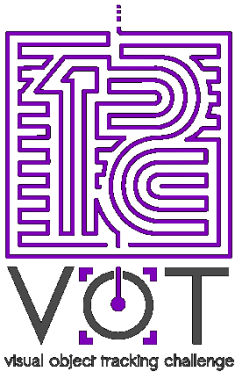


ECCV 2018
European Conference on Computer Vision
8 – 14 September 2018 | Munich, Germany

Distractor-aware Siamese Networks for Visual Object Tracking

Winning entry in VOT 2018 Real-time challenge

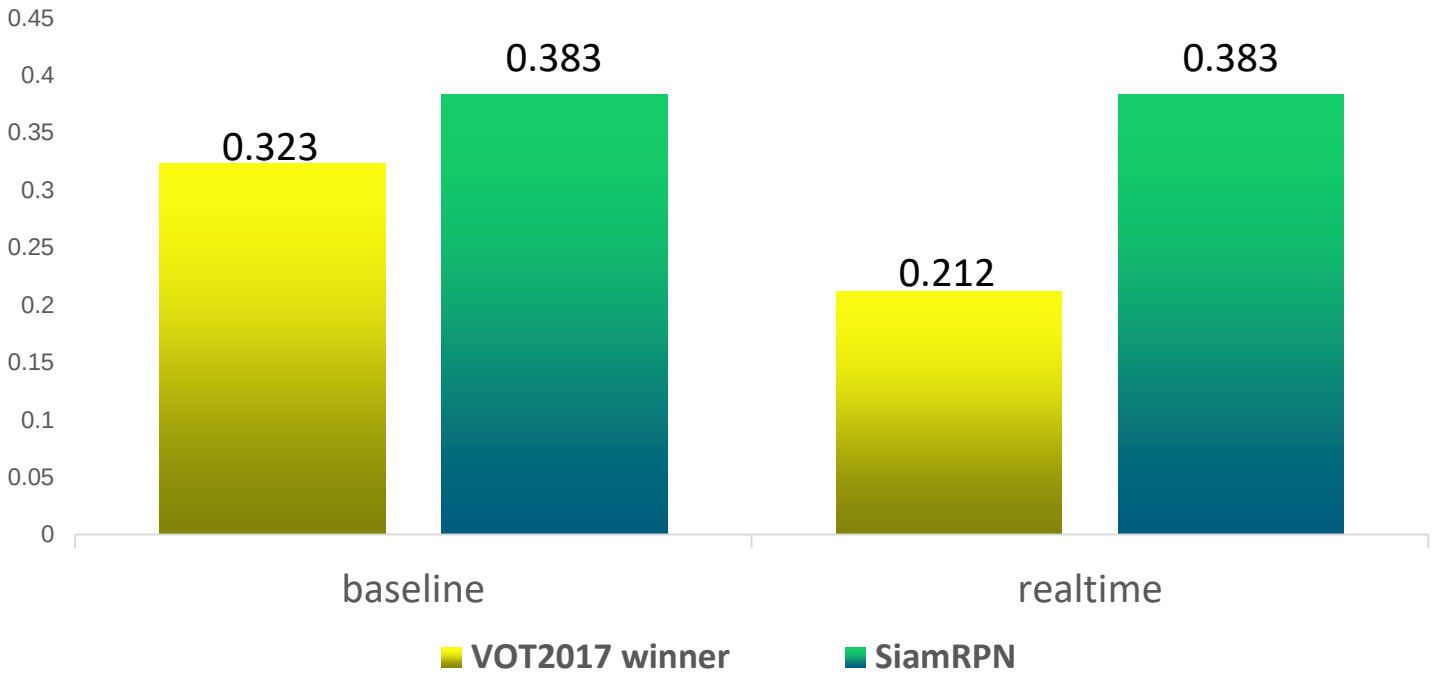
Speaker: Qiang Wang

Qiang Wang[1], Zheng Zhu[1], Bo Li[2], Wei Wu[2], Weiming Hu[1]

[1]Institute of Automation, Chinese Academy of Sciences [2]Sensetime Group Limited

