https://arxiv.org/abs/1912.12898

PPDM: Parallel Point Detection and Matching for Real-time Human-Object Interaction Detection

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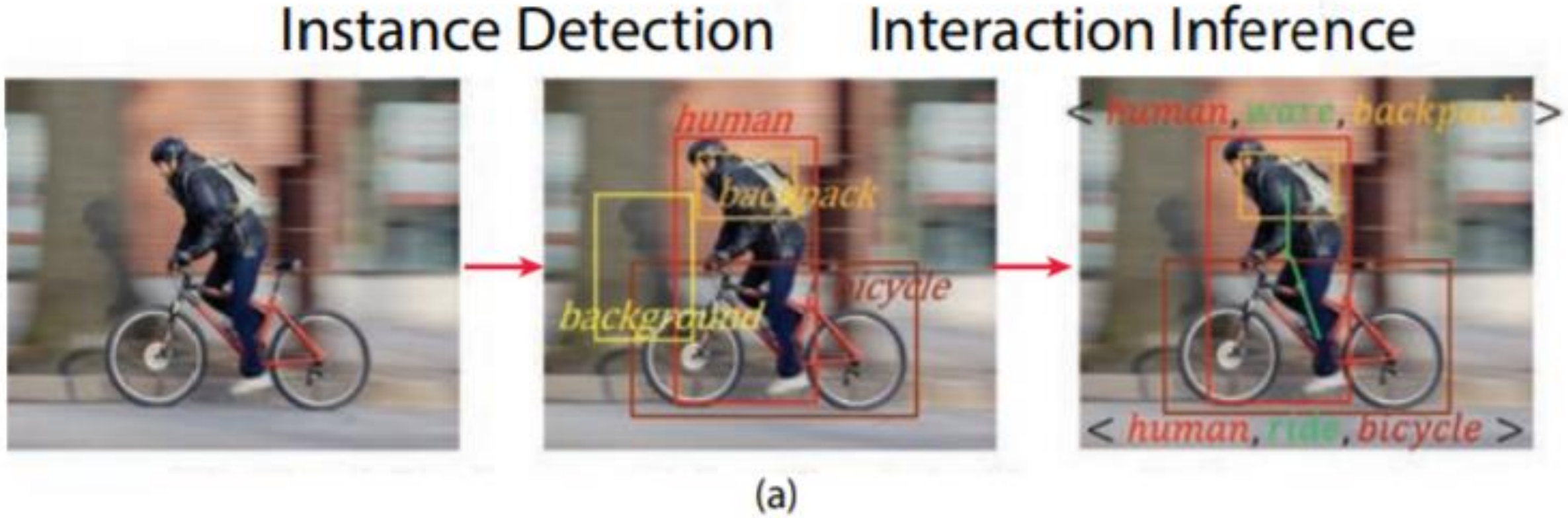
인공지능 연구실
석사과정 구자봉

문제 정의 :
HOI(Human Object Interaction)

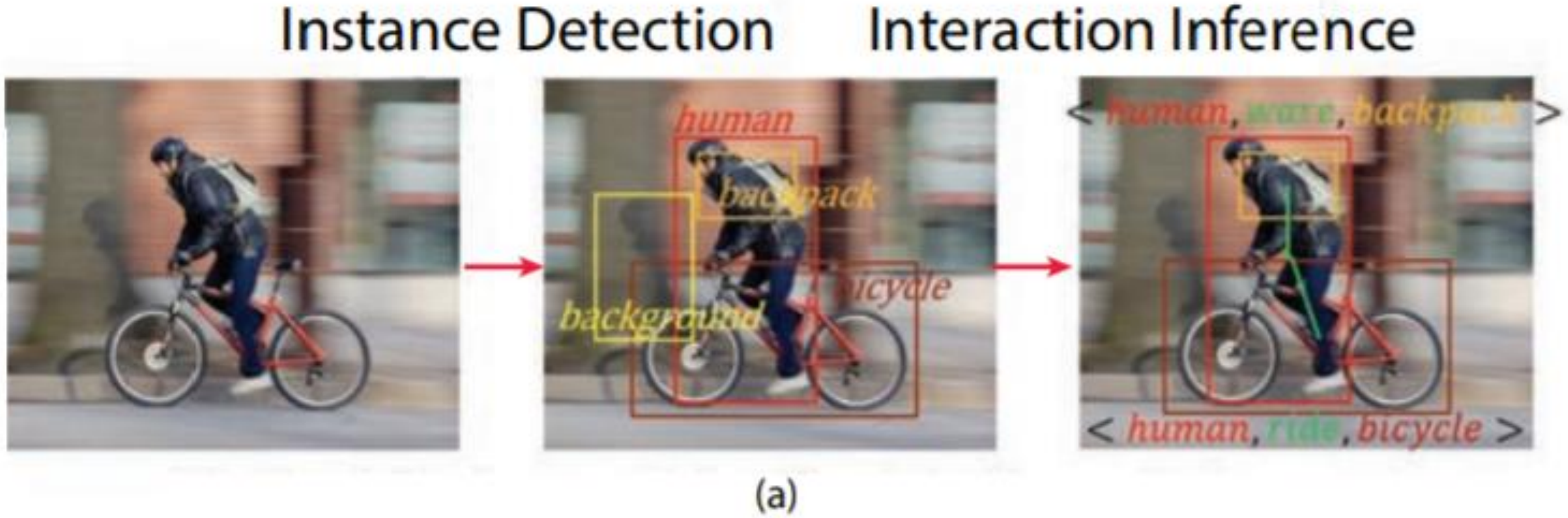
이미지에서 오브젝트 디텍션, 인간과 상호작용이 큰 객체쌍을 선택, 술어(상관관계)를 찾는 것이 목적



