Point Cloud Upsampling Using Frequency Models

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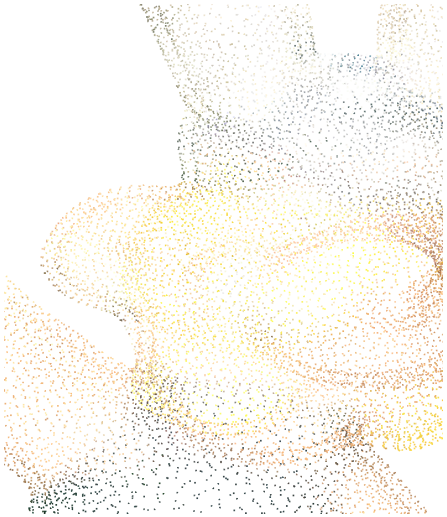
Virtual and Augmented Reality

- Zoom in 3D objects
- Point Cloud Upsampling is necessary

Point Cloud

Point Clouds

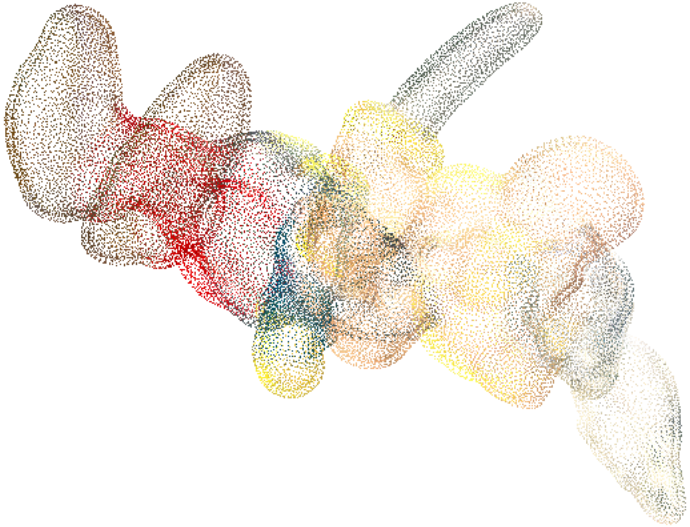


- Single points
  - Geometry (x,y,z)
  - Attribute (RGB)

