Enhanced-alignment Measure for Binary Foreground Map Evaluation

Deng-Ping Fan
Nankai University of Media Computing Lab

IJCAI’2018 Oral Presentation
http://dpfan.net/e-measure
Outline

- Overview of Binary Foreground Maps
- Previous Work
- Enhanced-alignment Measure
- Experiments
Enhanced-alignment Measure for Binary Foreground Map Evaluation

Deng-Ping Fan, http://dpfan.net/, 2018/7/7
The binary foreground map consists of values of either 0 or 1. 1 denotes foreground, 0 for background.
Application

Object Segmentation

(a) Image

(d) GT
Application

- Object Segmentation

(a) Image  
(b) MDF (CVPR’15)  
(c) DISC (TNNLS’16)

(d) GT  
(e) DCL (CVPR’16)  
(f) Noise
Evaluation

- Similarity evaluation is very important.
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- Overview of Binary Foreground Maps
- Previous Work
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Previous Work

- Intersection-over-Union (IoU)
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- Intersection-over-Union (IoU)

\[
IoU = \frac{A \cap B}{A \cup B}
\]
## Previous Work

- Intersection-over-Union (IoU)

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Previous Work

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Previous Work

- Intersection-over-Union (IoU)

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\text{IoU} = \frac{A \cap B}{A \cup B}
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Previous Work

- Contour Mapping (CM)$^{[1]}$

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Previous Work

- Contour Mapping (CM)[1]
- Weighted $F_\beta$-measure (Fbw)[2]

Previous Work

- Contour Mapping (CM)$^{[1]}$

- Weighted $F_\beta$-measure ($F_{bw}$)$^{[2]}$
  
  Introducing weight to the $F_\beta$-measure (related to IoU) framework.

\[
\text{IoU} = \frac{F_1}{2 - F_1}
\]

Previous Work

- Contour Mapping (CM)[1]
- Weighted $F_\beta$-measure (Fbw)[2]
  Introducing weight to the $F_\beta$-measure (related to IoU) framework.
- Visual Quality (VQ)[3]

---

Previous Work

- Contour Mapping (CM)\(^1\)
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  Introducing weight to the $F_\beta$-measure (related to IoU) framework.
- Visual Quality (VQ)\(^3\)
  Considering psychological function based on the IoU.

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\(^1\) Movahedi and Elder. Design and perceptual validation of performance measures for salient object segmentation. CVPRW, 2010.
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- Weighted $F_\beta$-measure (Fbw)[2]
  Introducing weight to the $F_\beta$-measure (related to IoU) framework.
- Visual Quality (VQ)[3]
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- Structure measure (S-measure)[4]

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- Contour Mapping (CM)[1]
- Weighted $F_\beta$-measure (Fbw)[2]
  Introducing weight to the $F_\beta$-measure (related to IoU) framework.
- Visual Quality (VQ)[3]
  Considering psychological function based on the IoU.
- Structure measure (S-measure)[4]
  Mainly focus on the non-binary maps evaluation.

## Previous Work

### Table 1. Current evaluation measure summary

<table>
<thead>
<tr>
<th>Measure</th>
<th>Year</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoU</td>
<td>190</td>
<td>easy to calculate</td>
<td>losing image level statistics</td>
</tr>
<tr>
<td>CM [1]</td>
<td>2010</td>
<td>considering both region and contour</td>
<td>noise sensitive</td>
</tr>
<tr>
<td>Fbw [2]</td>
<td>2014</td>
<td>assigning different weights for errors</td>
<td>error location sensitive, complicated</td>
</tr>
<tr>
<td>VQ [3]</td>
<td>2015</td>
<td>weighting errors by psychological function</td>
<td>subjective measure</td>
</tr>
<tr>
<td>S-measure [4]</td>
<td>2017</td>
<td>considering structure similarity</td>
<td>focusing on non-binary map properties</td>
</tr>
</tbody>
</table>

Problem

(a) Image (b) GT (c) Foreground map (d) Noise
Problem

- Almost all of current measure (e.g., IoU, CM, Fbw, VQ) prefer the **Noise map**.
Problem

- Almost all of current measures (e.g., IoU, CM, Fbw, VQ) prefer the Noise map.
- They are either edge-based (local details) or region-based (global information).
Problem

Almost all of current measure (e.g., IoU, CM, Fbw, VQ) prefer the Noise map.
They are either edge-based (local details) or region-based (global information).

None of them consider both local and global simultaneously.
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Motivation

1. **Global information**
can be captured by the eye movement.

2. **Local details**
recorded by focusing the special image region.

http://knowledgelotus.info/human-brain-facts/
Example

1. Global information

(a) Image

(b) GT
Example

1. Global information

(a) Image  (b) GT  (c) Noise
Example

1. Global information

(a) Image  (b) GT  (c) Noise  (d) Map1
Example

1. Global information

(a) Image  (b) GT  (c) Noise  (d) Map1
Example

1. Global information

(a) Image

(b) GT

(d) Map1

(c) Noise
Example

1. Global information & 2. Local Details

(a) Image  (b) GT  (c) Map1  (d) Map2
Example

1. Global information & 2. Local Details

(a) Image  (b) GT  (c) Map1  (d) Map2
Example

1. Global information & 2. Local Details

(a) Image  (b) GT  (c) Map1  (d) Map2
Example

1. Global information & 2. Local Details

(a) Image
(b) GT
(c) Map2
(d) Map1
Alignment term

1. Global information
   Firstly, we compute the **global mean** of the input map to capture global information.
Alignment term

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   Firstly, we compute the **global mean** of the input map to capture global information.

\[
u = \sum_{j=1}^{M} \sum_{i=1}^{N} X_{ij} = 5
\]

(a) Map \( X_{ij} \)  
(b) Global mean
Alignment term

1. **Global information**
   Firstly, we compute the **global mean** of the input map to capture global information.

