

Jie Zhou, Zheng-xing Sun, Ke-wei Yang, 2014. A controllable stitch layout strategy for random needle embroidery. *Journal of Zhejiang University-SCIENCE C (Computers & Electronics)*, 15(9):729-743. [doi:[10.1631/jzus.C1400099](https://doi.org/10.1631/jzus.C1400099)]

# A controllable stitch layout strategy for random needle embroidery

**Key words:** Random needle embroidery, Stitch style, Stitch layout, Stitch neighborhood graph, Reaction diffusion

Corresponding author: Zheng-xing Sun  
E-mail: [szx@nju.edu.cn](mailto:szx@nju.edu.cn)

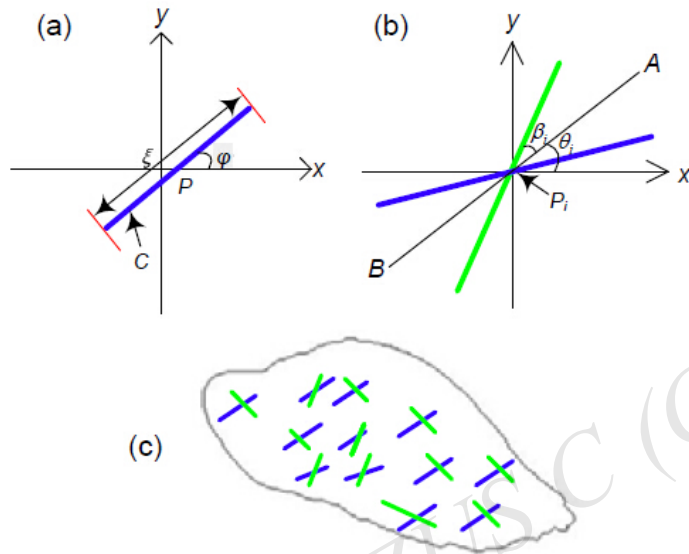
# Motivation

- Random needle embroidery (RNE): an art combining western oil painting theories and Chinese embroidery skills.
- Modelling various stitching styles is the basic and core issue for research on RNE.
- Existing embroidery software tools are not suitable due to the difference in stitching styles.
- Our previous work firstly confirmed the feasibility about its machine embroidery, but did not allow users to conveniently control the global stitch layout style.

# Features of our approach (I)

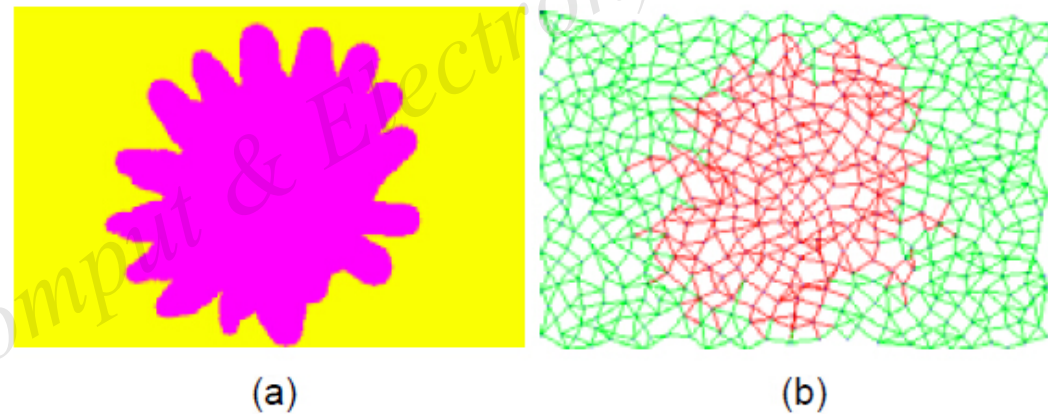
- Stitch layout model

- Stitch neighborhood graph



**Fig. 1** Stitch layout model for the random needle embroidery (RNE)

(a) A stitch with center coordinate  $P$ , length  $\xi$ , orientation  $\varphi$ , and color  $C$ ; (b) An intersecting-stitch with center coordinate  $P_i$ , intersection orientation  $\theta_i$ , and intersection angle  $\beta_i$ ; (c) Global layout of intersecting stitches. Each intersecting-stitch (b) includes two stitches (a). The global layout (c) is a combination of various intersecting-stitches