(a)

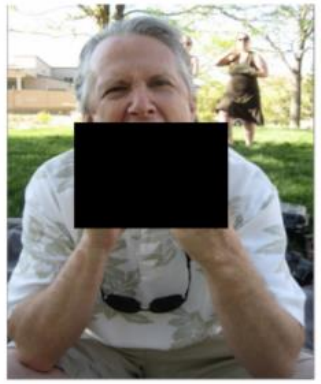
문제 제기 :

대부분의 HOI 모듈은
1)인간-대상 제안서 생성, 2)제안서 분류
2단계로 나뉘어 구성된다. 순차적이고 개별적인 아키텍처를 사용하여 성능이 제한된다.

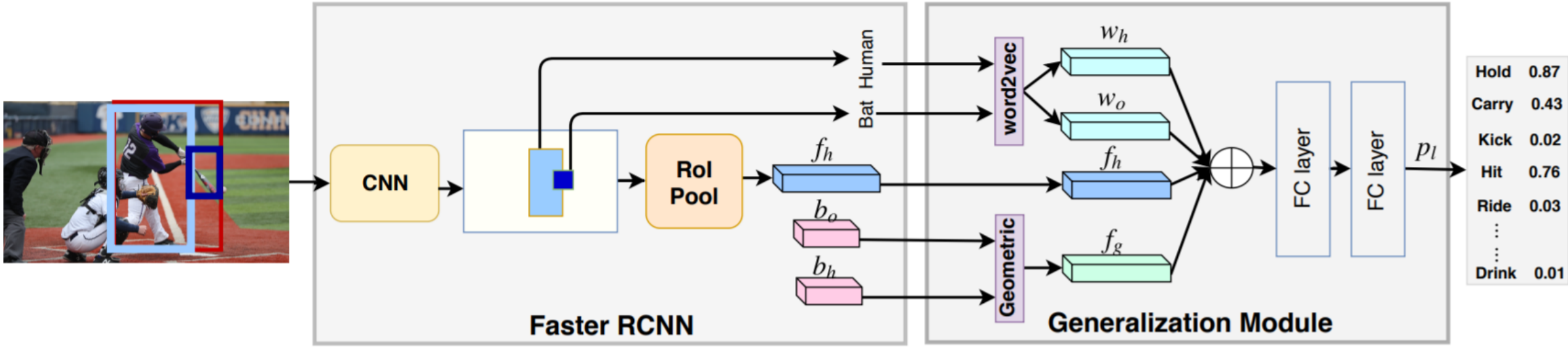


(a)

