Neural Compression of 3D Meshes using Sparse Implicit Representation

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Introduction

Challenges in 3D Mesh Compression: Inefficient data representation

- **Explicit Methods** (e.g., Draco,V-DMC): Struggles with complex topologies due to their unstructured nature, leading to significant geometric distortion at low bitrates.
- **Implicit Methods** (e.g., SDF-based): The $O(N^3)$ cubic complexity makes high-resolution storage and computation prohibitive.

Solution: Sparse Implicit Representation & Compression

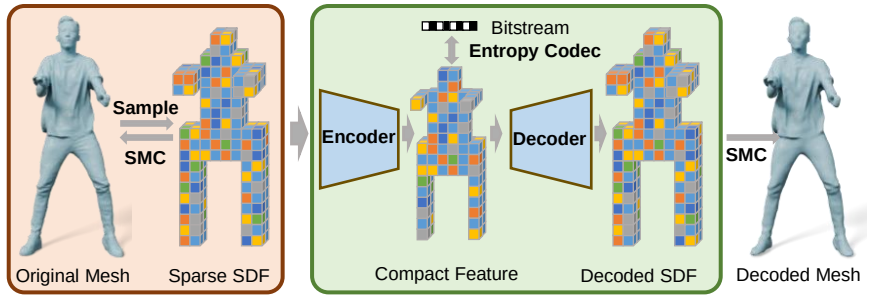
- **Sparse Implicit Representation (SIR):** Records SDF values exclusively on regular grids near the surface; reduces memory growth from $O(N^3)$ to $O(N^2)$.
- **Sparse Neural Compression (SNC):** A lightweight sparse convolutional autoencoder tailored for SIR to extract compact features and encode them into bitstream.

Achievements: SOTA Performance & Efficiency

- **Leading RD-Performance:** Substantial gains over SOTA mesh and point cloud compression frameworks.
- **Fast & Lightweight:** Maintains fast encoding/ decoding with a lightweight model footprint, validated across diverse, complex datasets.

Methodology

System Overview



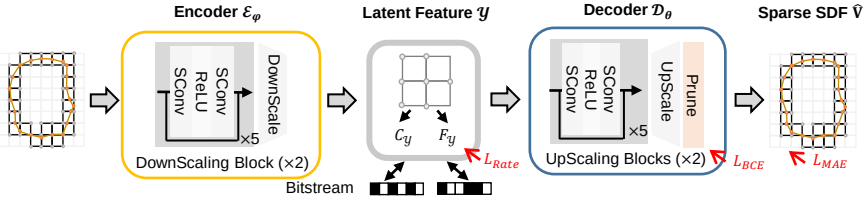
Sparse Implicit Representation **Sparse Neural Compression**

Sparse Implicit Representation

- **Sparse SDF Tensor:** Discretizes space into regular grids, retaining only near-surface samples within distance τ.
- **Surface Extraction:** Recovers high-fidelity meshes via Sparse Marching Cube.
- Robustly handles both watertight and non-watertight meshes.

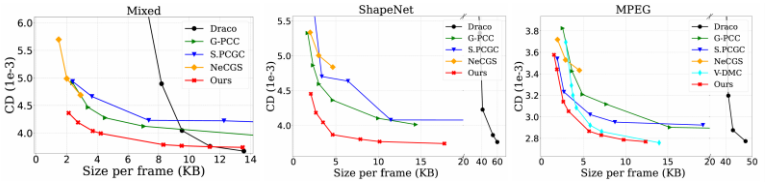
Sparse Neural Compression

- Employs a sparse autoencoder to extract compact latent features, optimized end-to-end for the rate-distortion trade-off.
- Features a lightweight model, enabling efficient encoding and decoding.

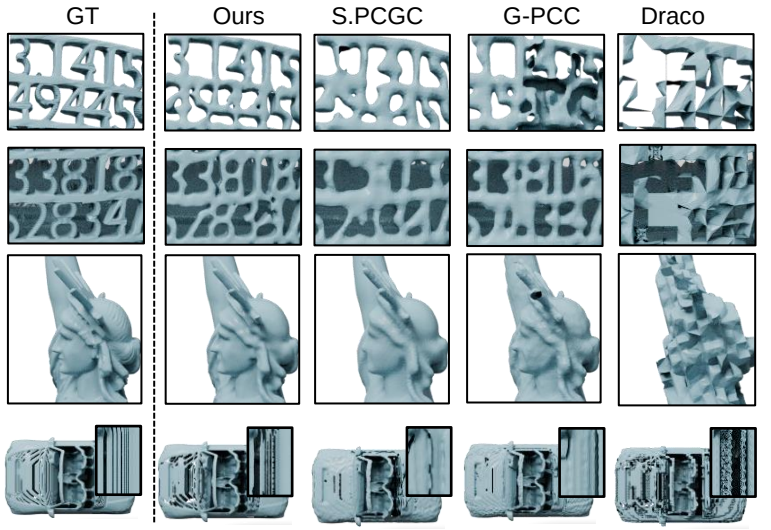


Results

Rate-Distortion Comparison



Visual Comparison



Computational Complexity

Complexity		G-PCC	S.PCGC	Draco	V-DMC	NeCGS	Ours
Time (s)	Pre-Enc.	0.53	0.53	-	-	20	**0.40**
	Enc.	1.64	0.40	0.22	3.42	60	**0.10**
	Dec.	0.26	0.68	0.19	0.42	0.11	**0.10**
	Post-Dec.	5.54	5.22	-	-	0.15	**0.02**
Model Size (MB)		-	6.63	-	-	0.77	**0.42**