**Fig. 4** Stitch neighborhood graph

Two graphs (b) are built for two regions (a) separately

# Features of our approach (II)

- Stitch attribute process

Attributes    Diffusion equation & Markov field energy

orientation     $\frac{d\theta}{dt} = R(\theta) + \lambda_\theta D(\theta) + \varepsilon_\theta, E(\theta) = \sum_i \varphi(\theta_i - \theta_i^*) + \lambda_\theta \sum_i \sum_{j \in N(i)} \omega_{ij} \varphi(\theta_i - \theta_j)$

length     $\frac{d\xi}{dt} = (\xi^* - \xi) + \lambda_\xi \sum_n \omega_n (\xi_n - \xi) + \varepsilon_\xi, E(\xi) = \sum_i \|\xi_i - \xi_i^*\|^2 + \lambda_\xi \sum_i \sum_{j \in N(i)} \omega_{ij} \|\xi_i - \xi_j\|^2$

$\frac{dh}{dt} = \sin(h^* - h) + \lambda_h \sum_n \omega_n \sin(h_n - h) + \varepsilon_h, E(h) = \sum_i \varphi(h_i - h_i^*) + \lambda_h \sum_i \sum_{j \in N(i)} \omega_{ij} \varphi(h_i - h_j)$

color     $\frac{ds}{dt} = (s^* - s) + \lambda_s \sum_n \omega_n (s_n - s) + \varepsilon_s, E(s) = \sum_i \|s_i - s_i^*\|^2 + \lambda_s \sum_i \sum_{j \in N(i)} \omega_{ij} \|s_i - s_j\|^2$

$\frac{dv}{dt} = (v^* - v) + \lambda_v \sum_n \omega_n (v_n - v) + \varepsilon_v, E(v) = \sum_i \|v_i - v_i^*\|^2 + \lambda_v \sum_i \sum_{j \in N(i)} \omega_{ij} \|v_i - v_j\|^2$