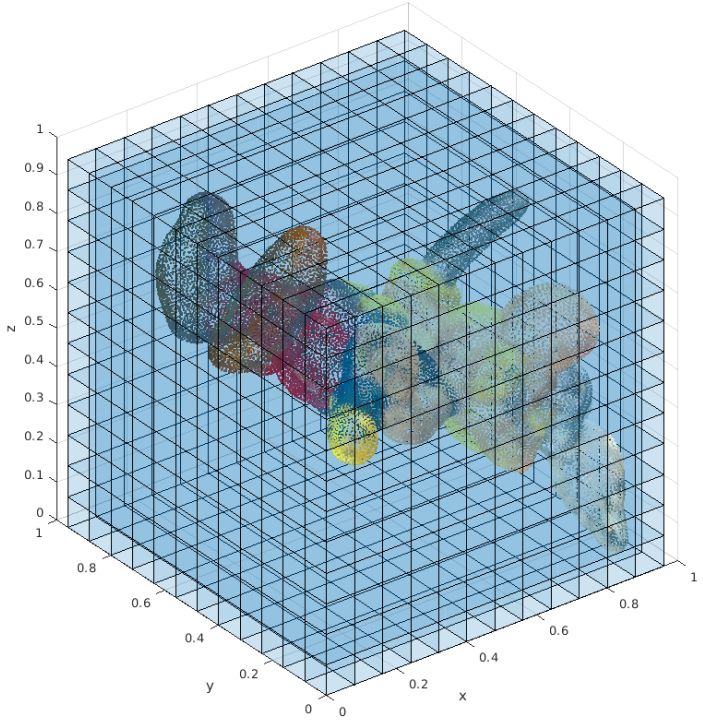
→ Geometry Upsampling

→ Color Upsampling

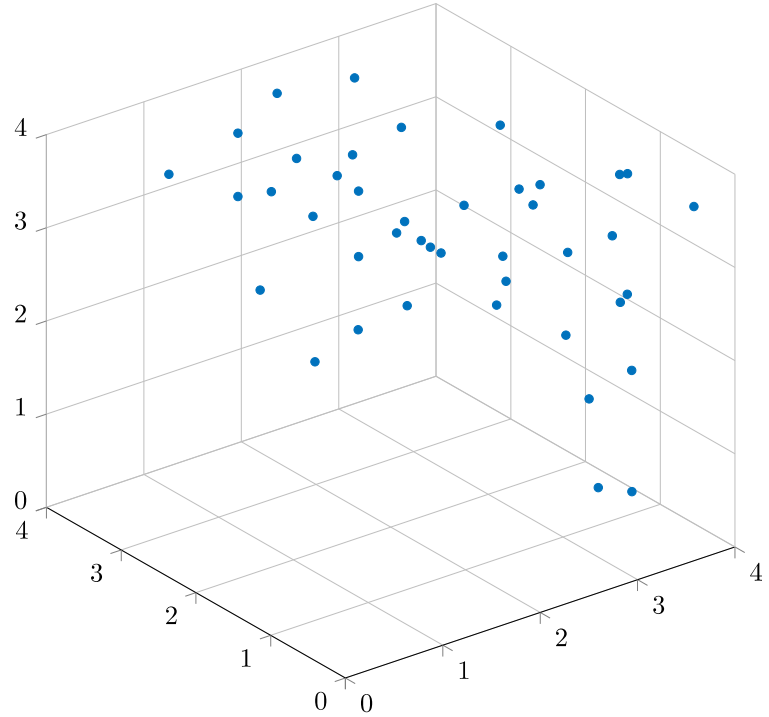
Input Point Cloud



Block Partitioning



Input Block



Geometry

Aim:

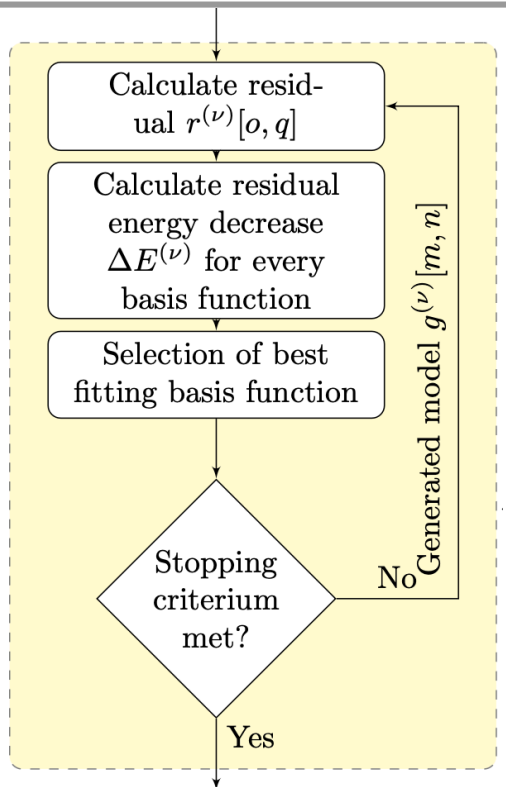
Generate model that estimates the surface of the point cloud

