Image Colorization Using Similar Images

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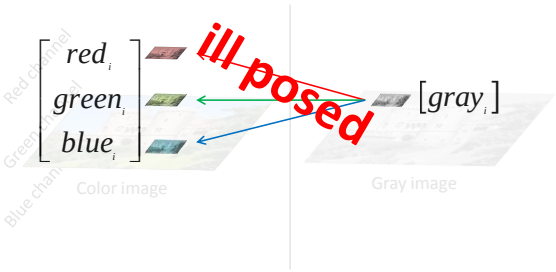
Goal

Challenges



Background

- Two broad classes of colorization method
  - Scribble based methods.
  - Example based methods.

Background

- Scribble based methods
  - [Levin et al. 2004]
  - [Huang et al. 2005]
  - [Qu et al. 2006]
  - [Luan et al. 2007]
  - …

- Require many color scribbles.
- Hard to assign perceptually meaningful colors scribbles.

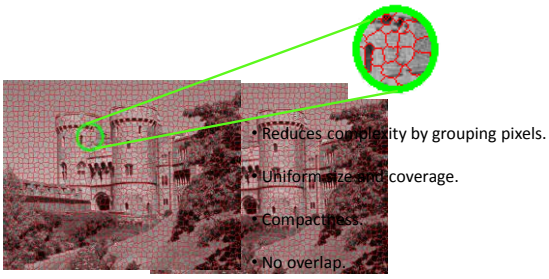
Background

- Example based methods
  - [Welsh et al. 2002]
  - [Irony et al. 2005]
  - [Charpiat et al. 2008]
  - …

Input image | Example image | Colorized Result

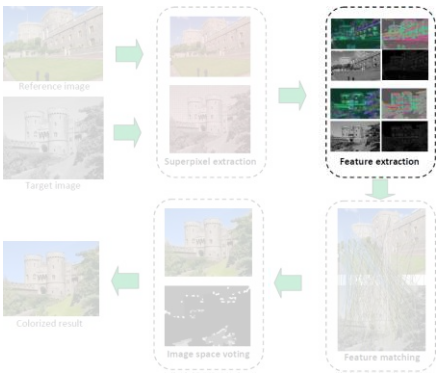
System overview

Superpixel Extraction

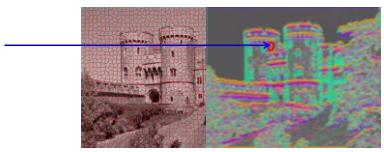


A. Levinshtein, A. Stere, K. N. Kutulakos, D. J. Fleet, S. J. Dickinson and K. Siddiqi, **TurboPixels: Fast Superpixels Using Geometric Flows**, *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol. 31, No. 12 (2009).

System overview



Feature Extraction

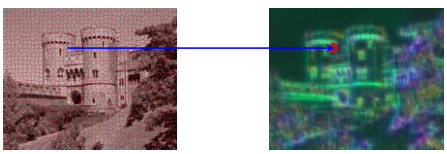


SURF Features

$D_s = \{d_1, d_2, d_3, . . d_{128}\}$

Image Features : **128D SURF Features**

Feature Extraction

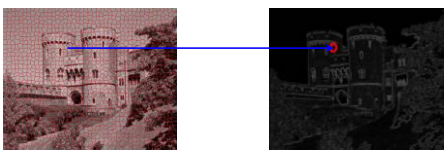


Gabor Features

$D_g = \{d_1, d_2, d_3, . . d_{40}\}$

Image Features : **40D Gabor Features**

Feature Extraction

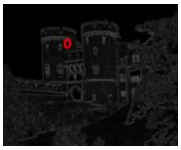


Standard Deviation

$D_{sd} = \{d_1, d_2\}$

Image Features : **2D Std. Dev. Features**

Feature Extraction



Standard Deviation

$D_{sd} = \{d_1, d_2\}$

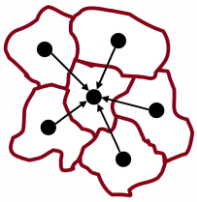


Image Features : **2D Std. Dev. Features**

Feature Extraction

Intensity

$D_I = \{d_1, d_2\}$

Image Features : **2D Intensity features**

Color Quantization

- **CIEL*ab*** color space is used to discretize the color values.

Superpixel	Color Value (C)
	(a_1, b_1)
	(a_2, b_2)
	(a_3, b_3)
⋮	⋮
	(a_{n-1}, b_{n-1})
	(a_n, b_n)

Color Quantization

- **CIEL*ab*** color space is used to discretize the color values.

