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Abstract—**In this letter, we propose an efficient one-nearest-neighbor classifier of texture via the contrast of local energy histograms of all the wavelet subbands between an input texture patch and each sample texture patch in a given training set. In particular, the contrast is realized with a discrepancy measure which is just a sum of symmetrized Kullback–Leibler divergences between the input and sample local energy histograms on all the wavelet subbands. It is demonstrated by various experiments that our proposed method obtains a satisfactory texture classification accuracy in comparison with several current state-of-the-art texture classification approaches.**

Index Terms—**Energy histogram, one-nearest-neighbor classifier, symmetrized Kullback–Leibler divergence (SKLD), texture classification, wavelet transform.**

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[1] [13],

: [3] [7]

[1], [8] [12].

[1] [7]. C

G G D (CGGD) [3], B P (BP) [5], [6], H (H) [4], G G D (GΓD) [7],

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A. Local Energy Feature Extraction in Wavelet Domain

F L- $3L$ $(B_1, B_2, \ldots, B_{3L})$ B_{3L+1}. (N -1) $S \times S$ j- $\Omega_i^j \times \Omega_i^j$ i-

$$E_{\mathrm{Loc}}^{i,j}(l,k) = \frac{1}{S^2} \sum_{u=1}^{S} \sum_{v=1}^{S} |w_{i,j}(l+u-1, k+v-1)| \quad (1)$$

$1 \le l,k \le \Omega_i^j - S + 1$ $w_{i,j}(m,n)$ (m,n) E_{Loc}^{L} (1).

N . O i. $E_{\mathrm{Loc}}^{i,j}$ $1/2^i$. F $1/4^L$ E_{Loc}^{L}

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B. Local Energy Histogram (LEH)

1) Definition: G M $E = (e_1, e_2, \ldots, e_M)$, - N_0 $e_{\max} < 2^{N_0}$. L $\Delta_n = [2^a(n-1), 2^a n)$, $n = 1, 2, \ldots, N$, $N = 2^{N_0 - a}$ $0 \le a \le N_0$, - . N $[0, 2^{N_0}) = \bigcup_{n=1}^{N} \Delta_n$. I , e_m, n_0 $(1 \le n_0 \le N)$ $e_m \in \Delta_{n_0}$. (LEH) $p(\Delta_n) = p_n = m_n/M$, m_n Δ_n. N , - . H , E $P = (p_1, p_2, \ldots, p_N)$, LEH .

2) Discrepancy Measure: O LEH $P = (p_1, p_2, \ldots, p_N)$, - LEH E , LEH . B - N_0 - , 2^{N_0}. N - a . $p_n = 0$ n - , η p_{n^*}, $n^* = \arg\max_n p_n$ η $\eta = 10^{-16}$. , $p'_n = p_n + \eta/(N-1)$ $n \neq n^*$, $p'_{n^*} = p_{n^*} - \eta$. I $\sum_{n=1}^{N} p'_n = \sum_{n=1}^{N} p_n = 1$. F , LEH $P = (p_1, p_2, \ldots, p_N)$ $P' = (p'_1, p'_2, \ldots, p'_N)$. A - K L (KLD) [4]. , KLD LEH H Q

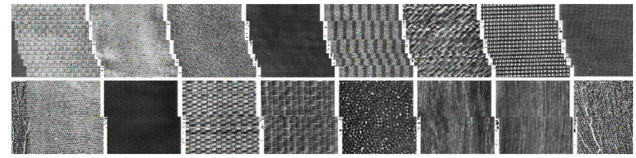
$$\mathrm{SKLD}(H, Q) = \sum_{n=1}^{N} p_n \log\left(\frac{p_n}{q_n}\right) + \sum_{n=1}^{N} q_n \log\left(\frac{q_n}{p_n}\right) \quad (2)$$

p_n q_n LEH H Q, - .

G I_1 I_2, $3L+1$ $(B_1^{I_1}, B_2^{I_1}, \ldots, B_{3L+1}^{I_1})$ $(B_1^{I_2}, B_2^{I_2}, \ldots, B_{3L+1}^{I_2})$, L- - ,

$$TD = \sum_{i=1}^{3L+1} d_i = HD + d_{3L+1} \quad (3)$$

$HD = \sum_{i=1}^{3L} d_i$, $d_i = \mathrm{SKLD}(H_i^{I_1}, Q_i^{I_2})$ KLD LEH $H_i^{I_1}$ $Q_i^{I_2}$ $B_i^{I_1}$ $B_i^{I_2}$, $i = 1, 2, \ldots, 3L+1$. A



F . 1. 80 B .

d_i $B_i^{I_1}$ $B_i^{I_2}$, . I TD . N , . ., HD, , - . I , TD HD.

C. One-Nearest-Neighbor Classifier

E TD, - - . I , , . I , TD, - - - k- - $k > 1$.

III. E PE IMEN AL E L

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I , 3- D 1 (1) E 1 4 . 3- . A N_0, $N_0 = 10$, , 2^{10}. , $N_0 = 10$. A , N_0.

A. Classification Performance

E 80 640×640 (-1, 16 80 F . 1) B [14], [17]. I -1, 16 160×160 , 1280 E N_{tr} 80 $N_{tr} = 2, 3, \ldots, 8$.

