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Scale-aware shape manipulation

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Key words: Differential coordinates, Scale-invariant measures, Surface deformation

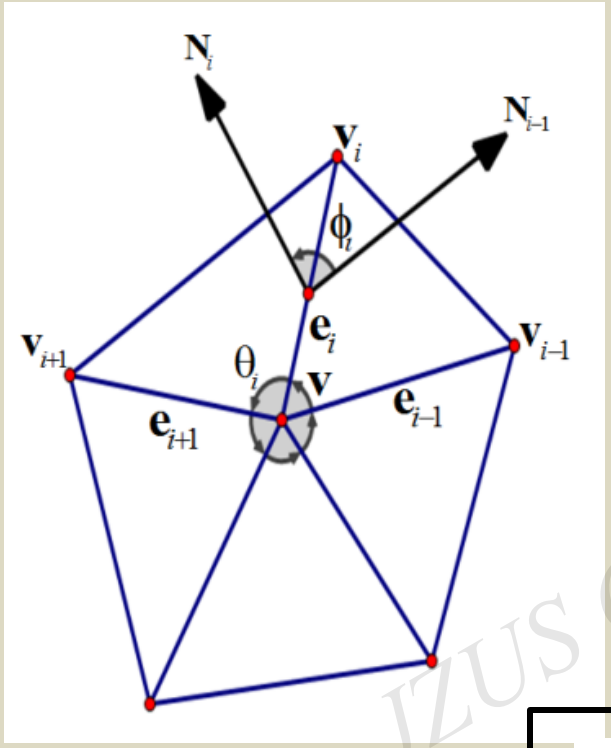
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Introduction

- We propose a novel representation of triangular mesh surface using a set of scale-invariant measures.
- The new measures consist of angles of the triangles (triangle angles) and dihedral angles along the edges (edge angles) which are scale and rigidity independent.
- We can reconstruct the vertex coordinates for a mesh given its scale-invariant measures, unique up to scaling, rotation, and translation.
- Based on the representation of the scale-invariant measures, we propose a two-step iterative deformation algorithm which can arbitrarily edit the mesh through simple handles interaction.

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Design method



Objective Function

$$E(V) = \sum_v \sum_i ((\theta_i^v - \tilde{\theta}_i^v)^2 + (\phi_i^v - \tilde{\phi}_i^v)^2)$$

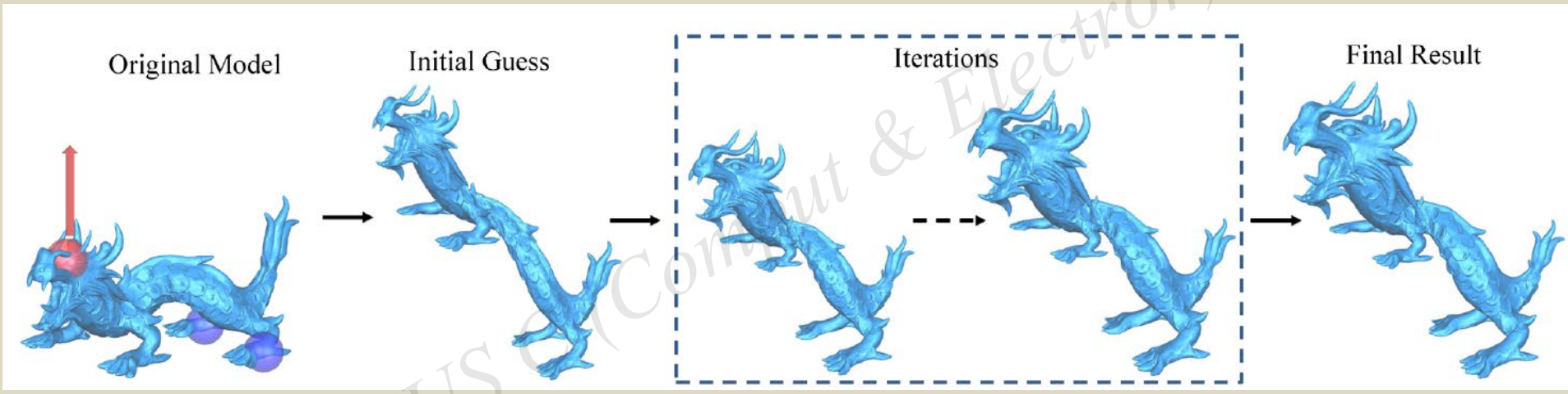
$$s.t \quad \mathrm{V}_i = \mathrm{V}_i^*$$

$$\min_{\mathbf{V}} E(\mathbf{V}) = \|\mathbf{G}(\Theta, \mathcal{N}(\mathbf{V}))\mathbf{V}\|^2 \qquad (6)$$

$$\text{s.t.}\{(4),\ (5)\}$$

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Pipeline



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Algorithm

Algorithm 1 Mesh reconstruction from the scale-aware variables

Require: The scale-aware variables Ω

Ensure: The mesh vertices $\mathbf{V}$

Initialization: Generate an initial guess $\mathbf{V}$.