Detecting Human-Object Interactions via Functional Generalization

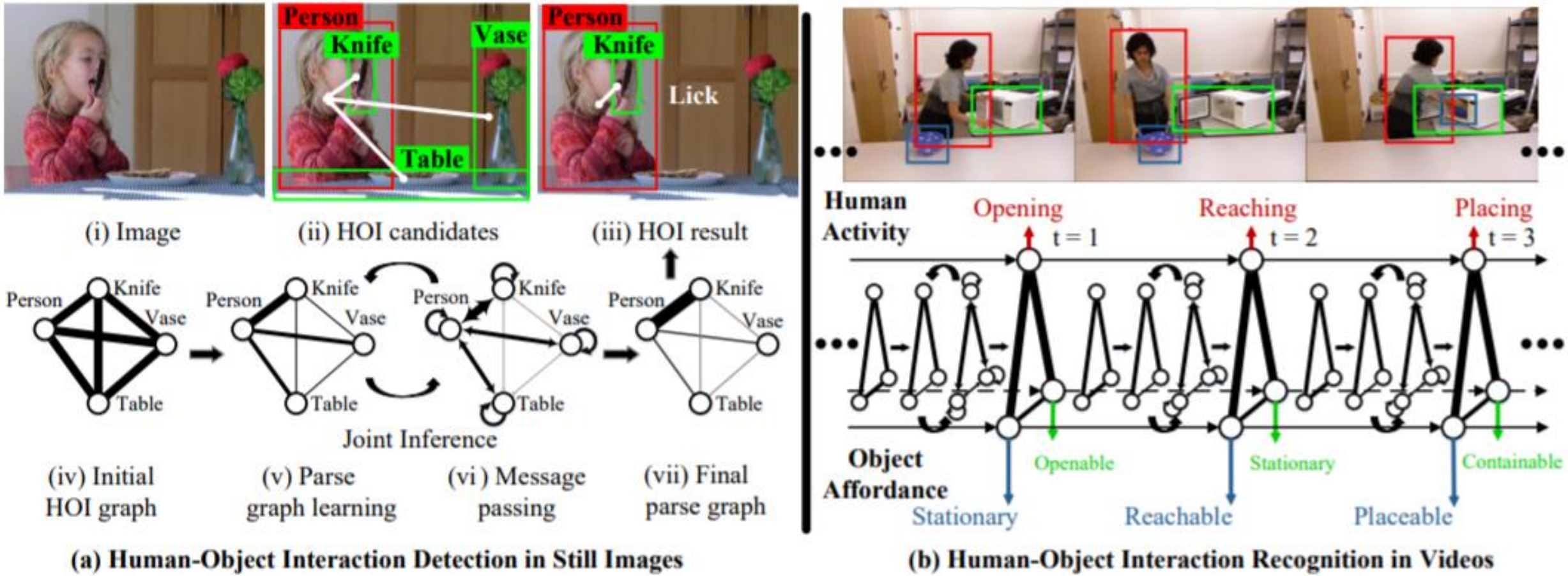


⟨human, eat, __



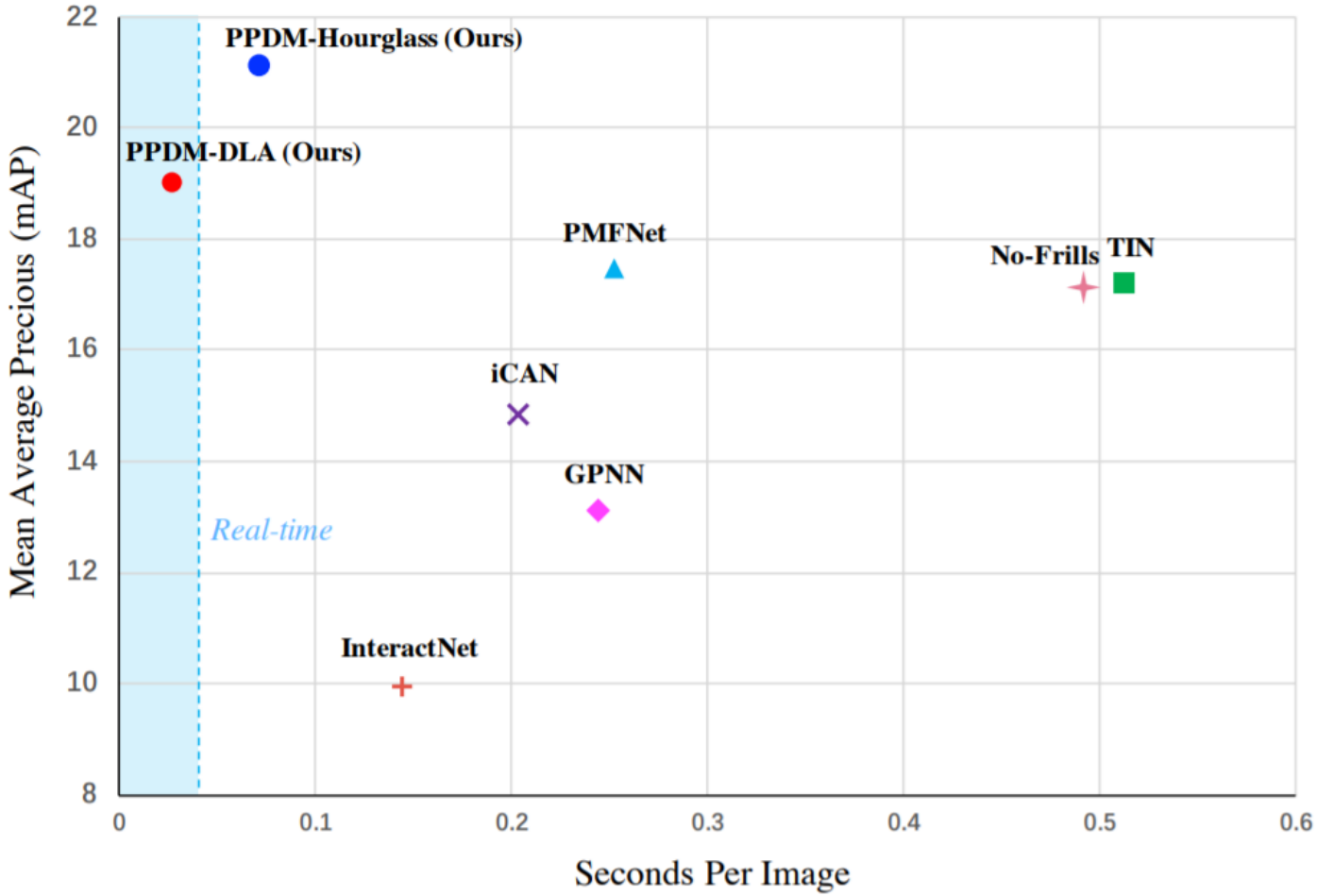
https://arxiv.org/pdf/1710.10903.pdf