中国科学院自动化研究所
Institute of Automation, Chinese Academy of Sciences

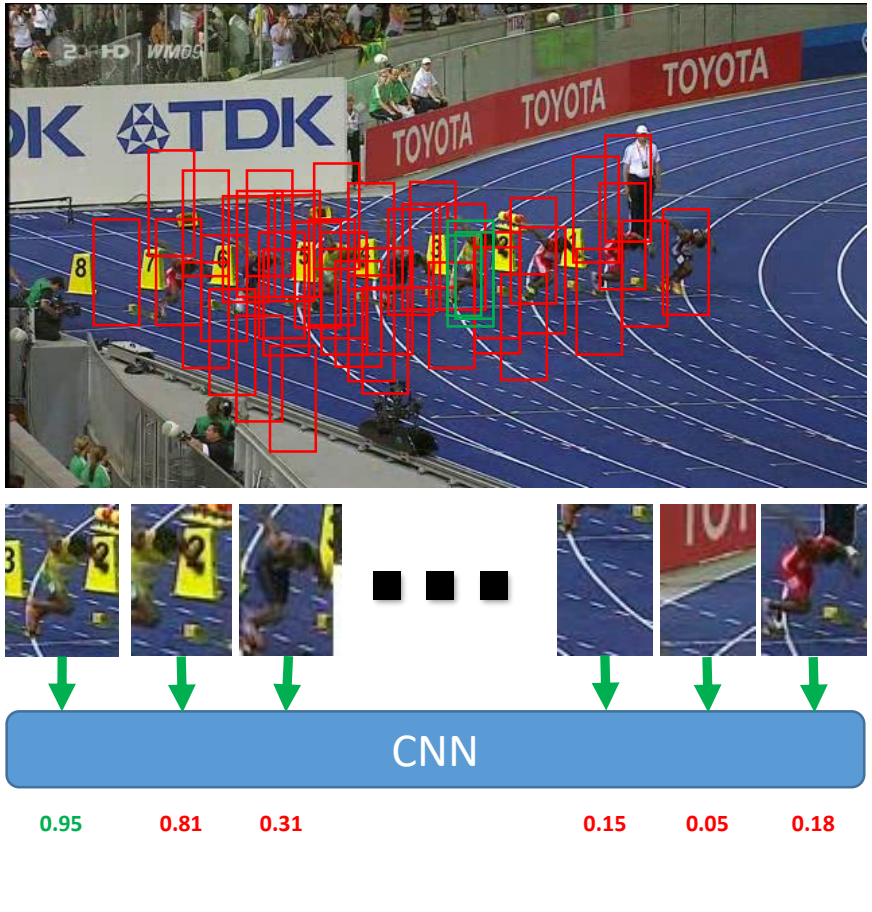
商汤
sensetime

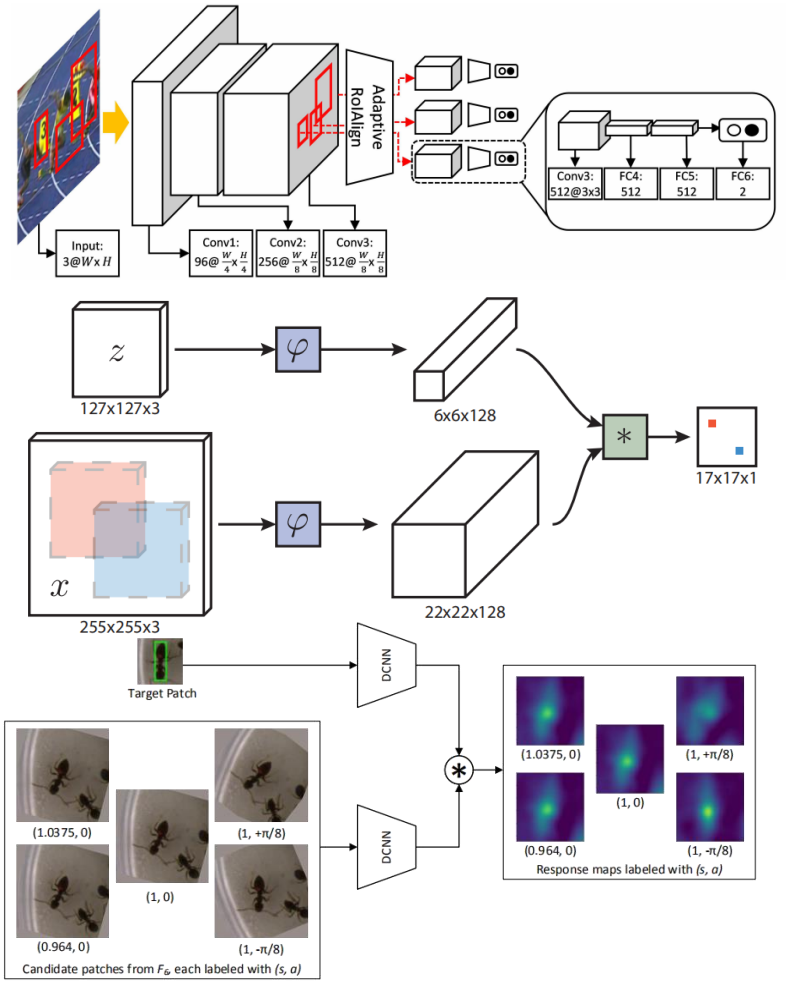


- Improvements
  - Baseline experiments
    - **6.0%** absolute and **18.5%** relative improvement
  - Realtime experiments
    - **17.1%** absolute and **80.7%** relative improvement

How to speed up your tracker?

Only verify each candidate?



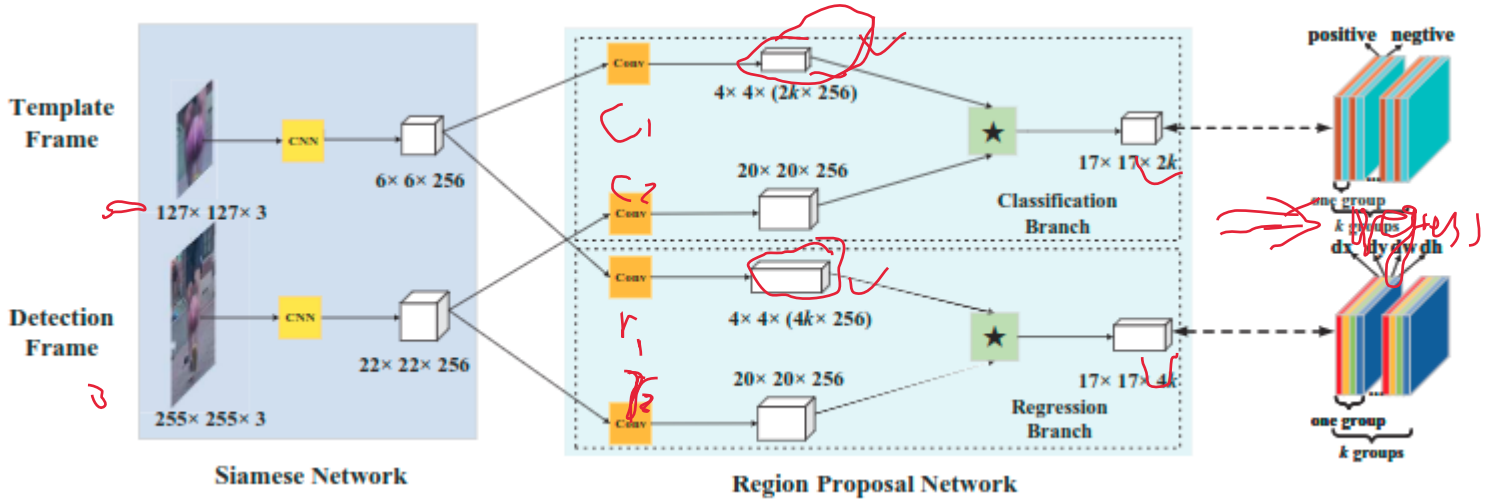


Jung, Ilchae and Son, Jeany and Baek, Mooyeol and Han, Bohyung. Real-Time MDNet. *ECCV*, 2018.

Bertinetto, Luca, et al. “Fully-convolutional siamese networks for object tracking.” *ECCV workshop*, 2016.

Anfeng He, Chong Luo, Xinmei Tian, Wenjun Zeng. Towards a Better Match in Siamese Network Based Visual Object Tracker. *ECCV workshop*, 2018.

Baseline: SiamRPN

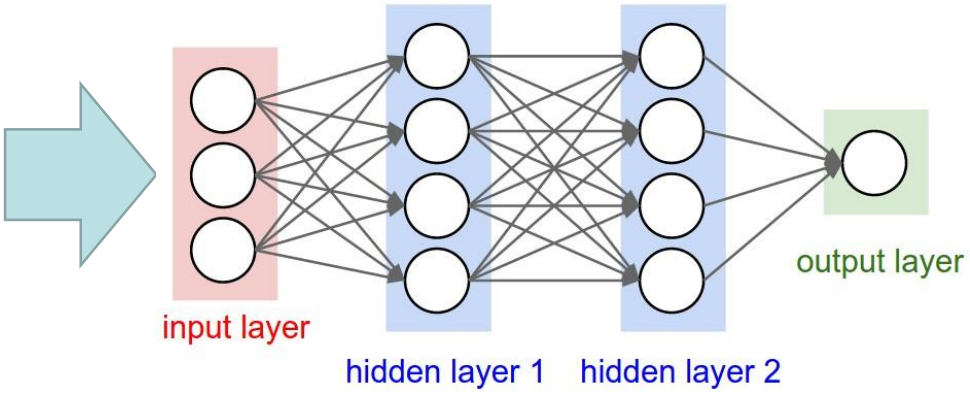


- Data-driven
- One-shot Detection
- Simultaneous Identification and Localization
- Anchor
- Fully Convolutional Networks
- Without Online Learning
- Without Multi-scale Detection

Bo Li, Junjie Yan, Wei Wu, Zheng Zhu, Xiaolin Hu. High Performance Visual Tracking With Siamese Region Proposal Network. *CVPR*, 2018

