

Zheng LIU, Wei-ming WANG, Xiu-ping LIU, Li-gang LIU, 2014. Scale-aware shape manipulation. *Journal of Zhejiang University-SCIENCE C (Computers & Electronics)*, **15**(9):764-775. [doi:[10.1631/jzus.C1400122](https://doi.org/10.1631/jzus.C1400122)]

# Scale-aware shape manipulation

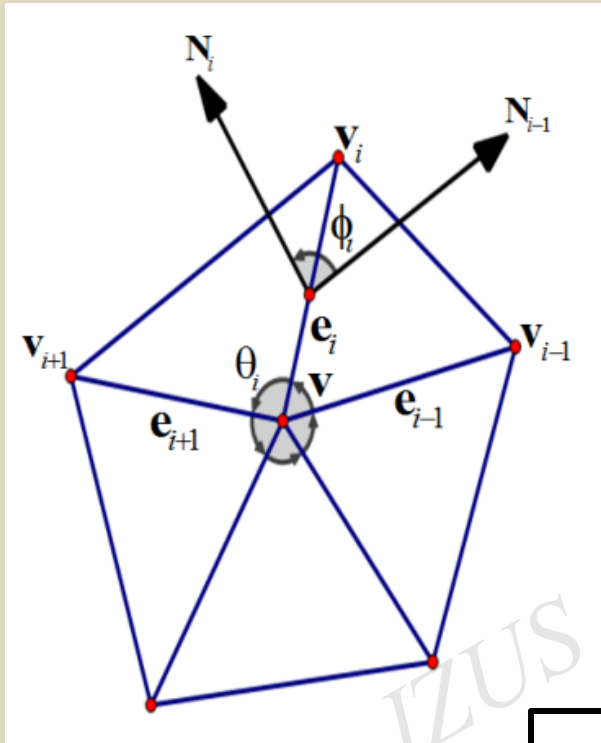
**Key words:** Differential coordinates, Scale-invariant measures, Surface deformation

Corresponding author: Zheng LIU  
E-mail: liu.zheng.jojo@gmail.com

# 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.

# Design method



*Objective Function*

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

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

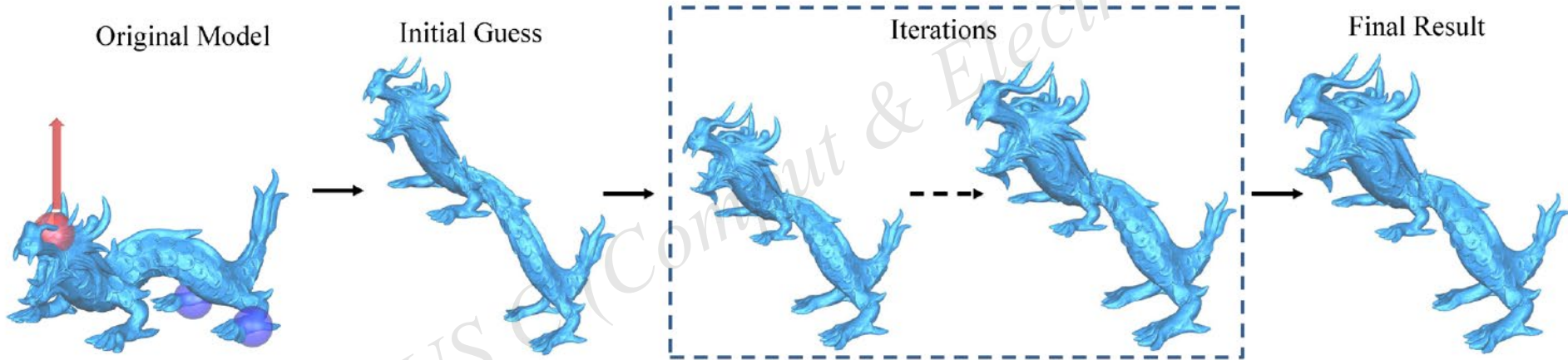


$$\min_{\mathbf{V}} E(\mathbf{V}) = \|\mathbf{G}(\Theta, \mathcal{N}(\mathbf{V}))\mathbf{V}\|^2$$

