Blind Omnidirectional Image Quality Assessment Based on Structure and Natural Features

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Motivation

- 在VR技术的应用中，为了更好的用户体验，全方向图像的质量越来越受到重视。

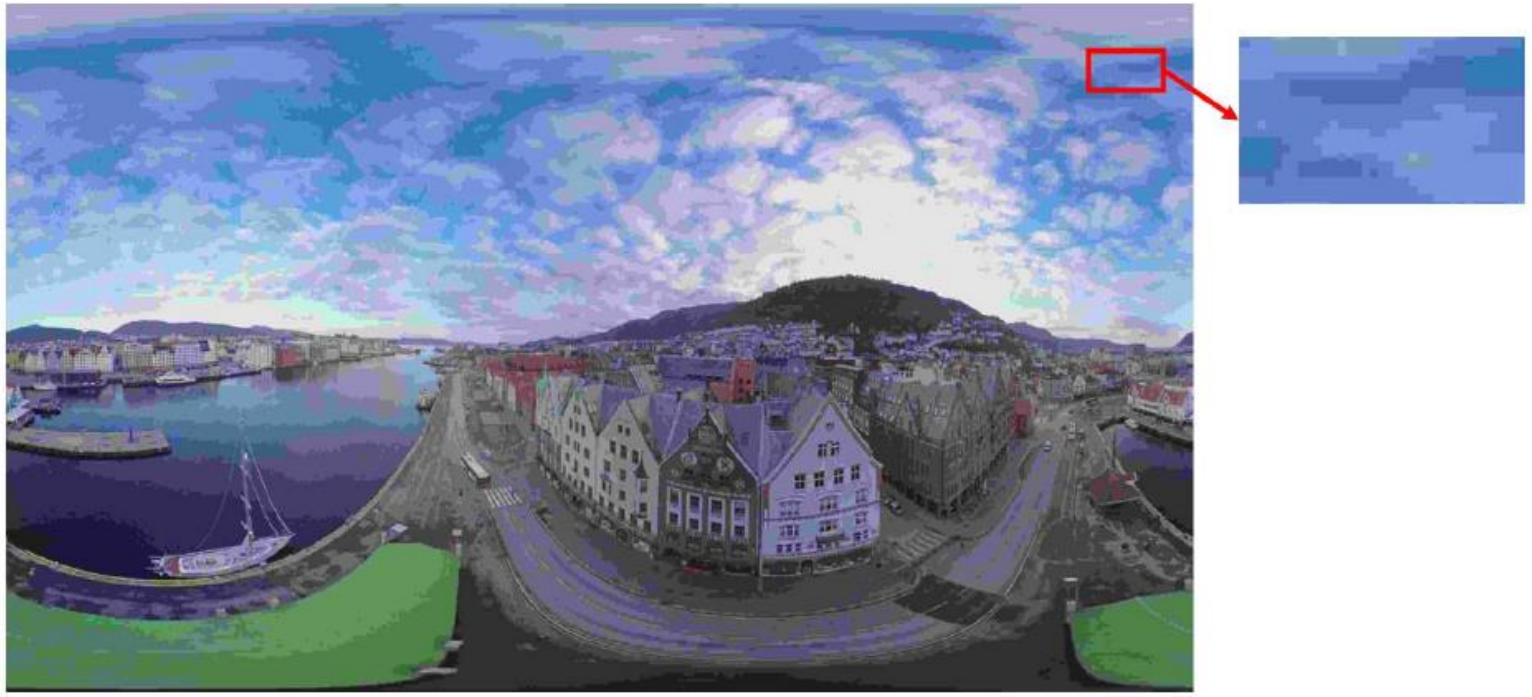


Fig. 1. Omnidirectional image under JPEG compression distortion in the equirectangular format.