Repeat until convergence {

Step one:

Repeat until convergence {

$\mathcal{N} \longleftarrow \mathbf{V}$;

Update $\mathcal{N}$ under constraints (4) (Section 4.2) }

Step two:

$\mathbf{V} \longleftarrow$ Solve (3) under constraints (5) (Section 4.3) }

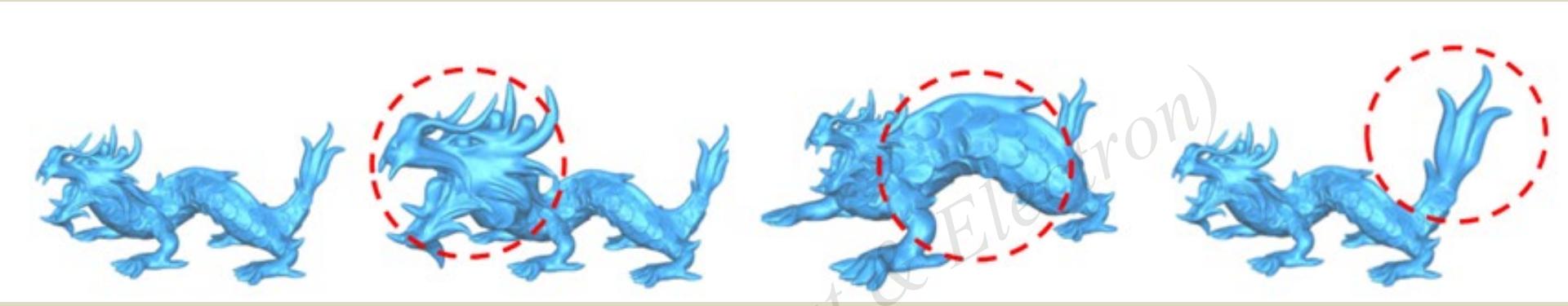
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Model statistic and performance

Model	n	Runtime(s)	E_θ	E_ϕ
Bumpy plane	40401	76	0.021	0.113
Cylinder	4802	8	0.013	0.238
Bar	2602	6	0.086	1.289
Cactus	5261	11	0.036	0.140
Xmas tree	8582	24	0.007	0.048
Dragon	19974	42(a)	0.022(a)	0.113(a)
Dino	5420	13(a)	0.033(a)	0.311(a)
Elder	12500	37(a)	0.004(a)	0.032(a)

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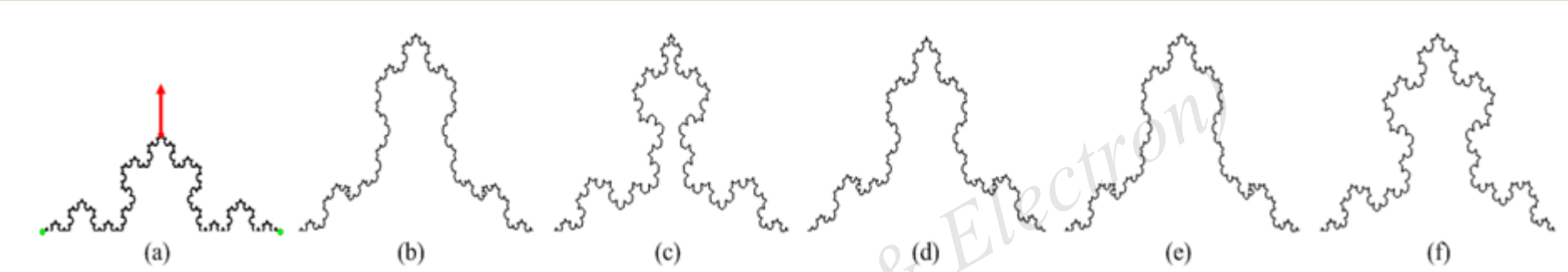
Major results (I)

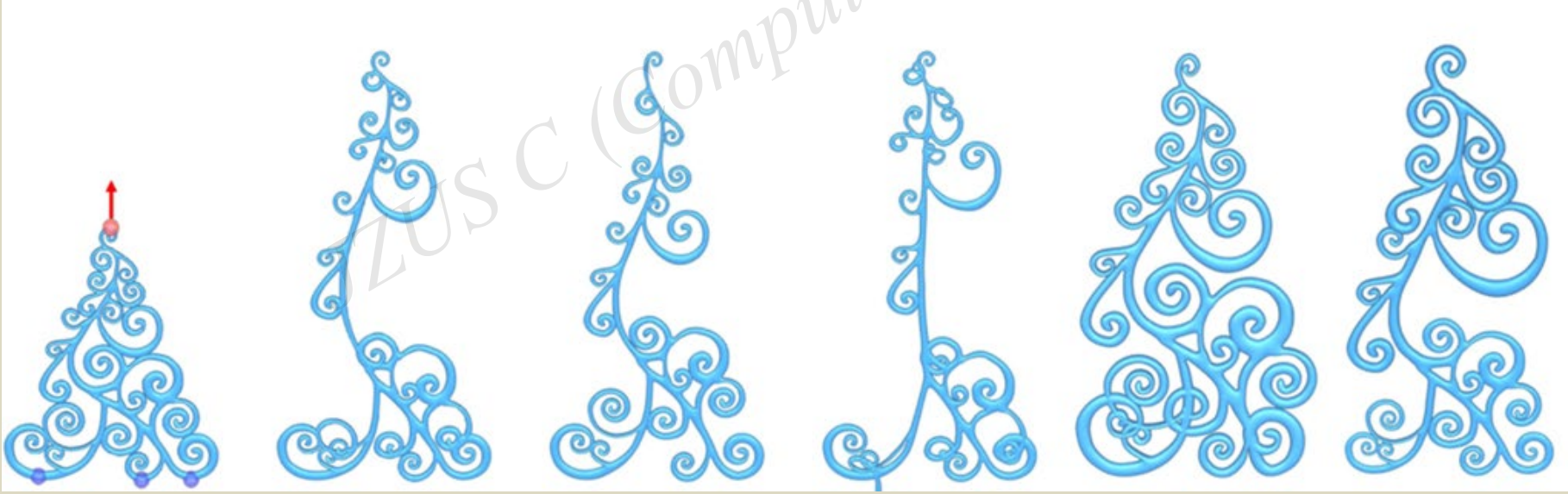




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Major results (II)





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