Fast Superpixel-based Color Transfer

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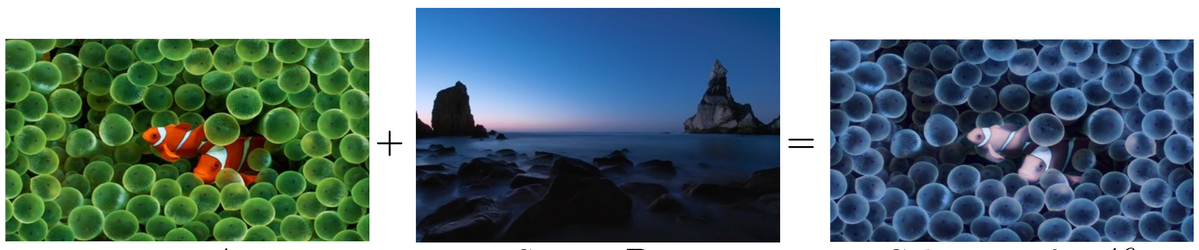
Color Transfer



Target A + Source B = Color transfer A^c

Properties:
- Reduced computational time (HD, video)
- Transfer of the global source color palette
- Respect of the target grain and exposure

- **The Proposed Method: Fast Superpixel-based Color Transfer (SCT)**
  - Decomposition into superpixels [1]
  - Fast superpixel matching, constrained to capture the global color palette
  - Color fusion based on spatial and color similarities

Color Fusion Framework

- **Color Fusion with Non-Local Means Framework [3]:**

  Superpixel $A_i = [X_i, C_i] = [(x_i/N_x, y_i/N_y), (r_i, g_i, b_i)/255]$

  For a pixel $p \in A_i$, contribution of all superpixels A_j matched to $B_{(j)}$ and weighted transfer of average colors $\bar{C}_{B_{(j)}}$,

$$A^c(p) = \frac{\sum_j \omega(p, A_j)\bar{C}_{B_{(j)}}}{\sum_j \omega(p, A_j)}$$

- **Weighting based on Spatial and Color Similarity:**

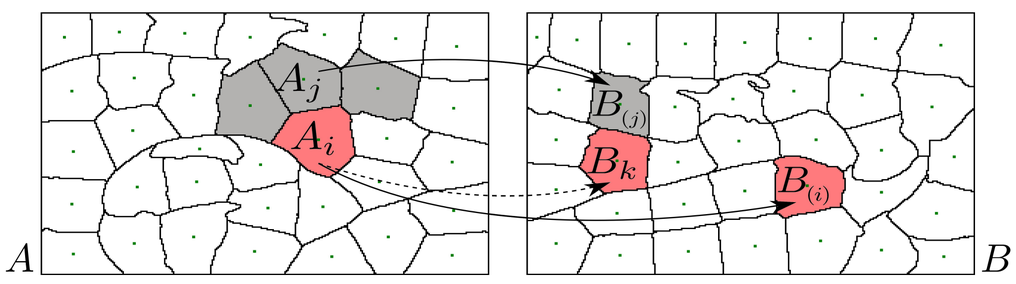
  Distance using covariance information of A_i ,

$$\omega(p, A_j) = \exp\left(-(p - \bar{A}_j)^T Q_i^{-1}(p - \bar{A}_j) + \sigma(p)\right)$$

$$Q_i = Q(A_i) = \begin{pmatrix} \delta_s^2 Cov(X_i) & 0 \\ 0 & \delta_c^2 Cov(C_i) \end{pmatrix}$$

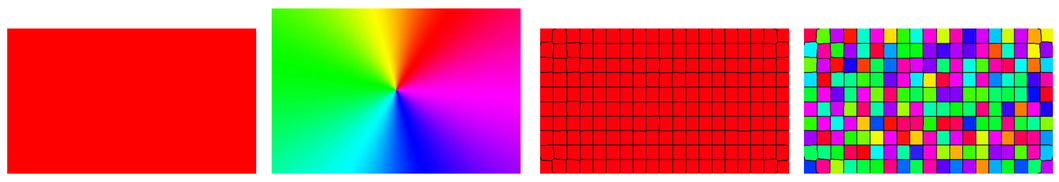
Superpixel Matching

- **SuperPatchMatch [2]:** Finds superpixel approximate nearest neighbor
  - Initialization: A superpixel $A_i \in A$ is assigned to a random one $B_{(i)} \in B$
  - Propagation: Minimization of $D(A_i, B_{(i)})$ using the neighbors's match



Problem: No control on the number of selected superpixels in B

Example: All red superpixels of A match a red one in $B \rightarrow$ no transfer



Target A | Source B | Matched colors no constraint ($\varepsilon = \infty$) | Matched colors constraint ($\varepsilon = 1$)

- **Constraint on Match Diversity:**

Proposition: To ensure the global capture of the source color palette, a superpixel in B cannot be selected more than ε times

What if A_i finds a better match B_k already taken by ε superpixels A_j ?