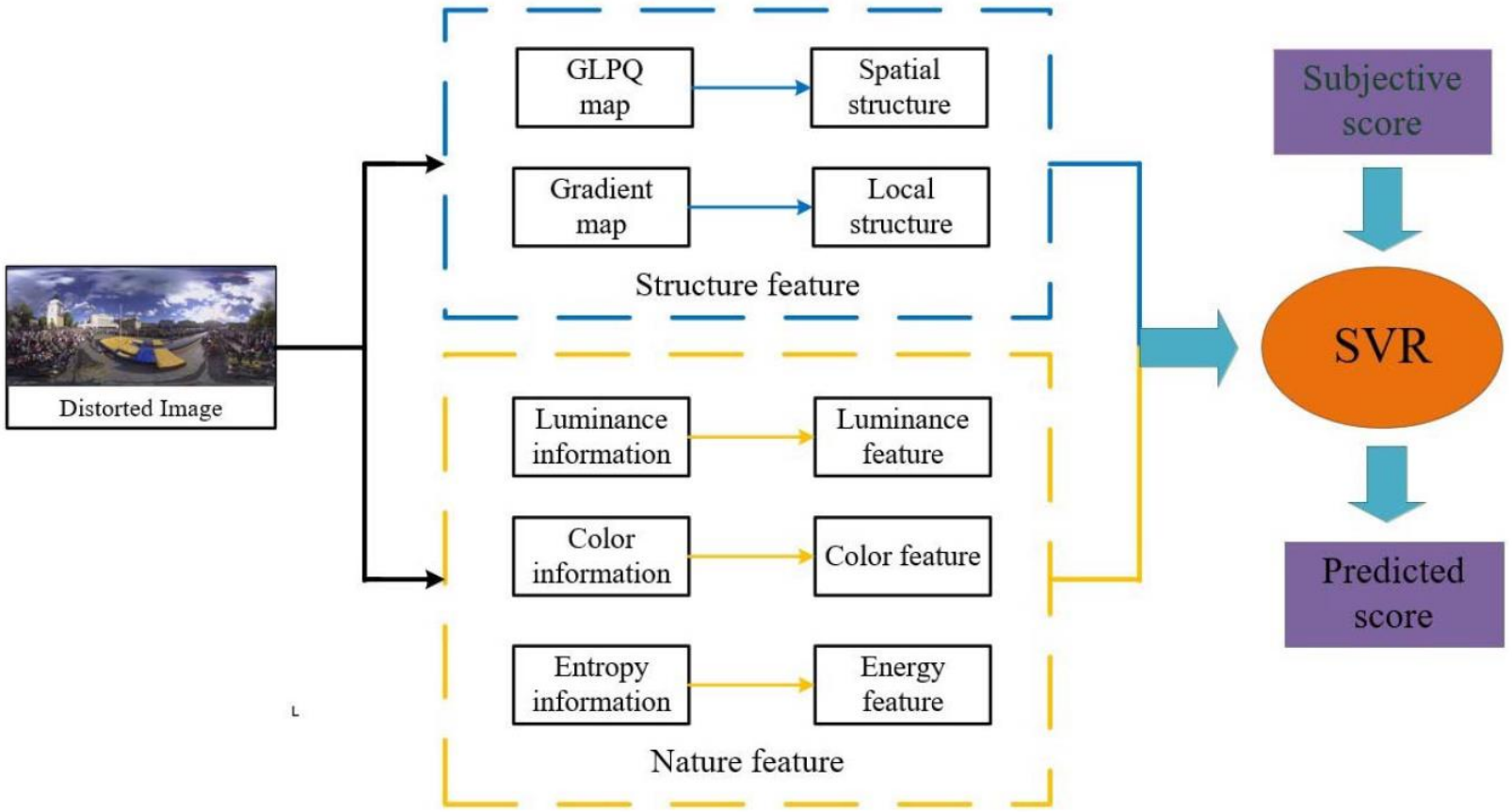
Motivation

- 结构特征
  - 结构特征能够帮助质量评价
  - 图像的纹理和梯度会受到图像失真的影响

- 自然特征
  - Natural Scene Statistics(NSS)
  - 颜色信息在人类视觉感知中有重要的作用
  - 信息熵受不同程度和类型的失真影响

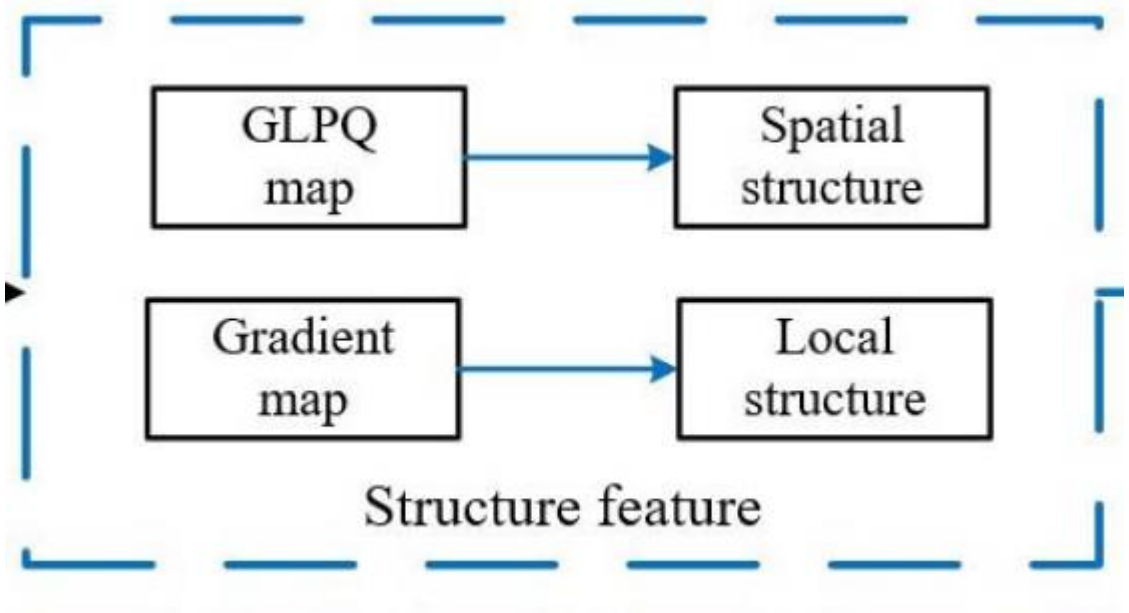
Method

- 整体框架


GLPQ map
Spatial structure
Gradient map
Local structure
Structure feature
Distorted Image
Luminance information
Luminance feature
Color information
Color feature
Entropy information
Energy feature
Nature feature
Subjective score
SVR
Predicted score

Structure Features

- Local Phrase Quantization(LPQ)能够根据图像的边、角、线的信息产生一种对纹理信息的描述特征。在梯度图上使用LPQ算子得到GLPQ map



