TECHNION
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Template Matching with Deformable Diversity Similarity

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Goal

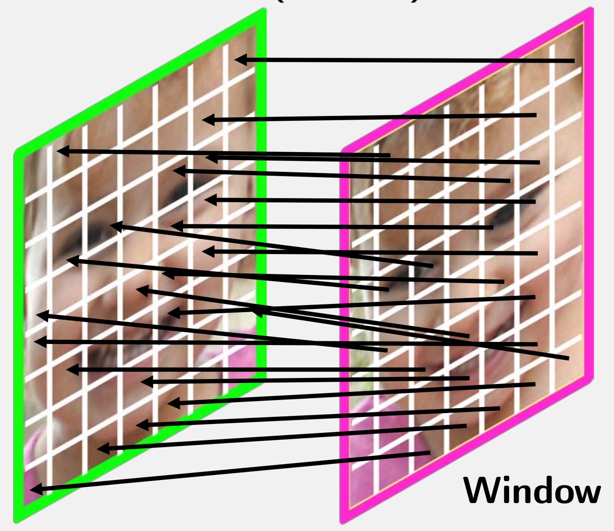
Input: a template and a target image
Output: the location of the template within the target image

Challenges

- Occlusions
- Complex deformations
- Out-of-plane rotation
- Background clutter

Algorithm overview

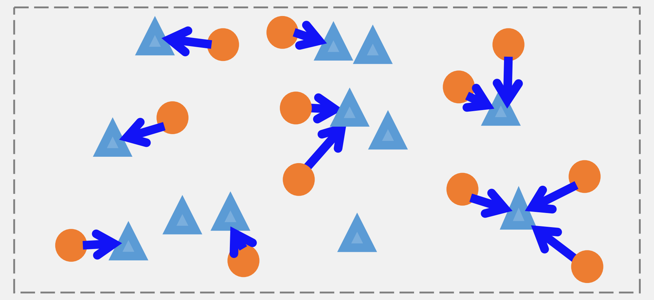
1. For each candidate window of the target image:
   1.1. Compute patch-based NNF
   1.2. Score the NNF using DDIS
2. Match = window with maximum score



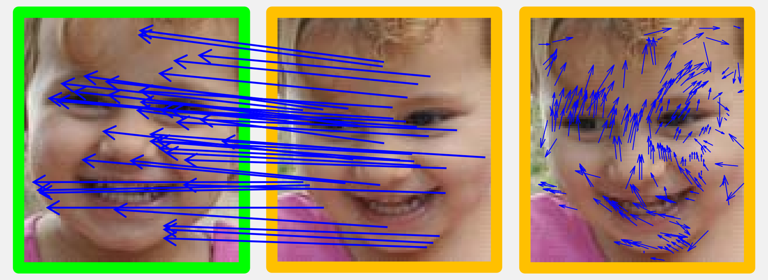
Key Ideas

window point   template point   Nearest neighbor

Good match = Similar distributions

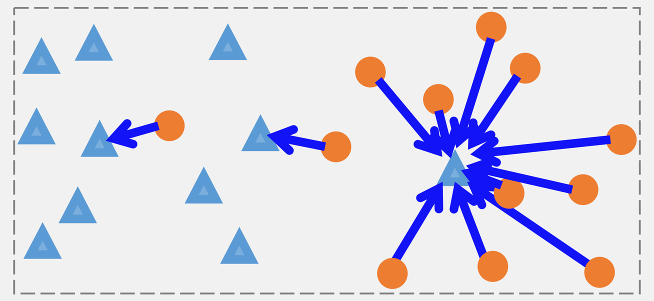


Diverse NNF matches

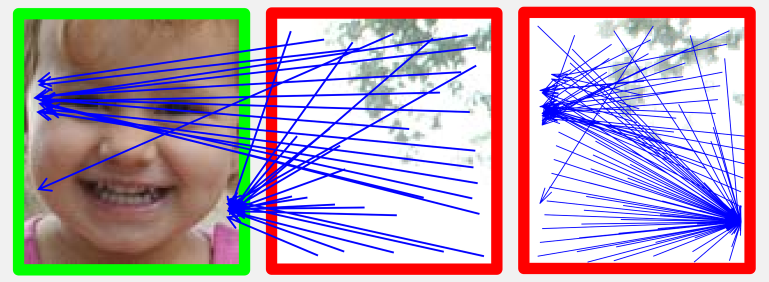


Small deformation

Bad match = Different distributions



Non-diverse NNF matches



Large deformation

Similarity Definition

$$\mathbf{DDIS} = \frac{1}{\#patches} \cdot \sum_{\substack{window\\patches}} \frac{1}{\boldsymbol{r}+1} \cdot \exp\left(1 - \boldsymbol{\kappa}\left(\begin{matrix}Nearest\\Template\\Patch\end{matrix}\right)\right)$$

