

Cubemap-Based Perception-Driven Blind Quality Assessment for 360-degree Images

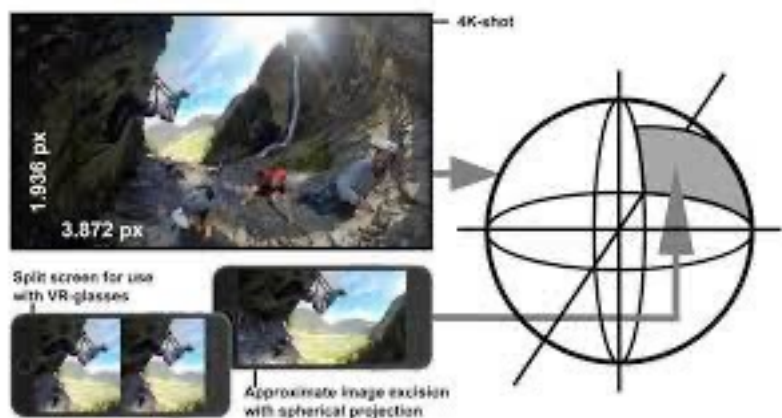
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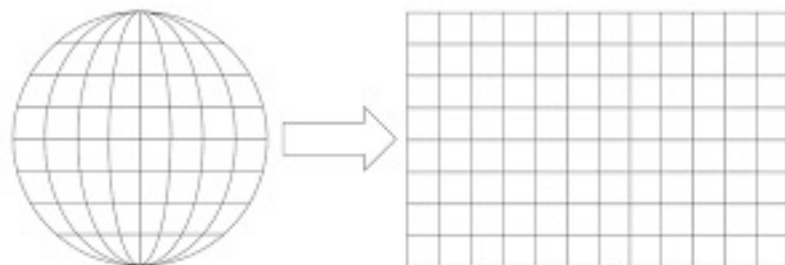
360-degree Images

- 360-degree Images / omnidirectional images: 全景图像
- 不同的表示方法
 - SP, ERP, CMP, ...
- 全景图像需要转化为2d的图像来储存和运输, 显示时又需要2d图像转化为全景图像, 故转化中涉及到的投影方式很重要

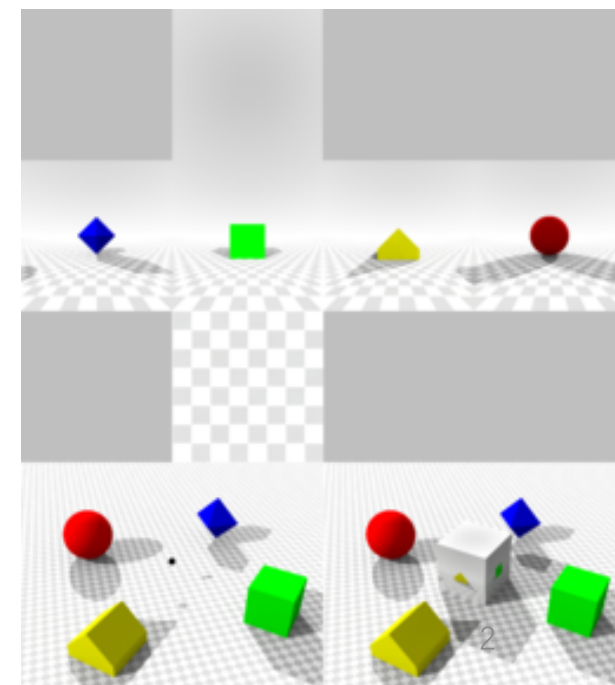
spherical projection (SP) image



equiarectangular projection (ERP) image



cubemap projection (CMP) image



Motivation

- 较多全景图像的客观质量评价集中于ERP图像的质量评估
- 但ERP图像存在：
 - 过采样的数据冗余（南极和北极）
 - 几何形变
 - 重映射失真（re-projection distortion）
- 故对于2D图像的NR-IQA无法直接用于ERP图像上