- Stitch rendering

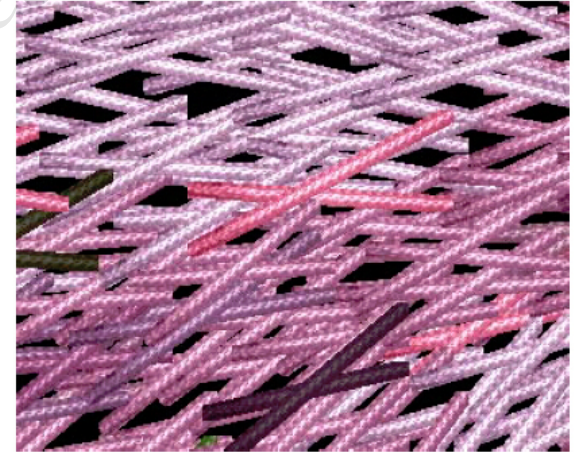


Fig. 7 Stitch rendering detail

# Major results (I)

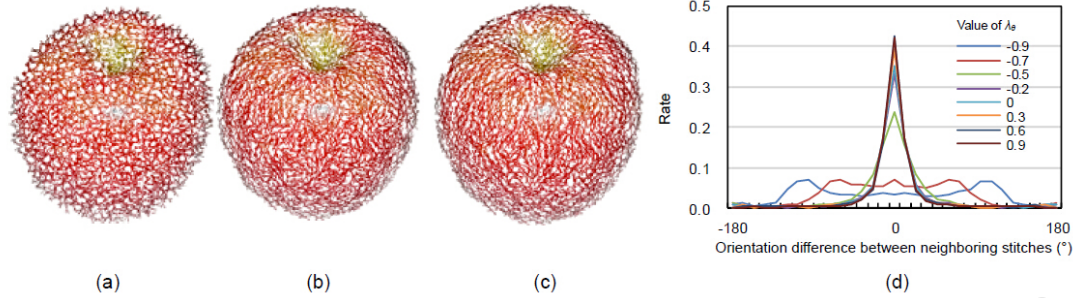


Fig. 12 Effects of  $\lambda_\theta$  on stitch orientation

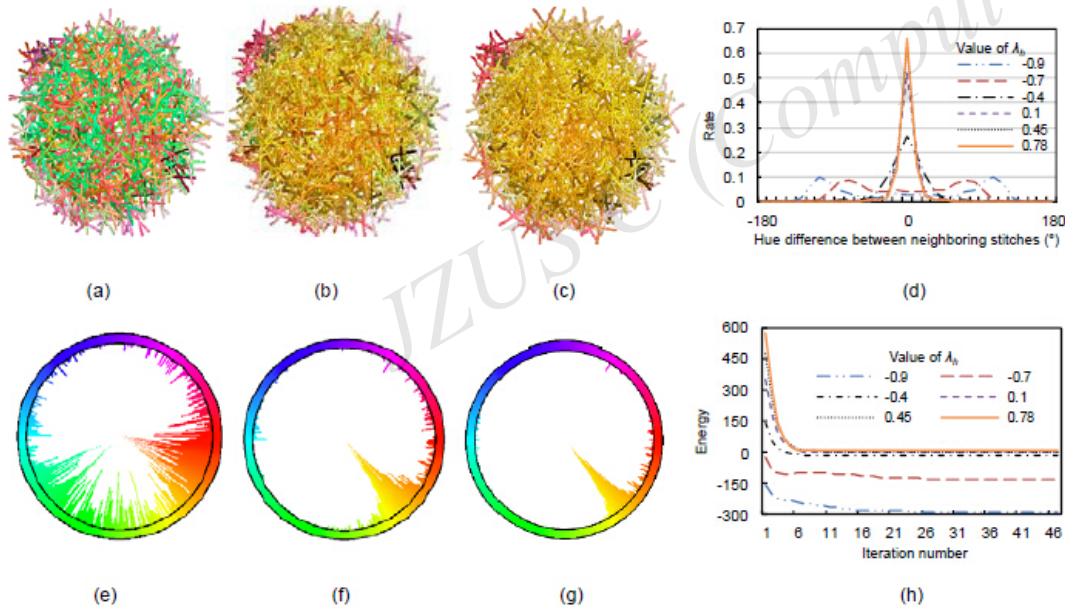


Fig. 14 Effects of  $\lambda_h$  on stitch hue

(a)  $\lambda_h = -0.9$ ; (b)  $\lambda_h = 0.1$ ; (c)  $\lambda_h = 0.78$ ; (d) Histograms of different  $\lambda_h$ 's; (e)  $\lambda_h = -0.9$ ; (f)  $\lambda_h = 0.1$ ; (g)  $\lambda_h = 0.78$ ; (h) Energy iterations of different  $\lambda_h$ 's



Fig. 15 Effects of  $\lambda_s$  on stitch saturation

(a)  $\lambda_s = -0.9$ ; (b)  $\lambda_s = -0.6$ ; (c)  $\lambda_s = 0.35$ ; (d)  $\lambda_s = 0.64$

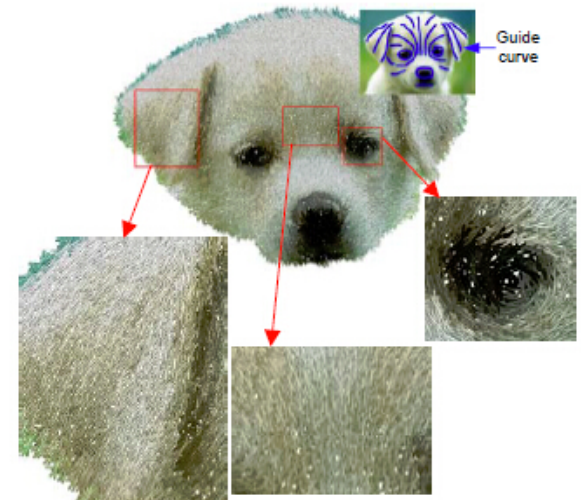


Fig. 18 A user interaction example of guide curves and final results with local details

# Major results (II)

**Table 1** General ranges of five layout parameters for RNE

Object	$\lambda_\theta$	$\lambda_\xi$	$\lambda_h$	$\lambda_s$	$\lambda_v$
Animal	0.16–0.52	–0.12–0.43	0.05–0.90	0.45–0.87	–0.05–0.15
Bird	0.02–0.53	–0.07–0.39	0.1–0.6	–0.03–0.71	0.01–0.15
Grass	–0.85–0.50	0.10–0.86	0.8–0.9	0.50–0.86	0.04–0.50
Flower	–0.9––0.7 or 0.50–0.78	0.40–0.89	–0.87––0.30 or 0.05–0.50	–0.1–0.3	0.10–0.67
Sky	0.8–0.9	–0.83––0.41	0.7–0.9	0.00–0.34	–0.4–0.4

$\lambda_\theta$ ,  $\lambda_\xi$ ,  $\lambda_h$ ,  $\lambda_s$ , and  $\lambda_v$  are diffusion factors for orientation, length, hue, saturation, and lightness, respectively



**Fig. 19** Final results of our proposed approach for RNE works of Apple (a), Flower (b), Bird (c), and Dog (d)

# Conclusions

Our approach has the following features:

- controllability of reflecting various stitch layout styles via high-level layout parameters and the diffusion-based stitch layout process;
- flexibility of user adjustment and interaction.