Scene classification with respect to image quality measurements

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Outline

Introduction

Experimental process & results
   1. Scene descriptors
   2. Correlation between scene susceptibility & scene descriptors
   3. Objective scene classification

Conclusion
Introduction

Psychophysical scaling

Physical scaling

- Image Quality Models
- Customer Image Quality Rating
- Customer Perceptions-The "Nesses"
- Visual Algorithms
- Physical Image Parameters
- Technology Variables
- System/Image Models
Introduction

Subjective image quality depends upon the pictorial content of the test images.

This is the nature of scene dependency in image quality and it causes problems in modelling image quality* and its prediction.

* Device –dependent models
Introduction

There are several ways of overcoming the problems caused by scene dependency.

1. One commonly employed is to exclude results obtaining from non-standard scenes in quality measurements.
2. Another is the scene classification with respect to image quality.
Introduction

Aim

To **objectively classify test scenes**, using objective **scene descriptors** that correlate with subjective criteria on **scene susceptibility** to image quality attributes.
Test-images

HOW (?)
Experimental process for scene classification

- Scene susceptibility
- Scene classification
- Scene calibration
- Scene descriptors
- Scene susceptibility descriptors

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1. Scene descriptors

Global / Local

Local region: using Kadir and Brade’s (2004) saliency model
1. Scene descriptors

<table>
<thead>
<tr>
<th>Image features</th>
<th>Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity/Contrast/Info content</td>
<td>First-order statistical Measures</td>
</tr>
<tr>
<td>Texture</td>
<td>Second-order statistical measures</td>
</tr>
<tr>
<td>Edge gradient</td>
<td>Measurements from edge detection</td>
</tr>
<tr>
<td>Colour variance</td>
<td>Measurements from the CIELAB image</td>
</tr>
</tbody>
</table>

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•
•
1. Scene descriptors

A. First-order statistical measures

- Mean
- Mode
- Skewness
- Median
- Variance (standard deviation$^2$)
- Entropy
1. Scene descriptors

B. Second-order statistical measures (GLCM)

- Inertia (or Contrast(Co))
  \[
  C_o = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} (i - j)^2 P(i,j)
  \]

- Homogeneity(\(H\))
  \[
  H = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} \frac{P(i,j)}{1 + |i - j|}
  \]

- Correlation (or Linearity(\(Cor\))
  \[
  Cor = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} \frac{(i - m_i)(j - m_j)P^2(i,j)}{\sigma_i \sigma_j}
  \]

- Energy (\(Eng\))
  \[
  E_{ne} = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} P(i,j)^2
  \]

Where \(P(i,j)\) is the joint probability distribution of pairs of pixels \((i,j)\). \(m_i\) and \(m_j\) are the mean values of the pair of gray levels \(i\) and \(j\). \(\sigma_i\) and \(\sigma_j\) are the standard deviation value of the pair of gray levels \(i\) and \(j\).

(by Pratt, 1991)
1. Scene descriptors

C. Measurements from edge detection

- Average Sobel
- Average Prewitt
- Average LOG (Laplacian of Gaussian)
D. Measurements from the CIE LAB image

- Variance of chroma \((VC^*)\)
  \[
  VC^* = \sqrt{\sigma_{a^*}^2 + \sigma_{b^*}^2}
  \]

- Variance of the saturation \((VS^*)\)
  \[
  VS^* = \frac{VC^*}{L_M^*}
  \]

\[
L_M^* = L_{M,mid}^* + \left| L_{M,mid}^* - L_{M,i}^* \right|
\]

(by Othman and Martinez, 2008)

(by Triantaphillidou et al, 2007)
1. Scene descriptors

Aim: To objectively classify test scenes in image quality tests.

<table>
<thead>
<tr>
<th>Images</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Variance</th>
<th>Skewness</th>
<th>Entropy</th>
<th>Inertia</th>
<th>Homogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>113.16</td>
<td>99</td>
<td>76</td>
<td>2095.10</td>
<td>0.36</td>
<td>7.26</td>
<td>0.19</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>112.12</td>
<td>102</td>
<td>11</td>
<td>8550.60</td>
<td>0.15</td>
<td>6.93</td>
<td>0.07</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>113.61</td>
<td>16</td>
<td>15</td>
<td>2297.70</td>
<td>-0.16</td>
<td>7.49</td>
<td>0.51</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Experimental process for scene classification

- Scene susceptibility
- Scene descriptors
- Scene classification
- Scene calibration

Scene susceptibility descriptors
Scene susceptibility parameters

Susceptibility to noisiness

\[ N_1 \approx 1.82 \]

\[ N_3 \approx 0.19 \]
Scene susceptibility parameters

Susceptibility to sharpness

$S_1 \approx 0.63$

$S_5 \approx 1.43$
2. Correlation between scene susceptibility & scene descriptors