Learning Human-Object Interactions by Graph Parsing Neural Networks (GPNN):

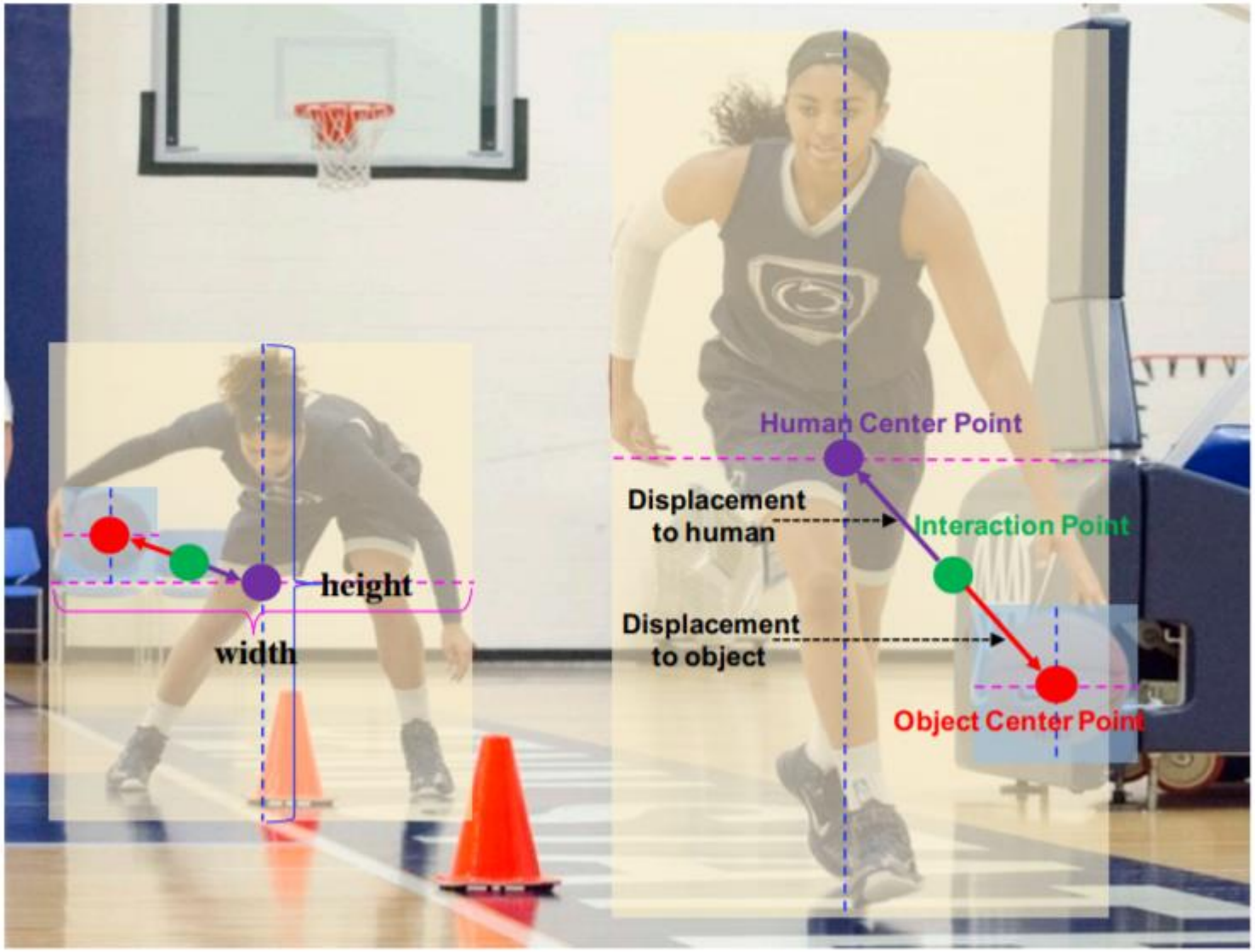


목표:

HOI 문제를 점 삼중항으로 정의하여 포인트 감지분기와 포인트 일치 분기를 병렬 아키텍처를 사용하여 쓸모없는 삼중항을 억제함으로써 정확도를 높임과 동시에 계산 비용을 절감한다.