$$q = f[o,p] = \sum_{k,l \in \mathcal{K}} c_{k,l} \varphi_{k,l}[o,p]$$

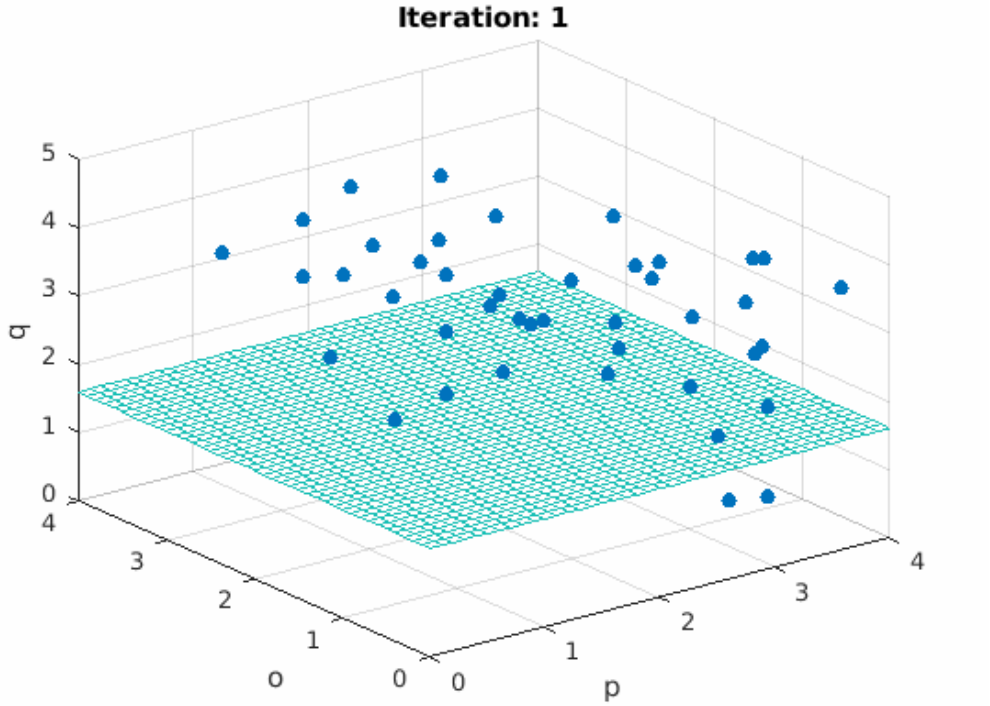
Basis function

Expansion coefficient

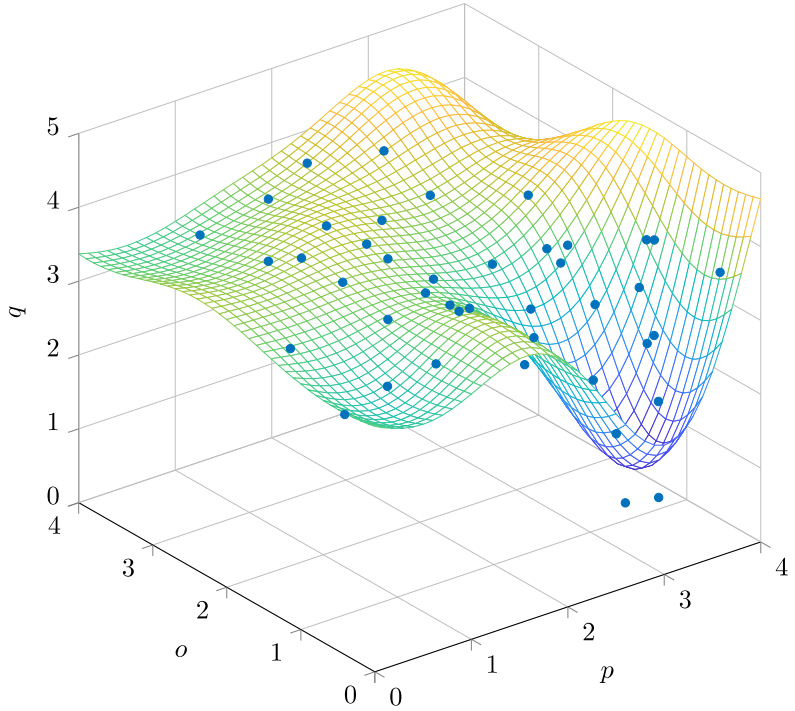
Frequency-Selective Geometry Upsampling



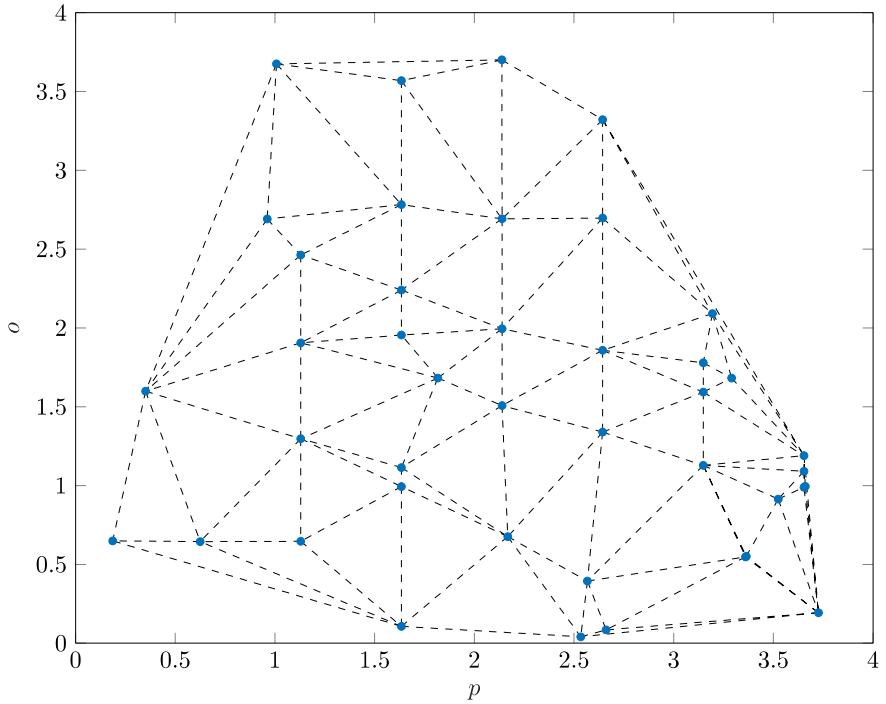
