Rapid Deformable Object Detection using Dual-Tree Branch and Bound

Iasonas Kokkinos
Center for Visual Computing
Ecole Centrale Paris

Galen Team
INRIA-Saclay

Deformable Part Model score:

\[
S(x) = \sum_{p=1}^{P} \max_{x_p} \left[ U_p(x_p) - (x_p - x - \mu_p)^T \begin{bmatrix} c_{p,1} & 0 \\ 0 & c_{p,2} \end{bmatrix} (x_p - x - \mu_p) \right]
\]

\[
\arg \max S(x)
\]

Felzenszwalb, Girshick, McAllester, Ramanan, PAMI 2010

Max-Product/Dynamic Programming \(O(PN^2)\)
Generalized Distance Transforms \(O(PN)\)

\[
N = |\{x\}|
\]

Approximate solutions:
Y. Chen et al. Rapid inference on a novel and/or graph for object detection, NIPS 2007
P. F. Felzenszwalb, R. B. Girshick, and D. A. McAllester. Cascade object detection with DPMs CVPR 2010
M. Pedersoli, A. Vedaldi, and J. Gonzalez. A coarse-to-fine approach for object detection, CVPR 2011
B. Sapp, A. Toshev, and B. Taskar. Cascaded models for articulated pose estimation, ECCV, 2010
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Branch and Bound: exact solution

Best-case: $O(P \log N)$

Input & Detection result

Detector score $S(x)$  BB for $\arg \max_x S(x)$  BB for $S(x) \geq -1$

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\[
\max_{x \in B_A} \max_{x_p \in B_1} - (x_p - x)^T \begin{bmatrix}
  c_1 & 0 \\
  0 & c_2
\end{bmatrix} (x_p - x)
\]

Upper and lower bounds

High: objects in A & parts in 1
Low: objects in A & parts in 6


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Comparisons with GDT on 3000 images (precomputed unary terms)

Single object: speedup increases with threshold
Multiple-objects, 1-best: 100-fold speedup for > 50% of images

Current bottleneck: unary term computation – *amenable to bounding*

*Code available from*
http://vision.mas.ecp.fr/Personnel/iasonas/

Iasonas Kokkinos, Ecole Centrale Paris/INRIA Saclay