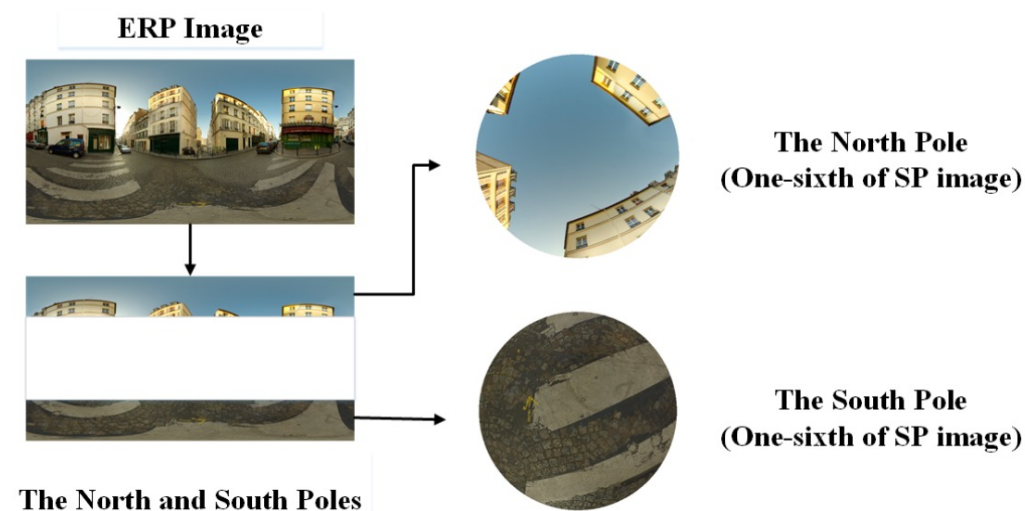


Fig. 1. The over-sampling redundancy between ERP image and SP image.

Motivation

- ERP表示方法的图像：客观质量与主观评价不太一致，但广泛用于全景图像的储存，压缩和传播
- SP表示方法的图像：质量与主观评价最为一致，但难以储存，压缩和传播
- CMP表示方法的图像：质量与主观评价较为一致

