Local Grouped Invariant Order Pattern for Grayscale-Inversion and Rotation Invariant Texture Classification

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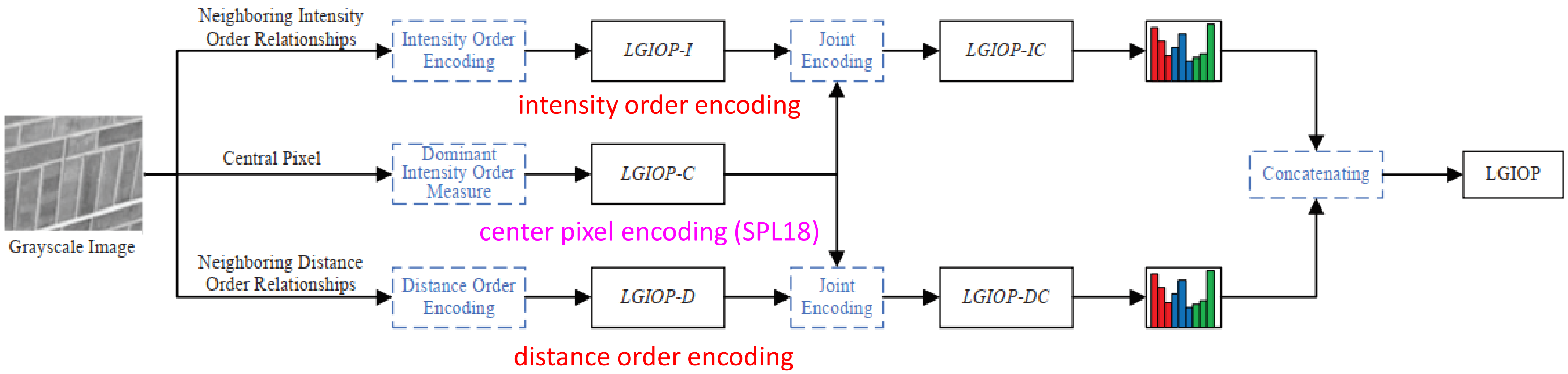
Motivations

- LBP is one of the popular texture features
  - fails to capture the complete intensity order information
- Intensity order based methods [1, 2]
  - do not address the grayscale inversion problem

[1] C. H. Chan, et al, “Full ranking as local descriptor for visual recognition: a comparison of distance metrics on s_n,” PR, 2015.
[2] T. Song, et al, “Robust texture description using local grouped order pattern and non-local binary pattern,” IEEE TCSVT, 2020.

Proposed method

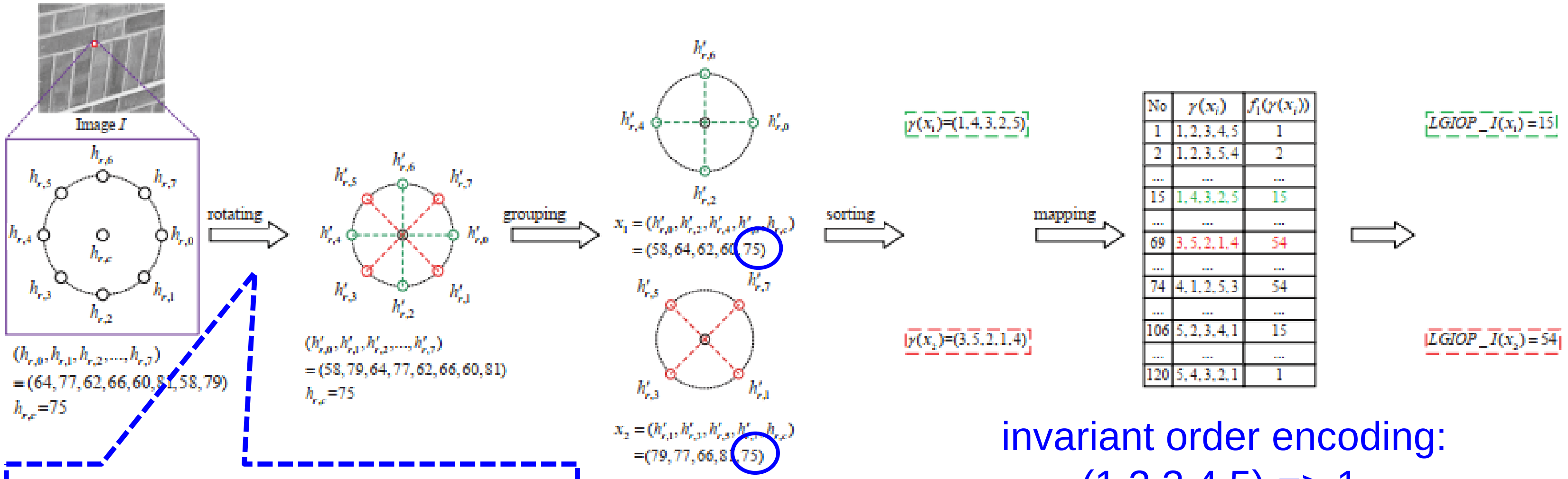
- Local grouped invariant order pattern (LGIOP)
  - grayscale-inversion and rotation invariant
  - jointly encoding three invariant components



T. Song, et al, “Grayscale-inversion and rotation invariant texture description using sorted local gradient pattern,” IEEE Signal Processing Letters, 2018.

