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SQuadGen: Generating Simple Quad Layouts via Chart Distance Fields

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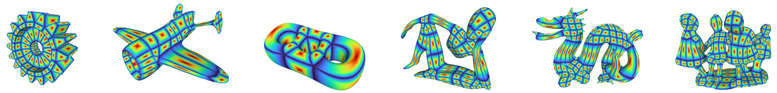
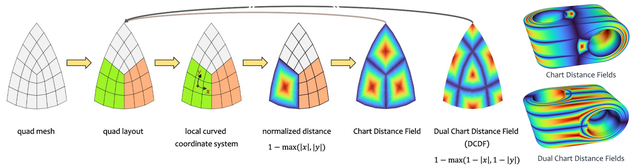


Contributions

- **Representation: Chart Distance Field —** easy-to-learn continuous fields for quad layout generation
- **Loop Simplicity**: Loop-editing-aware metric
- **Dataset — 230k simple quad layouts**: diverse, large-scale, high loop simplicity scores.
- **SQuadGen**: Diffusion model to generate CDFs and yield simple quad layouts.

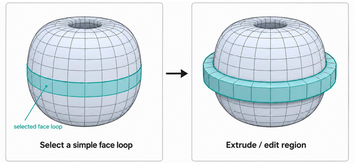
Representation: Chart Distance Fields

- Quad Layouts <==> Continuous Scale Fields over surfaces.
- Distance field defined on each chart
- L_∞ distance → CDF, and its dual field → DCDF.
- CDF/DCDF are easy-to-learn and recover the quad layout easily.



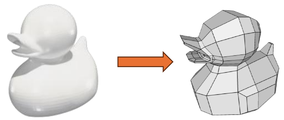
Motivation

- What kind of Mesh Layouts are preferred by 3D artists? How do they model and edit meshes?
  - Easily Editable Quad Layout.
  - They rarely move one vertex at a time; instead, they edit with **loops** — edge loops, face loops. edge rings.
- The loop-based editing works best when
  - the layout is **"simple":** 1. loops without spiral/self-crossing. 2. quad(-dominant) mesh layouts.

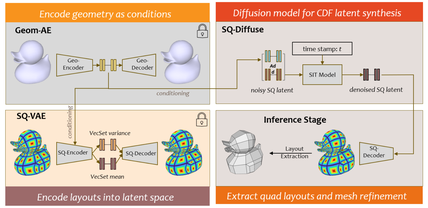


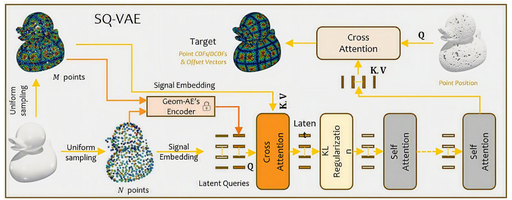
- **Questions**: (1) How to measure loop-aware editability? (2) How to generate the "simple" quad layout?

Framework: SQuadGen



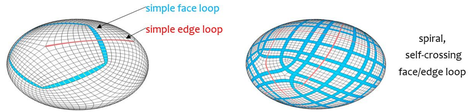
Goal: given 3D surface, generate simple quad layout





Editability Metric: Loop Simplicity

- Common metrics: Fewer charts or fewer irregular vertices.
  - They don't tell if a loop is easily editable.
- Our Metric: **Loop Simplicity** (S_{fl} for face loop, S_{el} for edge loop)
- A loop is **SIMPLE** if no spiral and cross
- **Loop simplicity** of a quad mesh: **area ratio covered/controlled by simple loops.**
- Overall Loop Simplicity of a Quad Mesh: $S_l = \min(S_{fl}, S_{el})$. 1 is the best, 0 is the worst.



$S_{fl} = S_{el} = 1,\ N_c = 60$

spiral, self-crossing face/edge loop

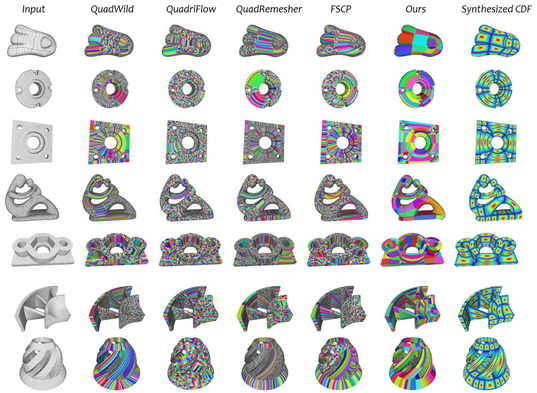
$S_{fl} = 0, S_{el} = 0.093,\ N_c = 436$

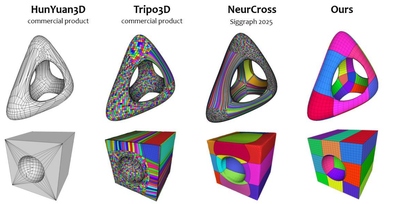
Our Key Insights

- **Learning perspective:** Learn from artist-created quad layouts to match artists' preference
- **Representation Perspective**: Treat layout generation as continuous field synthesis, NOT next token(vertex/face) prediction !
- **Generative Perspective**: Diffusion models excel at smooth signals, generate the field first, then read the quad layout out of it.

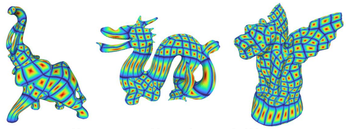
Evaluation

Dataset	Method	↑	S_l ↑	N_c ↓
Part1k *in-domain*	Ground-Truth		1.00	23.33
	QuadriFlow		0.55	1645.69
	QuadWild		0.86	127.21
	QuadRemesher		0.82	558.83
	FSCP		0.79	685.15
	SQuadGen		**0.95**	47.65
ABC1k *out-of-domain*	QuadriFlow		0.26	2468.44
	QuadWild		0.64	5057.44
	QuadRemesher		0.69	2887.89
	FSCP		0.61	4074.68
	SQuadGen		**0.78**	**216.73**
Model300 *stress test*	QuadriFlow		0.14	3106.90
	QuadWild		0.38	9032.79
	QuadRemesher		0.37	7637.73
	FSCP		0.31	6626.65
	SQuadGen		**0.48**	**670.77**





simple layouts with feature preserving



well generalization ability