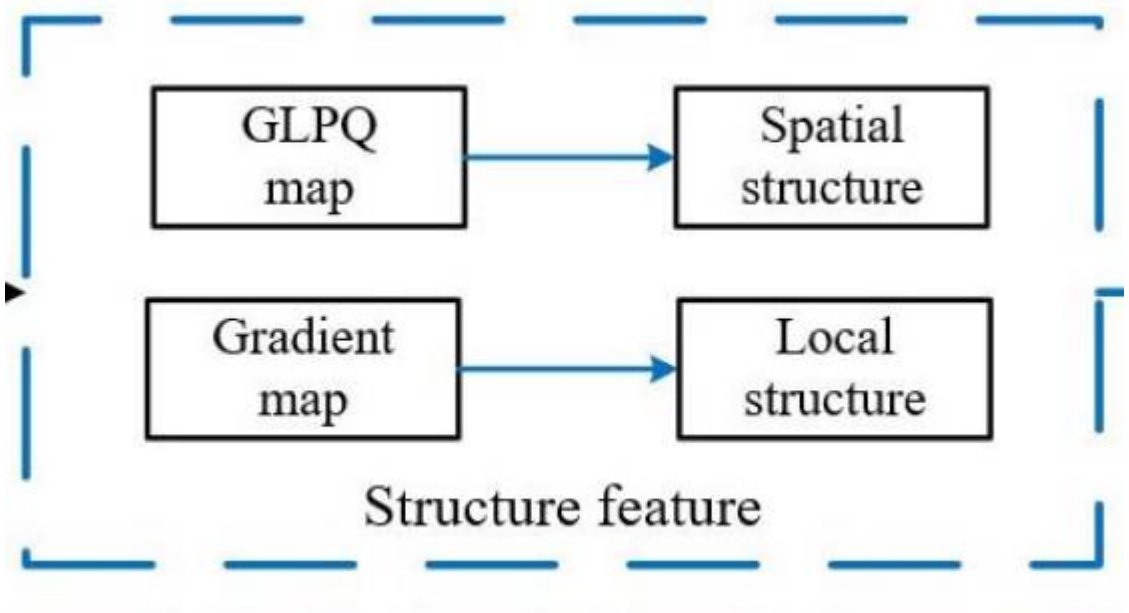
Structure Features

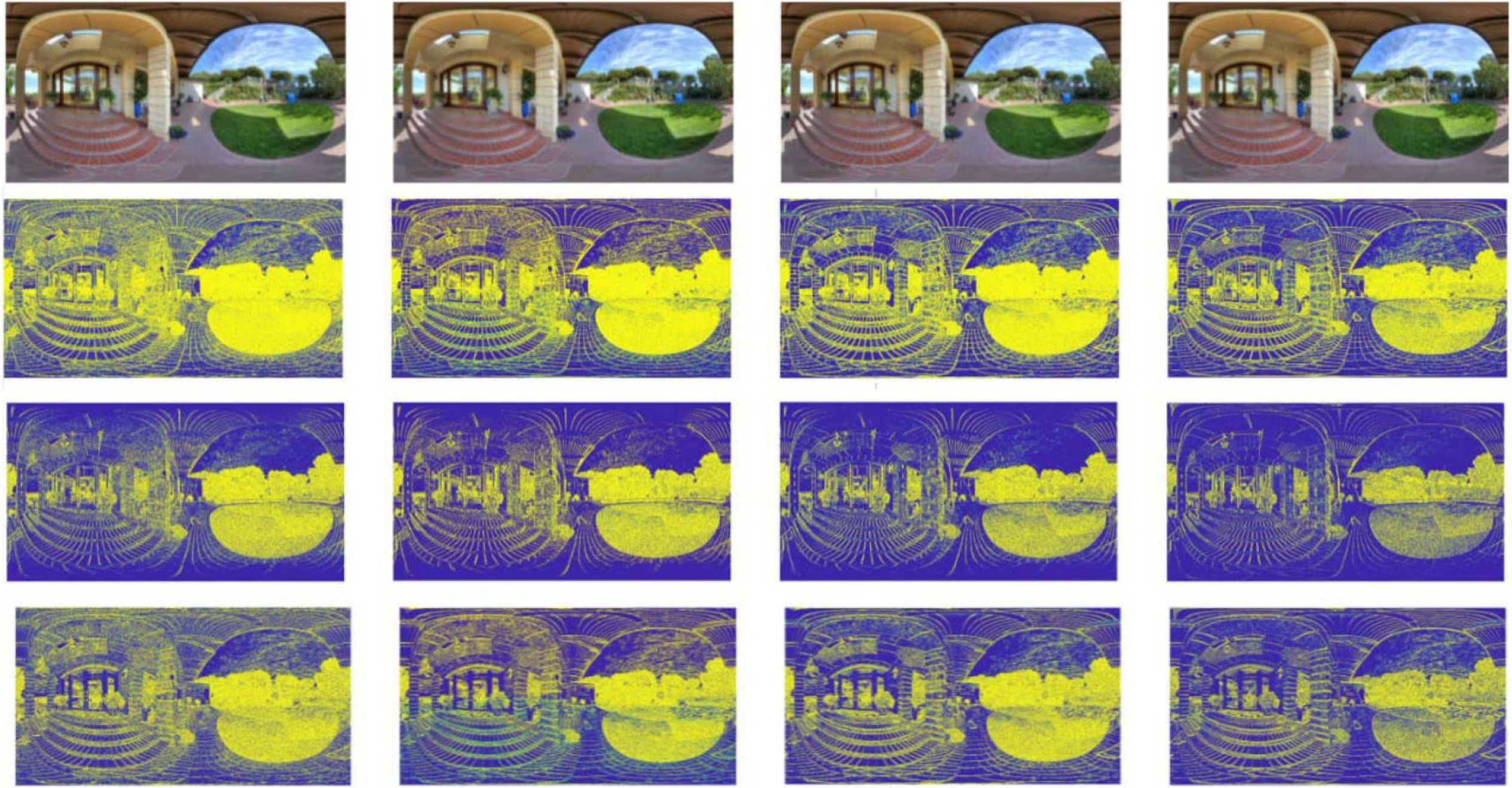
- 图像的梯度能够为HVS提供关于边缘和结构分布的信息
- 在水平和垂直方向上使用Sobel滤波器对图像进行卷积计算梯度

