Example-based Contrast Rendering for Portrait Photograph

Xiaoyan Zhang, Institute for Media Innovation, School of Electrical & Electronic Engineering, NTU

Assoc Prof. Kap Luk Chan, School of Electrical and Electronic Engineering, NTU.

Asst. Prof Martin Constable, School of Art Design and Media, NTU.
Outline

- Motivation & Objective
- Previous Research
- The Proposed Method
- Conclusions
Motivation and Objective

• Portrait: representation of a person to display the likeness, personality and mood.
• The portrait artist is able to **filter** and **manipulate** the subject scene based on the visual perception.
• In snap-shot photographs, the **lightness, color, space, and contrast** of the figure is not in good consideration.

Left: Francisco Goya (1746 - 1828), ‘Portrait of King Ferdinand VIII’ 1803, Right: the portrait divided into clear FG / BG.

• Objective: learn form portrait paintings for captured photographs.
Previous Research

• Portrait rendering
  • The styles are limited to simulate the abstraction, line drawing, brush stroke styles or organic models.


Previous Research

- Relight the face in image rendering


- All the research above focus on the face models
  - However, the composition, shadow, lighting and color organization, contrast also play important roles to enhance the visual impact of the portrait.
The Proposed Method

- Learn the lightness and color contrast organizations in the example portrait painting and transfer these to the photograph.

- The framework of the rendering is...
Depth Segmentation

• Normal vector and depth are used as features to segment the figure/non-figure.

• We consider every $d$ by $d$ square forming one surface plane. The normal vector of the plane is calculated as

$$\vec{N} = \vec{P}_1 \times \vec{P}_2,$$

$$n = \left[ \frac{\vec{N}}{||\vec{N}||} \right] = \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

• The feature used for the region clustering is $[a, b, c, z]$
Depth Segmentation

- k-means method is chosen to cluster the regions for its simplicity and speed in clustering.
- The initial cluster centers are defined based on the priori knowledge of the data.

before post-processing  after post-processing
Based on the contrast relationship of the FG and BG, the portraits can be classified into three cases:

• **dark FG, bright BG**
• **similar FG/BG**
• **bright FG, dark BG**

Based on the complexity of the background, the portraits can be considered in indoor and outdoor styles.

Selected according to **similarity** in terms of natural properties.

This natural property can be measured by the **contrasts within and between** FG and BG (intra- and inter- contrasts).
Reference Portrait Painting Selection

• The feature vector describing the inter contrast of the portrait:

\[ V = \left( L_F, L_B, C_l, S_F, S_B, C_s, C_h, C_B \right) \]

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_F )</td>
<td>the average lightness of the FG</td>
</tr>
<tr>
<td>( L_B )</td>
<td>the average lightness of the BG</td>
</tr>
<tr>
<td>( C_l )</td>
<td>lightness inter contrast ( C_l = \lg_{10}(L_F) - \lg_{10}(L_B) )</td>
</tr>
<tr>
<td>( S_F )</td>
<td>the average saturation of the FG</td>
</tr>
<tr>
<td>( S_B )</td>
<td>the average saturation of the BG</td>
</tr>
<tr>
<td>( C_s )</td>
<td>saturation inter contrast ( C_s = S_F - S_B )</td>
</tr>
<tr>
<td>( C_h )</td>
<td>inter hue contrast defined as the average hue difference between FG and BG</td>
</tr>
<tr>
<td>( C_B )</td>
<td>global contrast factor of BG calculated as the weighted average of local contrasts at various resolution levels</td>
</tr>
</tbody>
</table>

• The similarity of the normalized feature vectors \( V_1 \) and \( V_2 \) is calculated as

\[ \Gamma_V = e^{-\|W_0 \bullet (V_1 - V_2)\|}, \quad W_0 \text{ is the weight vector} \]
Reference Portrait Painting Selection

- The intra contrasts of FG and BG are expressed by the 10-bins normalized histogram distributions $T_{lf}, T_{lb}, T_{sf}, T_{sb}, T_{hf}, T_{hb}$.

- The similarity of histograms is calculated by histogram intersection

$$\Gamma_{T_{1,2}} = \sum_{i=1}^{n} \min(T_1(i), T_2(i)), \quad n \text{ is the number of bins}$$

- The similarity of the intra contrasts is

$$\Gamma_T = W_1[\Gamma_{T_{lf}}, \Gamma_{T_{lb}}, \Gamma_{T_{sf}}, \Gamma_{T_{sb}}, \Gamma_{T_{hf}}, \Gamma_{T_{hb}}]^T, \quad W_1 \text{ is the weight vector}$$

- The similarity of two portrait images is

$$\Gamma = (1-w)\Gamma_T + w\Gamma_V, \quad w \text{ is the weight scale}$$

- For each portrait photograph, the top $n$ ranked paintings are recommended as the references.
Reference Selection Result

• Totally 140 portrait paintings were collected.
• The figures in the portrait paintings were outlined manually.
• The depth of the photograph was captured by Xbox 360 Kinect depth sensor.

Photos  FG/BG  Top 5 ranked paintings
Rendering Results

Input

Selected 4 top ranked paintings

FG/BG

Not selected painting

Corresponding rendering results \( \alpha = 0.5, \beta = 1 \)
Conclusions

• Proposed a portrait reference selection method based on depth for example-based rendering.

• Proposed a novel region-based contrast rendering method.

• The rendering results using the proposed method are more encouraging compared with the global contrast mapping methods.
Thank You!

Questions and suggestions?