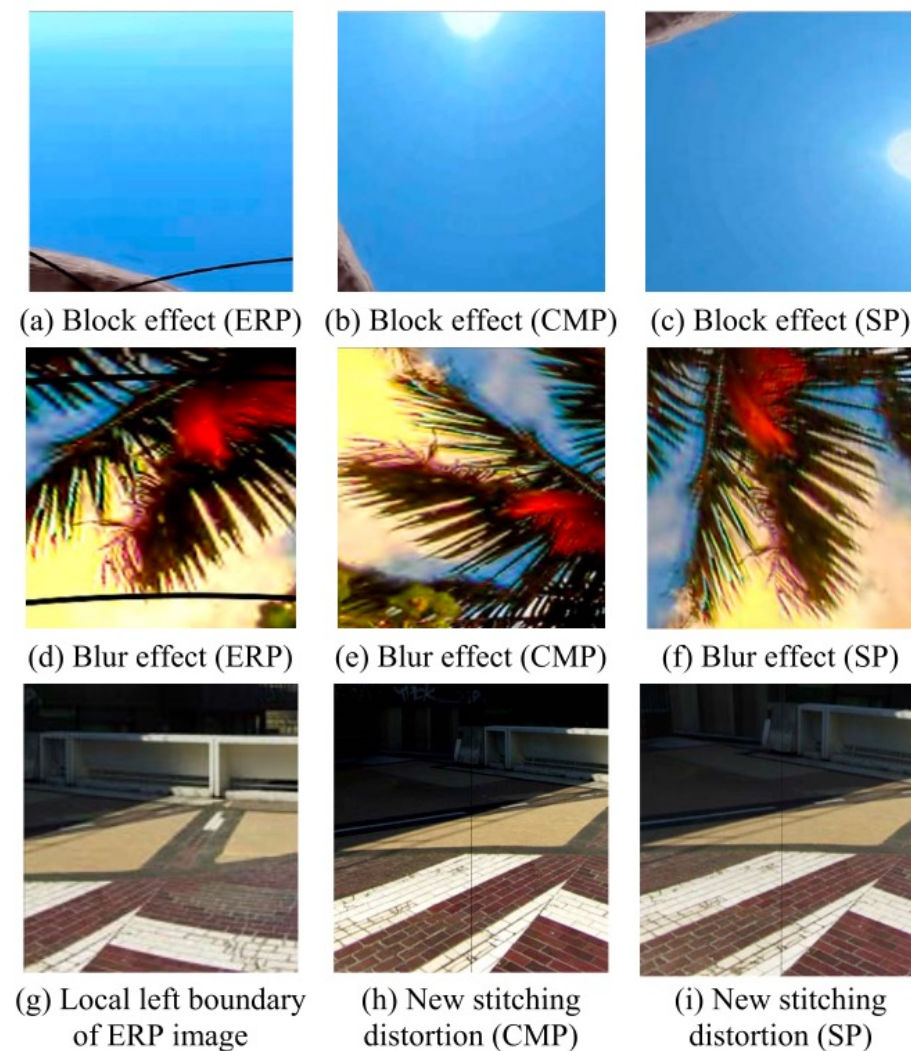


Fig. 2. Distortion comparison of ERP, CMP and SP images.

Method

- 考虑全景图像的多种特征
- Cubemap Quality Feature Subset
 - CMP图像中，每个面的图像的预测质量分数记作 f_k ，通过2D图像的NR-IQA方法得到
 - **Quality Feature Subset:** $F_Q = \{f_1, f_2, f_3, f_4, f_5, f_6\}$

Method

- Attention Feature Subset
 - head movement (HM), eye movement (EM) 反应了被试在注视图像时的关注重点
 - 将注意力热力图分为四个区域：non, mild, moderate and severe
 - 并将注意力图转化为CMP表示
 - H_{mi_k} :第k个面的HM热力图中, mild的面积占比
 - E_{mo_k} :第k个面的EM热力图中, moderate的面积占比

$$A_W = \begin{pmatrix} H_{mi_1} & H_{mo_1} & H_{s_1} & E_{mi_1} & E_{mo_1} & E_{s_1} \\ H_{mi_2} & H_{mo_2} & H_{s_2} & E_{mi_2} & E_{mo_2} & E_{s_2} \\ H_{mi_3} & H_{mo_3} & H_{s_3} & E_{mi_3} & E_{mo_3} & E_{s_3} \\ H_{mi_4} & H_{mo_4} & H_{s_4} & E_{mi_4} & E_{mo_4} & E_{s_4} \\ H_{mi_5} & H_{mo_5} & H_{s_5} & E_{mi_5} & E_{mo_5} & E_{s_5} \\ H_{mi_6} & H_{mo_6} & H_{s_6} & E_{mi_6} & E_{mo_6} & E_{s_6} \end{pmatrix}$$

Attention Weight Subset:

