Fast Superpixel-based Color Transfer

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Color Transfer

Target $A$ + Source $B$ = Color transfer $A'$

Properties:
- Reduced computational time (HD, video)
- Transfer of the global color source 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

Superpixel Matching

- SuperPatchMatch [2]: Finds superpixel approximate nearest neighbor
  - Initialization: A superpixel $A_1 \in A$ is assigned to a random one $B_{(i)} \in B$
  - Propagation: Minimization of $D(A_i, B_{(i)})$ using the neighbor'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

Constraint on Match Diversity:

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

What if $A_j$ finds a better match $B_k$ already taken by $\varepsilon$ 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 $B_k$, $C(A_i, B_k, A_j) = (D(A_i, B_k) - D(A_i, B_{(i)}))$

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

$\arg \min_{A_{(i)}} C(A_i, B_k, A_j) \rightarrow B_{(i)}$

Color Fusion Framework

- Color Fusion with Non-Local Means Framework [3]:
  - Superpixel $A_i = [x_i, C_i]$ = $[(x_i/N_x, y_i/N_y), (r, g, b)]/255$
  - For a pixel $p \in A_i$, contribution of all superpixels $A_j$ matched to $B_{(i)}$ and weighted transfer of average colors $C_{B_{(i)}}$:
    $A'(p) = \sum_{j} \sum_{i} \omega(p, A_i) C_{B_{(i)}}$

- Weighting based on Spatial and Color Similarity:
  - Distance using covariance information of $A_i$:
    $\omega(p, A_i) = \exp \left( -\frac{(p - A_j)^T Q_i^{-1} (p - A_j) + \sigma(p)}\right)$
    $Q_i = Q(A_i) = \left( \begin{array}{cc} \delta_x^2 \text{Cov}(X_i) & 0 \\ 0 & \delta_y^2 \text{Cov}(C_i) \end{array} \right)$

- Results

  - SCT pipeline steps: Total computational time <1s (480x360 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

Maps showing the selection of source superpixels (black is zero, white is highest number of selection)

- Comparison to State-of-the-Art Methods:
  - Visually competitive results. Respect of the target grain and exposure

Source/Target SCT $\varepsilon = \infty$ SCT $\varepsilon = 3$ Source/Target SCT $\varepsilon = \infty$ SCT $\varepsilon = 1$


* This work has been carried out with financial support from the French State, managed by the French National Research Agency (ANR) in the frame of the GOTMI project (ANR-16-CE33-0010-01) and the Investments for the future Program IdEx Bordeaux (ANR-10-IDEX-03-02) with the Cluster of excellence CPU.