$$|G| = |G_h| + |G_v|$$

$$G_h = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * I$$

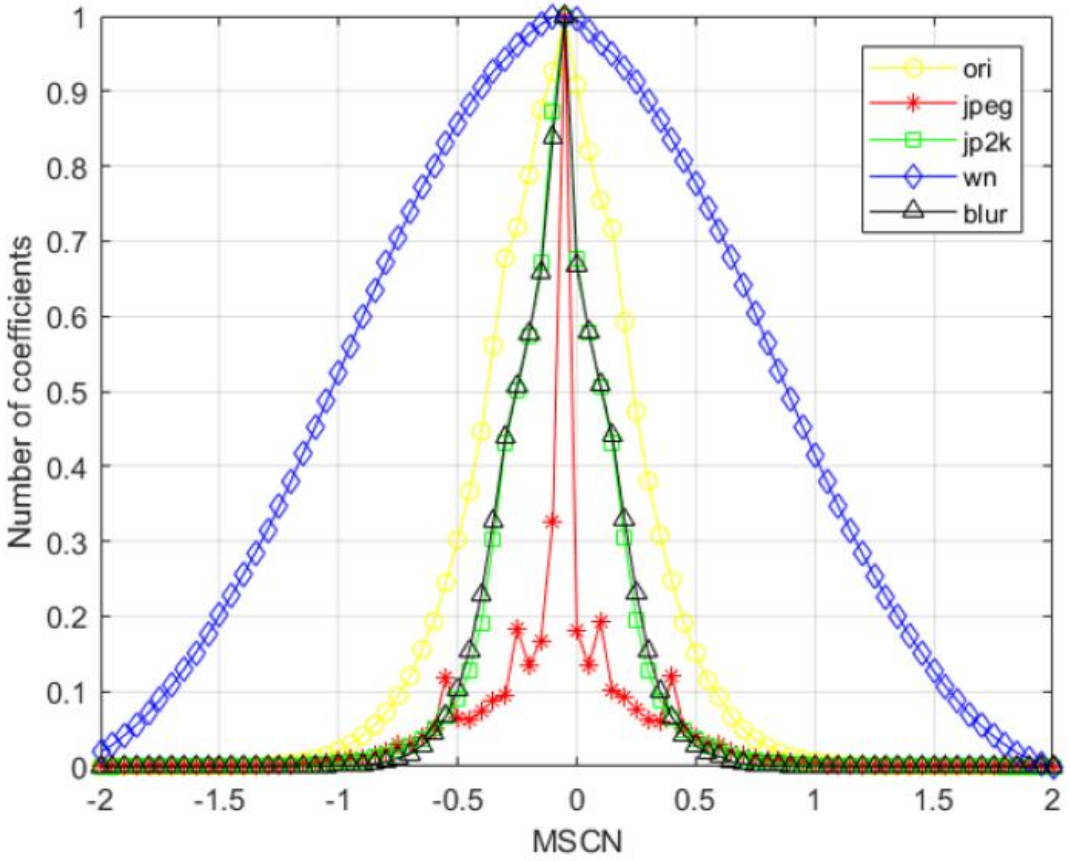
$$G_v = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * I$$