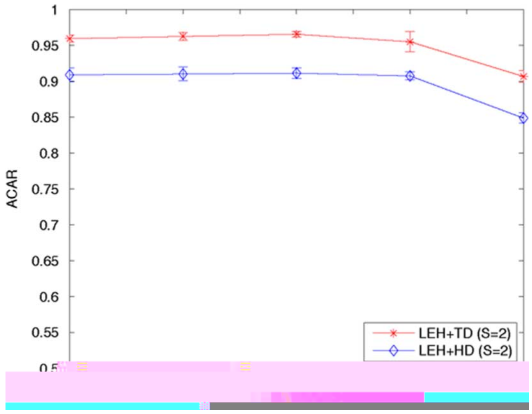

Fig. 2. LEH+ D ($S =$) LEH+HD ($S =$) 8.

(ACA) N_{tr}.

F TD LEH+ D, LEH HD (3) LEH+HD. Fig. 2 ACA LEH+ D LEH+HD ($a = 0, 1, \ldots, 4$) 2×2 (., $S = 2$) $N_{tr} = 8$. N Fig. 2 . F

Fig. 2, ACA LEH+ D LEH+HD a, LEH+ D LEH+HD 5.00% 6.00%, TD HD . I ACA $a = 0$ $a = 4$ 5.00% 6.50%, a . N a 3 0, ACA a LEH ACA . H (., $a = 0$), . I $a = 1$.

E 2×2, 3×3 4×4 (, $S = 2, 3,$ 4). Fig. 3( ), ( ) ( ) ACA ( ) LEH+ D LEH+HD N_{tr} . A ACA LEH+ D LEH+HD E LEH+ D LEH+HD 4.00% 6.00% N_{tr}

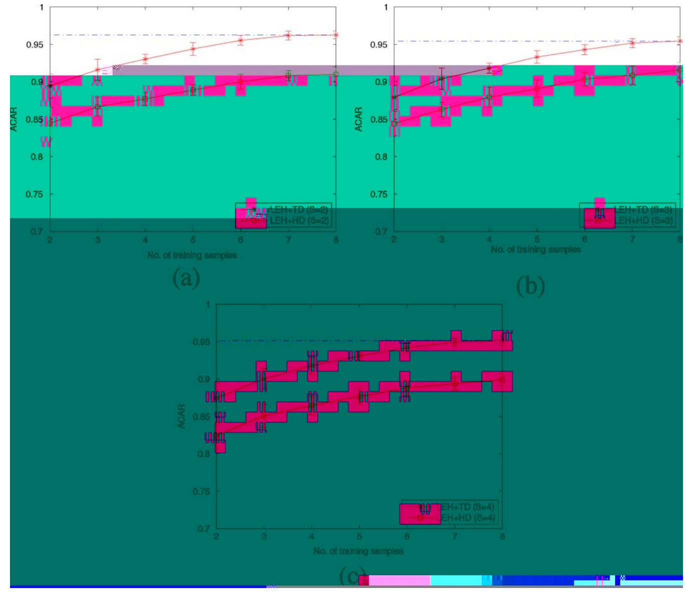

Fig. 3. C LEH+ D LEH+HD :( ) $S =$; ( ) $S = 3$; ( ) $S = 4$.

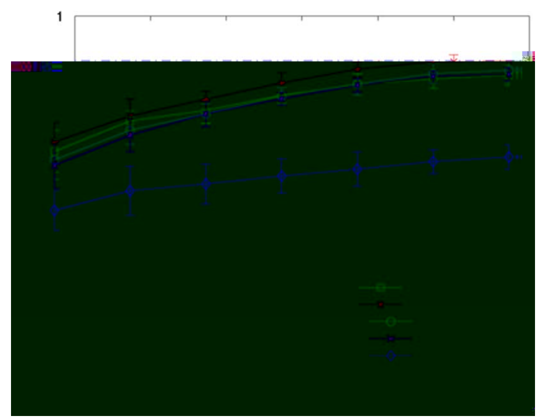

Fig. 4. C .

TD HD.

E , LEH+ D, (BP) 5], BP M . Fig. 4 ACA , N_{tr}. I Fig. 4 ACA LEH+ D BP M E LEH+ D ($S = 2$) LEH+ D ($S = 1$), LEH+ D ($S = 3$) LEH+ D ($S = 4$) 1.00%, BP M 6.00% 8.00% N_{tr}, $S = 2$. M LEH+ D ($S = 2$) G 17] (GMM M) $N_{tr} = 8$. ACA GMM M LEH+ D ($S = 2$) 93.44% 96.25%, .

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	LEH+TD ($S=2$)	CLBP_S	CLBP_S/M/C
ACAR	95.29	92.46	98.08
TTC	140.99	138.36	144.37

, LEH+ D ($S = 2$) GMM M 2.81%. A LEH+ D N_{tr} 0.90%, BP M , 1.48%. I , LEH+ D , LEH+ D.

B. Comparisons With the Other Existing Methods

I , LEH+ D ($S = 2$) B 14 111 640 × 640 (-2), BP M (ICA) (ICA M) 16 . E 25 128 × 128 - . , 10 . ACA LEH+ D ($S = 2$), BP M , ICA M 85.80%, 74.90%, 80.7%, E LEH+ D ($S=2$) - - - BP M ICA M B .

LEH+ D ($S = 2$), LEH+ D ($S = 2$) (CLBP), CLBP CLBP /M/C 18 , 15 30 512 × 512 E 18 19 . O 3 . A . I ( ) C (M) 5 CP (3.2 GH) M . I ACA (C) . A , LEH+ D ($S = 2$) CLBP 2.83% CLBP /M/C LEH+ D ($S = 2$) 2.79%. ACA G , 3 , . ., 88.1%. A C , LEH+ D ($S = 2$) CLBP /M/C. , LEH+ D ($S = 2$) - - - CLBP CLBP /M/C .

I . CONCL ION

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EFE ENCE

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