Classfication Training

ImageNet

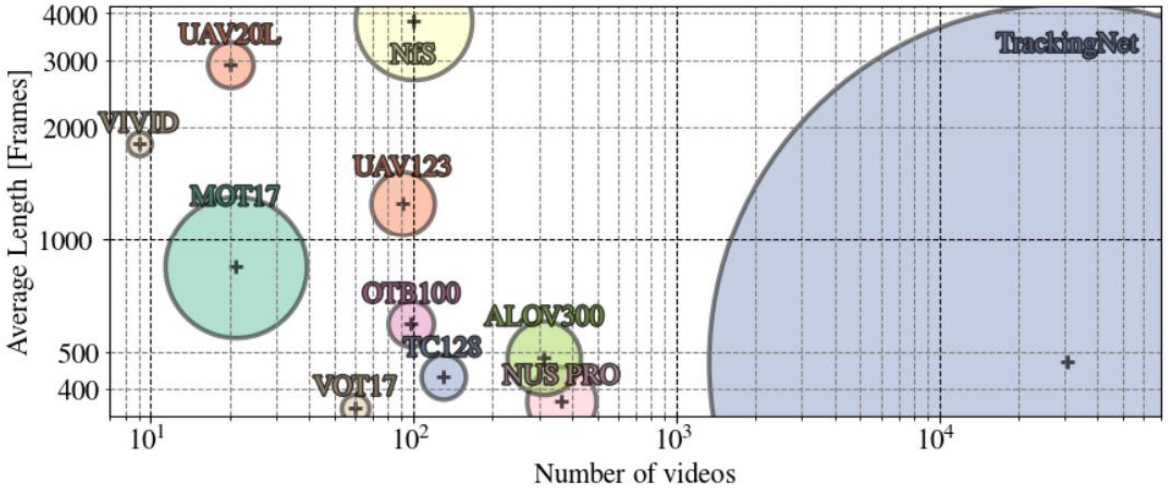


Classification v.s. Tracking

Classification	Tracking
• Predefined Categories(1000)	• General Object
• Recognition	• Metric Learning +Bounding box Regression
• Image Input	• Video Input

Training Datasets for Visual Tracking

OxUvA long-term dataset & TrackingNet



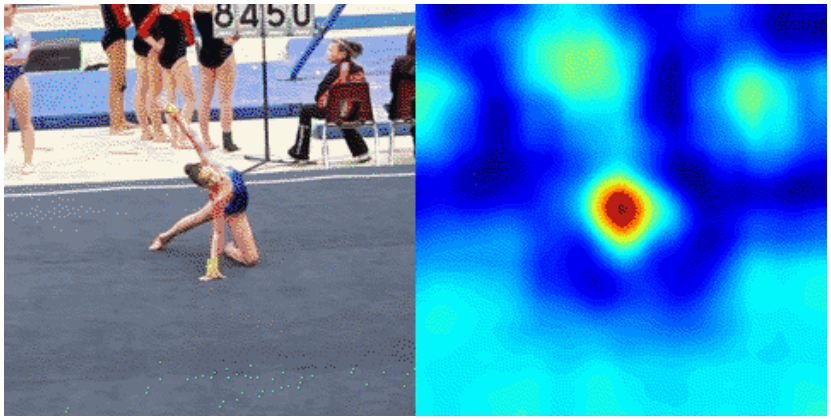
	OxUvA 2018	OTB-100 2015 [35]	VOT 2017 [14]	UAV123 2016 [22]	DTB 2017 [16]	NUS-PRO 2016 [15]	TC 2015 [17]	ALOV 2013 [29]	NfS 2017 [11]
Frames	**1.55M**	59k	21k	113k	15k	135k	60k	152k	380k
Tracks	**366**	100	60	123	70	**365**	128	314	100
. . . w/ **absent** labels	**52%**	0%	0%	0%	0%	0%	0%	0%	0%
Avg length (min)	**2.36**	0.33	0.20	0.51	0.12	0.21	0.26	0.27	0.26
Median length (min)	**1.46**	0.22	0.17	0.49	0.10	0.17	0.22	0.15	0.17
Max length (min)	**20.80**	2.15	0.83	1.71	0.35	2.8	2.15	3.32	1.44
Min length (min)	**0.50**	0.04	0.02	0.06	0.04	0.08	0.04	0.01	0.01
Avg **absent** labels	**2.2**	0	0	0	0	0	0	0	0
Object classes	22	16	24	9	15	8	**27**	–	–

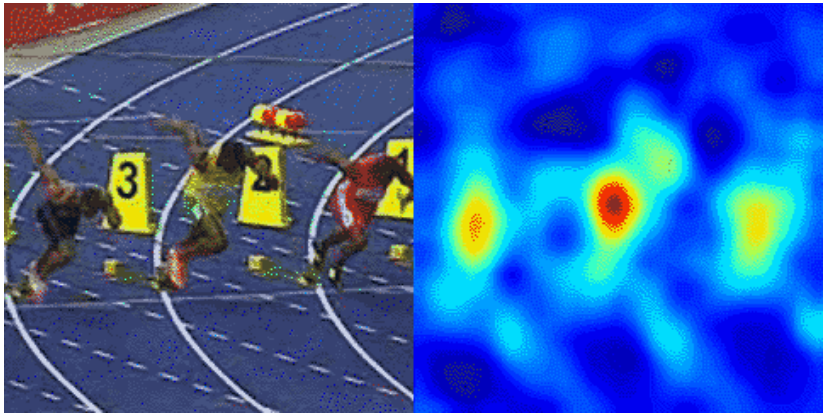
Valmadre, Jack, et al. "Long-term Tracking in the Wild: A Benchmark." *ECCV*, 2018

Müller, Matthias, et al. "TrackingNet: A Large-Scale Dataset and Benchmark for Object Tracking in the Wild." *ECCV*, 2018

