


Tiled EvoLisa Image Evolution With Blending Triangle Brushstrokes and Gene Compression DE

ALES.ZAMUDA@UM.SI, UROS.MLAKAR@UM.SI

http://labraj.feri.um.si

University of Maribor

Problem & Novelty

EvoLisa challenge: an image is to be approximated using **artistic elements** (such as **brushstrokes**).

New **tiled image evolution approaches**:

→ Following 5 **methods** were developed:

- 0) blending filled triangles and jDE,
- 1) blending filled triangles and canonical DE with $F = 0.5, CR = 0.9$,
- 2) filled triangles without blending, jDE,
- 3) empty triangles without blending, jDE,
- 4) lines between first two encoded points instead of a triangle, jDE.

→These methods are tested on different **classes** of experiments:

- class 1) setting MAXFES to 1e+6 (base class);
- class 2) setting MAXFES to 1e+8 and only running with the best settings $T_{\max}, R_x = R_y$ where a best setting was found at the base class (1) experiment, and also $R_x = R_y = 100$ for that $T_{\max}$; and
- class 3) setting parameter NP initially at 500 and halving it through 4 population reductions, while keeping the rest same as for class 2 (in order to also study the parameter NP).

Method & Contributions

→ Using **differential evolution (DE)** optimization algorithm, a **lossy image representation** with **variable number of brushstrokes** is evolved.

- Several different methods to **represent or combine** a brushstroke on an image canvas,
- including the **control parameters** of the proposed methods.
- An image is **tiled** equidistantly and a **DE is run on each tile separately**.
- The proposed **blending joins multiple brushstrokes** over several pixels,
- while **gene compression** strives to select only the **effective part** of the potential full genome,
- it selects the **rendered codon** with a **limited subset** number of brushstrokes.

→ The difficulty increased significantly exponentially with FES – for all methods, when requiring smaller RN (residual noise) degree to attain.

→ The results show that **different proposed algorithms differ significantly in performance**, but through a prolonged evolution they all obtain evolved images **fairly closely resembling the reference images**, which was not demonstrated yet at any previous EvoLisa experiments (previously, merely down to 5%–10% results were reported).

Tab. 1. Experiments 2, method 0 (ad hoc): final fitness [%].

Baboon (3)	Lena (4)	Plane (5)	Paprica (7)
4.3	**3.46**	**3.18**	**3.58**

References

[1] A. Zamuda, U. Mlakar. Tiled EvoLisa Image Evolution With Blending Triangle Brushstrokes and Gene Compression DE. *IEEE World Congress on Computational Intelligence (IEEE WCCI)*, Vancouver, Canada, 24-29 July 2016.

[2] A. Zamuda and U. Mlakar, "Differential Evolution Control Parameters Study for Self-Adaptive Triangular Brushstrokes," *Informatica - An International Journal of Computing and Informatics*, vol. 39, pp. 105–113, 2015.