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

(6)

# Pipeline



# Algorithm

---

**Algorithm 1** Mesh reconstruction from the scale-aware variables

---

**Require:** The scale-aware variables  $\Omega$

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

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

Repeat until convergence {

**Step one:**

        Repeat until convergence {

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

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

**Step two:**

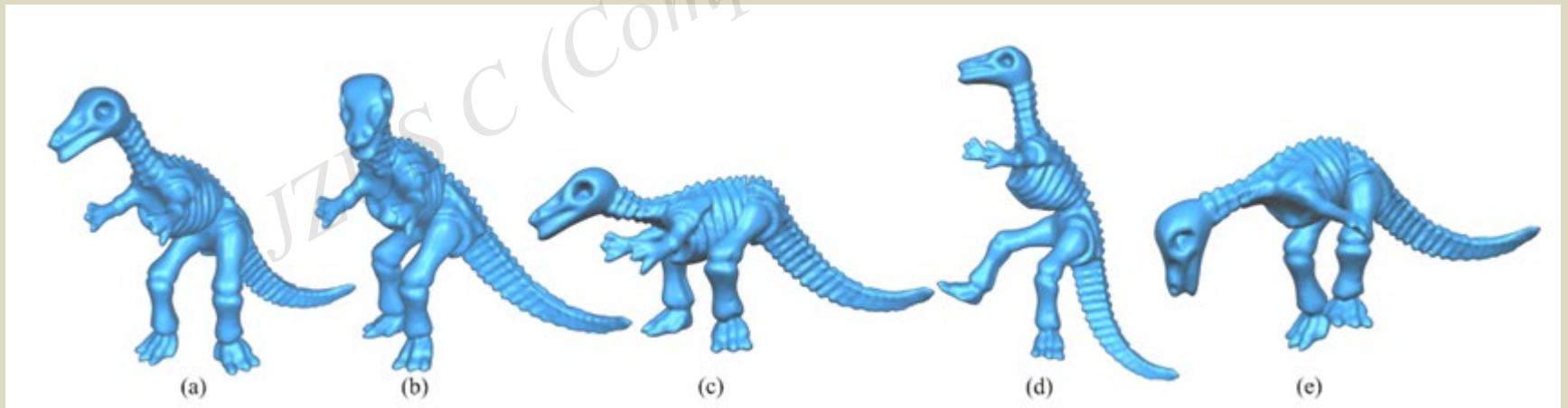
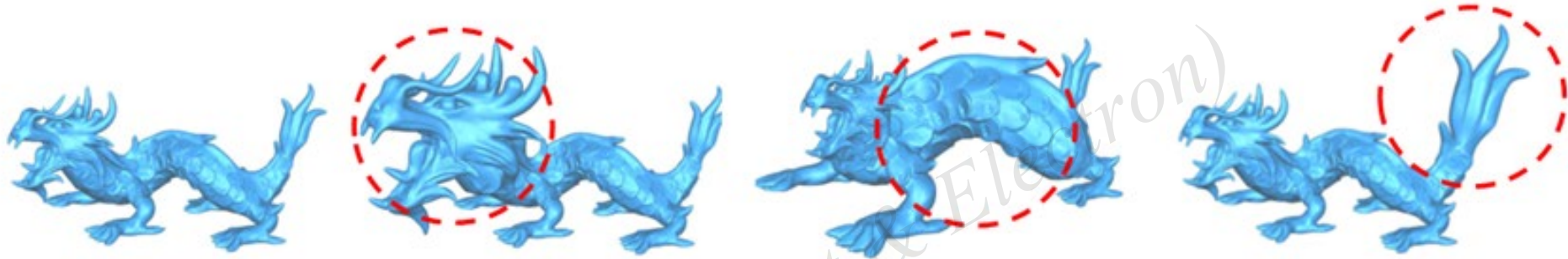
$\mathbf{V} \leftarrow$  Solve (3) under constraints (5) (Section 4.3) }

---

# Model statistic and performance

Model	$n$	Runtime(s)	$E_{\theta}$	$E_{\phi}$
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)

# Major results (I)



# Major results (II)