Superpixel	Color Value (C)
	(a_1, b_1)
	(a_2, b_2)
	(a_3, b_3)
⋮	⋮
	(a_{n-1}, b_{n-1})
	(a_n, b_n)

Color Quantization

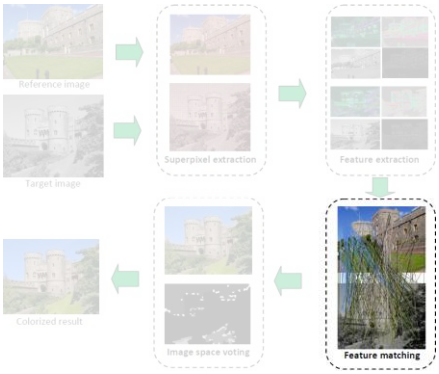
- ***k*-means** clustering has been used to group the chromatic color values.

Superpixel	Color Label (C)
	1
	
	
⋮	⋮
	k

Color Quantization

Superpixel	Features	Color Label (C)
	$f_{surf}, f_{gabor}, f_{sd}, f_{int}$	1
	$f_{surf}, f_{gabor}, f_{sd}, f_{int}$	
	$f_{surf}, f_{gabor}, f_{sd}, f_{int}$	
⋮	⋮	⋮
	$f_{surf}, f_{gabor}, f_{sd}, f_{int}$	k
	$f_{surf}, f_{gabor}, f_{sd}, f_{int}$	

System overview



Feature Matching

- Cascade feature matching scheme.
- Search space are pruned at each step of the cascade.
- Discriminative Gabor and SURF features are used at the initial cascade steps.

$$f_{surf} \longrightarrow f_{gabor} \longrightarrow f_{sd} \longrightarrow f_{intensity}$$

Feature Matching

- The matching cost is computed as:

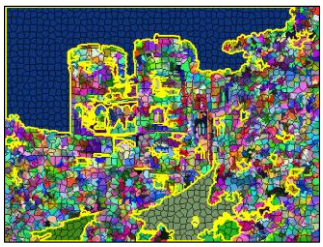
$$F(r_b, t_i) = w_1 M_1(r_b, t_i) + w_2 M_2(r_b, t_i) + w_3 M_3(r_b, t_i) + w_4 M_4(r_b, t_i)$$

Where M_1, M_2, M_3 and M_4 are the Euclidean distance between the Gabor, SURF, intensity and standard deviations features, and w_1, w_2, w_3 and w_4 are their accompanying weights fixed as 0.2, 0.5, 0.2 and 0.1, respectively.

Feature Matching

System overview

Color Scribble Refinement



D. Comaniciu and P. Meer, **Mean shift: A robust approach toward feature space analysis**, *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol. 24, No. 5 (2002).

Color Scribble Propagation

- Color Scribbles are propagated to neighboring pixels with similar luminance values through optimization.

A. Levin, D. Lischinski and Y. Weiss, **Colorization using Optimization**, Proc. *SIGGRAPH* (2004).

Results

Input Gray Image

Reference Image

Results

Welsh *et al. 2002*

Irony *et al. 2005*

Charpiat *et al. 2008*

Our Result

Results

Input Gray Image

Reference Image

Results

Welsh *et al. 2002*

Irony *et al. 2005*

Charpiat *et al. 2008*

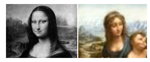
Our Result

Results

Input Gray Image

Reference Image

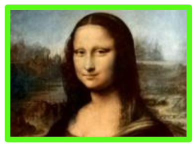
Results




Welsh *et al. 2002*


Irony *et al. 2005*


Charpiat *et al. 2008*

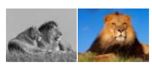

Our Result

Results


Input Gray Image


Reference Image

Results




Welsh *et al. 2002*


Irony *et al. 2005*


Charpiat *et al. 2008*

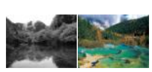

Our Result

Results


Input Gray Image


Reference Image

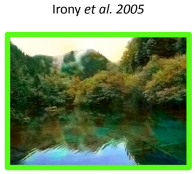
Results




Welsh *et al. 2002*


Irony *et al. 2005*

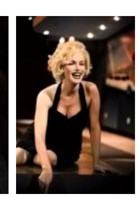

Charpiat *et al. 2008*


Our Result

Results


Input Gray Image


Reference Image

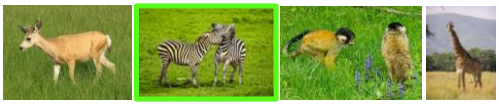

Colorization Result

Keyword-based Colorization

J. Zhu, S. C. H. Hoi, M. R. Lyu, and S. Yan., **Near-duplicate keyframe retrieval by semi-supervised learning and non-rigid image matching**. ACM Transactions on Multimedia Computing, Communications, and Applications, 7(1), 2011.

User Study

- 30 volunteers (with normal color vision)



- Our method: 64.90% classified as real color images.

User Study

Algorithms	Classified as real images
Welsh *et al. 2002*	48.90%
Irony *et al. 2005*	53.20%
Charpiat *et al. 2008*	32.30%
Chia *et al. 2011*	66.59%
Our Method	**64.90%**

Limitations

- Superpixel accuracy at object boundaries.
- Availability of suitable color exemplars.
- Small image segments in dense textured image regions.

Thanks!