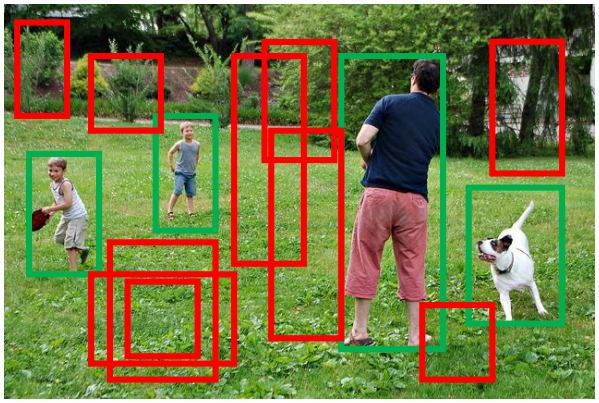
Motivation

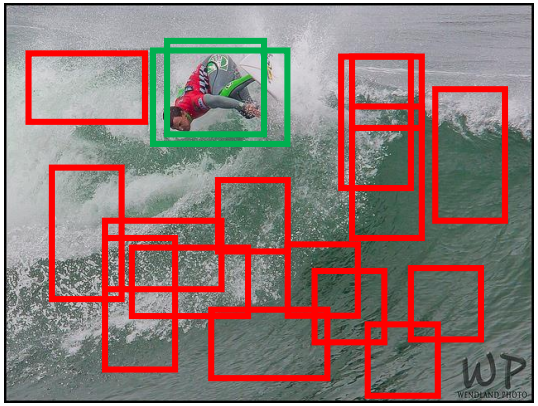
Response Maps predicted by SiamFC

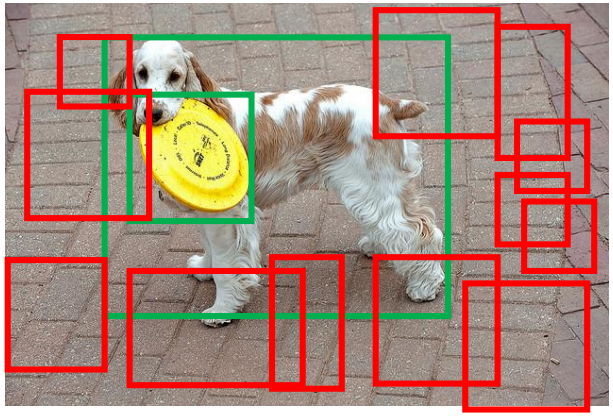




Non-semantic >> Semantic

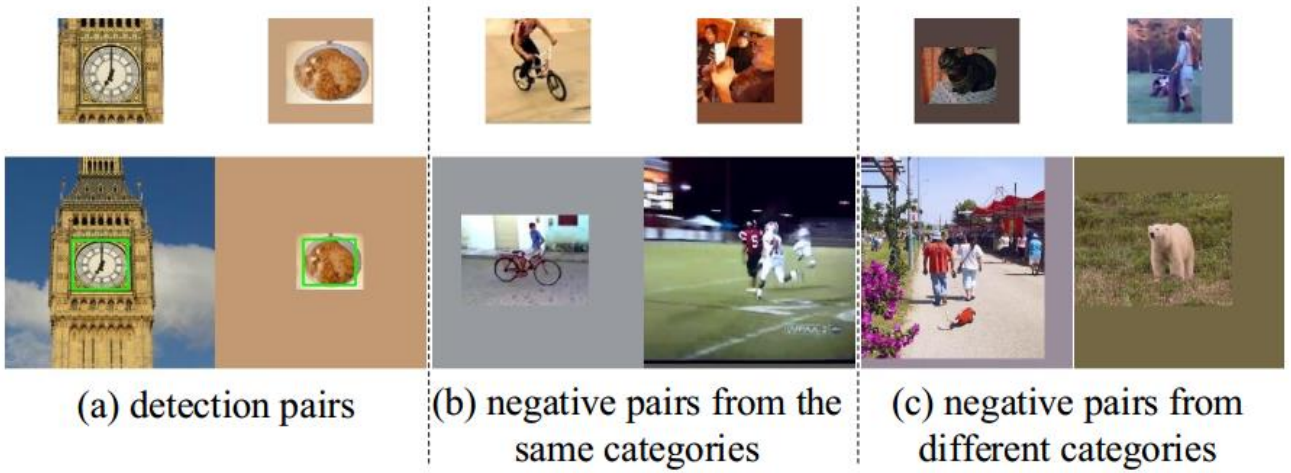






Distractor-aware Training

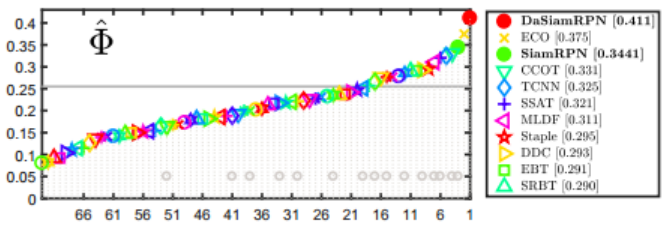
- Diverse categories of positive pairs can promote the generalization ability.
- Semantic negative pairs can improve the discriminative ability.
- Customizing effective data augmentation for visual tracking



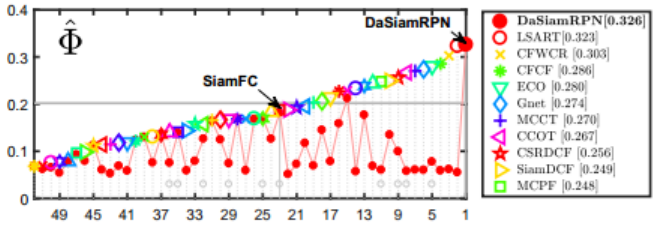
Zheng Zhu*, Qiang Wang*, Bo Li*, Wei Wu, Junjie Yan, and Weiming Hu. Distractor-aware Siamese Networks for Visual Object Tracking. *ECCV*, 2018

DaSiamRPN (ECCV2018)