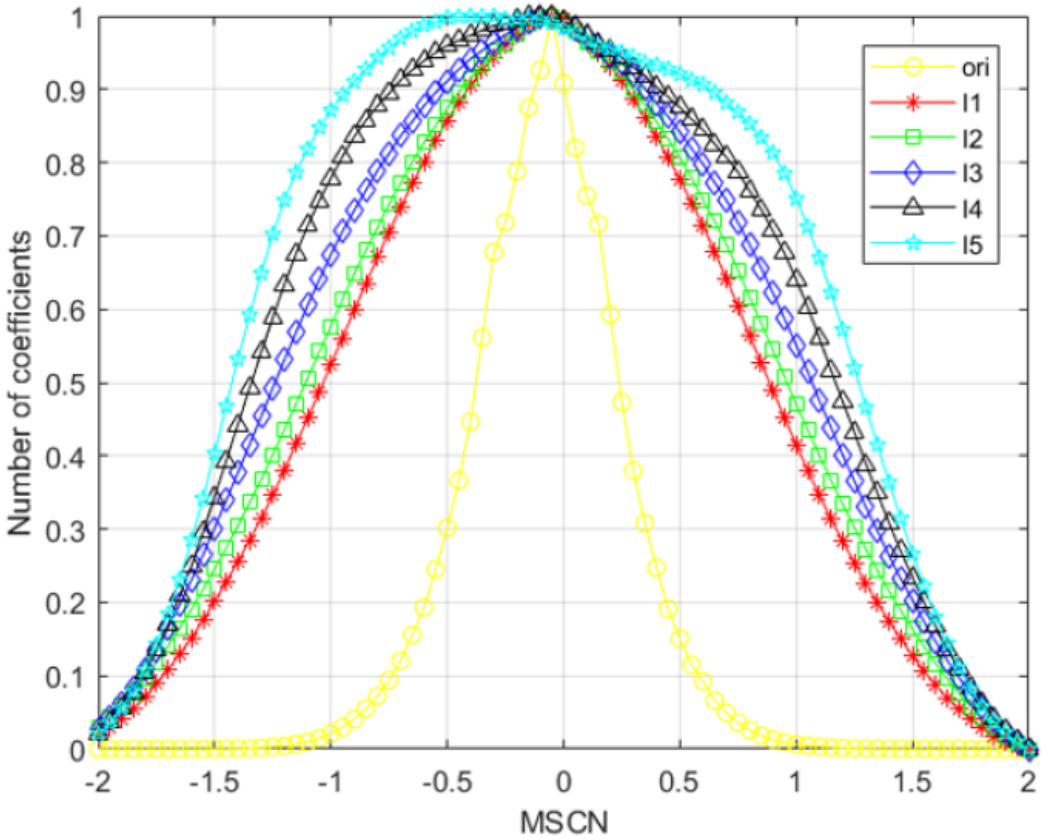


Nature Features

- MSCN能够显示图像质量的退化程度，用于提取图像的亮度特征。



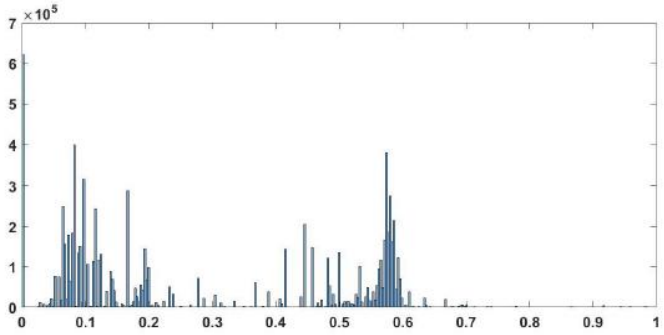
(a)



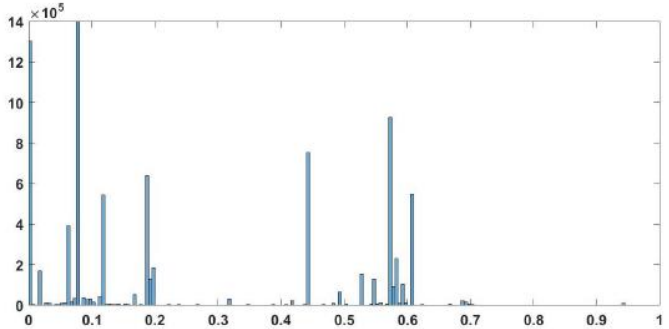
(b)

Nature Features

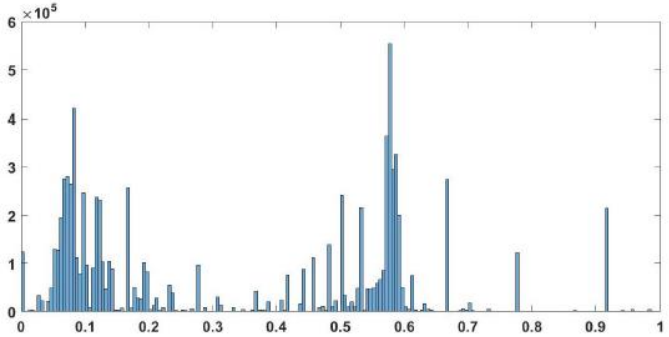
- HSV色彩空间用于表示颜色信息。而H通道的信号能更好地描述图像质量的下降。



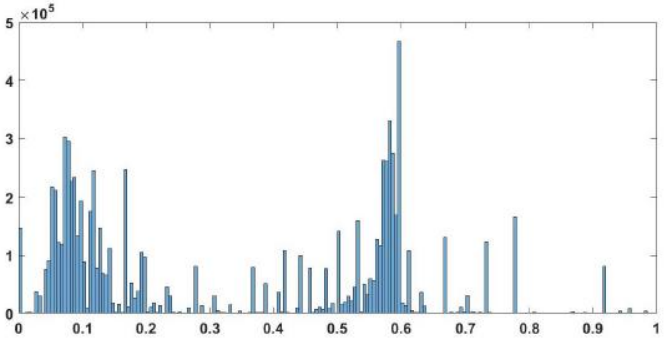
(a)
参考图像



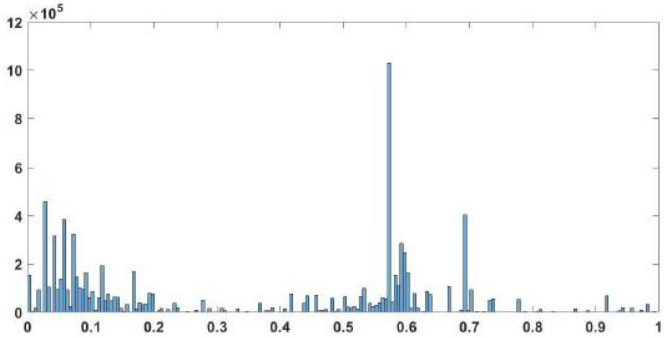
(b)
JPEG压缩



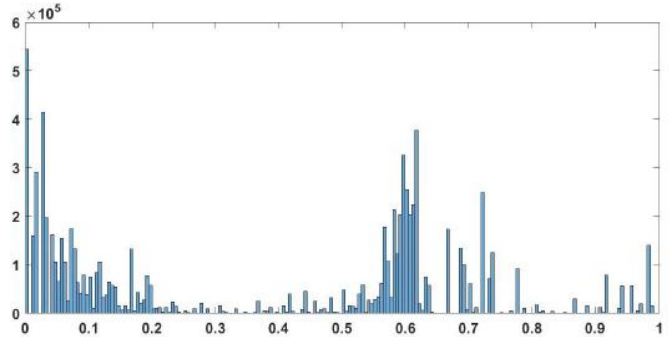
(c)
HEVC压缩



(d)



(e)



(f)

