Score Fusion For Screen Contents

To fuse the scores, two images, ref, and dst, are fed to FR algorithms. Each algorithm generates a score. These scores comprise a feature vector. A SVR then maps this feature vector to a final quality measure.

The SQMS [1] was used as a base SCI-FR algorithm and the effect of combining it with the following FR algorithms was studied.

1. HaarPSI [2]
2. VIF [2]
3. GMSD [3]
4. LBPSI [4]

Since Wavelet's horizontal and vertical subbands are found to be effective in representing text structures, HaarPSI was included. The same justification applies to using LBPSI [4], which is a FR QA algorithm for document images. Contrast change is a challenging distortion for assessors and the information theory-based method, VIF, seems to be the best for such distortions. GMSD is also incorporated to consider gradient degradations.

The following cobminations were possible, and were considered for experiments:

1- "SQMS"

2- "SQMS+HaarPSI"

3- "SQMS+GMSD"

4- "SQMS+VIF"

5- "SQMS+LBPSI"

6- "SQMS+HaarPSI+GMSD"

7- "SQMS+HaarPSI+VIF"

8- "SQMS+HaarPSI+LBPSI"

9- "SQMS+GMSD+VIF"

10- "SQMS+GMSD+LBPSI"

11- "SQMS+VIF+LBPSI"

12- "SQMS+HaarPSI+GMSD+VIF"

13- "SQMS+HaarPSI+GMSD+LBPSI"

14- "SQMS+HaarPSI+VIF+LBPSI"

15- "SQMS+GMSD+VIF+LBPSI"

(by *2- "SQMS+HaarPSI"* , we mean that the feature vector is the scores generated by SQMS and HaarPSI , $\vec{f} = [SQMS, HaarPSI]$. The same is true for other 14 functions. *1- SQMS* , is not a combination; it is the single score generated by SQMS.)

Datasets

SCID has 9 distortions, and SIQAD has 7. The table summarizes the information of the datasets.

Dataset	#Refs	#Dsts	#Dst Levels	Dst types
SIQAD[6]	20	7	7	$GN - GB - MB - CC - JPEG - JPE$
SCID[7]	40	9	5	$GN - GB - MB - CC - JPEG - JPEG2000$ -

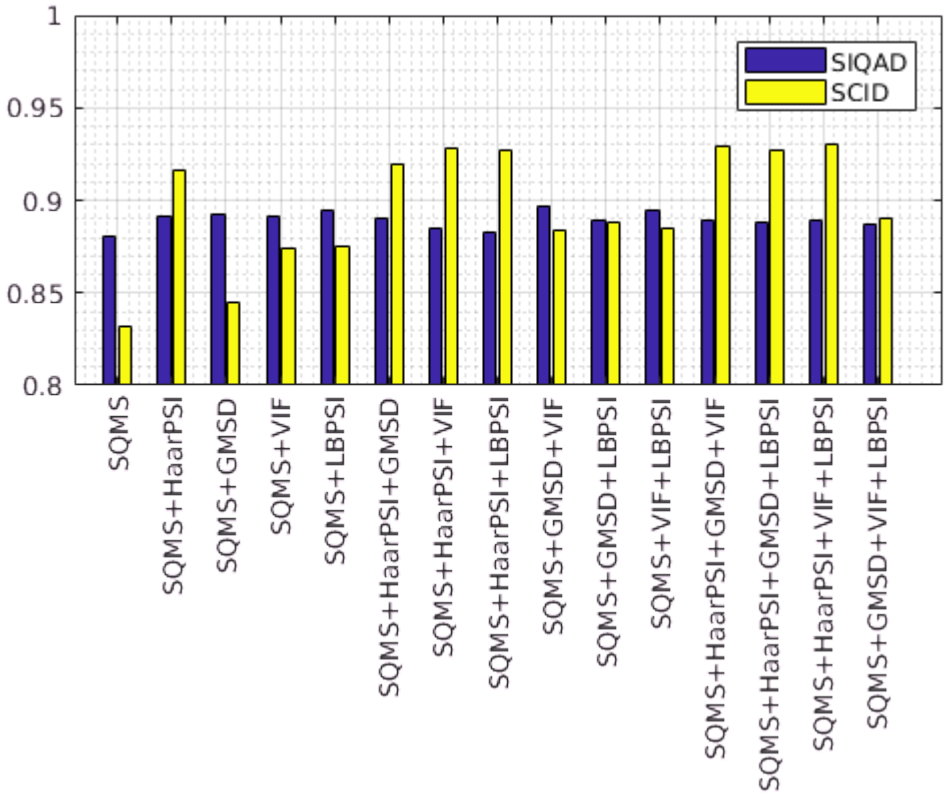
We see that six distortions are common. (A description of distortions is provided at the end of the document.)

Testing the Entire Datasets

In the first experiment, the methods were evaluated on the entire datasets. The SVR models were trained and tested 1000 times on random 80-20 splits **with optimized** C **and** γ parameters.

```
% this is just the code for plotting the data.
load('data_SCID.mat');
load('data_SIQAD.mat');
load('f_names_15.mat');
for ii = 1:15
    all_two_datasets(1,ii) = data_SIQAD{end, ii+1};
    all_two_datasets(2, ii) = data_SCID{end, ii+1};
end
bar(all_two_datasets'), legend('SIQAD', 'SCID'), grid('on'), grid('minor'),...
    xticks(1:15), xticklabels(f_names_15), xtickangle(90)

xlim([0.2 16.2])
ylim([0.8 1])
```



Distortions in SCID

Generation of distorted SCIs in the SCID

The distorted SCIs are generated by applying various image operations to each reference SCI, individually. Image operations to generate 9 distortion types with 5 degradation levels (ranging from imperceptible level to highly-annoying one) are introduced as below:

- Gaussian Noise (GN): the corresponding distorted SCIs with GN are obtained by performing MATLAB function "*imnoise*". The mean is zero, and the standard deviation is set as 0.001, 0.005, 0.01, 0.05 and 0.1, respectively.