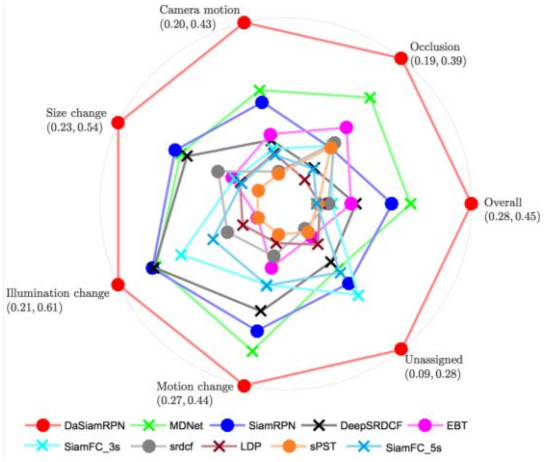
- State-of-the-art comparsions on VOT

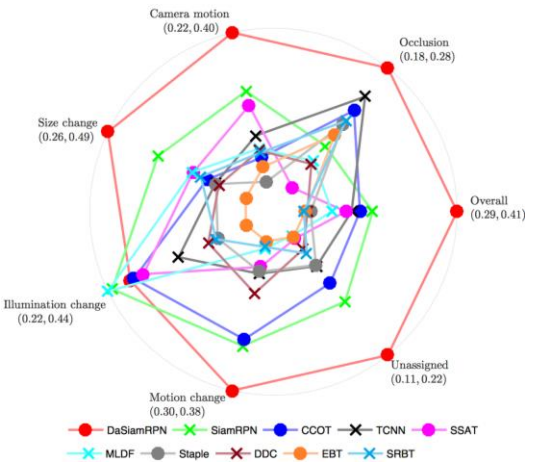


(a) EAO on VOT2016



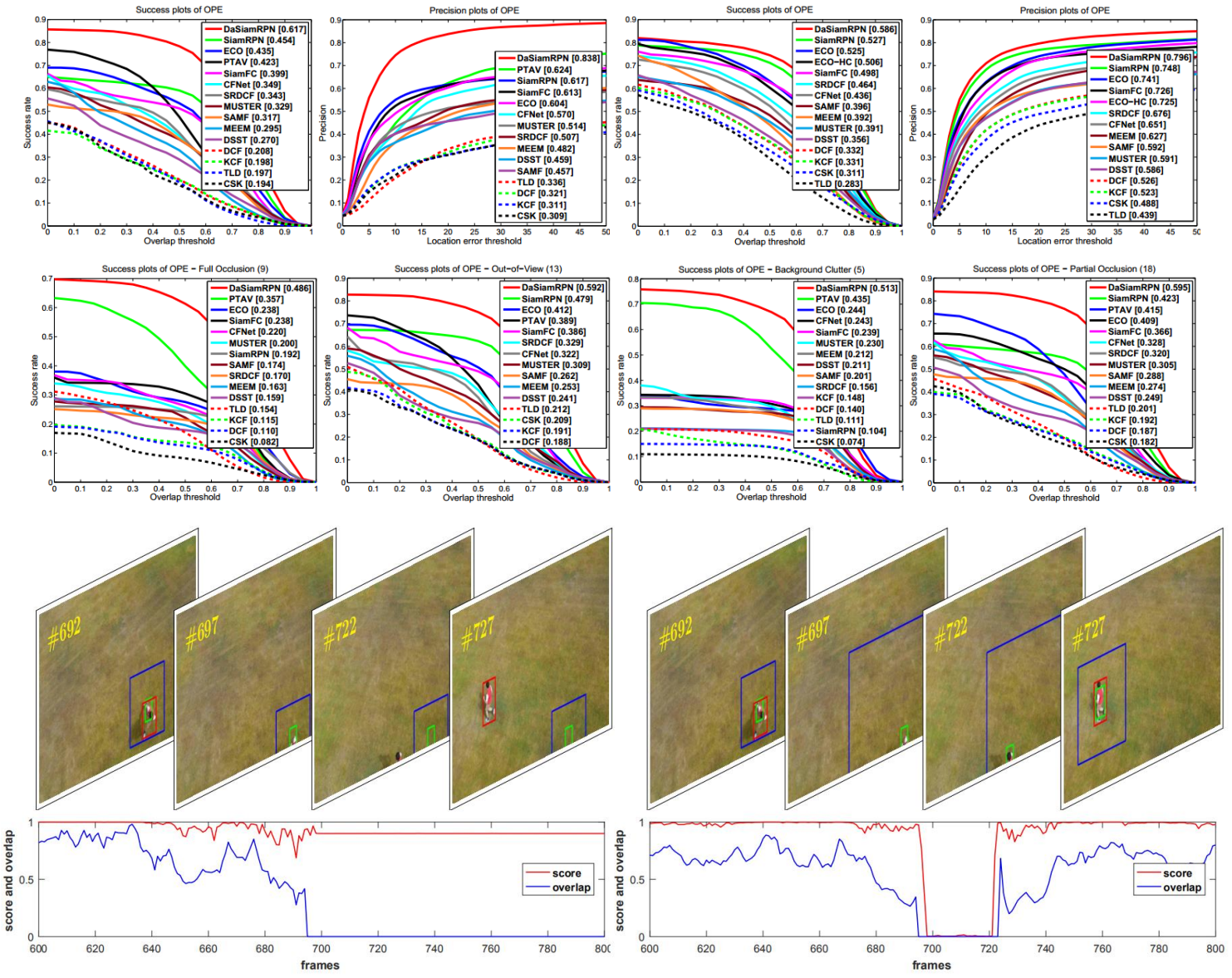
(b) EAO on VOT2017





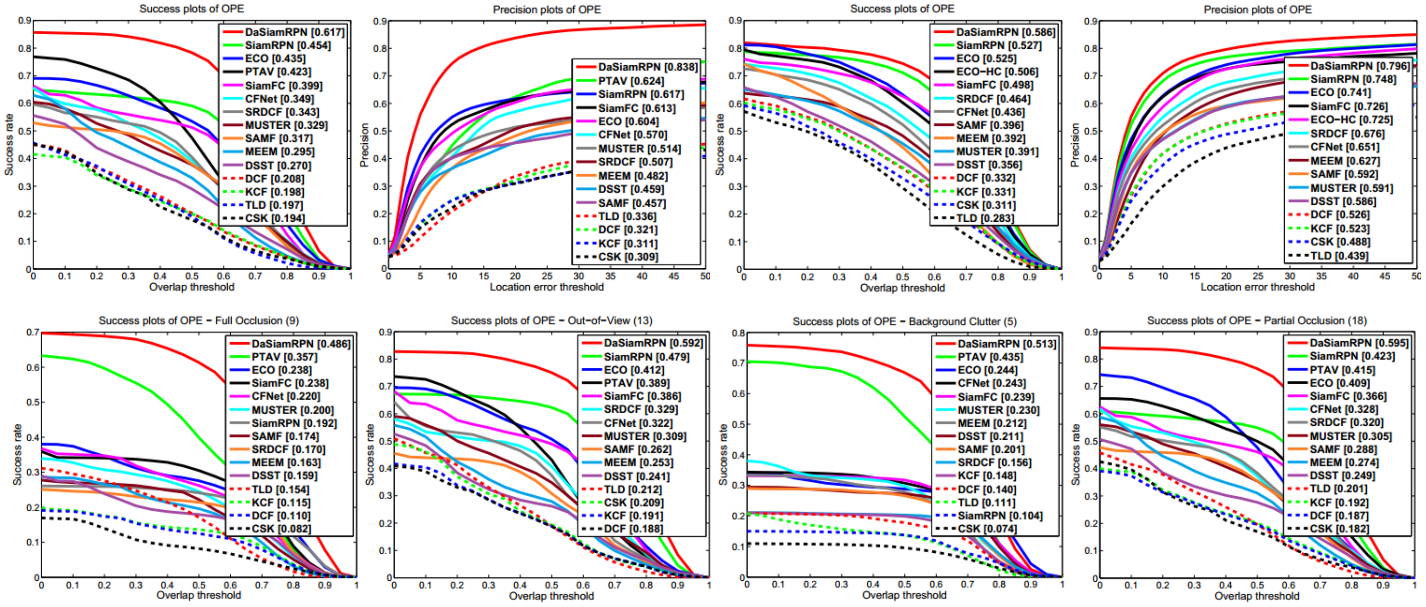
Zheng Zhu*, Qiang Wang*, Bo Li*, Wei Wu, Junjie Yan, and Weiming Hu. Distractor-aware Siamese Networks for Visual Object Tracking. *ECCV*, 2018

Second Prize in VOT2018-LT



(a) scores and overlaps in SiamRPN (b) scores and overlaps in DaSiamRPN

Zheng Zhu*, Qiang Wang*, Bo Li*, Wei Wu, Junjie Yan, and Weiming Hu. Distractor-aware Siamese Networks for Visual Object Tracking. *ECCV*, 2018



Trackers	OTB-2013		OTB-2015		VOT2015			VOT2016			VOT2017			FPS
	OP	DP	OP	DP	A	R	EAO	A	R	EAO	A	R	EAO	
SiamFC	77.8	80.9	73.0	77.0	0.533	0.88	0.289	0.53	0.46	0.235	0.50	0.59	0.188	86
CFNet	76.8	80.7	69.9	74.7	-	-	-	-	-	-	-	-	-	75
Staple	75.3	79.2	70.9	78.4	0.57	1.39	0.300	0.54	0.38	0.295	*0.52*	0.69	0.169	80
CSRDCF	75.3	80.0	70.7	78.7	0.56	0.86	0.320	0.51	0.24	0.338	0.49	0.36	0.256	13
BACF	82.3	84.4	76.7	81.5	0.59	1.56	-	-	-	-	-	-	-	35
ECO-HC	80.9	87.4	78.4	85.6	-	-	-	0.54	0.30	0.322	0.49	0.44	0.238	60
CREST	85.9	88.8	77.5	83.7	-	-	-	0.51	0.25	0.283	-	-	-	1
MDNet	**91.1**	**94.8**	*85.4*	*90.9*	*0.60*	*0.69*	*0.378*	0.54	0.34	0.257	-	-	-	1
C-COT	83.1	89.9	82.0	89.8	0.54	0.82	0.303	0.54	0.24	0.331	0.49	*0.32*	0.267	0.3
ECO	88.7	*93.0*	84.9	**91.0**	-	-	-	0.55	**0.20**	*0.375*	0.48	**0.27**	*0.280*	8
SiamRPN	85.7	88.3	81.9	85.0	0.58	1.13	0.349	*0.56*	0.26	0.344	0.49	0.46	0.244	**200**
DaSiamRPN	*89.4*	90.7	**86.5**	88.0	**0.63**	**0.66**	**0.446**	**0.61**	*0.22*	**0.411**	**0.56**	0.34	**0.326**	*160*