Model Generation



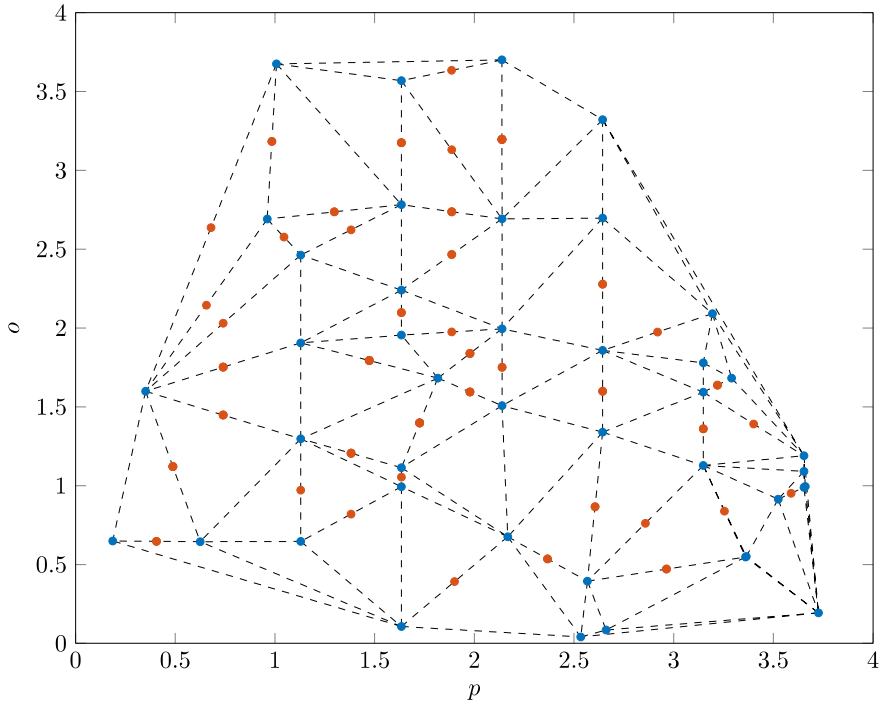
Continuous Model and Input Points



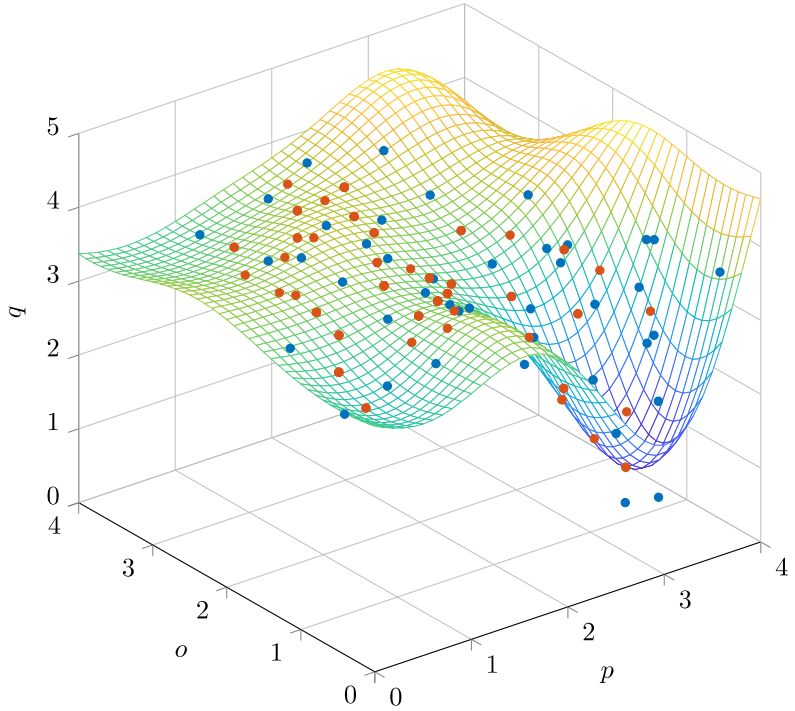
Delaunay Triangulation



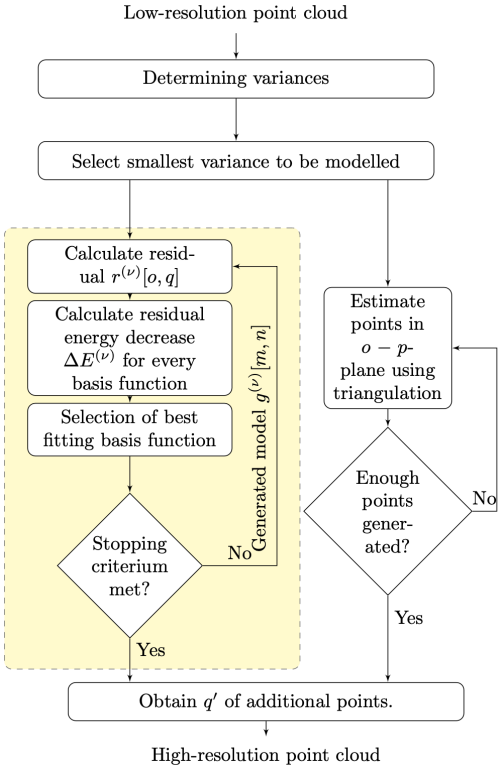
Delaunay Triangulation