메인 아이디어



두개의 병렬 분기

1) 포인트 검출
   - 사람 중심점, 객체 중심점, 상호작용 중심점 찾기
2) 포인트 매칭
   - 상호작용 중심점에서 인간과 물체로의 변위 추정

➢ 동일한 상호작용 중심점에서의 변위가 일치하면 상호작용 쌍으로 간주함

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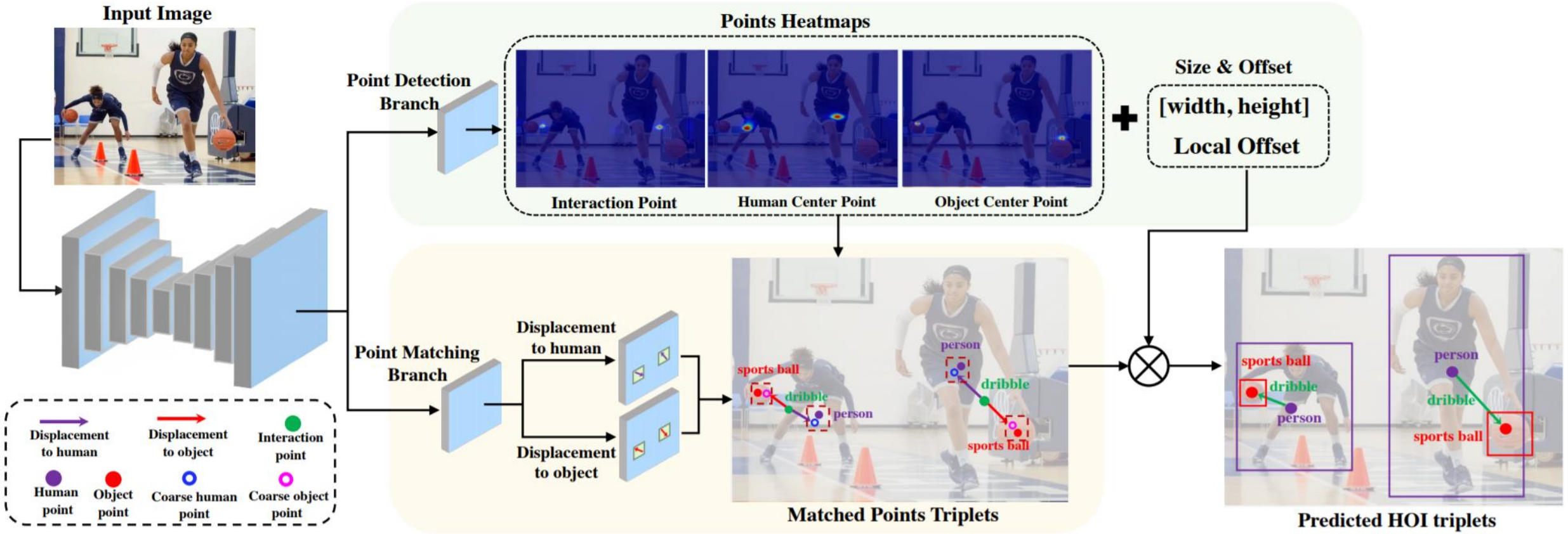
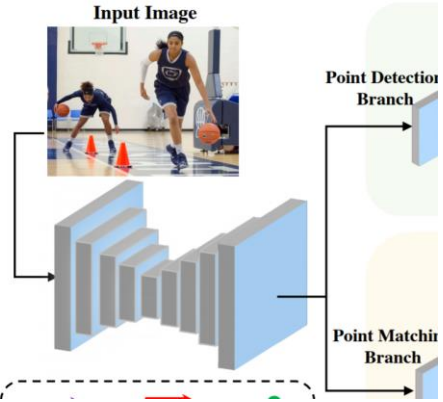
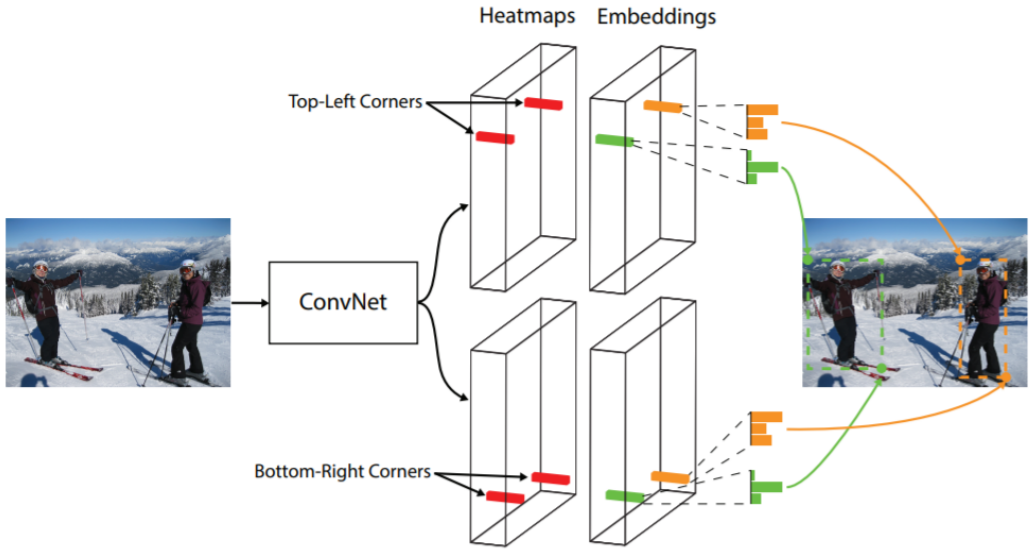