Zheng Zhu*, Qiang Wang*, Bo Li*, Wei Wu, Junjie Yan, and Weiming Hu. Distractor-aware Siamese Networks for Visual Object Tracking. *ECCV*, 2018

Results Ablation

SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	250

Baseline:
CVPR’18 Paper version of SiamRPN

Optimized Coding ⚡⚡⚡

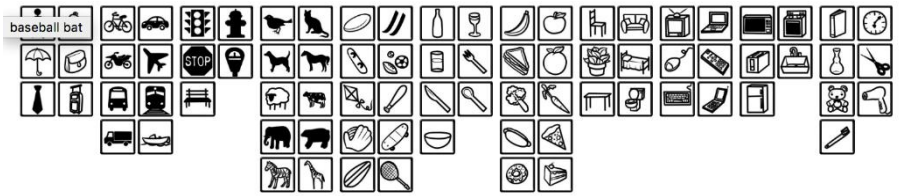
Results Ablation (Training)

SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	250
	+ ImageNetDet&COCO	0.510	0.410	0.273	250
	+ train-pair aug.	0.560	0.340	0.326	250

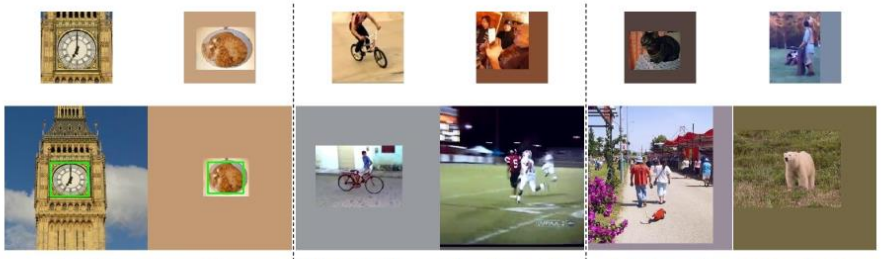
IMAGENET

COCO Common Objects in Context

200 synsets for Object detection

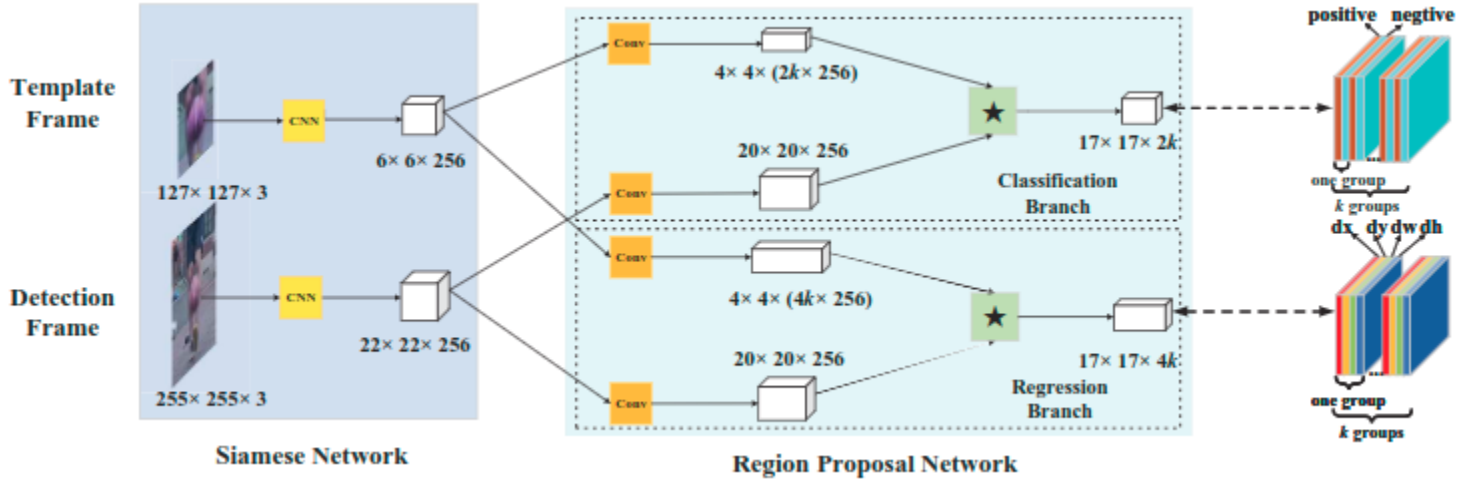


DaSiamRPN
（ECCV2018）



(a) detection pairs (b) negative pairs from the same categories (c) negative pairs from different categories

Results Ablation (Backbone)



Kernel Size

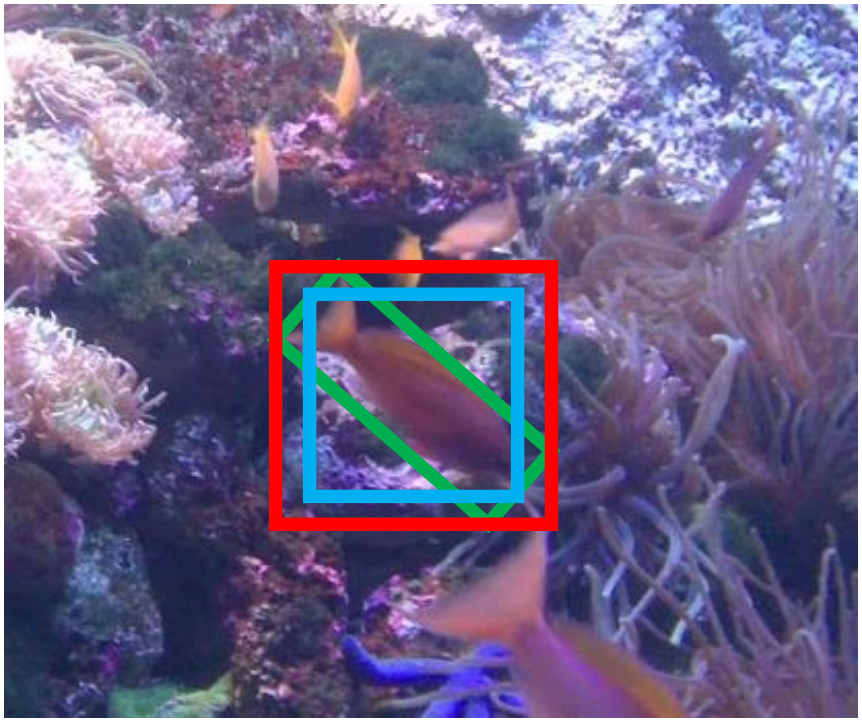
SiamRPN	Lost	EAO
11+5+(3+3+3)	65	0.324
11+(3+3)+(3+3+3)	65	0.322
(9+3)+5+(3+3+3)	63	0.324
(7+5)+5+(3+3+3)	66	0.325
(7+3+3+3)+5+(3+3+3)	66	0.312
...	...	...
(3*5)+(3+3)+(3+3+3)	67	0.301