   ![Map $X_{ij}$](image)

   $u = \sum_{j=1}^{M} \sum_{i=1}^{N} X_{ij} = 5$

2. **Local details**
   Then, we treat each pixel in the map as the local details. (e.g., $X_{12} = 6$)
Alignment term

1. Global information
   Firstly, we compute the global mean of the input map to capture global information.

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   u = \sum_{i=1}^{M} \sum_{j=1}^{N} X_{ij} = 5
   \]

   (a) Map \( X_{ij} \)  
   (b) Global mean

2. Local details
   Then, we treat each pixel in the map as the local details. (e.g., \( X_{12} = 6 \))

3. Combine global information with local details
   Finally, we need to combine them simultaneously. Thus, we introduce a bias matrix
   which can be treated as the signal centering by removing the mean from the signal.
Alignment term

1. Global information
   Firstly, we compute the **global mean** of the input map to capture global information.

   \[
   u = \sum_{j=1}^{M} \sum_{i=1}^{N} X_{ij} = 5
   \]

   ![Map \(X_{ij}\)]
   ![Global mean](http://dpfan.net/)

2. Local details
   Then, we treat each pixel in the map as the local details. (e.g., \(X_{12} = 6\))

3. Combine global information with local details
   Finally, we need to combine them simultaneously. Thus, we introduce a **bias matrix** which can be treated as the signal centering by removing the mean from the signal.

   \[
   \varphi_{ij} = X_{ij} - u \times I
   \]

   ![Bias matrix](http://dpfan.net/)
Alignment term

1. Global information
   Firstly, we compute the **global mean** of the input map to capture global information.

   \[
   u = \sum_{j=1}^{M} \sum_{i=1}^{N} X_{ij} = 5
   \]

   (a) Map $X_{ij}$

2. Local details
   Then, we treat each pixel in the map as the local details. (e.g., $X_{12} = 6$)

3. Combine global information with local details
   Finally, we need to combine them simultaneously. Thus, we introduce a **bias matrix** which can be treated as the signal centering by removing the mean from the signal.

   (c) Bias matrix
Alignment term

4. Alignment matrix

(a) $GT$

(c) $\mu_{GT}$

(e) $\varphi_{GT}$
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Alignment term

4. Alignment matrix

(a) GT

(c) $\mu_{GT}$

(e) $\varphi_{GT}$

(b) FM

(d) $\mu_{FM}$

(f) $\varphi_{FM}$
Alignment term

4. Alignment matrix

\[ \xi_{FM} = \frac{2\varphi_{GT} \odot \varphi_{FM}}{\varphi_{GT} \odot \varphi_{GT} + \varphi_{FM} \odot \varphi_{FM}}, \]

alignment matrix \([1][2]\)

---

Alignment term

4. Alignment matrix

(a) GT

(c) $\mu_{GT}$

(e) $\varphi_{GT}$

(b) FM

(d) $\mu_{FM}$

(f) $\varphi_{FM}$

(h) $\phi_{FM}$
Alignment term

4. Alignment matrix

(a) GT

(c) \( \mu_{GT} \)

(e) \( \varphi_{GT} \)

(b) FM

(d) \( \mu_{FM} \)

(f) \( \varphi_{FM} \)

(h) \( \phi_{FM} \)
Alignment term

4. Alignment matrix

(a) $GT$

(c) $\mu_{GT}$

(e) $\varphi_{GT}$

(b) $FM$

(d) $\mu_{FM}$

(f) $\varphi_{FM}$

(h) $\phi_{FM}$
Alignment term

5. Enhanced alignment matrix

\[
\xi_{FM} = \frac{2 \varphi_{GT} \circ \varphi_{FM}}{\varphi_{GT} \circ \varphi_{GT} + \varphi_{FM} \circ \varphi_{FM}},
\]

\[
f(x) = \frac{1}{4}(1 + x)^2 \quad \phi_{FM} = f(\xi_{FM}).
\]
Outline

- Overview of Binary Foreground Maps
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Experiments

1. Meta-Measure 1: Application Ranking
Experiments


(a) Image  (b) GT  (c) FM  (d) Generic
Experiments


Experiments


(a) Image  (b) GT  (c) FM  (d) Generic


(a) Image  (b) GT  (c) FM  (d) Noise
Experiments


[Tips]: The human ranked datasets can be download through our website: [http://dpfan.net/e-measure](http://dpfan.net/e-measure)
Experiments

5. Meta-Measure 5: Ground truth Switch

(a) Image  (b) FM  (c) GT  (d) Switched GT
5. Meta-Measure 5: Ground truth Switch

6. Results
Experiments

5. Meta-Measure 5: Ground truth Switch

6. Results

<table>
<thead>
<tr>
<th>Measure</th>
<th>PASCAL</th>
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<tr>
<td></td>
<td>MM1</td>
<td>MM2</td>
<td>MM3</td>
<td>MM1</td>
<td>MM2</td>
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<td>MM1</td>
<td>MM2</td>
<td>MM3</td>
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<td>CM</td>
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<td>100.0%</td>
<td>34.62%</td>
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<tr>
<td>VQ</td>
<td>0.339</td>
<td>17.97%</td>
<td>15.32%</td>
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<td>IOU/F1/JI</td>
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<tr>
<td>Fbw</td>
<td>0.308</td>
<td>2.353%</td>
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<tr>
<td>S-measure</td>
<td>0.315</td>
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<tr>
<td>Ours</td>
<td>0.34%</td>
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9.08%-19.65% improvement.
Related papers

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