Color Texture Description Based on Holistic and Hierarchical Order-Encoding Patterns

Tiecheng Song, Jie Feng, Yuanlin Wang and Chenqiang Gao

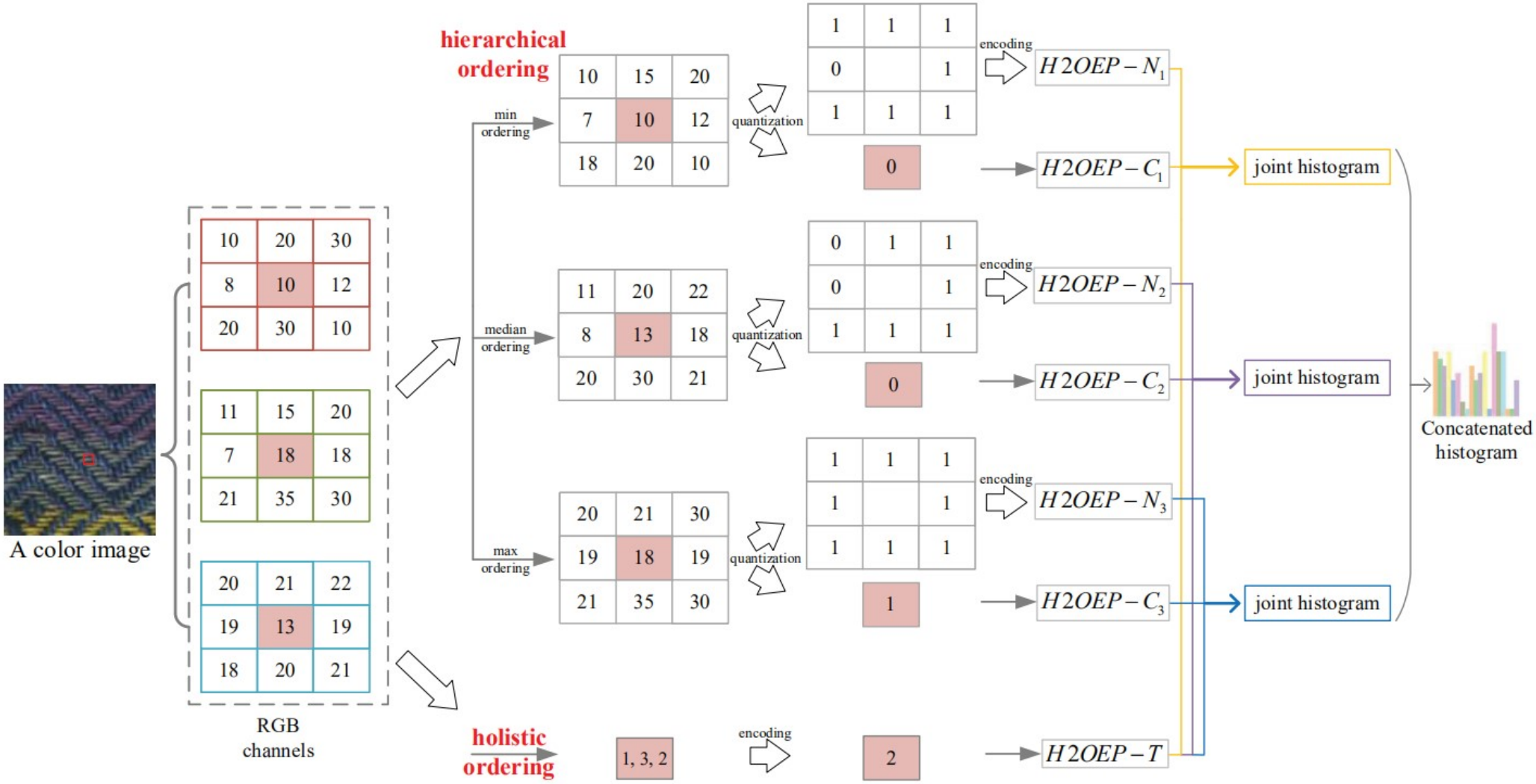
Chongqing University of Posts and Telecommunications, China

Email: {songtc, gaocq}@cqupt.edu.cn; {fengjie_cqupt, wwangyuanlin}@foxmail.com

Motivations

- Most of LBP-based methods were designed for gray. However, color spaces (e.g., RGB or HSV) were shown to be closer to human perception and can be effectively incorporated to describe images.
- Ranks (or orders) of values can effectively describe texture structure or color information.
- Distinguish more distinct intensity patterns (e.g., [1 2 3 4] and [10 20 30 40]) in a color image rather than our recent work SWOBP.