Channel Size

SiamRPN	Lost	EAO
256F+256R	65	0.324
512F+256R	62	0.342
512F+1024R	**56**	0.341
512F+512R+SE	62	0.344
512F+1024R+SE	64	0.322
1024F+512R	74	0.318
1024F+1024R	73	0.312
512F+512R	60	**0.345**

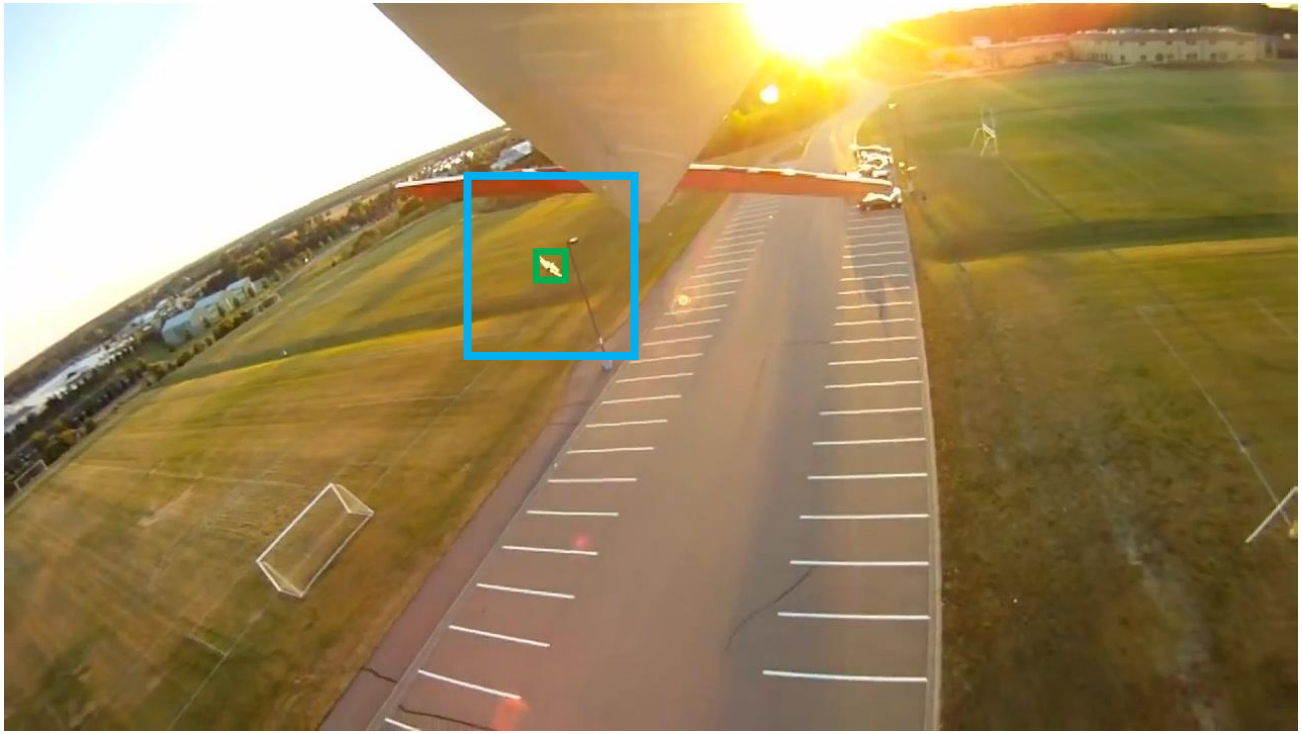
Results Ablation (Trick1)

SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	250



Results Ablation (Trick2)

SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	250



Results Ablation (Trick2)

SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	250

Results Ablation

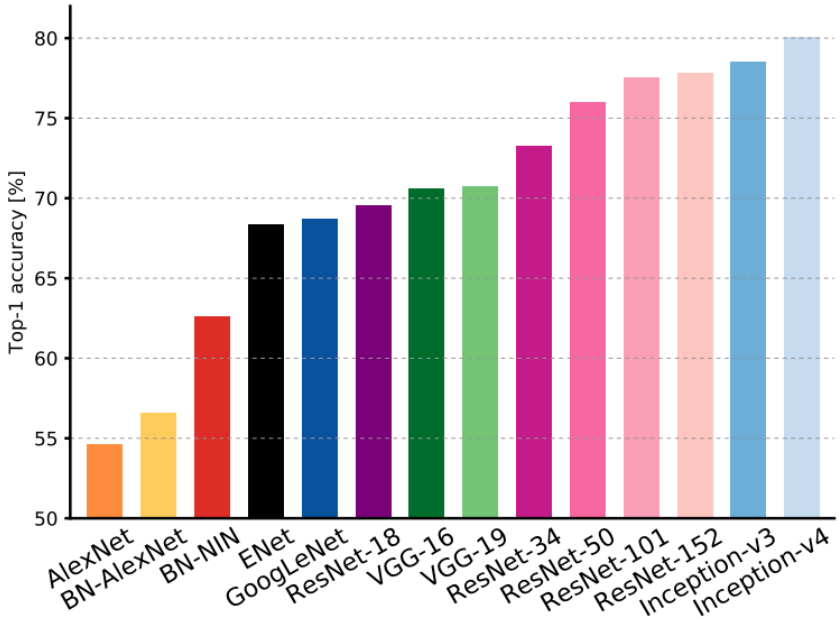
SiamRPN		A	R	EAO	FPS
AlexNet 256C	CVPR'18	0.490	0.460	0.244	**250**
	+ ImageNetDet&COCO	0.510	0.410	0.273	**250**
	+ train-pair aug.	0.560	0.340	0.326	**250**
AlexNet 512C	+ wider	0.570	0.330	0.345	100
	+ large search region	0.571	0.330	0.361	90
(final entry)	+ adaptive Search Region	**0.588**	**0.320**	**0.383**	90

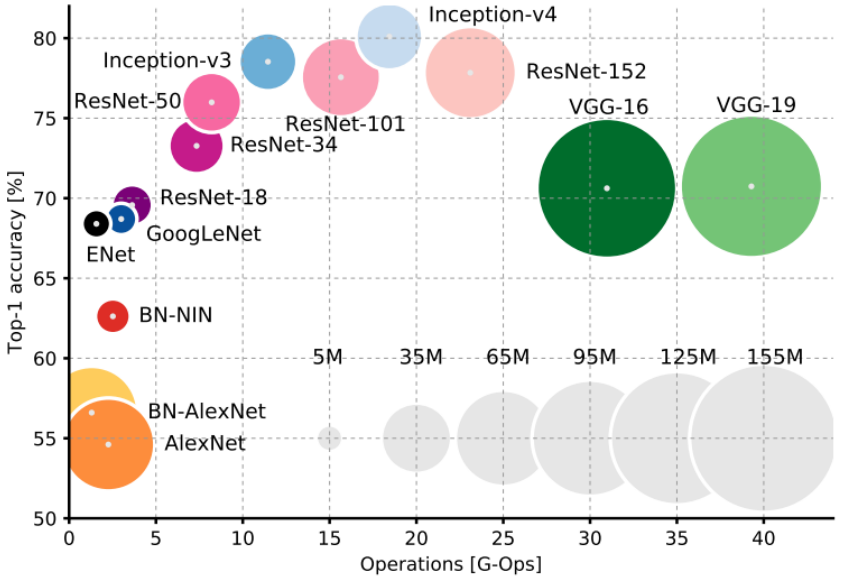
- CVPR'18 Paper version of SiamRPN
- ECCV'18 Paper version of DaSiamRPN

Performance Drop / No Effect

The backbone net is the engine of recognition!!!