Continuous Model with In- and Output Points

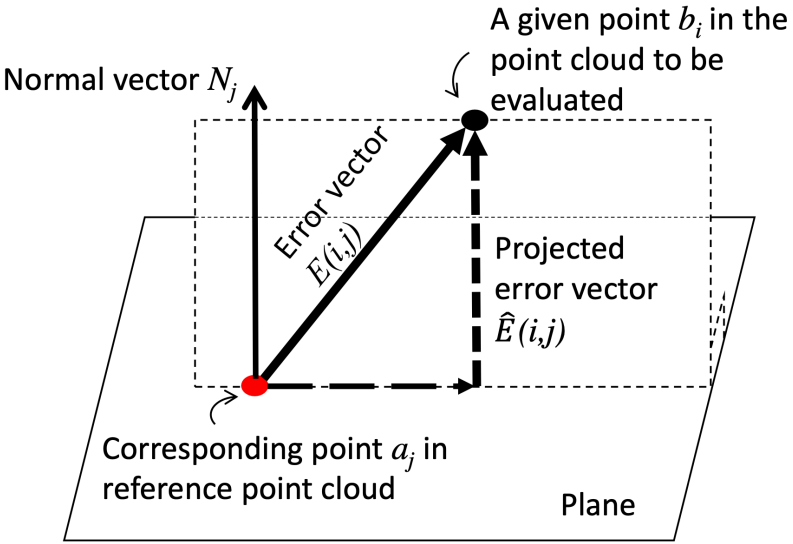


Frequency-Selective Geometry Upsampling



V. Heimann et al., "Frequency-Selective Geometry Upsampling of Point Clouds," accepted for ICIP 2022.

Error Metrics