Switch move: A_i can match B_k by proposing to A_j its current match $B_{(i)}$:

$\forall A_j$ assigned to B_k , $C(A_i, B_k, A_j) = (D(A_i, B_k) - D(A_i, B_{(i)})) + (D(A_j, B_{(i)}) - D(A_j, B_k))$

If $\exists A_j,\ C(A_i, B_k, A_j) < 0$, the global distance can be reduced with

$$\begin{cases} \underset{A_j}{\text{argmin}}(C(A_i, B_k, A_j)) \rightarrow B_{(i)} \\ A_i \rightarrow B_k \end{cases}$$

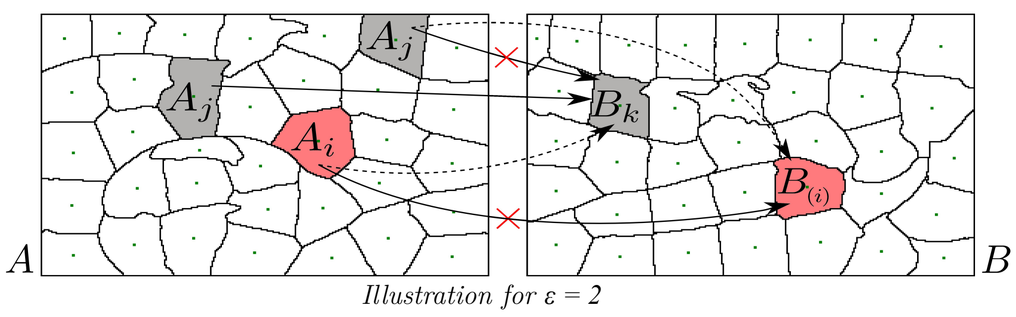
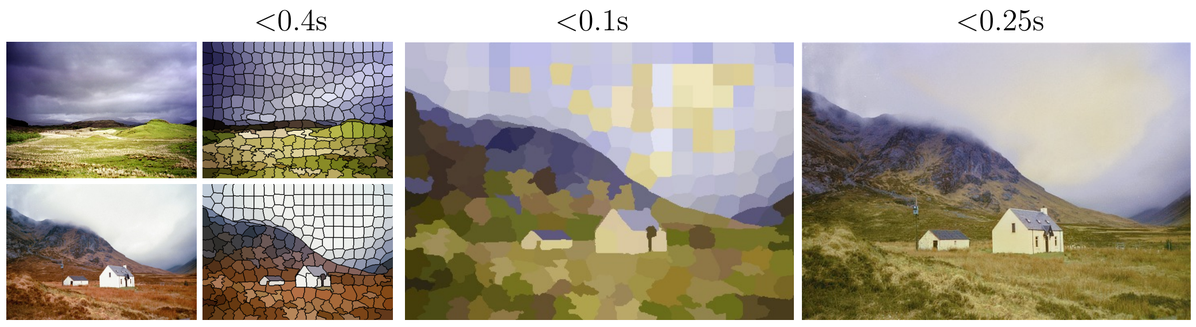


Illustration for $\varepsilon = 2$

Results

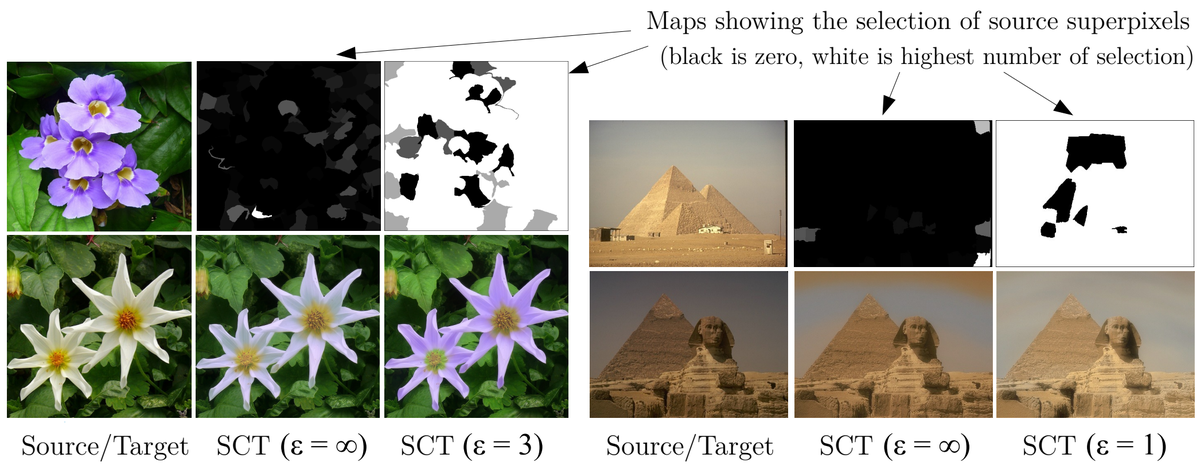
- **SCT pipeline steps:** Total computational time <1s (480×360 pixels)