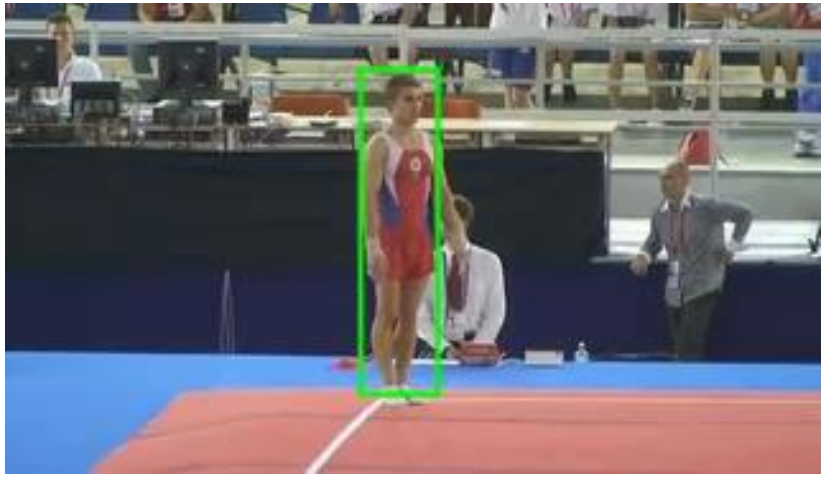
- × Modern networks: VGG, Inception or ResNet (padding? or training methods?)
- × Attention Network
- × Ensemble (× Average × Max Win)
- × Focal Loss





Canziani, Alfredo, Adam Paszke, and Eugenio Culurciello. "An analysis of deep neural network models for practical applications." arXiv 2016.

Visualizations



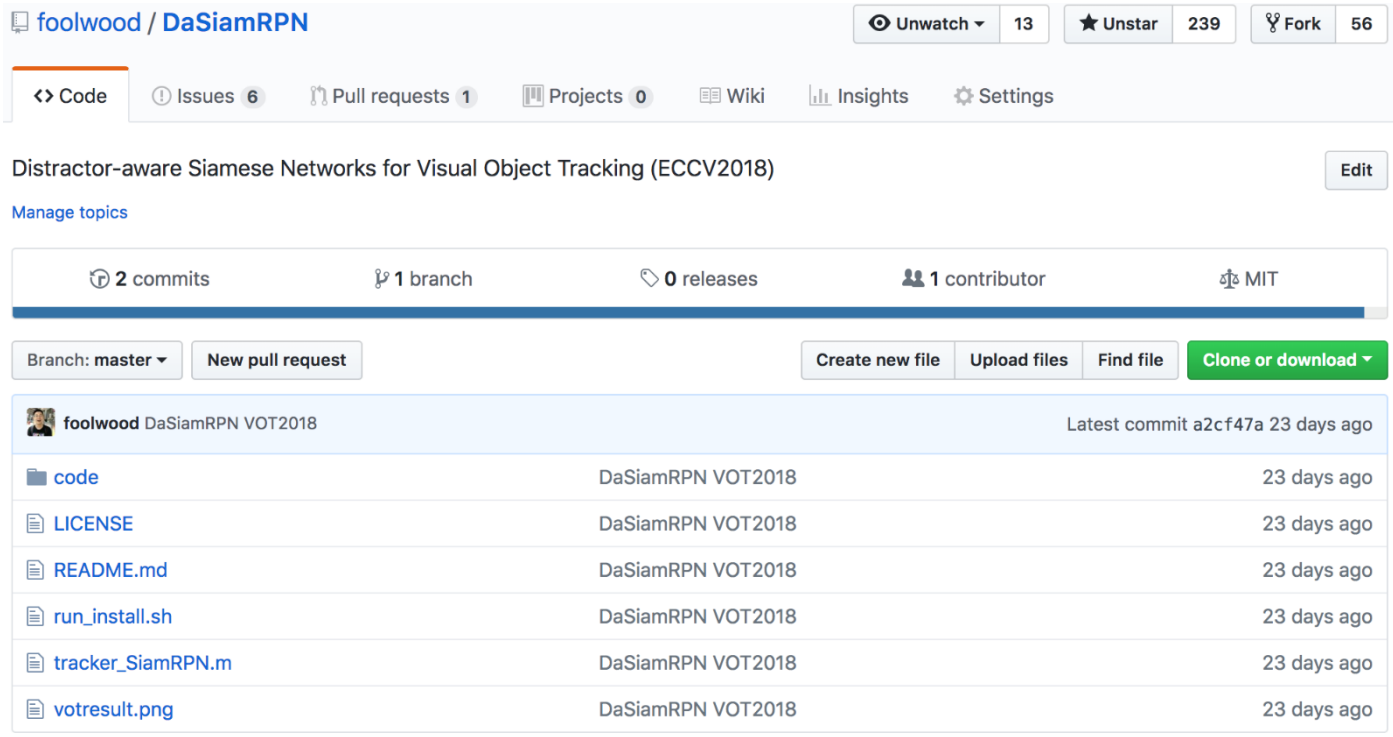
Conclusion

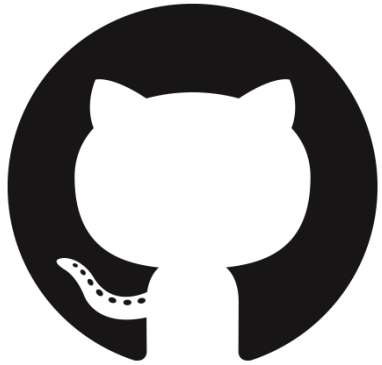
SiamRPN

- ✓ Simultaneous Identification and Localization
- ✓ Training Strategies
- ✓ Widen Backbone
- ✓ Adaptive Search Area

	Baseline SiamRPN ⟹	Training Strategy ⟹	Network 512C ⟹	Adaptive Searching
EAO	0.244	0.326	0.361	**0.383**
Accuracy	0.490	0.560	0.571	**0.588**
Robustness	0.460	0.340	0.330	**0.320**
FPS	**250**	**250**	100	90

Thanks! Questions?





Zheng Zhu*, Qiang Wang*, Bo Li*, Wei Wu, Junjie Yan, and Weiming Hu. Distractor-aware Siamese Networks for Visual Object Tracking. *ECCV*, 2018

https://github.com/foolwood/DaSiamRPN