臺北科技大學暨北京工業大學
學術合作專題研究計畫成果發表

FFA-Net: Fast Frequency-Aware LiDAR Point Cloud Compression for Machine Vision

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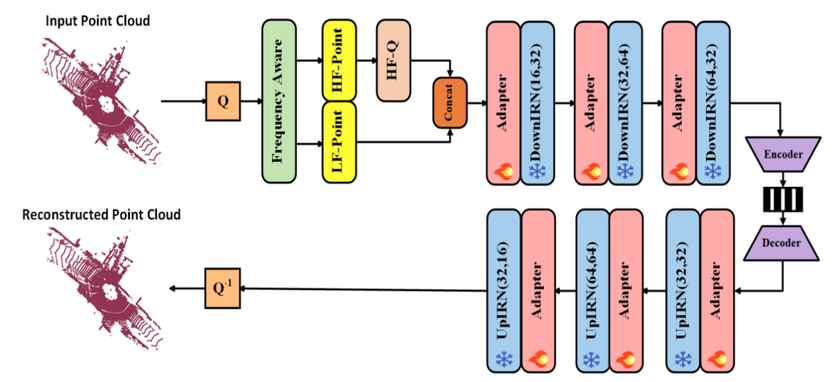
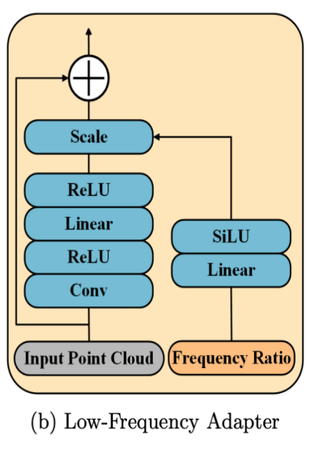
Abstract:

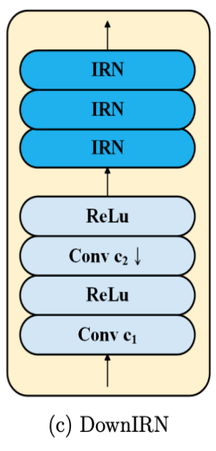
Efficient point cloud compression is essential for applications such as autonomous driving and robotic vision navigation. Recently, point cloud data has received significant attention in machine vision tasks that rely on accurate geometric representations. However, most existing point cloud compression methods are designed for human visual perception rather than specifically for machine vision tasks, and their decoding processes are often computationally expensive, limiting applicability in fast-processing scenarios. To better support machine vision tasks that depend on global geometric structure, we propose a Fast FrequencyAware Network (FFA-Net) for point cloud compression, with large-scale 3 object detection serving as a representative evaluation scenario. We observe that high-frequency components are less critical than low-frequency components for preserving global shape information in geometry-driven perception tasks, which typically rely on stable structural cues rather than fine-grained local details. Based on this observation, FFA-Net employs graph filtering to separate point clouds into high-frequency and low-frequency components. It then applies an adaptive quantization strategy, using a larger step size for high-frequency points and a finer step size for low-frequency points to preserve structural details. Furthermore, a lightweight adapter is introduced to adaptively adjust the high-to-low frequency ratio and enhance low-frequency representations. Experimental results demonstrate that the proposed method effectively preserves task-relevant geometric structures that are fundamental to geometry-driven machine vision tasks, while significantly improving processing speed.