- Gaussian Blur (GB): the corresponding distorted SCIs with GB are obtained by performing MATLAB function "*imfilter*" with Gaussian kernel. The size of the Gaussian kernel is 5×5, and the standard deviation is set to 0.58, 0.76, 0.96, 1.2 and 2.1, respectively.

- Motion Blur (MB): the corresponding distorted SCIs with MB are obtained by performing MATLAB function "*imfilter*" with motion kernel, which stimulates the linear motion of a camera. The blurring level is controlled by the following two parameters "len" and "theta". The former one controls the linear motion of a camera by 'len' pixels, while the latter one controls the degree of angle in a counterclockwise direction. In our experiments, 'theta' is zero and 'len' is set as 2, 3.4, 4, 5.5, and 6.4, respectively.

- Contrast Change (CC): the corresponding distorted SCIs with CC are obtained by performing MATLAB function "*imadjust*". The contrast change level is controlled by the parameter "[low_in; high_in]" and "[low_out; high_out]", which individually means the scale of the reference SCI and contrasted changed SCI. In our experiments, ([low_in; high_in], [low_out; high_out]) is set as: ([;], [0.3; 0.5]), ([;], [0.1;0.7]), ([0.1;0.8],[0.1; 0.9]), ([0.2; 0.8],[0.1; 0.8]), and ([0.2; 0.7],[;]), respectively.

- JPEG compression: the corresponding distorted SCIs with JPEG compression are obtained by performing MATLAB function "*imwrite*". The quality factor is set as 75, 35, 18, 8, and 5, respectively.

- JPEG2000 compression: the corresponding distorted SCIs with JPEG2000 compression are obtained by performing JasPer software [a], [b] (in this response letter). The compression ratio is set as 0.08, 0.045, 0.02, 0.015, and 0.01.

- JPEG 2000. [Online]. Available: https://jpeg.org/jpeg2000/software.html JasPer Software. [Online]. Available: http://www.ece.uvic.ca/~frodo/jasper/

- Color Saturation Change (CSC): the corresponding distorted SCIs with CSC are obtained by keeping the luminance component unchanged while changing the chrominance components. Firstly, MATLAB function 'rgb2ycbcr' is used to transform SCI from RGB to YCbCr. Then, the chrominance component is adjusted according to the following equation : where ,, ,, , and means the Y, Cb, Cr components of reference SCI and distorted SCI , respectively. is the parameter to control the level of color saturation change and is set as 0.96, 0.72, 0.58, 0.42, 0.1, respectively.

- HEVC Screen Content Compression (HEVC-SCC): the corresponding distorted SCIs with HEVC-SCC compression are obtained by performing HEVC-SCC encoder with standard configuration—"All Intra Main setting". The quantization parameters are set as 16, 36, 40, 42, and 48, respectively.

- Color quantization with dithering (CQD): the corresponding distorted SCIs with CQD are obtained by performing MATLAB function "*rgb2ind*". This function is used to convert RGB image to indexed image using dithering minimum variance quantization, where the parameter "N" is to control the number of color and is set as 30, 28, 25, 10, and 5, respectively.

Distortions in SIQAD

Generation of distorted SCIs in the SIQAD

Seven distortion types with seven distortion levels:

- Gaussian Noise (GN): distorted images are generated by the MATLAB function 'imnoise' with zero mean. The standard deviation is set from 0.02 to 0.24: 0.02, 0.04, 0.06, 0.1, 0.14, 0.18 and 0.24.

- Gaussian Blurring (GB): blurred images are obtained by implementing the MATLAB function 'imfilter' with Gaussian kernel. Size of the Gaussian kernel is 7 by 7, and the standard deviation is set to 0.58, 0.68, 0.76, 0.96, 1.2, 1.8 and 2.4.

- Motion Blurring (MB): motion blur is added to images by using the MATLAB function 'imfilter' with the motion kernel that approximates the linear motion of a camera. Two parameters 'len' and 'theta' are set to control the blurring level. Len: linear motion of a camera by 'len' pixels;Theta: an angle degree in a counterclockwise direction.Here, 'len' is set to [3, 3.4, 3.6, 4, 4.8, 6, 9], and 'theta' is zero.

- Contrast Change (CC): MATLAB function 'imadjust' is used to change contrast of test images. The contrast changes are listed as follows. Left is the scale of original image, and right is the scale of contrast changed image.[ ] to [0.3, 0.5], [ ] to [0.1, 0.7], [0.1, 0.8] to [0.1, 0.9], [0.2, 0.8] to [0.1, 0.8], [0.1, 0.6] to [0.1, 0.8], [0.2, 0.6] to [0.1, 0.8], [0.2, 0.7] to [ ]

- JPEG compression: the JPEG is implemented via MATLABs imwrite function. The quality factor is set to [75, 55, 48, 32, 25, 18, 13].

- JPEG2000 compression: MATLAB function 'imwrite' is also used to generated images compressed by JPEG2000. The compression factor is set to [20, 28, 32, 40, 46, 54, 65].

- Layer-Segmentation based Compression (LSC): we change the classification index map artificially. Some textual blocks are randomly misclassified to pictorial regions with misclassification ratio ranging from 40% to 80%. Quantization factor is set to [10, 8, 7, 6, 5, 4, 3] for the textual layer, while the pictorial layer is gradually of better quality (with the quality factor of JPEG equally spaced from 15 to 60).