피쳐 추출기(heatmap prediction networks)



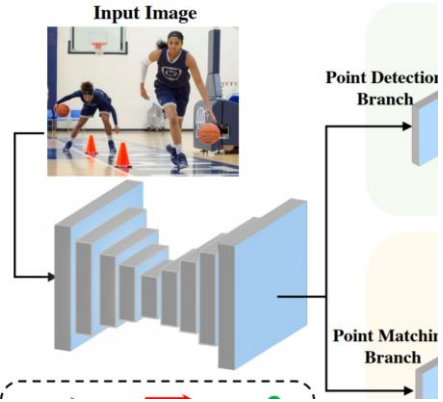
Hourglass-104(CornetNet)



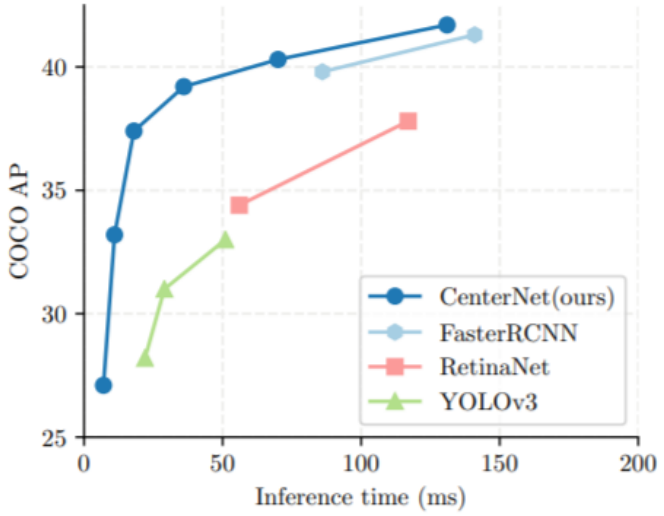
Method	Backbone	AP
Two-stage detectors		
DeNet (Tychsen-Smith and Petersson, 2017a)	ResNet-101	33.8
CoupleNet (Zhu et al., 2017)	ResNet-101	34.4
Faster R-CNN by G-RMI (Huang et al., 2017)	Inception-ResNet-v2 (Szegedy et al., 2017)	34.7
Faster R-CNN+++ (He et al., 2016)	ResNet-101	34.9
Faster R-CNN w/ FPN (Lin et al., 2016)	ResNet-101	36.2
Faster R-CNN w/ TDM (Shrivastava et al., 2016)	Inception-ResNet-v2	36.8
D-FCN (Dai et al., 2017)	Aligned-Inception-ResNet	37.5
Regionlets (Xu et al., 2017)	ResNet-101	39.3
Mask R-CNN (He et al., 2017)	ResNeXt-101	39.8
Soft-NMS (Bodla et al., 2017)	Aligned-Inception-ResNet	40.9
LH R-CNN (Li et al., 2017)	ResNet-101	41.5
Fitness-NMS (Tychsen-Smith and Petersson, 2017b)	ResNet-101	41.8
Cascade R-CNN (Cai and Vasconcelos, 2017)	ResNet-101	42.8
D-RFCN + SNIP (Singh and Davis, 2017)	DPN-98 (Chen et al., 2017)	45.7
One-stage detectors		
YOLOv2 (Redmon and Farhadi, 2016)	DarkNet-19	21.6
DSOD300 (Shen et al., 2017a)	DS/64-192-48-1	29.3
GRP-DSOD320 (Shen et al., 2017b)	DS/64-192-48-1	30.0
SSD513 (Liu et al., 2016)	ResNet-101	31.2
DSSD513 (Fu et al., 2017)	ResNet-101	33.2
RefineDet512 (single scale) (Zhang et al., 2017)	ResNet-101	36.4
RetinaNet800 (Lin et al., 2017)	ResNet-101	39.1
RefineDet512 (multi scale) (Zhang et al., 2017)	ResNet-101	41.8
CornerNet511 (single scale)	Hourglass-104	40.6
CornerNet511 (multi scale)	Hourglass-104	42.2