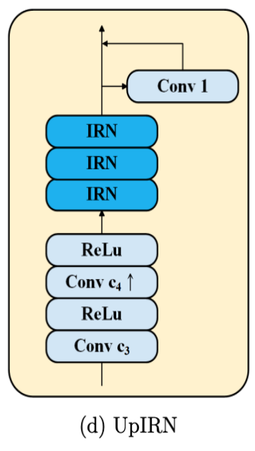
(a) Overall Framework of FFA-Net



(b) Low-Frequency Adapter

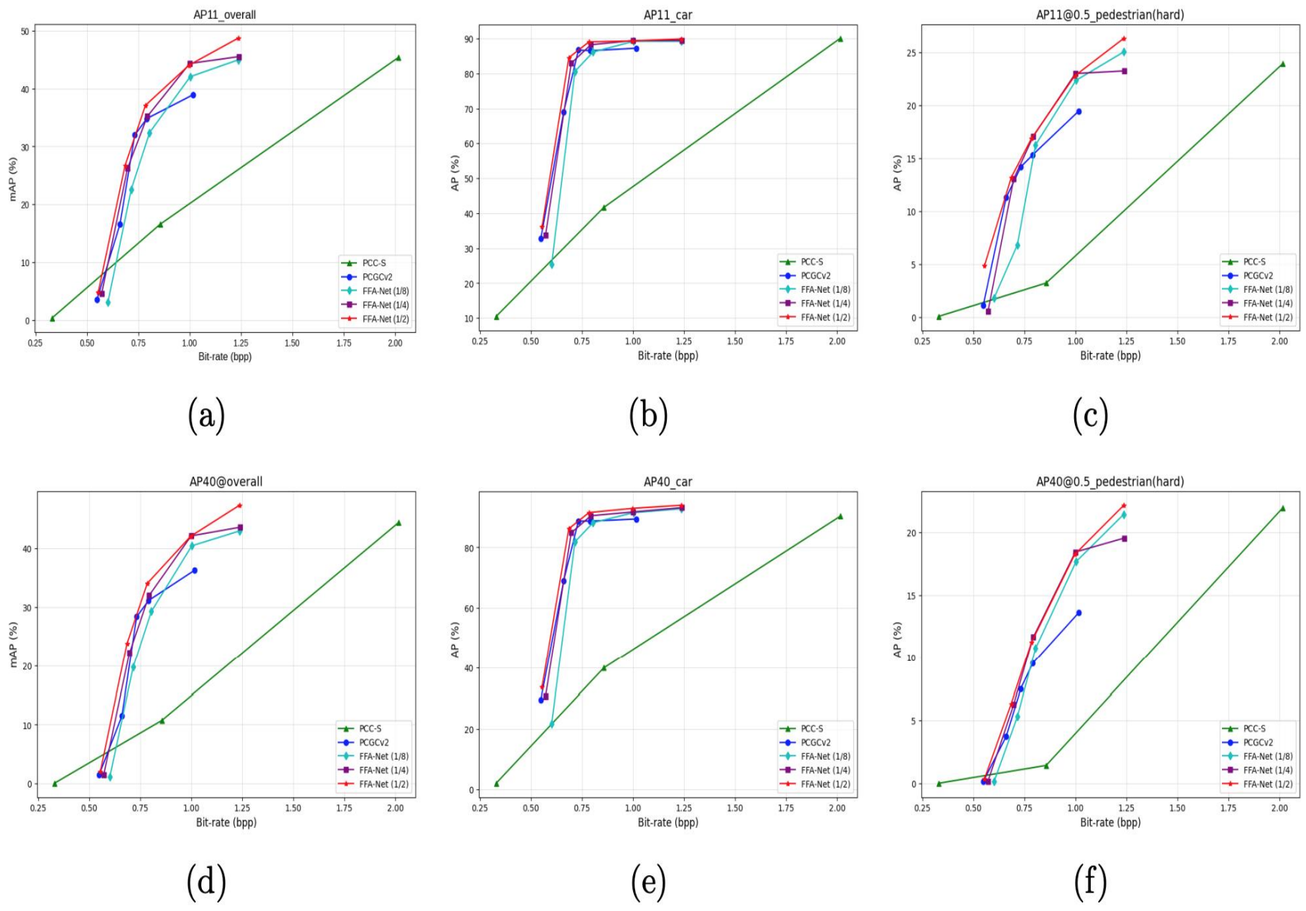


(c) DownIRN



(d) UpIRN

Proposed method



(a) (b) (c)

(d) (e) (f)

Experimental results

Conclusion:

In this work, we have presented FFA-Net, a fast LiDAR point cloud compression framework specifically optimized for machine vision tasks in time-sensitive application scenarios. The key contribution of FFA-Net lies in its frequency-aware design: by applying secondary coarse quantization to high-frequency points—those less critical for downstream perception—it becomes possible to preserve a larger proportion of lowfrequency points at a reduced bit rate, thereby retaining the essential spatial structures required by geometry-driven machine vision algorithms.