Proposed method

- LGIOP-I (Intensity order)
  - rotating, grouping, sorting, mapping (encoding)



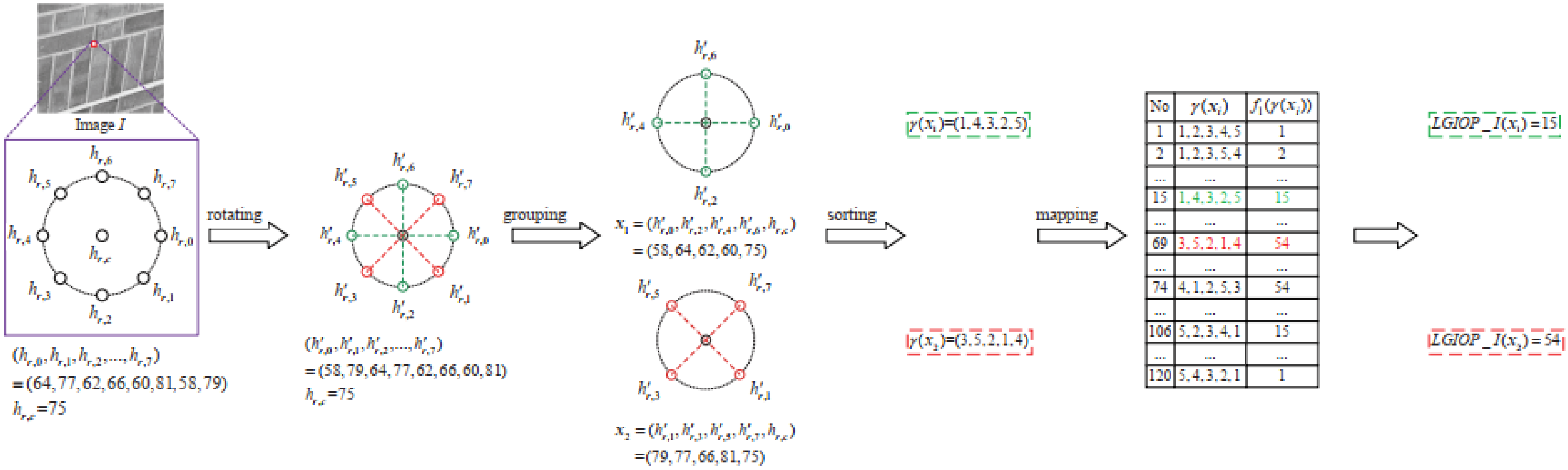
$$\boxed{d = \underset{p\in\{0,1,\cdots,P-1\}}{\arg\max} |h_{r,p} - h_{r,c}|}$$

central pixel

invariant order encoding:
(1,2,3,4,5) => 1
(5,4,3,2,1) => 1
(two to one mapping)

Proposed method

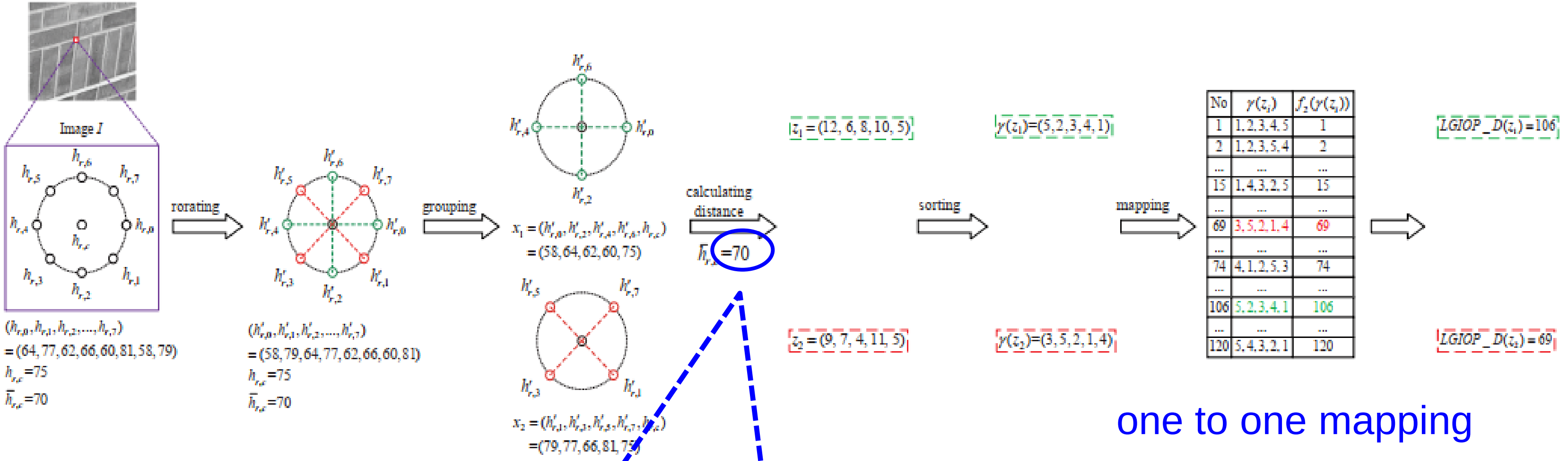
- LGIOP-I (Intensity order)
  - rotating, grouping, sorting, mapping (encoding)