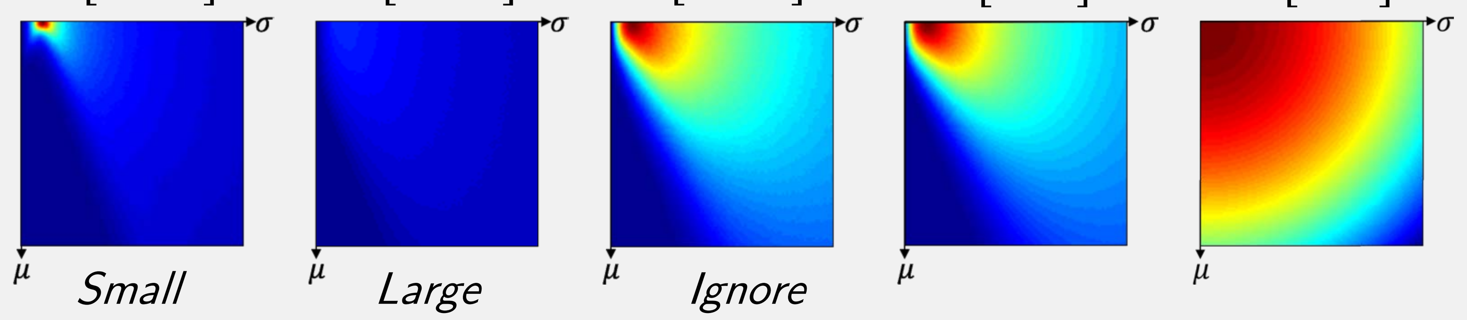
spatial distance: $\boldsymbol{r} = \|(x,y) - (\dot{x},\dot{y})\|$

$\boldsymbol{\kappa}\left(\begin{matrix}template\\patch\ p_i\end{matrix}\right) = \#$ window patches whose **NN** is p_i

Expected behavior – 1D Gaussian case

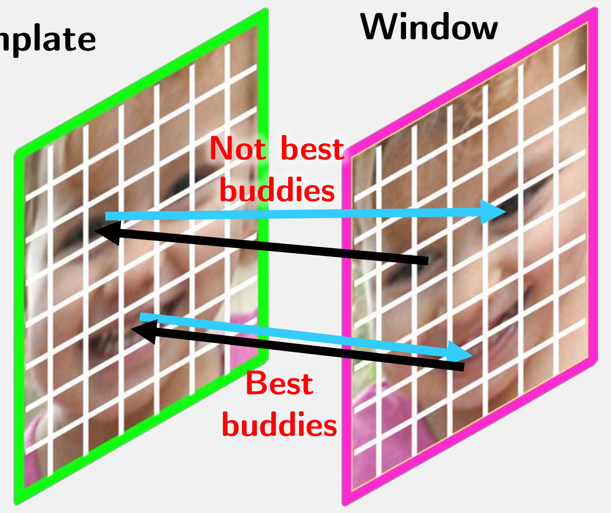
Expected similarity between points sampled from two gaussian distributions:

$N(0,1)$ and $N(\mu,\sigma),\ \ \mu,\sigma \in [0,1]$



Previous work: Best-Buddies Similarity

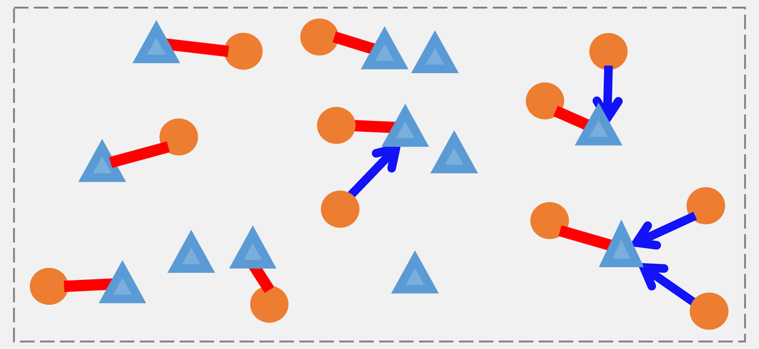
- Use Bi-directional NNF
- Count Best-Buddies pairs
- A Best-Buddies pair is a template patch and a window patch that are NN of each other



[1] Oron and Dekel et al. Best-buddies similarity for robust template matching CVPR2015, arXiv 2016
[2] Simakov et al. Summarizing visual data using bidirectional similarity CVPR, 2008.