$$F_{AW} = \{ H_{mi_k}, H_{mo_k}, H_{s_k}, E_{mi_k}, E_{mo_k}, E_{s_k} \}$$

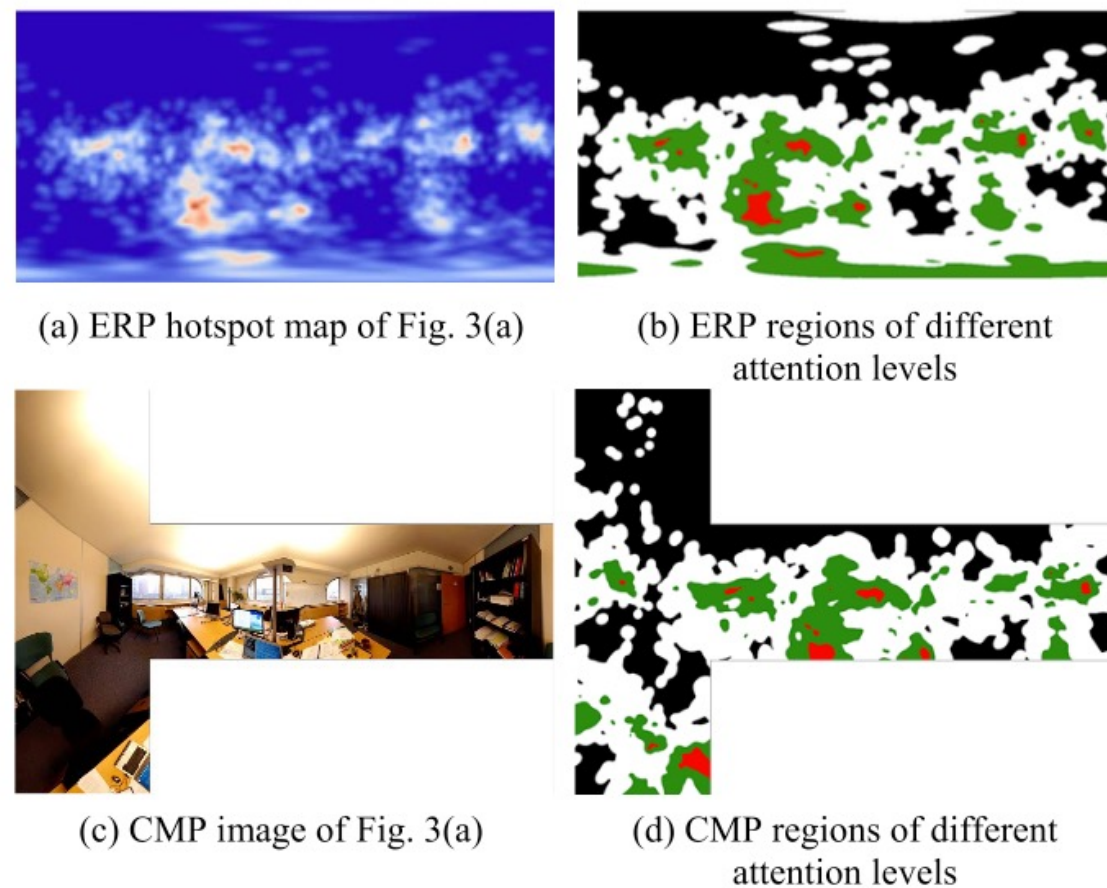


Fig. 7. Human attention behavior in 360-degree image.