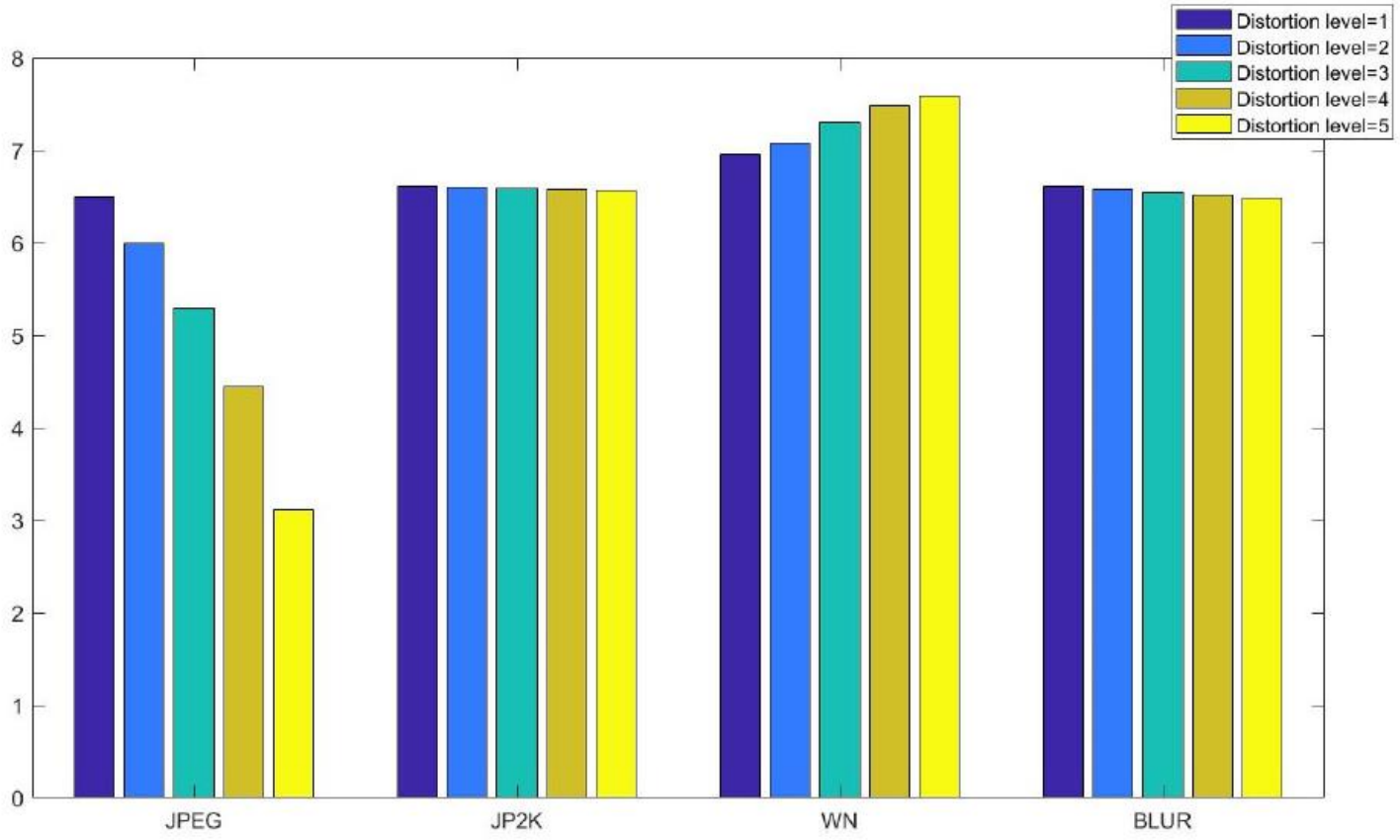
AVC压缩,程度从左到右依次增加

Nature Features

- 信息熵包含了丰富的NSS信息，对图像的失真很敏感。
- 采用了全局熵:

