14th European Signal Processing Conference
EUSIPCO 2006, 4-8 September 2006

Special Session, Image and Video Quality Evaluation

Task impact on the visual attention in subjective image quality assessment

A. Ninassi ¹², O. Le Meur ¹, P. Le Callet ², D. Barba ², A. Tirel ²

¹ THOMSON R&D, VCL, Cesson-Sevigné
² IRCCyN UMR 6597 CNRS, Nantes
Introduction

“ The most efficient quality metrics are based on the Human Visual System ”

An important component of the HVS

= Visual attention
Synopsis

1. Visual attention
2. Some questions …
3. Experiments
4. Results : Some answers …
5. Conclusion
Synopsis

1. Visual attention
2. Some questions …
3. Experiments
4. Results: Some answers …
5. Conclusion
Visual attention: Definition

“Visual attention allows us to select the relevant information in our environment, in connection or not with a particular task”

Two mechanisms are involved in visual attention control

**Bottom-up**
(voluntary attention)
Salient elements of our visual field catch our attention

**Top-down**
(involuntary attention)
Our attention is guided by the task to accomplish

Mechanism based on signal

Mechanism based on task
Synopsis

1. Visual attention
2. Some questions ...
3. Experiments
4. Results: Some answers ...
5. Conclusion
Synopsis

1. Visual attention
2. Some questions …
3. Experiments
4. Results : Some answers …
5. Conclusion
Some questions …

Does the quality assessment task affect the visual strategy?

*Importance of the mechanisms:*
  
  – Bottom-up?
  – Top-down?

*It is fundamental if we want to elaborate a quality metric based on visual attention model: Which visual strategy must be imitated?*
Some questions …

Does a learning process exist during a quality assessment campaign?

If the same picture is shown several times (DSIS protocol as an example):

– Do we learn how to evaluate the picture?
– Do we learn where to look?
Some questions …

Do the artifacts modify the visual strategy?

*It is fundamental if we want to elaborate a quality metric based on visual attention model: Which visual strategy must be imitated?*
Synopsis

1. Visual attention
2. *Some questions* …
3. Experiments
4. Results: Some answers …
5. Conclusion
Synopsis

1. Visual attention
2. Some questions ...
3. Experiments
4. Results: Some answers ...
5. Conclusion
Eye gaze tracking experiments

An *eye-tracker* is a device elaborated to measure and to record the position where a human observer is looking at

Experiments:
- 20 observers
- 120 still pictures
- Visualization distance 4H
Experiments: *The ground truth*

Free viewing task
20 pictures (*10 unimpaired references, 10 impaired versions*)

<table>
<thead>
<tr>
<th>Picture</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean grey picture</td>
<td>3 s</td>
</tr>
<tr>
<td>Picture 1</td>
<td>8 s</td>
</tr>
<tr>
<td>Mean grey picture</td>
<td>3 s</td>
</tr>
<tr>
<td>Picture 2</td>
<td>8 s</td>
</tr>
<tr>
<td>Mean grey picture</td>
<td>3 s</td>
</tr>
</tbody>
</table>

Picture quality assessment task

- 130 pictures (*10 unimpaired references, 120 impaired versions*)
- DSIS protocol (*Double Stimulus Impairment Scale*)
- **Constraint**: 2 sequences from the same reference picture must not follow themselves

<table>
<thead>
<tr>
<th>Picture</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean grey picture</td>
<td>3 s</td>
</tr>
<tr>
<td>Reference picture</td>
<td>8 s</td>
</tr>
<tr>
<td>Mean grey picture</td>
<td>3 s</td>
</tr>
<tr>
<td>Picture to assess</td>
<td>8 s</td>
</tr>
<tr>
<td>Scoring screen</td>
<td>...</td>
</tr>
</tbody>
</table>
Experiments: *The ground truth*

Degradation category rating (5 scores):

- **Imperceptible**
- **Not annoying**
- **Slightly annoying**
- **Annoyng**
- **Very annoying**

**How to rate?**

- Scoring screen
- Selection and confirmation based on eye gaze position

Score is **Not annoying**
Synopsis

1. Visual attention
2. Some questions …
3. *Experiments*
4. Results: Some answers …
5. Conclusion
Synopsis

1. Visual attention
2. Some questions …
3. Experiments
4. Results: Some answers …
5. Conclusion
Results: Analysis

- Fixation duration
- Saliency map (average fixation density map)
  - Kullback-Leibler divergence $KL$
  - Correlation coefficient $CC$
Results: Some answers ...