LGIOP-I cannot distinguish patterns like (10, 20, 30, 40, 50) and (10, 20, 30, 200, 250)

Proposed method

- LGIOP-D (Distance order)
  - rotating, grouping, calc. distance, sorting, mapping



No	$\gamma(z_i)$	$f_2(\gamma(z_i))$
1	1, 2, 3, 4, 5	1
2	1, 2, 3, 5, 4	2
...	...	...
15	1, 4, 3, 2, 5	15
...	...	...
69	3, 5, 2, 1, 4	69
...	...	...
74	4, 1, 2, 5, 3	74
...	...	...
106	5, 2, 3, 4, 1	106
...	...	...
120	5, 4, 3, 2, 1	120

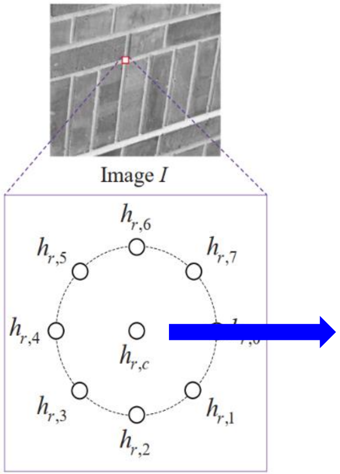
one to one mapping

average gray value of image *I*

$$z_i = \left|x_i - \bar{h}_{r,c}\right|$$

Proposed method

- LGIOP-C (Central pixel encoding)
  - dominant intensity order measure (DIOM, SPL18)



- We divide the central pixels into two subsets:

$$C_A = \{y_{c,j} \in C : y_{c,j} \geq T\}$$
$$C_B = \{y_{c,j} \in C : y_{c,j} < T\}$$

T: the average gray value of all central pixels.

- We encode all central pixels in the larger subset (dominant pixels) as 1 and others as 0:

$$LGIOP\text{-}C(y_{c,j}) = \begin{cases} 1, & \text{if } y_{c,j} \in C_A \text{ and } |C_A| > |C_B| \\ 1, & \text{if } y_{c,j} \in C_B \text{ and } |C_B| > |C_A| \\ 0, & \text{otherwise} \end{cases}$$

T. Song, et al, "Grayscale-inversion and rotation invariant texture description using sorted local gradient pattern," IEEE Signal Processing Letters, 2018.

Experiments

- Texture datasets
  - Outex (TC10): 24 classes
    - ➢ TC10: rotation changes
    - ➢ TC12 (t184, horizon): rotation + illumination changes
  - KTH-TIPS: 10 classes, illumination & scale changes
- Classification
  - Nearest-neighborhood (NN) classifier with the chi-square distance

Classification results: TC10

	Linear grayscale-inversion changes				Nonlinear grayscale-inversion changes			
	r=1, P=8	r=2, P=16	r=3, P=24	three scales	r=1, P=8	r=2, P=16	r=3, P=24	three scales
LBP [4]	29.42	32.13	44.08	39.98	29.40	32.14	44.09	40.63
LTP [5]	12.95	17.81	21.45	21.37	14.24	29.51	43.67	36.56
CLBP [6]	20.48	24.03	24.25	24.49	18.13	22.45	24.15	22.99
GLBP [11]	50.34	77.45	93.39	–	48.23	76.43	92.79	–
LGP [12]	60.48	87.86	89.35	94.58	54.40	82.91	83.88	91.27
NRLBP [14]	38.63	75.36	86.61	89.66	38.52	74.87	86.15	89.48
CGRI-LBP [15]	85.43	96.90	98.02	98.15	73.26	94.58	96.80	96.41
SLGP [13]	97.79				95.60			
MRELBP [10]	17.06				16.30			
LGONBP [21]	24.66				25.39			
LGIOP	**88.44**	**98.44**	**99.04**	**98.85**	**83.54**	**97.01**	**98.05**	**98.05**

