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No-reference noisy image quality assessment incorporating features of entropy, gradient, and kurtosis

Key words: Noisy image quality assessment; Noise estimation; Kurtosis; Human visual system; Support vector regression

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Motivation

1. Through the study, we found that most prediction methods were designed in the same domain (e.g., the spatial, wavelet, or gradient domain).

2. Few methods were involved operations in multiple domains and explored the mutual relationship between different domains.

3. Even for images with the same noise level, the subjective quality scores, i.e., mean opinion score (MOS) and differential MOS (DMOS), still have significant differences.

Main idea

1. In this study, we aim to estimate the noise level of the given test image based on the scale invariance of skewness in the discrete cosine transform (DCT) domain and adapt the noise injection strategy.

2. The second proposed feature uses four directional filters to generate gradient maps that are comprehensively considered to obtain the gradient feature.

Main idea

3. The third feature of the kurtosis feature is designed using the assumption of scale invariance of kurtosis in the principal component analysis (PCA) domain and by combining the effect of the image content.

4. The quality model using support vector regression (SVR) training is employed to predict the objective score of the test image.

Method

1. The image entropy feature is extracted based on the combination of noise estimation in the frequency domain and variation coefficient in the gradient domain.

2. The rationality of kurtosis in the PCA domain as human-perceived noise distortion is thoroughly analyzed, and an adaptive optimization of the kurtosis feature in combination with the visual masking effect is conducted.

3. In the process of SVR training of the regression model, the particle swarm optimization (PSO) algorithm is used to improve the prediction accuracy of the model.

Major results

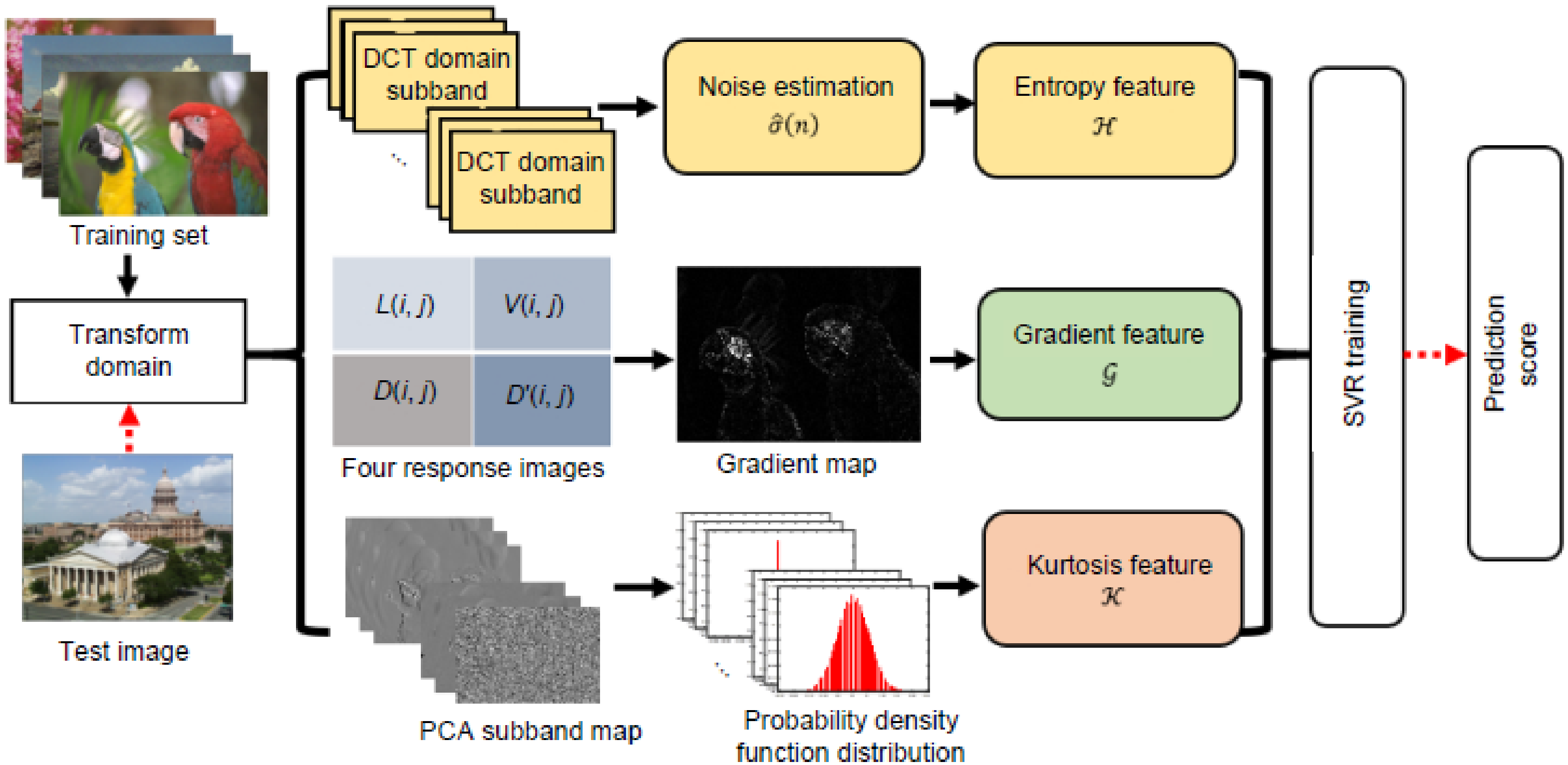

Fig. 2 Flow diagram of the proposed method

Major results (Cont’d)