Does the quality assessment task affect the visual strategy?

- Fixation duration:
  Reference in quality task > Reference in free task
  Observers try to accurately memorize some parts of the picture

- Saliency map:

<table>
<thead>
<tr>
<th>Comparison A) and C)</th>
<th>KL range</th>
<th>CC range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference in quality task vs reference in free task</td>
<td>[0.3,0.5]</td>
<td>[0.77,0.92]</td>
</tr>
<tr>
<td>Impaired in quality task vs reference in free task</td>
<td>[0.42,0.95]</td>
<td>[0.66,0.9]</td>
</tr>
</tbody>
</table>

Notable dissimilarity

→ The quality assessment task affects the visual strategy
Results: Some answers ...

Average fixation duration by picture for:

- The reference pictures in free task
- The reference pictures in quality task
- The impaired pictures in quality task

![Graph showing average fixation duration by picture](image-url)
Results: Some answers ...

- **A)** Reference in quality task vs reference in free task
- **C)** Impaired in quality task vs reference in free task
Results: Some answers ...

Illustration of the comparison A):
Reference in quality task (1, 2 and 5\textsuperscript{th}) vs reference in free task
(Difference between saliency maps)
Results: Some answers ...

Does a learning process exist during a quality assessment campaign?

Saliency map:

<table>
<thead>
<tr>
<th>Comparison B)</th>
<th>KL range</th>
<th>CC range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference in quality task vs first reference in quality task</td>
<td>[0.12,0.18]</td>
<td>[0.9,0.97]</td>
</tr>
</tbody>
</table>

No notable dissimilarity

→ No significant learning process
Results: Some answers...

- B) Reference in quality task vs first reference in quality task
Results: Some answers ...

Do the artifacts modify the visual strategy?

- Saliency map comparison:

<table>
<thead>
<tr>
<th>Comparison D)</th>
<th>KL range</th>
<th>CC range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impaired in quality task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vs its associated reference in quality task</td>
<td>[0.11, 0.4]</td>
<td>[0.8, 0.96]</td>
</tr>
</tbody>
</table>

Notable dissimilarity

- Saliency map cross analysis (confidence intervals $ci$):

<table>
<thead>
<tr>
<th>Comparison A) and C)</th>
<th>KL$ci$ range</th>
<th>CC$ci$ range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference in quality task vs reference in free task</td>
<td>[0.02, 0.09]</td>
<td>[0.007, 0.04]</td>
</tr>
<tr>
<td>Impaired in quality task vs reference in free task</td>
<td>[0.04, 0.13]</td>
<td>[0.008, 0.1]</td>
</tr>
</tbody>
</table>

Confidence interval increase between A) and C)

→ The artifacts do modify the visual strategy
Results: Some answers ...

- D) Impaired in quality task vs its associated reference in quality task
Results: Some answers …

Illustration of the comparison D):
Impaired in quality task vs its associated reference in quality task
(Difference between saliency maps)

Clown / JPEG2000 / JPEG (rate 1) / JPEG (rate 2)

Boats / JPEG2000 / JPEG / Blur
Results: Some answers ...

- A) Reference in quality task vs reference in free task
- C) Impaired in quality task vs reference in free task
Synopsis

1. Visual attention
2. Some questions ...
3. Experiments
4. Results: Some answers ...
5. Conclusion
Synopsis

1. Visual attention
2. Some questions …
3. Experiments
4. Results : Some answers …
5. Conclusion
Conclusion

The quality assessment task affects the visual strategy
- Fixation duration
- Saliency map

No significant learning process
Observers are not more competitive at the end of the test than at the beginning. No visual adaptation or task learning.

To elaborate a quality metric based on visual attention model, we must be conscious that:
- We can use a bottom-up model (free view condition)
- But, in a quality assessment campaign the visual strategy is different

Future work:
Study the dependence between visual attention and type of degradation
The artifacts do modify the visual strategy
Appendix
Appendix: Results

- **A)** Reference in quality task vs reference in free task
- **B)** Reference in quality task vs first reference in quality task

![Graph showing the comparison of reference in quality task vs reference in free task and reference in quality task vs first reference in quality task for different images like Barba, Isabe, Clown, Mandrill, Boats, Lena, Peppers, Plane, House, Fruit. The graph plots the average KL divergence with error bars for each image.](image-url)
Appendix : Results

- **C)** Impaired in quality task vs reference in free task
- **D)** Impaired in quality task vs its associated reference in quality task