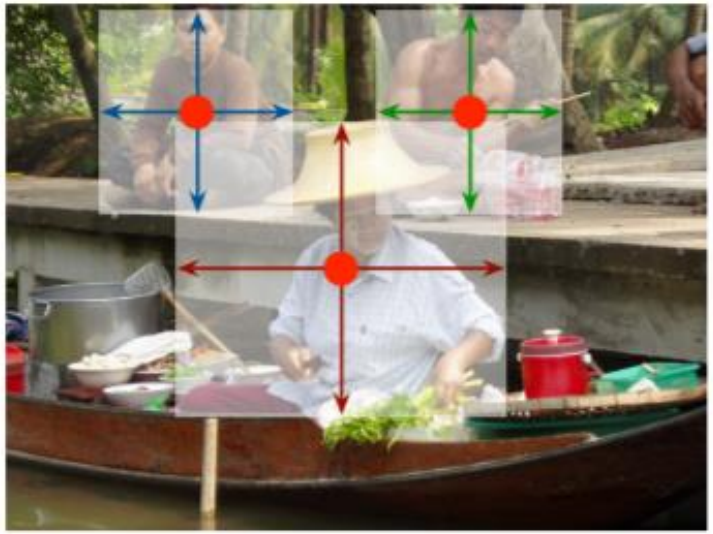
https://arxiv.org/abs/1808.01244

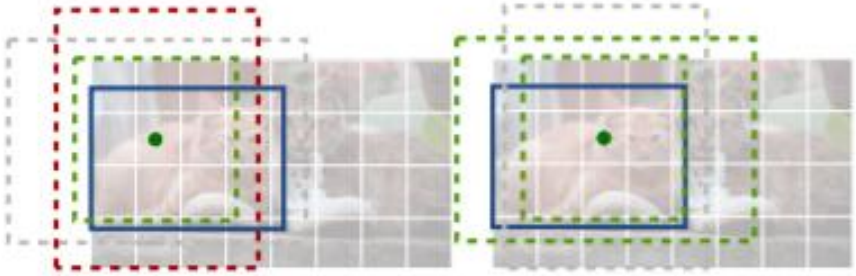
피쳐 추출기(heatmap prediction networks)