Spearman’s Correlation Coefficient:

\[ r_s = 1 - \frac{1}{n(n^2 - 1)} \sum_{i=1}^{n} d_i^2 \]

- \(d\): difference in ranks
- \(n\): number of items in the sample
2. Correlation between scene susceptibility & scene descriptors

Correlation coefficients: -1.0 indicates perfect anti-correlation
1.0 indicates perfect correlation
0.0 denotes no correlation
2. Correlation between scene susceptibility & scene descriptors

<table>
<thead>
<tr>
<th>Susceptibility to Noisiness</th>
<th>Descriptor (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.82</td>
<td>113.13</td>
</tr>
<tr>
<td>0.97</td>
<td>112.12</td>
</tr>
<tr>
<td>0.19</td>
<td>113.61</td>
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</tbody>
</table>

$r = -0.29$
### 2. Correlation between scene susceptibility & scene descriptors

<table>
<thead>
<tr>
<th>Susceptibility to Noisiness</th>
<th>Descriptor (Homogeneity)</th>
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<tr>
<td>1.82</td>
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<td>0.81</td>
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</tbody>
</table>

$r = 0.95$
2. Correlation between scene susceptibility & scene descriptors: Noisiness

Scene descriptors for noisiness susceptibility

- Mean: \( r_S = 0.067 \)
- Homogeneity: \( r_S = 0.738^* \)
- Average Sobel: \( r_S = -0.701^* \)
- VC*: \( r_S = -0.232 \)

*\( r_S \) at 1% probability should exceed ±0.468

\( r_s = 0.738 \)
### Scene descriptors for sharpness susceptibility

<table>
<thead>
<tr>
<th>Scene Descriptor</th>
<th>( r_S )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.172</td>
</tr>
<tr>
<td><strong>Homogeneity</strong></td>
<td>-0.781*</td>
</tr>
<tr>
<td><strong>Average Sobel</strong></td>
<td>0.786*</td>
</tr>
<tr>
<td>VC*</td>
<td>0.378</td>
</tr>
</tbody>
</table>

*\( r_S \) at 1% probability should exceed ±0.468

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### 2. Correlation between scene susceptibility & scene descriptors: Noisiness

The correlation coefficient \( r_S = 0.786 \) indicates a strong positive correlation between the scene susceptibility scale and the average Sobel descriptor.
### 2. Correlation between scene susceptibility & scene descriptors

<table>
<thead>
<tr>
<th>Scene descriptors</th>
<th>Correlation coefficient ($r_s$) for scene susceptibility to noisiness</th>
<th>Correlation coefficient ($r_s$) for scene susceptibility to sharpness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inertia (contrast):</td>
<td>-0.694</td>
<td>0.802</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>0.738</td>
<td>-0.781</td>
</tr>
<tr>
<td>Correlation (linearity)</td>
<td>0.644</td>
<td>-0.550</td>
</tr>
<tr>
<td>Energy</td>
<td>0.577</td>
<td>-0.647</td>
</tr>
<tr>
<td>Average Sobel gradient</td>
<td>-0.701</td>
<td>0.786</td>
</tr>
<tr>
<td>Average Prewitt gradient</td>
<td>-0.701</td>
<td>0.786</td>
</tr>
<tr>
<td>Average LOG gradient</td>
<td>-0.593</td>
<td>0.747</td>
</tr>
</tbody>
</table>
Experimental process for scene classification

Scene susceptibility

Scene classification

Scene descriptors

Scene calibration

Scene susceptibility descriptors
3. Objective scene classification

Homogeneity (noisiness) vs. Average Sobel (sharpness) graph with points marked for different K values. The highlighted data points correspond to K=3.
3. Objective scene classification

- **Homogeneity** (noisiness)
  - Group1
  - Group2
  - Group3

- **Average Sobel** (sharpness)
  - K=3
3. Objective scene classification

Group 1
3. Objective scene classification

Group 2
3. Objective scene classification

Group 3
Conclusion

1. The work successfully derived three groups of test scenes, based on scene descriptors that correlated with sharpness and noisiness scene susceptibility.

2. A number of scene descriptors were derived to describe a number of selected scene properties that play a role in IQ measurement.

3. Successful correlations were obtained between:
   - scene susceptibility parameter for noisiness and texture homogeneity descriptor,
   - scene susceptibility parameter for sharpness and the average edge gradient descriptor.
Conclusion

Results indicate that there is a potential for tackling the problem of sharpness and noisiness scene dependency when modelling image quality.
Further work

• More extensive investigations of scene descriptors.
  
  ➢ the derivation of scene descriptors from specific image regions of interest (algorithm application locally).
  ➢ the combination of various scene descriptors.
Any questions or Comments?