Proposed color descriptor



Holistic color-order encoding

- A central pixel in an three-channel image:

$$\boldsymbol{g}_c = [g_c^1, g_c^2, g_c^3] \tag{6}$$

- Sort these intensity values and record their color order information:

$$\boldsymbol{g}_{c_{order}} = [g_{c_I}^1, g_{c_I}^2, g_{c_I}^3] = sort(\boldsymbol{g}_c) \tag{7}$$

- Holistic order-encoding pattern for each central pixel is defined as:

$$H2OEP - T = f(\boldsymbol{g}_{c_{order}}) \tag{8}$$

Number	$\boldsymbol{g}_{c_{order}}$	Tendency	Attribute	$f(\boldsymbol{g}_{c_{order}})$
1	[1, 2, 3]	↗	monotone	1
2	[3, 2, 1]	↘	monotone	1
3	[1, 3, 2]	⌒↘	convex	2
4	[2, 3, 1]	⌒↘	convex	2
5	[2, 1, 3]	⌣↗	concave	3
6	[3, 1, 2]	⌣↗	concave	3

Fig. 3: Illumination of the holistic color-order encoding

Hierarchical color-order encoding

- Given the color order:

$$\boldsymbol{g}_{c_{order}} = [g_{c_I}^1, g_{c_I}^2, g_{c_I}^3]$$

- Use min ordering, median ordering and max ordering to rearrange color channels.

$$g_{c,i} = \begin{cases} g_c^1, & \text{if } g_{c_I}^1 == i \\ g_c^2, & \text{if } g_{c_I}^2 == i \\ g_c^3, & \text{if } g_{c_I}^3 == i \end{cases} \qquad (9)$$

where i = 1, 2, 3 indicates the index of rearranged color channels after min ordering, median ordering and max ordering. Similarly, we can rearrange all neighboring points and denote them as $g_{p,i}$

- The hierarchical order-encoding pattern for each central pixel is defined as:

$$H2OEP - N_i = \sum_{p=0}^{P-1} s\left(g_{p,i} - g_{c,i}\right) 2^p \qquad (10)$$

Joint histogram representation

- Define the central pixel encoding operator for image I as follows:

$$H2OEP - C_i = s\left(g_{c,i} - \bar{g}_{c,i}\right) \qquad (11)$$

where $\bar{g}_{c,i}$ is the average value of all $g_{c,i}$ in the i-th rearranged color channel for image I, and "C" means central pixels.

- Build a 3D joint histogram like CLBP and transform it into a 1D vector denoted as:

$$H_{H2OEP-TCN_i}$$

- concatenate all the generated histograms:

$$H_{H2OEP} = [H_{H2OEP-TCN_1}, H_{H2OEP-TCN_2}, H_{H2OEP-TCN_3}] \qquad (12)$$

Experiments

- Texture datasets
  - KTH-TIPS: 10 classes, illumination & scale changes
  - KTH-TIPS2-b: 11 classes, illuminations, rotations, poses & scales changes
  - STex: 476 classes, 7616 color images in total
  - Outex (TC31): 68 classes, resolutions (dpi) changes
- Nearest-neighborhood (NN) classifier with the chi-square distance:

$$\chi^2(H_1, H_2) = \sum_k \frac{[H_1(k) - H_2(k)]^2}{H_1(k) + H_2(k)}$$

Classification results

TABLE I: Classification accuracy in percent (mean±standard deviation) on four color texture databases

Method	KTH-TIPS	KTH-TIPS2-b	STex	Outex-TC-00031	Dimension
LBP	94.44±0.63	55.82±1.84	82.02±0.58	88.46	1665
CLBP	94.71±1.93	56.97±0.84	87.65±0.56	84.12	4056
SLGP	94.04±1.56	53.56±4.54	78.81±0.64	76.76	504
mGIST	96.20±1.05	53.15±1.77	60.28±0.54	79.60	1536
mSIFT	92.10±1.36	55.52±2.90	35.85±0.35	44.78	3000
Full ranking	93.52±0.84	51.00±2.81	64.90±0.32	81.47	720
maLBP	93.17±1.22	54.36±5.56	86.17±0.60	82.86	1024
mdLBP	95.12±1.11	58.31±6.04	90.08±0.45	86.39	2048
LBPC	92.92±1.24	50.74±2.40	75.54±0.57	84.40	256
SWOBP	95.98±0.99	64.17±2.91	89.53±0.43	**93.20**	2226
H2OEP	**97.34**±0.79	**64.18**±2.82	**92.06**±0.33	**92.79**	1062

THANKS!