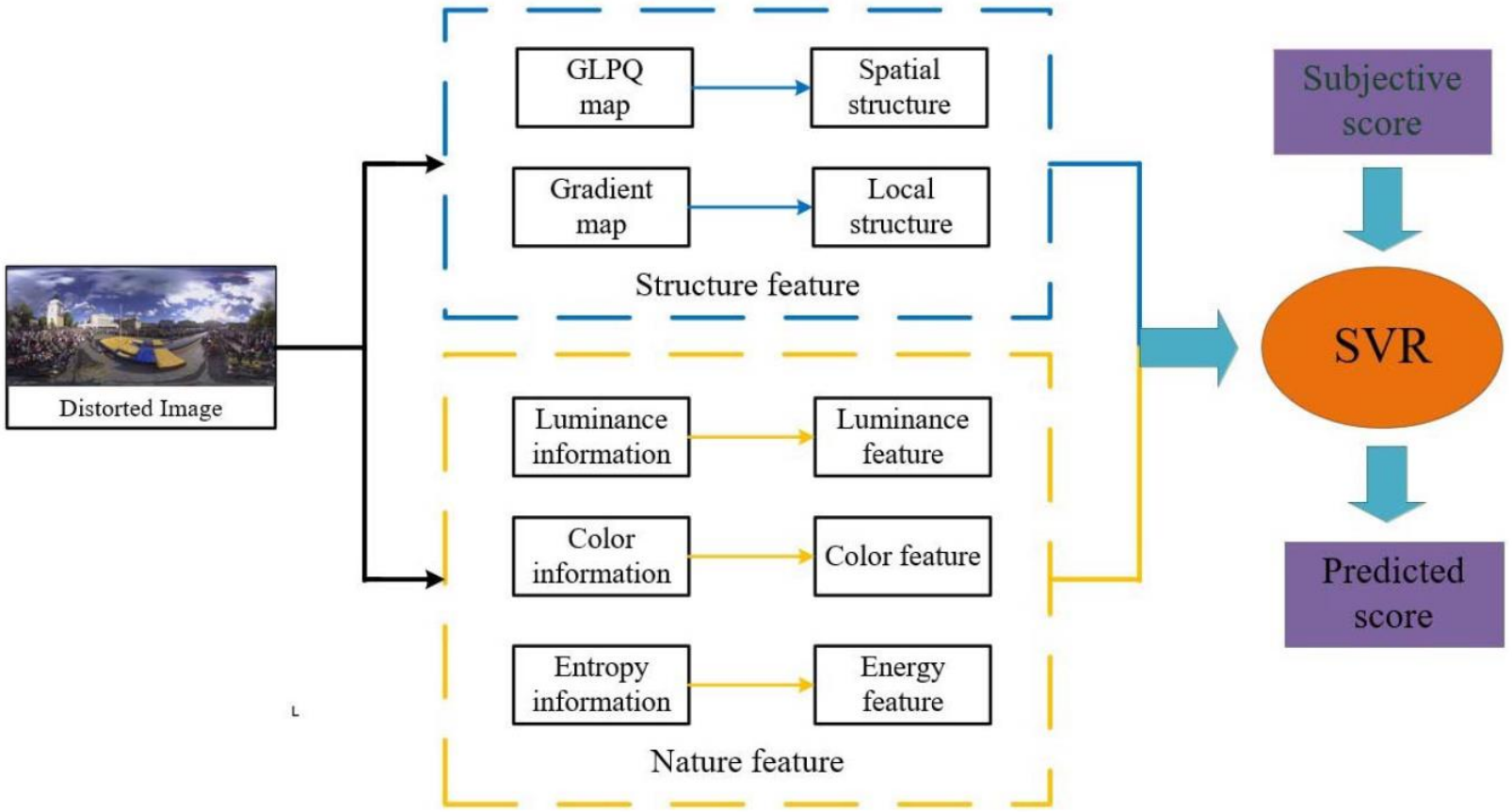
$$E_I = -\sum_n p(n)\log_2 p(n)$$

- N为像素值，p(n) 为概率密度。



Method

- 最后使用SVR进行质量的预测



Experiment

- 数据集
- CVIQD2018
  - 由16张原始图像生成的544张失真图像。有三种失真类型：JPEG，AVC和HEVC。
- QIQA
  - 由16张原始图像生成的320张失真图像。有四种失真类型：Gaussian blur, JPEG2000, JPEG和Gaussian noise

TABLE II

PERFORMANCE EVALUATION ON CVIQD2018 IMAGE DATABASE

Types	Metrics	SRCC	KRCC	PLCC	RMSE
FR-IQA	PSNR	0.7731	0.5698	0.2585	13.8028
	SSIM	0.6747	0.4819	0.6901	10.3403
	VIF	0.8347	0.6428	0.8368	7.8230
	VSI	0.8929	0.7115	0.9130	5.8277
	GMSD	-0.8503	-0.6527	0.8647	7.1864
	FSIM	0.9150	0.7425	0.9248	5.3094
	FSIMc	0.9161	0.7448	0.9298	5.2952
FR-OIQA	CPP-PSNR	0.8256	0.6268	0.8397	7.5900
	S-PSNR	0.7997	0.5999	0.8330	7.6747
	WS-SSIM	0.9116	0.7445	0.9293	5.2626
BIQA	BRISQUE	**0.9192**	**0.7628**	0.9377	4.8705
	NIQE	-0.8168	-0.6200	0.8454	7.6316
BOIQA	MC360IQA	0.9153	NA	0.9391	5.6728
	MC360IQA(20)	0.9139	NA	**0.9506**	**3.0905**
	SSP-BOIQA	0.8614	0.6954	0.9077	6.1178
Proposed		**0.9344**	**0.7847**	**0.9481**	**4.4964**

TABLE III

PERFORMANCE EVALUATION ON OIQA IMAGE DATABASE

Types	Metrics	SRCC	KRCC	PLCC	RMSE
FR-IQA	PSNR	0.5634	0.3940	0.5828	1.7916
	SSIM	0.8573	0.6598	0.8679	1.0953
	VIF	0.8305	0.6413	0.8331	1.2194
	VSI	0.9165	0.7388	0.9191	0.8684
	GMSD	-0.3186	-0.2229	0.3166	2.0913
	FSIM	0.9225	0.7482	0.9274	0.8250
	FSIMc	0.9240	0.7496	0.9284	0.8194
FR-OIQA	CPP-PSNR	0.5182	0.3502	0.5186	1.8078
	S-PSNR	0.5303	0.3588	0.5319	1.7904
	WS-PSNR	0.5032	0.3414	0.5044	1.8256
BIQA	BRISQUE	**0.9247**	**0.7728**	**0.9374**	**0.7367**
	NIQE	-0.8155	-0.6186	0.8155	1.2760
BOIQA	ASY-PIQA	0.7150	0.5270	0.7408	1.4264
	MC360IQA(20)	0.9187	NA	0.2947	4.6247
Proposed		**0.9369**	**0.7852**	**0.9437**	**0.7191**