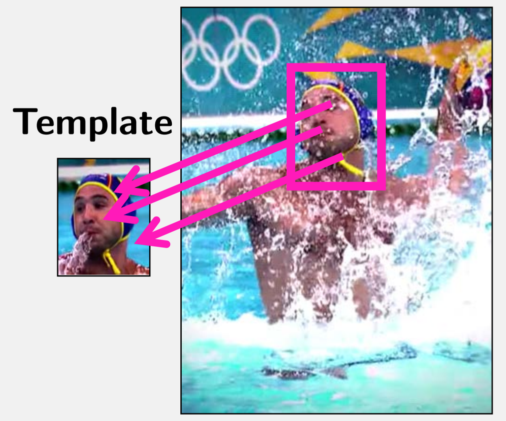
Comparison to BBS

E(diversity) ≈ E(BBS)

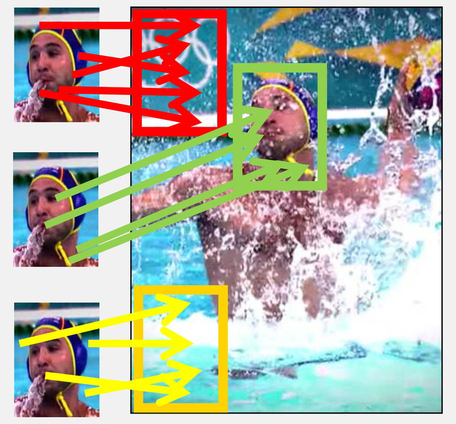


Best-Buddies
Nearest Neighbor

Don't need bi-directional similarity
(One Direction suffices)



Required NNF



Redundant NNF
(also: can't use ANN)

Runtime

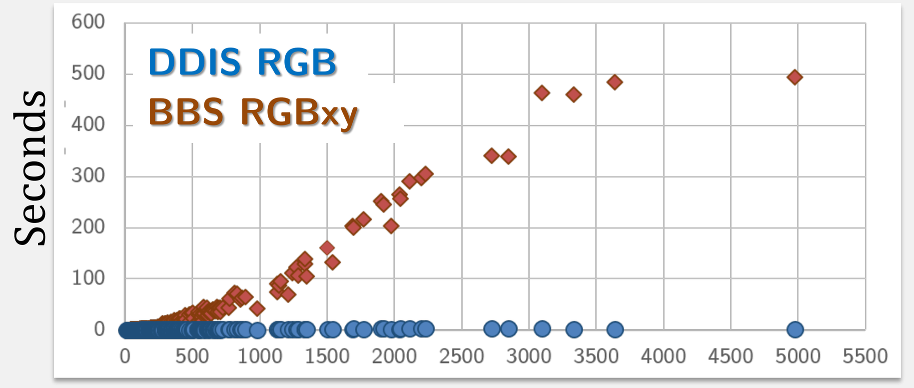
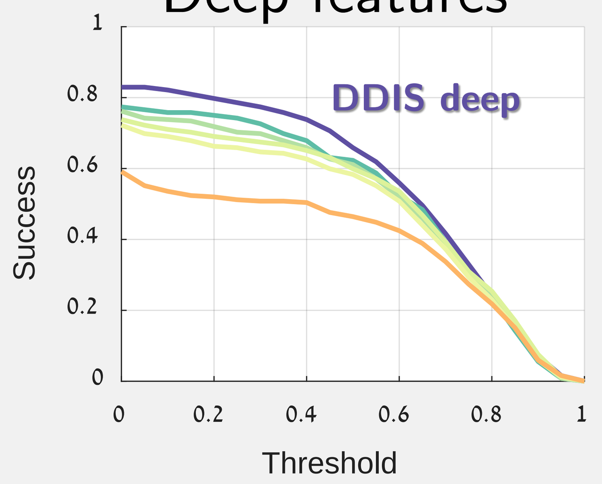
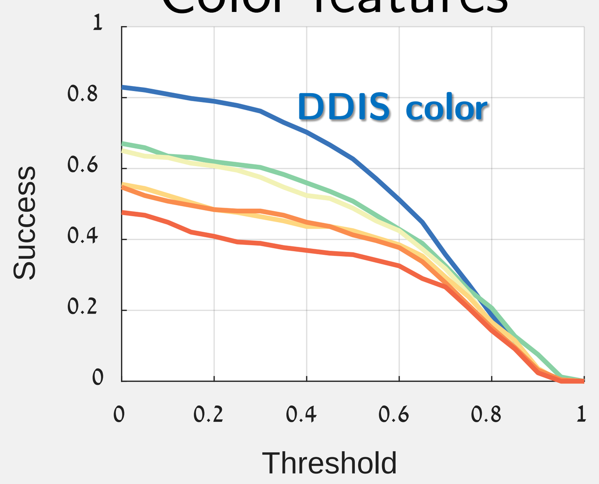


