From Edges to Objects

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outline

structured edge prediction [Dollár & Zitnick, ICCV13, arXiv14]

from edges to objects [Zitnick & Dollár, ECCV14]
what defines an edge?

Brightness
Color
Texture
Parallelism
Continuity
Symmetry
...

Let the data speak.
upgrading the output space

\[
\{ 0, 1 \}
\]

\[
\{ 2, 4, 6, \ldots \}
\]

<table>
<thead>
<tr>
<th>bits</th>
<th>year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CVPR 06</td>
</tr>
<tr>
<td>\ldots 8</td>
<td>CVPR 13</td>
</tr>
<tr>
<td>25</td>
<td>ICCV1 3</td>
</tr>
</tbody>
</table>
random forests
structured forests
structured prediction
pixel prediction
sharpening
sharpened prediction
original image

structured

sharpened

pixel
SH = sharpen  
MS = multiscale  
gPb   ODS=.73  

ODS = 0.73  
FPS ≈ 1/240 Hz  

SH  

ODS = 12.5  
0.74  
Hz  
gPb  

ODS=.73  

SH+MS  

ODS = 30  
0.73  
Hz  

ODS = 2.5Hz  

SH+MS  

ODS = 0.75  
z  

FPS ≈ 1/240 Hz
structured edge prediction [Dollár & Zitnick, ICCV13, arXiv14]

from edges to objects [Zitnick & Dollár, ECCV14]
sliding window detection

restrictive!
Object proposals

- Class-agnostic detectors
- High recall
- Decrease the number of detections evaluated per image
- Removal of spurious false positives
object proposals
object proposals from?

sliding windows? segments?
EdgeBoxes feature

• Hand-coded
• Derived solely from edge information
• Sum of magnitudes of contours wholly enclosed by a bounding box
• Removal of contours straddling the bounding box boundary
Approach

1) Structured edge detector
   Each edgel has orientation + probability
Approach

1) Structured Edges
2) Edge groups ...

Greedy approach
- Progressive connection of edgels in 8-neighbourhood until sum of orientation differences > 0.5 pi
Approach

1) Structured Edges
2) Edge groups ... $s_i$
3) Affinity computation

$$a(s_i, s_j) = |\cos(\Theta_i - \Theta_{ij}) \cos(\Theta_j - \Theta_{ij})|^\gamma$$

$s_i, s_j$ separated by $> 2\text{px}$ ... $a(s_i, s_j) = 0$
Approach

1) Structured Edges
2) Edge groups ... $s_i$
3) Affinity computation
4) Bounding box scoring
Bounding box scoring

\[ h_b = \frac{\sum_i w_b(s_i) m_i}{2(b_w + b_h)} \]

- bounding box score
- \( b \) ... scored bounding box
- \( m_i \) ... sum of magnitudes of \( s_i \) edgels
- \( w_b(s_i) \in [0,1] \) ... bounding box specific weight of edge group \( s_i \)
  - \( w_b(s_i) = 0 \) ... \( s_i \) outside box \( b \)
  - \( w_b(s_i) = 0 \) ... \( s_i \) straddles boundary of box \( b \)
  - \( w_b(s_i) = 1 \) ... \( s_i \) part of contour wholly inside \( b \)
  - \( w_b(s_i) = 1 - \max_T \prod_{j}^{T-1} a(t_j, t_{j+1}) \) ... \( s_i \) part of contour straddling boundary of \( b \)

- Integral image for numerator of \( h_b \)
- Subtraction of magnitudes in the center of \( b \)
from edges to objects

Original image

Contour removal
Sliding window

\( \alpha \ldots \text{density of windows} \)

\( \beta \ldots \text{non maximal suppression threshold} \)

Different values provide trade-off between accuracy and recall

Refinement of promising detections after SW
thanks!  source code available online