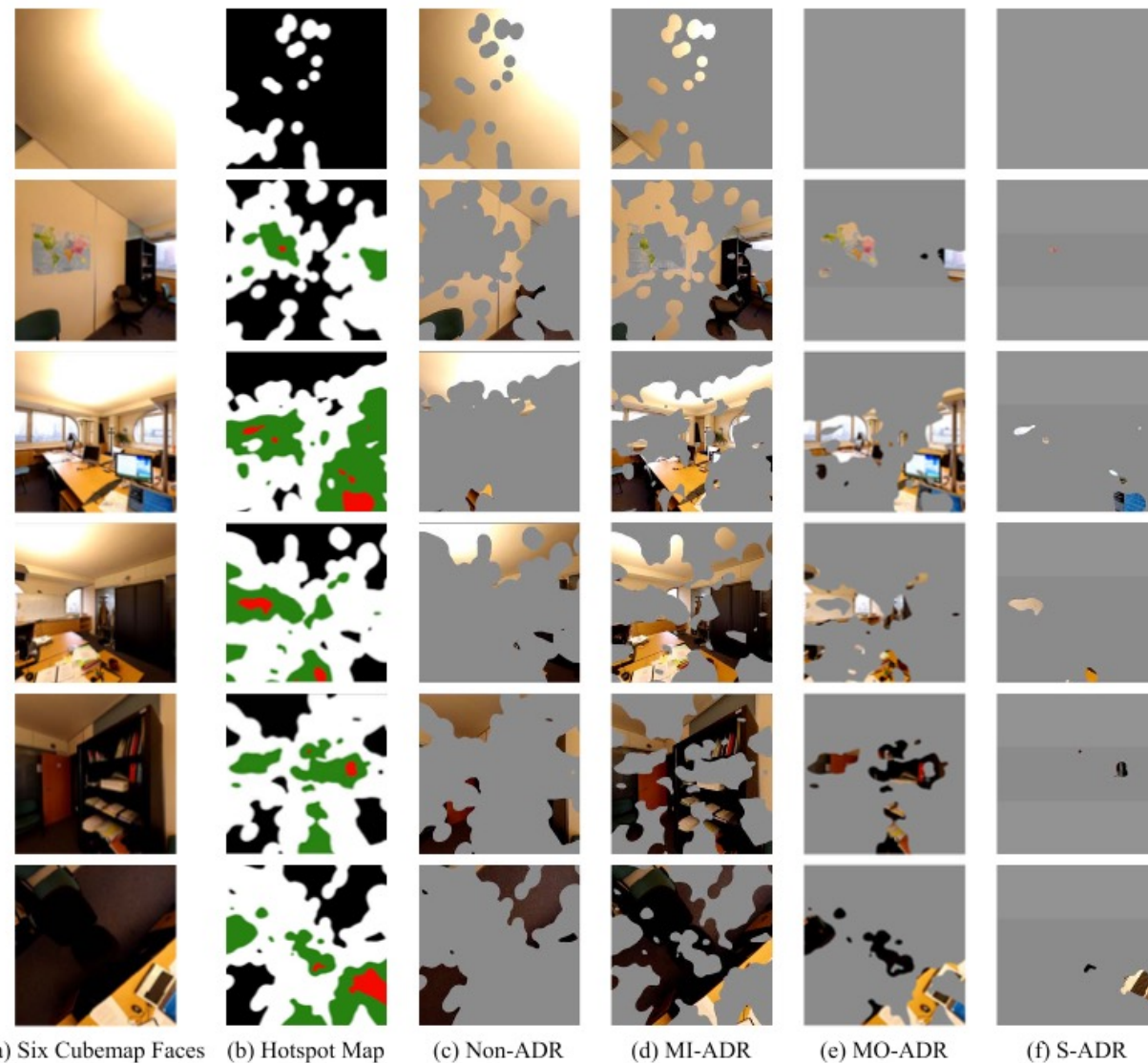
Method

- D_{S_k} : 第k个面上的severe区域的失真情况
(用NR-IQA 产生的特征向量表示)

$$A_D = \begin{pmatrix} D_{non_1} & D_{mi_1} & D_{mo_1} & D_{s_1} \\ D_{non_2} & D_{mi_2} & D_{mo_2} & D_{s_2} \\ D_{non_3} & D_{mi_3} & D_{mo_3} & D_{s_3} \\ D_{non_4} & D_{mi_4} & D_{mo_4} & D_{s_4} \\ D_{non_5} & D_{mi_5} & D_{mo_5} & D_{s_5} \\ D_{non_6} & D_{mi_6} & D_{mo_6} & D_{s_6} \end{pmatrix}$$

Attention Distortion Subset:

$$F_{AD} = \{ D_{non_k}, D_{mi_k}, D_{mo_k}, D_{s_k} \}$$



Method

- Scheme-I : 只使用 F_Q (Quality Feature Subset)
- Scheme-II : 使用 F_Q (Quality Feature Subset)和 F_{AW} (Attention Weight Subset)
- Scheme-III : 使用 F_{AD} (Attention Distortion Subset)