$$e_{A,B}^{P2Point} = \frac{1}{N_A} \sum_{\forall a_j \in A} \|E(i,j)\|_2^2$$

$$e_{A,B}^{P2Plane} = \frac{1}{N_A} \sum_{\forall a_j \in A} (E(i,j) \cdot N_j)^2$$

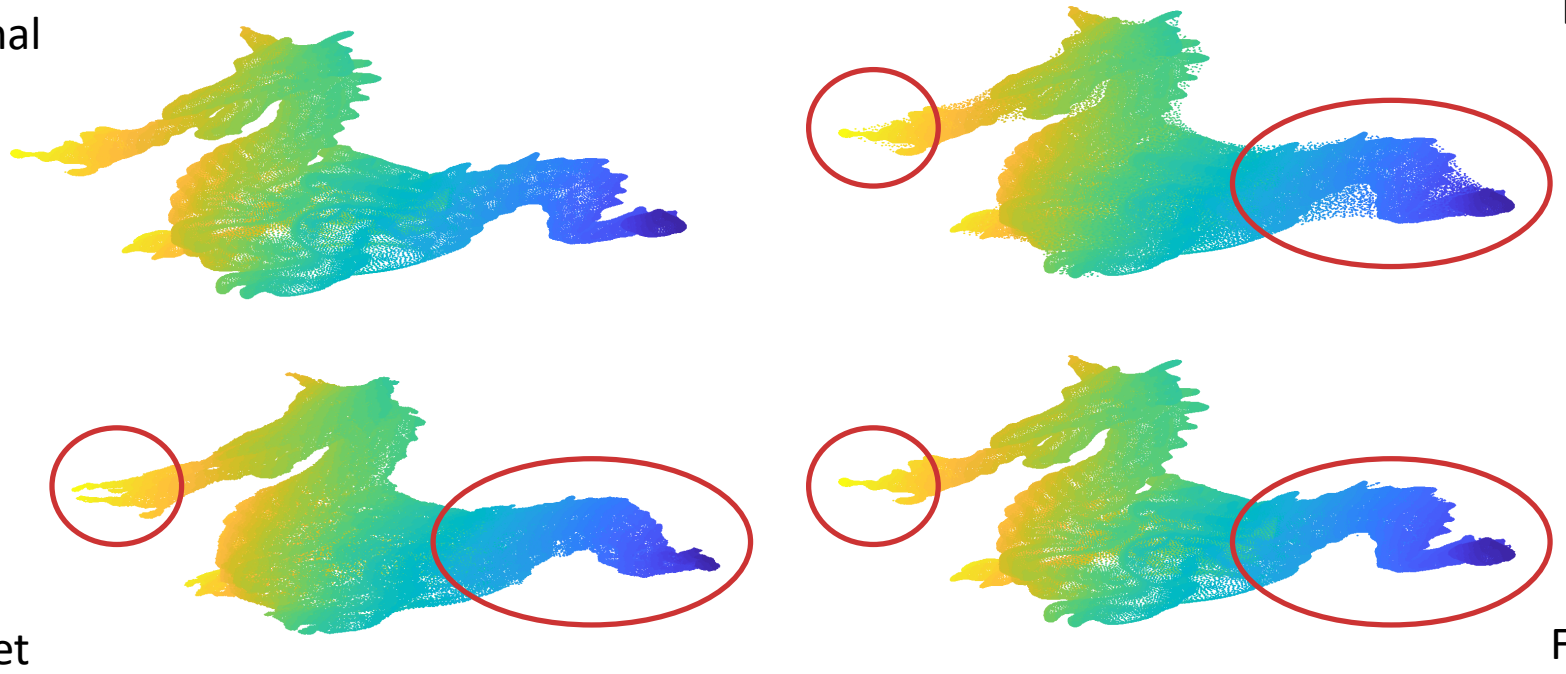
Tian et al., „Geometric distortion metrics for point cloud compression," ICIP 2017.