Results

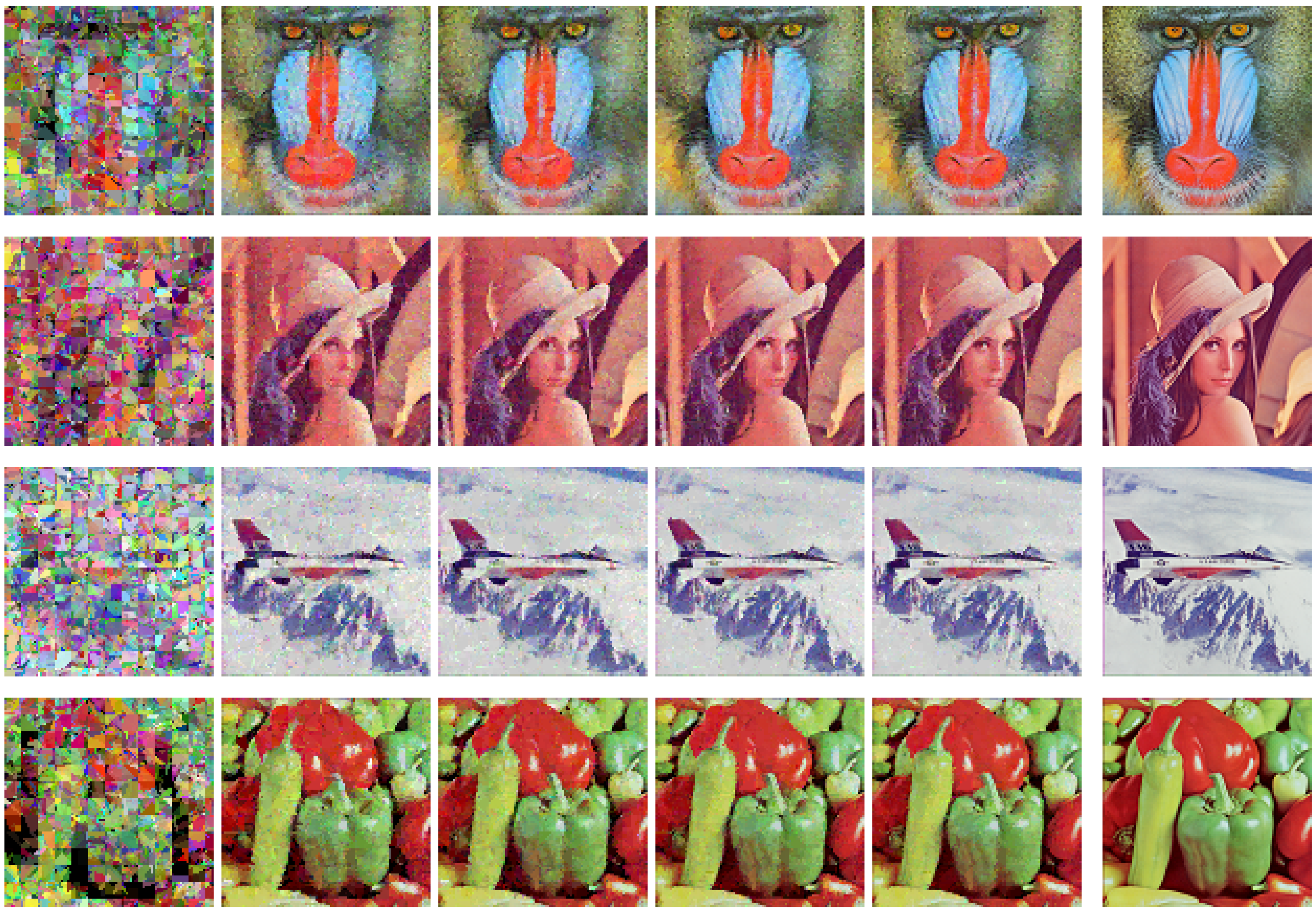


Fig. 1. The evolved and the reference images.

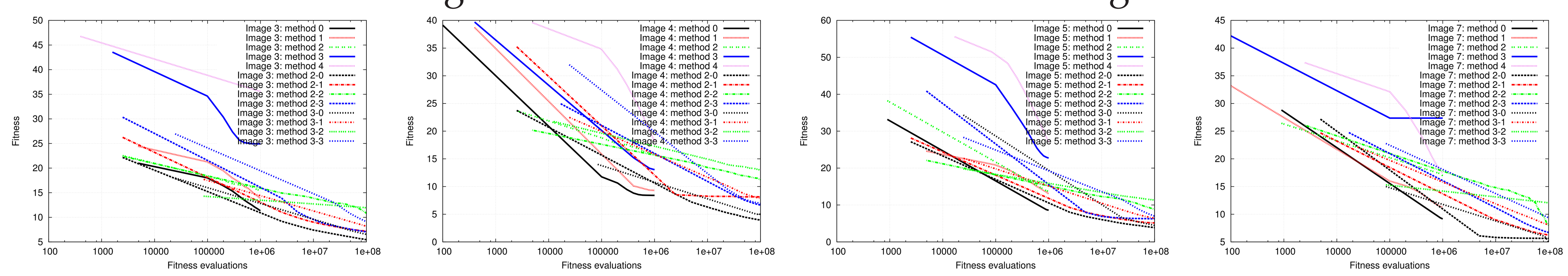


Fig. 2. Combined convergences on test images for different algorithms, aligned on FES.