- 对每个方案, 使用随机森林计算每个特征的权重, 并使用加权后的特征作为全景图像的特征表示

Datasets

- 提出数据集MVAQD：
 - 基于全景图像数据集 visual attention dataset (VAD), 本身包含HM和EM数据
 - 取15张不同分辨率, 不同场景全景图像作为参考图像
 - 生成5种失真类型, 4种失真程度的失真图像
 - JPEG compression, JP2K compression, HEVC intra-frame coding, white noise and Gaussian blur
 - 考虑到失真产生的原因, white noise在CMP图像上生成; 其余四种失真是在ERP图像上生成
 - 共315张图像
 - 使用主观实验进行打分
- OIQA数据集：
 - 16张原始图像, 4种失真类型, 5种失真等级, 共336张图像
 - 没有HM和EM数据, 实验中使用主体预测的方法生成注意力图

Experiments

TABLE II
PLCC AND SROCC OF DIFFERENT QUALITY ASSESSMENT
METHODS ON MVAQD DATASET

Quality Assessment Methods		PLCC	SROCC
FR-IQA (For ERP images)	S-PSNR [14]	0.7268	0.6939
	WS-PSNR [15]	0.7074	0.7097
	SSIM [16]	0.7844	0.7833
	S-SSIM [17]	0.8109	0.7950
BIQA (For ERP images)	IL-NIQE [18]	0.1849	0.0830
	OG-IQA [19]	0.4116	0.2362
	GM-LOG [20]	0.2301	0.1961
	BRISQUE [21]	0.6181	0.6176
	hotspot map based BRISQUE [21]	0.7141	0.7075
BIQA (For CMP images Cube-4×3)	IL-NIQE [18]	0.1977	0.0176
	OG-IQA [19]	0.4997	0.1055
	GM-LOG [20]	0.4654	0.2599
	BRISQUE [21]	0.6853	0.6598
Proposed Scheme Using Feature Subsets from IL-NIQE [18]	<i>Scheme-I</i> Feature set: F_Q	0.7535	0.7453
	<i>Scheme-II</i> Feature set: F_{360}	0.7703	0.7591
	<i>Scheme-III</i> Feature set: F_{AD}	0.8019	0.7987
Proposed Scheme Using Feature Subsets from BRISQUE [21]	<i>Scheme-I</i> Feature set: F_Q	0.7339	0.7253
	<i>Scheme-II</i> Feature set: F_{360}	0.7387	0.7341
	<i>Scheme-III</i> Feature set: F_{AD}	0.7416	0.7471