Source/Target | Superpixels | Matched colors | SCT color fusion result

- **Influence of Match Diversity:**

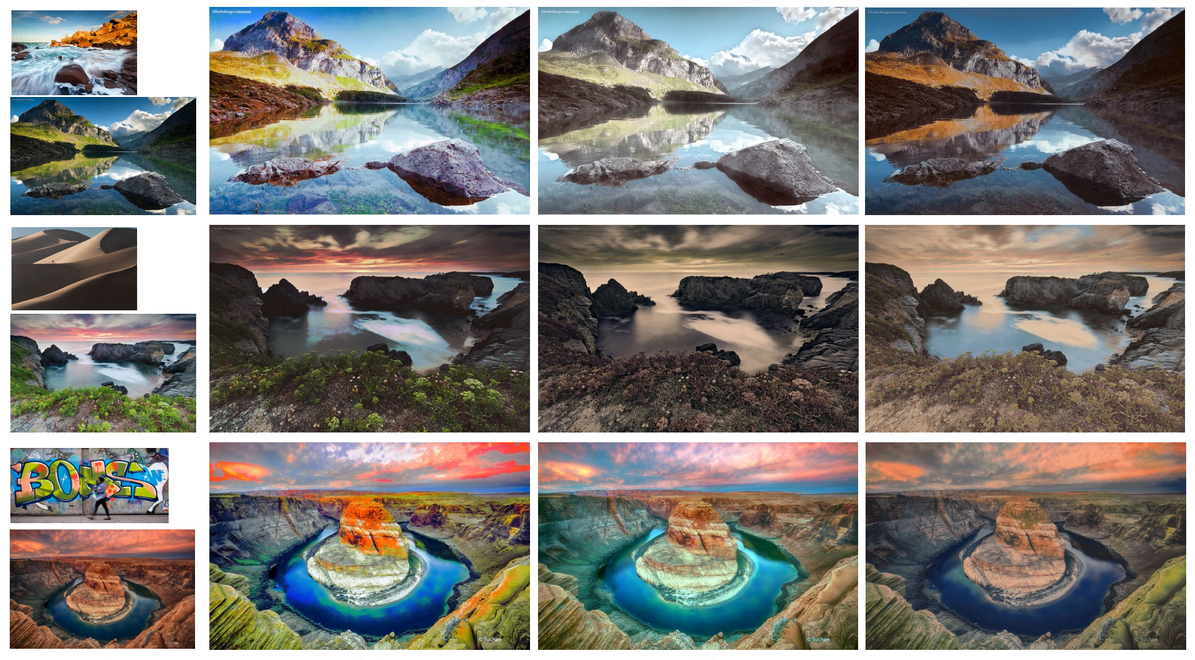
With the proposed constraint, global capture of the source color palette



Source/Target | SCT ($\varepsilon = \infty$) | SCT ($\varepsilon = 3$) | Source/Target | SCT ($\varepsilon = \infty$) | SCT ($\varepsilon = 1$)

- **Comparison to State-of-the-Art Methods:**

Visually competitive results. Respect of the target grain and exposure



Source/Target | [4] | [5] | SCT

[1] R. Giraud, et al. "SCALP: Superpixels with contour adherence using linear path," ICPR, 2016.
[2] R. Giraud, et al. "SuperPatchMatch: An algorithm for robust correspondences of superpixel patches," HAL preprint, 2017.
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[4] N. Papadakis, et al. "A variational model for histogram transfer of color images," TIP, vol. 20, no. 6, pp. 1682–1695, 2011.
[5] R. Nguyen, et al. "Illuminant aware gamut-based color transfer," in Computer Graphics Forum, 2014, vol. 33, pp. 319–328.

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