Find and Replace Color Gradients

New Interactive Tools for Color and Contrast Adjustment

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Color and Contrast in Art

- The human eye can distinguish about 2.28 million colors.

The Turning Road, 1906
Andre Derain, 1880-1954
Color and Contrast in Art

- Contrast directs attention while color evokes emotion.

“I don’t paint things.
I only paint the difference between things.”
— Henri Matisse (1869–1954)
Color and Contrast in Art

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Color and Contrast Research

Making color and contrast adjustment easier to control.

- **Histogram Warping**: 1D tone transformation.
  - Automatic global color histogram specification for transferring the color scheme of one image to another.
  - Interactive global contrast enhancement by direct manipulation.
  - Interactive local contrast enhancement by contrast brushes.

- **Gamut Warping**: 3D color transformation.
  - Interactive global color and contrast adjustment by finding and replacing color gradients.
Histogram Transformation

- Formulate a global color or gray level mapping function.
Histogram Warping

- Apply a piecewise rational quadratic interpolating spline.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Prevention of False Contour Artifacts</th>
<th>Solution</th>
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</thead>
<tbody>
<tr>
<td>The contrast changes too abruptly.</td>
<td></td>
<td>Apply continuously differentiable splines.</td>
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Histogram Warping

- Apply a piecewise rational quadratic interpolating spline.

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<th>Problem</th>
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<td>The natural order of colors isn't preserved.</td>
<td></td>
<td>Apply monotonic interpolating splines.</td>
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</table>
Color Transfer by Example

- Apply a color space that has perceptually uniform color axes with statistically independent chromatic components.
- Map the quantiles of the color distribution of the source image to the corresponding quantiles of the target image.

Original Input Images
Color Transfer by Example

- Apply a color space that has perceptually uniform color axes with statistically independent chromatic components.

- Map the quantiles of the color distribution of the source image to the corresponding quantiles of the target image.

Output Images with Colors Exchanged
Interactive Contrast Adjustment

- Enable the user to quickly select the key tones of an image and change their contrast without affecting their color.
Contrast Brushes

In collaboration with Rahul Vohra
Interactive Color Adjustment

- Enable the user to control the global color composition by designating a mapping of color gradients.
Find Color Gradient
Replace Color Gradient
Specify Color Gradient

Enable the user to control color independently from contrast.

- **Cartesian Coordinates: A geometric approach.**
  
  Line Segment in Color Space

- **Spherical Coordinates: A perceptual approach.**
Specify Color Gradient

Enable the user to control color independently from contrast.

- **Cartesian Coordinates**: A geometric approach.

  ![Line Segment in Color Space](image)

- **Spherical Coordinates**: A perceptual approach.

  ![Central Midpoint Color](image)  ![Color Contrast Radius](image)  ![Color Orientation Angles](image)
Color Gradient Transformation

- For a color shift, translate the midpoint color.
Color Gradient Transformation

- For a color inversion, reflect the endpoint colors.
Color Gradient Transformation

- For a color contrast change, apply uniform scaling.
Color Gradient Transformation

- For a luminance contrast change, apply nonuniform scaling.
Color Gradient Transformation

- For a luminance variation, rotate the luminance angle.
Color Gradient Transformation

- For a hue variation, rotate the hue angle.
Color Gradient Segmentation

Each color gradient $G_i$ has a region of influence in color space.

- For each pixel, find its nearest gradient color in order to determine its distance $D_i$ from the color gradient in the CIE-Lab color space.

- To assess the perceptual similarity, when comparing categorically different colors, use Shepard’s model of generalization: $S_i = \exp(-D_i/\delta_i)$.
Color Gradient Mapping

Apply a feature-based warping technique to calculate a nonlinear volumetric deformation of the color space.

- For each gradient mapping, use Rodrigues’ formula to derive the linear transformation $P_i$ that maps its source colors to its target colors.
- For each gradient mapping, determine the relative weight of its influence on each pixel: $w_i = S_i / \max(\lambda, \sum S_i)$.
- Determine the portion of the original image $T_0$ that is unaffected by the influence of any of the color gradient mappings: $w_0 = 1 - \sum w_i$.
- The final transformation is the weighted sum: $P = w_0 P_0 + \sum w_i P_i$.
- In effect, the resulting image can be seen as a composite of the original image and its color gradient transformations, with the mask of each layer determined by the region of influence of its color gradient.
- Compared with previous work, our approach benefits from operating on color spans rather than individual colors.
Application: Redecoration

<table>
<thead>
<tr>
<th>Original Treats</th>
<th>Preserve = 4.00</th>
<th>Recolored Treats</th>
<th>Influence = 1.00</th>
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Edit Gradients

LAB
Application: Relighting
Application: Contrast Adjustment

Original Bridge  Preserve = 1.00  Recolored Bridge  Influence = 1.00

Edit Gradients

LAB
Application: Artistic Expression