efficient agricultural production. The authors then transition into discussing the integration of Big Data and AI technologies. They highlight the ability of Big Data to process and analyze vast volumes of agricultural data swiftly, enabling optimized decision-making. This benefit is especially relevant in improving production methods, tweaking marketing strategies, and even in the realm of food safety. However, the article also points out the limitations and potential challenges facing IoT, big data and AI technologies, such as the high cost of equipment, data standardization and privacy issues. The authors, therefore, call on policymakers and practitioners to work together to develop solutions to ensure that these emerging technologies can be successfully applied in agriculture and the food industry.

The authors conclude that the strategic integration of these advanced technologies - IoT, Big Data, and AI - can dramatically overhaul the agriculture and food sector. By boosting productivity, streamlining supply chains, enabling precision farming, enhancing food safety, and promoting informed decision-making, these technologies can fortify global food security.

This paper has the following advantages in introducing and analyzing the application of AI in the food industry. Firstly, it provides a comprehensive introduction to the application of IoT, big data and AI technologies in agriculture, citing a wide range of literature and detailing their development and use cases. Secondly, the article integrates IoT, big data and AI applications into a complete process, facilitating communication between the fields of agriculture, food, electronics, and computer science. In addition, the article explores the future development of AI in the food industry and provides valuable thoughts and suggestions. There are also some shortcomings in this article. Consideration can be given to adding descriptions of specific implementations and technical details of IoT technologies in smart agriculture so that readers can better understand the application scenarios.

Overall, the article provides good insights that cover the applications and contributions of IoT, big data and AI in the agriculture and food industries. The article explores the potential applications of these technologies from several perspectives, including agricultural production, food safety, supply chain management, marketing, and consumer engagement. The depth of content, usefulness, and richness of references in the article is excellent, which is very helpful for readers. The article also raises some very interesting points in terms of challenges and limitations that deserve to be understood and researched in more depth.

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