Results

Scale factor	Metric	Method	Dragon	Duck	Jaguar	Rabbit	camel	elephant	kitten	star	9	21	45	76	Avg
2	P2Point $\times 10^{-3}$	EAR [1]	11.3	9.5	14.4	29.6	13.6	8.7	8.3	7.4	7.5	7.4	7.9	7.6	11.1
		PU [2]	13.4	12.7	12.4	9.0	15.3	17.1	18.0	22.4	13.3	13.6	14.0	13.0	14.5
		FSGU (Ours)	**1.9**	**3.8**	**1.5**	**2.9**	**3.5**	**3.6**	**3.6**	**3.8**	**3.1**	**2.5**	**3.3**	**2.6**	**3.0**
	P2Plane $\times 10^{-3}$	EAR [1]	5.0	4.3	6.6	9.2	2.8	2.0	1.7	0.7	3.0	3.6	3.5	4.0	3.9
		PU [2]	11.3	8.3	10.1	7.3	7.5	8.6	7.0	7.6	7.1	8.9	9.4	8.6	8.5
		FSGU (Ours)	**0.5**	**0.6**	**0.4**	**1.3**	**0.5**	**0.5**	**0.4**	**0.5**	**0.5**	**0.5**	**0.6**	**0.4**	**0.6**
4	P2Point $\times 10^{-3}$	EAR [1]	27.8	12.7	16.6	12.1	17.9	20.6	16.4	15.2	18.9	14.6	14.0	14.3	16.8
		PU [2]	11.7	11.4	11.4	8.7	16.6	16.6	16.7	16.6	12.9	12.9	14.0	12.6	13.5
		FSGU (Ours)	**1.5**	**3.5**	**1.2**	**2.8**	**3.4**	**3.5**	**3.8**	**4.0**	**3.7**	**3.0**	**4.1**	**3.0**	**3.1**
	P2Plane $\times 10^{-3}$	EAR [1]	9.0	5.0	6.6	3.7	4.0	5.4	4.5	4.5	6.3	5.4	4.9	5.8	5.4
		PU [2]	6.0	6.3	6.5	4.5	6.4	6.8	7.2	7.3	5.8	6.1	6.4	7.2	6.4
		FSGU (Ours)	**0.4**	**0.4**	**0.4**	**1.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.5**	**0.6**	**0.5**	**0.5**	**0.5**

[1] H. Huang et al., "Edge-aware point set resampling," ACM Transactions on Graphics, 2013. [2] L. Yu et al. "PU-Net: Point Cloud Upsampling Network," CVPR 2018.
Point Clouds taken from: Nouri et al., "Technical report : Greyc 3D colored mesh database," 2017., [2], and Z.Lian et al., "SHREC'11 track: shape retrieval on non-rigid 3d watertight meshes," 2011
Metric taken from Tian et al., „Geometric distortion metrics for point cloud compression," ICIP 2017.

Visual Results – Dragon



Conclusion

Frequency-selective model estimation

- *uses*
  - Expansion coefficients
  - Basis functions
- *works*
  - Block-based
  - Iteratively
- *is successfully applied to*
  - Geometry Upsampling