TABLE IV

COMPARISON OF DIFFERENT DISTORTION TYPES ON THE CVIQD2018 DATABASE

Types	Metrics	JPEG				AVC				HEVC			
		SRCC	KRCC	PLCC	RMSE	SRCC	KRCC	PLCC	RMSE	SRCC	KRCC	PLCC	RMSE
FR-IQA	PSNR	0.7637	0.5738	0.8880	7.8492	0.7842	0.5761	0.7842	7.6693	0.7450	0.5387	0.7468	7.9984
	SSIM	0.7439	0.5414	0.8392	9.2835	0.5782	0.4019	0.5729	10.1313	0.5761	0.3999	0.5746	9.8431
	VIF	0.9417	0.7985	0.9743	3.8452	0.9422	0.7852	0.9440	4.0792	**0.9379**	**0.7796**	**0.9394**	**4.1235**
	VSI	0.9198	0.7582	0.9625	4.6319	0.9133	0.7353	0.9157	4.9679	0.8710	0.6751	0.8814	5.6813
	GMSD	-0.9129	-0.7521	0.9659	4.4230	-0.8604	-0.6691	0.8574	6.3620	-0.8634	-0.6655	0.8630	6.0770
	FSIM	0.9286	0.7772	0.9711	4.0750	0.9430	0.7878	0.9460	4.0073	**0.9303**	0.7671	**0.9318**	4.3662
	FSIMc	0.9322	0.7835	0.9719	4.0209	**0.9453**	**0.7918**	**0.9467**	3.9801	0.9297	0.7656	0.9308	4.3964
FR-OIQA	WS-PSNR	0.7520	NA	0.8772	8.1974	0.7690	NA	0.7708	7.8743	0.7389	NA	0.7428	8.0515
	CPP-PSNR	0.7604	NA	0.8802	8.1019	0.7726	NA	0.7748	7.8143	0.7430	NA	0.7469	7.9974
	S-PSNR	0.7729	NA	0.8886	7.8302	0.7815	NA	0.7854	7.6506	0.7540	NA	0.7578	7.8471
BIQA	BRISQUE	**0.9541**	**0.8247**	**0.9818**	3.2431	0.9377	0.7847	0.9428	4.1214	0.9015	0.7300	0.8991	5.2640
	NIQE	-0.8427	-0.6557	0.8965	7.5642	-0.8217	-0.6103	0.8166	7.1337	-0.7766	-0.5755	0.7835	7.4736
BOIQA	MC360IQA(20)	0.9316	NA	0.9746	**2.6388**	0.9244	NA	0.9461	**2.6983**	0.8985	NA	0.9126	**3.2935**
Proposed		**0.9650**	**0.8501**	**0.9844**	**2.9991**	**0.9545**	**0.8200**	**0.9576**	**3.5623**	0.9278	**0.7749**	0.9289	4.4534

TABLE V

COMPARISON OF DIFFERENT DISTORTION TYPES ON THE OIQA DATABASE

Types	Metrics	JPEG				JP2K				WN				BLUR			
		SRCC	KRCC	PLCC	RMSE	SRCC	KRCC	PLCC	RMSE	SRCC	KRCC	PLCC	RMSE	SRCC	KRCC	PLCC	RMSE
FR-IQA	PSNR	0.7351	0.5347	0.7579	1.4987	0.7697	0.5814	0.7333	1.5025	0.9293	0.7586	0.9483	0.5971	0.5009	0.3480	0.4967	1.6945
	SSIM	0.8938	0.7053	0.9103	0.9510	0.9270	0.7688	0.9233	0.8488	0.8794	0.7003	0.8980	0.8278	0.9205	0.7502	0.9179	0.7747
	VIF	0.9041	0.7224	0.9233	0.8822	0.9441	0.8030	0.9411	0.7471	0.9451	0.8023	0.9621	0.5129	0.8661	0.6741	0.8783	0.9334
	VSI	0.9483	0.8029	0.9527	0.6982	0.9408	0.7866	0.9380	0.7661	0.9100	0.7098	0.9375	0.6548	0.9307	0.7642	0.9272	0.7313
	GMSD	-0.3011	-0.2104	0.3601	2.1430	-0.3521	-0.2416	0.3589	2.0627	-0.4296	-0.2985	0.5079	1.6208	-0.0583	-0.0417	0.1932	1.9156
	FSIM	0.9351	0.7719	0.9478	0.7321	**0.9573**	**0.8163**	**0.9545**	**0.6592**	0.9176	0.7256	0.9466	0.6067	0.9474	0.7971	0.9441	0.6437
	FSIMc	0.9410	0.7858	0.9510	0.7105	0.9551	0.8106	0.9539	0.6629	0.9192	0.7269	0.9498	0.5965	**0.9478**	**0.7978**	**0.9444**	**0.6422**
FR-OIQA	WS-PSNR	0.8278	NA	0.8607	7.9919	0.8322	NA	0.8435	8.0719	0.6583	NA	0.6609	9.9652	0.8853	NA	0.9221	4.9415
	CPP-PSNR	0.8282	NA	0.8654	7.8678	0.8375	NA	0.8488	7.9449	0.6666	NA	0.6734	9.8162	0.8851	NA	0.9201	5.0010
	S-PSNR	0.8285	NA	0.8703	7.7319	0.8489	NA	0.8555	7.7811	0.6917	NA	0.6929	9.5736	0.8846	NA	0.9190	5.0329
BIQA	BRISQUE	**0.9587**	**0.8226**	**0.9590**	**0.6508**	0.8731	0.6840	0.8847	1.0301	**0.9715**	**0.8587**	**0.9793**	**0.3809**	0.9382	0.7762	0.9436	0.6461
	NIQE	-0.8613	-0.6603	0.8842	1.0730	-0.8710	-0.6928	0.8751	1.0694	-0.9473	-0.8004	0.9581	0.5389	-0.8446	-0.6493	0.8443	1.0463
BOIQA	MC360IQA(20)	0.9190	NA	0.9279	4.5058	0.9252	NA	0.9324	4.5825	0.9353	NA	0.9220	4.5256	0.9345	NA	0.9344	3.7908
Proposed		**0.9536**	**0.8200**	**0.9612**	**0.6333**	**0.9676**	**0.8474**	**0.9697**	**0.5394**	**0.9737**	**0.8633**	**0.9789**	**0.3845**	**0.9558**	**0.8320**	**0.9645**	**0.5158**

Comments

- 通过计算梯度图上的LPQ，能够得到一种新颖的结构特征，描述图像的结构失真
- 利用了之前模型忽略的颜色特征，提高模型的准确性

- 一些对于全方向图像适用的特征可能并不适用于普通的图像

Thanks!