Linear grayscale-inversion changes: the test images are transformed by $I' = -\lambda \times I + 255$

Nonlinear grayscale-inversion changes: $I' = -\sqrt{I} + 255$

Classification results: TC12t

	Linear grayscale-inversion changes				Nonlinear grayscale-inversion changes			
	r=1, P=8	r=2, P=16	r=3, P=24	three scales	r=1, P=8	r=2, P=16	r=3, P=24	three scales
LBP [4]	24.26	31.77	42.50	39.34	24.28	31.71	42.69	38.91
LTP [5]	22.48	25.63	32.47	37.99	12.92	29.56	42.78	35.32
CLBP [6]	17.79	22.56	23.17	22.12	17.15	22.64	23.63	23.15
GLBP [11]	45.99	74.59	90.43	–	41.75	72.94	89.32	–
LGP [12]	51.11	70.30	78.47	78.47	41.78	63.89	67.52	71.08
NRLBP [14]	32.57	64.88	70.42	73.09	31.92	64.65	70.51	73.01
CGRI-LBP [15]	63.50	83.09	87.76	85.16	59.31	72.82	80.63	77.99
SLGP [13]	84.17				75.49			
MRELBP [10]	25.02				25.14			
LGONBP [21]	23.80				24.58			
LGIOP	**83.63**	**93.52**	**96.09**	**95.90**	**73.52**	**89.21**	**90.90**	**91.25**

LGIOP is robust to linear and nonlinear grayscale inversion as well as image rotation.

Classification results: TC12h

	Linear grayscale-inversion changes				Nonlinear grayscale-inversion changes			
	r=1, P=8	r=2, P=16	r=3, P=24	three scales	r=1, P=8	r=2, P=16	r=3, P=24	three scales
LBP [4]	22.66	32.59	42.78	39.63	22.99	32.52	42.89	39.40
LTP [5]	24.56	27.80	33.43	38.91	15.25	30.44	41.47	37.08
CLBP [6]	17.85	22.38	23.34	22.72	17.18	23.01	23.80	23.87
GLBP [11]	47.55	76.97	89.35	–	41.67	74.86	88.70	–
LGP [12]	52.30	71.09	76.65	76.65	45.14	61.18	68.75	70.49
NRLBP [14]	29.42	55.46	63.89	66.80	29.35	55.64	64.05	66.50
CGRI-LBP [15]	62.83	82.31	83.57	82.99	62.26	71.46	76.18	75.56
SLGP [13]	83.82				73.63			
MRELBP [10]	24.68				24.91			
LGONBP [21]	25.30				26.60			
LGIOP	**82.45**	**94.03**	**95.35**	**95.02**	**72.50**	**86.78**	**88.80**	**88.43**

LGIOP is robust to linear and nonlinear grayscale inversion as well as image rotation.

Classification results: KTH-TIPS

	Linear grayscale-inversion changes				Nonlinear grayscale-inversion changes			
	r=1, P=8	r=2, P=16	r=3, P=24	three scales	r=1, P=8	r=2, P=16	r=3, P=24	three scales
LBP [4]	39.27	39.51	45.37	47.07	38.78	38.05	44.63	46.93
LTP [5]	28.12	31.10	29.83	54.46	24.32	36.46	38.98	41.66
CLBP [6]	42.59	41.02	39.41	43.15	44.54	42.17	39.80	44.93
GLBP [11]	76.85	86.03	88.21	–	73.39	85.68	87.90	–
LGP [12]	64.73	67.20	69.30	88.85	60.67	62.33	65.13	87.49
NRLBP [14]	67.90	76.07	79.63	84.85	66.73	75.61	78.98	84.80
CGRI-LBP [15]	89.58	92.71	93.08	95.04	88.75	**91.81**	**91.93**	**92.85**
SLGP [13]	93.83				90.82			
MRELBP [10]	38.39				38.85			
LGONBP [21]	36.02				34.72			
LGIOP	**93.55**	**94.37**	**93.88**	**95.10**	**91.43**	**91.52**	**90.31**	**92.19**

LGIOP is robust to linear and nonlinear grayscale inversion as well as scaling.

Summary

- We propose a LGIOP descriptor
  - It jointly encodes neighboring order information and central pixels to construct a histogram representation.
  - It uses two order encoding methods: intensity order encoding and distance order encoding.
  - It achieves good results for texture classification under (linear or nonlinear) grayscale inversion and image rotation.

Thanks!