Image size x template size

Evaluation

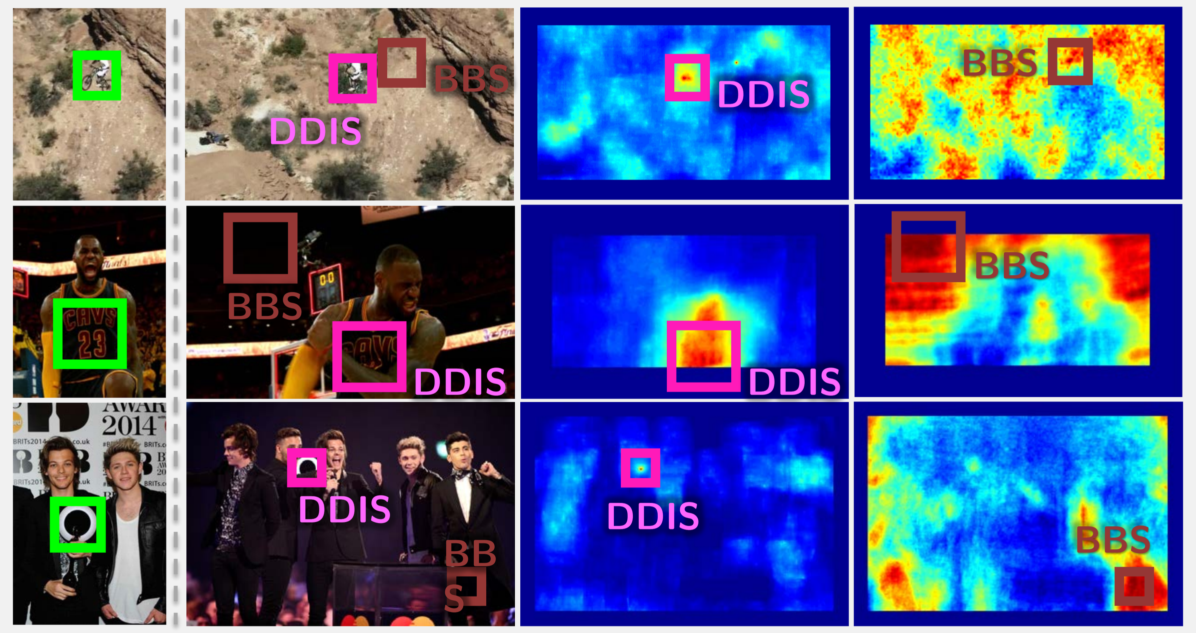




Template matching Benchmark [1]

Method	Dataset 25	Dataset 50	Dataset 100	Mean
DDIS - D	**0.679**	**0.583**	**0.571**	**0.611**
DDIS - C	0.650	0.590	0.540	0.593
Best-Buddies Similarity[1] - D	0.598	0.514	0.532	0.548
Sum of Square Differences - D	0.584	0.512	0.519	0.538
Sum of Absolute Differences - D	0.582	0.507	0.513	0.534
Normalized Cross Correlation - D	0.581	0.509	0.491	0.527
Best-Buddies Similarity[1] - C	0.590	0.505	0.445	0.513
Bi-Directional Similarity[2] - C	0.564	0.471	0.425	0.486
Bi-Directional Similarity[2] - D	0.513	0.447	0.401	0.454
Sum of Absolute Differences - C	0.516	0.412	0.365	0.431
Normalized Cross Correlation - C	0.483	0.398	0.359	0.413
Sum of Square Differences - C	0.427	0.363	0.308	0.366

D=deep features
C=color space



Summary

1. NNF with high diversity and low deformation is a strong cue for similarity
2. Improve 5%-10% detection accuracy on the standard benchmark
3. Use one-direction search and dramatically improve runtime

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