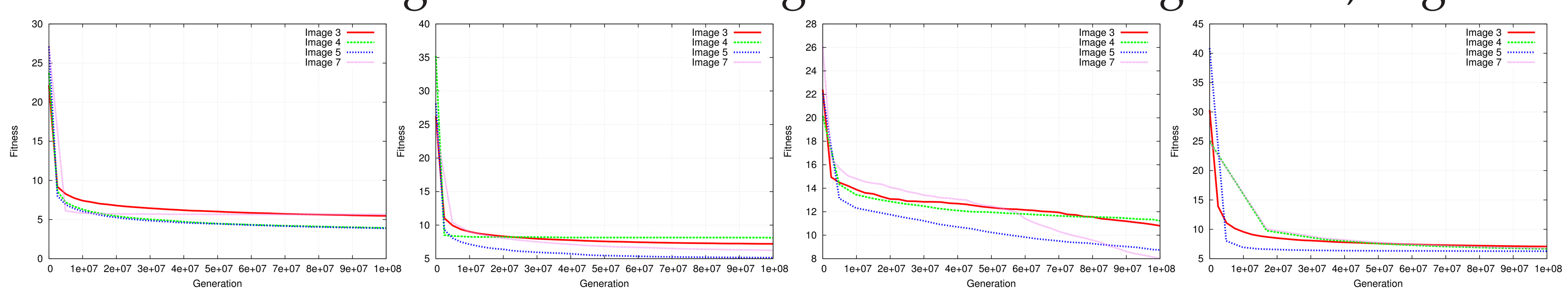


Fig. 3. Convergences on test images for different methods (experiments class 2).

Background – Differential Evolution (DE)

Three DE operators:
– mutation (Eq. (1)),
– crossover (Eq. (2)),
– selection (Eq. (3)).
Add-ons: jDE (self-adaptation).

$$\mathbf{v}_{i,g+1} = \mathbf{x}_{r_1,g} + F(\mathbf{x}_{r_2,g} - \mathbf{x}_{r_3,g}), \quad (1)$$

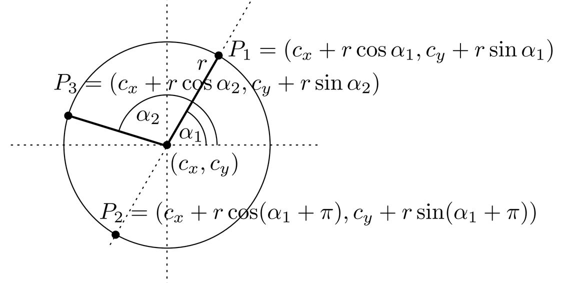
$$u_{i,j,g+1} = \begin{cases} v_{i,j,g+1}, & \text{if } rand(0,1) \leq CR \text{ or } j = j_{\text{rand}}, \\ x_{i,j,g} & \text{otherwise,} \end{cases} \quad (2)$$

$$\mathbf{x}_{i,g+1} = \begin{cases} \mathbf{u}_{i,g+1} & \text{if } f(\mathbf{u}_{i,g+1}) < f(\mathbf{x}_{i,g}), \\ \mathbf{x}_{i,g} & \text{otherwise.} \end{cases} \quad (3)$$

Encoding & Fitness Function

Gene compression: variable T_i (Eq. (4)).

$$T_i = \begin{cases} T_i^{\text{U}} - T_i^{\text{L}} + 1 & \text{if } T_i^{\text{L}} < T_i^{\text{U}} \\ (T^{\max} - T_i^{\text{L}}) + T_i^{\text{U}} & \text{otherwise.} \end{cases} \quad (4)$$



$$P_{1,k} = (\lfloor c_{x,k} + r_k \cos \alpha_{1,k} \rfloor, \lfloor c_{y,k} + r_k \sin \alpha_{1,k} \rfloor), \quad (5)$$

$$P_{2,k} = (\lfloor c_{x,k} + r_k \cos(\alpha_{1,k} + \pi) \rfloor, \lfloor c_{y,k} + r_k \sin(\alpha_{1,k} + \pi) \rfloor), \quad (6)$$

$$P_{3,k} = (\lfloor c_{x,k} + r_k \cos \alpha_{2,k} \rfloor, \lfloor c_{y,k} + r_k \sin \alpha_{2,k} \rfloor). \quad (7)$$

Each triangle T_i encoded to 3 points: $P_{1,k}, P_{2,k}, P_{3,k}$.

$$\mathbf{z}_{k,x,y} = \sum_{\mathbf{T}_k \text{ over } (x,y)} \mathbf{b}_{k,x,y} = \sum_{\mathbf{T}_k \text{ over } (x,y)} \left\lfloor b_k \mathbf{b}_{k,x,y}^{\text{RGB}} \right\rfloor, \quad (8)$$

Fitness (Eqs. (8),(9)): blending & reference image comparison.

$$f(\mathbf{Z}) = 100 \times \frac{\sum_{y=0}^{R_y - 1} \sum_{x=0}^{R_x - 1} |\, z_{x,y}^{*\text{R}} - z_{x,y}^{\text{R}} \,| + |\, z_{x,y}^{*\text{G}} - z_{x,y}^{\text{G}} \,| + |\, z_{x,y}^{*\text{B}} - z_{x,y}^{\text{B}} \,|}{3 \times 255 \times R_x R_y}. \quad (9)$$