Table 3 Comparison of the proposed method with state-of-the-art methods on the LIVE, CSIQ, and TID2013 databases

Method	PLCC (rank)			SRCC (rank)			Average PLCC rank (rank)
	LIVE	TID2013	CSIQ	LIVE	TID2013	CSIQ	
PSNR	0.9878 (3)	0.9073 (3)	0.9363 (4)	0.9854 (2)	0.9046 (3)	0.9385 (4)	3.33 (3)
SSIM	0.9693 (9)	0.7843 (7)	0.8974 (6)	0.9694 (9)	0.7865 (8)	0.8952 (6)	7.33 (7)
DIIVINE	0.9623 (11)	0.7043 (12)	0.8118 (11)	0.9167 (12)	0.7090 (12)	0.8313 (10)	11.33 (12)
BLIINDS	0.9482 (12)	0.7296 (11)	0.8825 (7)	0.9477 (11)	0.7280 (11)	0.8863 (7)	10.00 (11)
BRISQUE	0.9780 (6)	0.7824 (8)	0.9292 (5)	0.9786 (5)	0.7784 (9)	0.9310 (5)	6.33 (5)
CORNIA	0.9870 (4)	0.7611 (10)	0.7523 (12)	0.9760 (7)	0.7561 (10)	0.7458 (12)	8.67 (9)
NIQE	0.9773 (7)	0.8255 (6)	0.8182 (10)	0.9718 (8)	0.8194 (5)	0.8098 (11)	7.67 (8)
PWN	0.9770 (8)	0.8262 (5)	0.8823 (8)	0.9816 (4)	0.8184 (6)	0.8752 (8)	7.00 (6)
DMDM	0.9789 (5)	0.8987 (4)	0.9383 (3)	0.9782 (6)	0.8953 (4)	0.9387 (3)	4.00 (4)
GSVD	0.9666 (10)	0.7731 (9)	0.8721 (9)	0.9618 (10)	0.7942 (7)	0.8480 (9)	9.33 (10)
QENI	0.8919 (13)	0.5322 (13)	0.6242 (13)	0.8828 (13)	0.3540 (13)	0.5978 (13)	13.00 (13)
BNIQAK	0.9904 (2)	0.9543 (1)	0.9550 (2)	0.9889 (1)	0.9411 (1)	0.9594 (1)	1.67 (2)
Proposed	0.9909 (1)	0.9294 (2)	0.9638 (1)	0.9830 (3)	0.9187 (2)	0.9486 (2)	1.33 (1)

Major results (Cont'd)

Table 6 Performance comparison with different feature or feature combinations

Feature or feature combination	Database	PLCC	SRCC
$\mathcal{H}$	LIVE	0.9868	0.9764
	TID2013	0.8941	0.8875
	CSIQ	0.9223	0.8974
$\mathcal{G}$	LIVE	0.9260	0.8872
	TID2013	0.5244	0.5152
	CSIQ	0.5643	0.5433
$\mathcal{K}$	LIVE	0.9034	0.8763
	TID2013	0.5558	0.5434
	CSIQ	0.7445	0.6977
$\mathcal{H}+\mathcal{G}$	LIVE	0.9901	0.9814
	TID2013	0.9023	0.8928
	CSIQ	0.9463	0.9355
$\mathcal{K}+\mathcal{H}$	LIVE	0.9865	0.9730
	TID2013	0.8983	0.8934
	CSIQ	0.9387	0.9003
$\mathcal{K}+\mathcal{G}$	LIVE	0.9334	0.9133
	TID2013	0.7497	0.7376
	CSIQ	0.7844	0.7701
$\mathcal{K}+\mathcal{H}+\mathcal{G}$	LIVE	**0.9909**	**0.9830**
	TID2013	**0.9294**	**0.9187**
	CSIQ	**0.9638**	**0.9486**

Best results are in bold

Conclusions

1. A blind image quality assessment (IQA) metric for noisy images incorporating the features of entropy, gradient, and kurtosis was designed in this paper.

2. The three relevant features were extracted from different domains, and the gradient variation coefficient that can establish relationships between different domains was designed in combination with the masking effect of the human visual system (HVS).

3. The results demonstrated the efficacy and superiority of the proposed method, especially under the criterion of Pearson linear correlation coefficient (PLCC).

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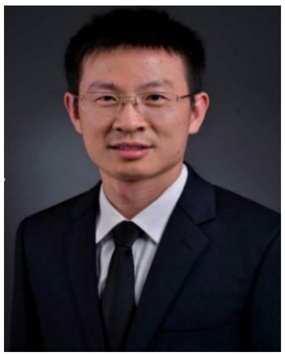

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