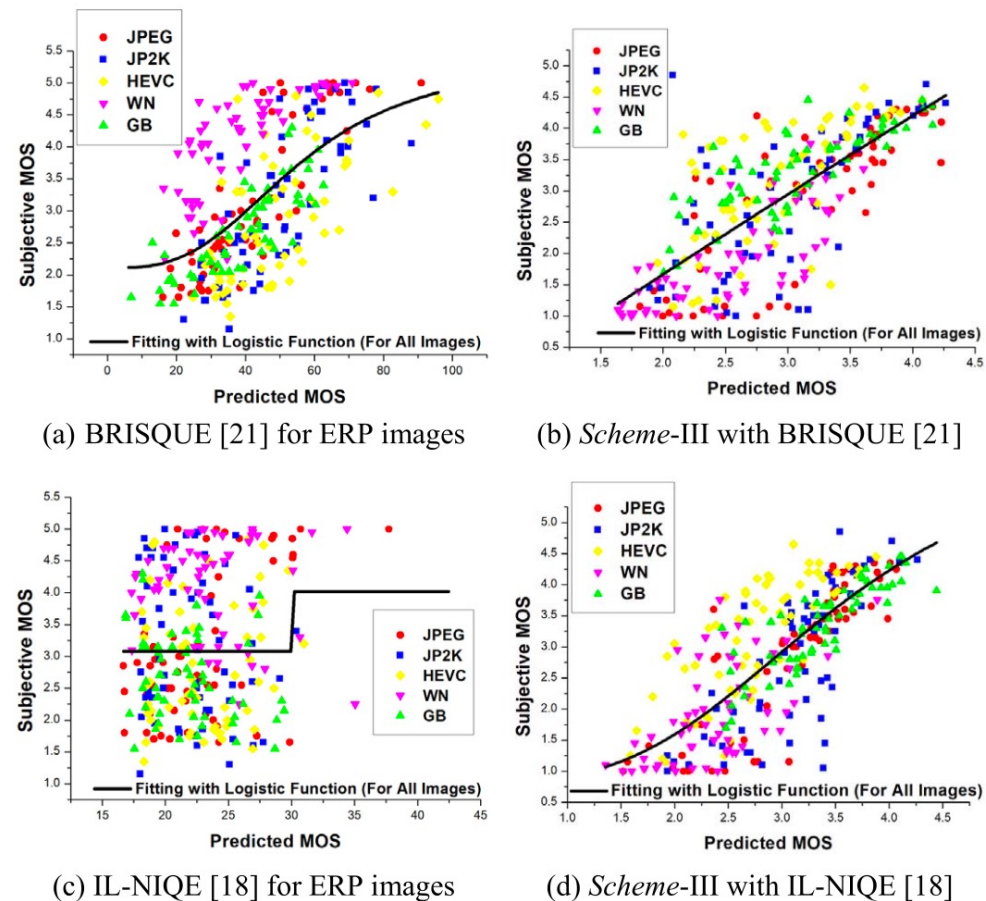


Fig. 9. Scatter plots for proposed and benchmark schemes on MVAQD dataset.

Experiments

TABLE III

PLCC AND SROCC OF DIFFERENT QUALITY ASSESSMENT METHODS ON OIQA DATASET

Dataset	Quality Assessment Methods		PLCC	SROCC
OIQA Dataset	Proposed Scheme Using Feature Subsets from IL-NIQE [18]	<i>Scheme-I</i> Feature set: F_Q	0.8034	0.7908
		<i>Scheme-II</i> Feature set: F_{360}	0.8198	0.8107
		<i>Scheme-III</i> Feature set: F_{AD}	0.8348	0.8320
	Proposed Scheme Using Feature Subsets from BRISQUE [21]	<i>Scheme-I</i> Feature set: F_Q	0.7525	0.7411
		<i>Scheme-II</i> Feature set: F_{360}	0.7682	0.7595
		<i>Scheme-III</i> Feature set: F_{AD}	0.7757	0.7631

TABLE IV

PLCC AND SROCC OF DIFFERENT DISTORTIONS OF CROSS DATASET VALIDATION

Dataset	Quality Assessment Methods	Distortion Type	PLCC	SROCC
Cross Dataset	IL-NIQE for ERP images	JPEG	0.7312	0.6914
		JPEG2000	0.2982	0.2464
		Gaussian Blur	0.6611	0.6655
		Gaussian Noise	0.6706	0.6764
		ALL	0.5673	0.5442
	Proposed scheme using F_Q from IL-NIQE	JPEG	0.7963	0.7558
		JPEG2000	0.7593	0.7579
		Gaussian Blur	0.8457	0.7706
		Gaussian Noise	0.8632	0.8577
		ALL	0.7982	0.7648

Summary

- 使用CMP格式的全景图像，将全景图像转化为2D图像，并使用注意力信息分割图像，分别预测质量
 - 全景图像的质量预测主要涉及：
 - 转化成2D表示的全景图像与实际全景图像有较大差别（无法直接套用2D图像的IQA方法）
 - 重映射带来的失真如何表示
- + CMP格式的使用使得2D图像的IQA方法变得可用
- + motivation讲的较为详细
- HM和EM数据不易获得
 - 目前的数据集规模仍比较小
 - 没有考虑视点的选择问题