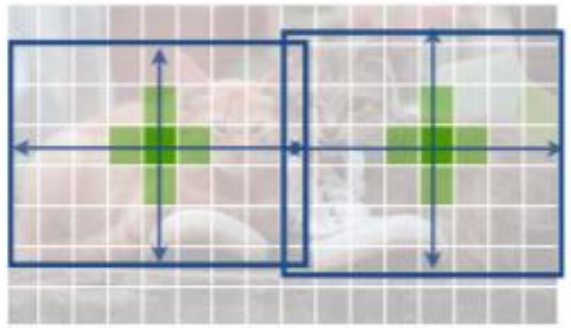


DLA-34







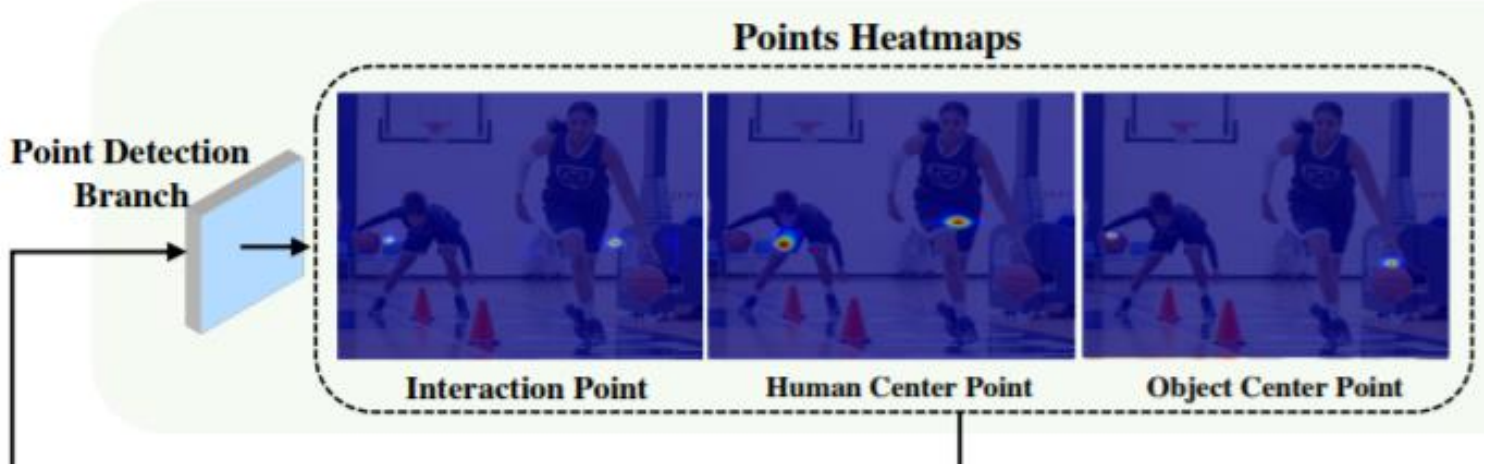


	AP			Time (ms)			FPS		
	N.A.	F	MS	N.A.	F	MS	N.A.	F	MS
Hourglass-104	**40.3**	**42.2**	**45.1**	71	129	672	14	7.8	1.4
DLA-34	37.4	39.2	41.7	19	36	248	52	28	4
ResNet-101	34.6	36.2	39.3	22	40	259	45	25	4
ResNet-18	28.1	30.0	33.2	**7**	**14**	**81**	**142**	**71**	**12**

https://arxiv.org/abs/1904.07850

포인트 디텍션

사람 상자, 객체 상자, 상호작용 지점을 추정(가우시안 커널을 사용하여 히트맵으로 표시)



$(x^h, y^h) \in \mathbb{R}^2$

$(w^h, h^h) \in \mathbb{R}^2$

$\boldsymbol{\delta c^h} \in \mathbb{R}^2$

(x^h, y^h)

$\tilde{\boldsymbol{C}}^{\boldsymbol{h}} \in [0,1]^{\frac{H}{d} \times \frac{W}{d}}$

$(x^a, y^a) \in \mathbb{R}^2$

(x^o, y^o)

$\tilde{\boldsymbol{C}}^{o} \in [0,1]^{T \times \frac{H}{d} \times \frac{W}{d}}$

$(\tilde{x}^a, \tilde{y}^a) = (\lfloor \frac{\tilde{x}^h + \tilde{x}^o}{2} \rfloor, \lfloor \frac{\tilde{y}^h + \tilde{y}^o}{2} \rfloor).$

(x^a, y^a)

$\tilde{\boldsymbol{C}}^{a} \in [0,1]^{K \times \frac{H}{d} \times \frac{W}{d}}$

포인트 디텍션

로스, 알파2, 배타4, 사람과 오브젝트도 동일한 식 사용하여 로스 적용

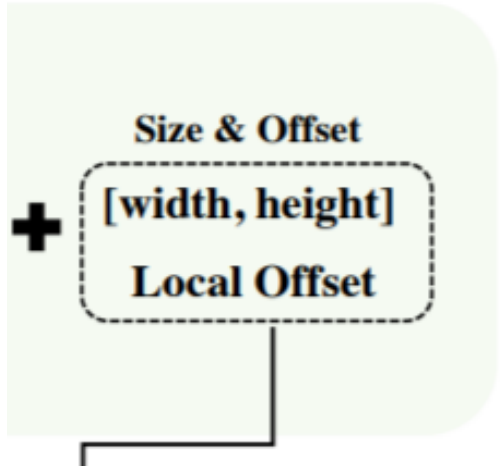
$$L_a = -\frac{1}{N}\sum_{kxy}\begin{cases}(1-\hat{C}^a_{kxy})^{\alpha}\log(\hat{C}^a_{kxy}) & \text{if } \tilde{C}^a_{kxy}=1\\ (1-\tilde{C}^a_{kxy})^{\beta}(\hat{C}^a_{kxy})^{\alpha} & \text{otherwise}\\ \log(1-\hat{C}^a_{kxy}), & \end{cases} \tag{1}$$

크기 및 오프셋 손실

$$(\tilde{\delta}^x_{(\tilde{x}^h,\tilde{y}^h)}, \tilde{\delta}^y_{(\tilde{x}^h,\tilde{y}^h)}) = (\frac{x^h}{d} - \tilde{x}^h, \frac{y^h}{d} - \tilde{y}^h).$$

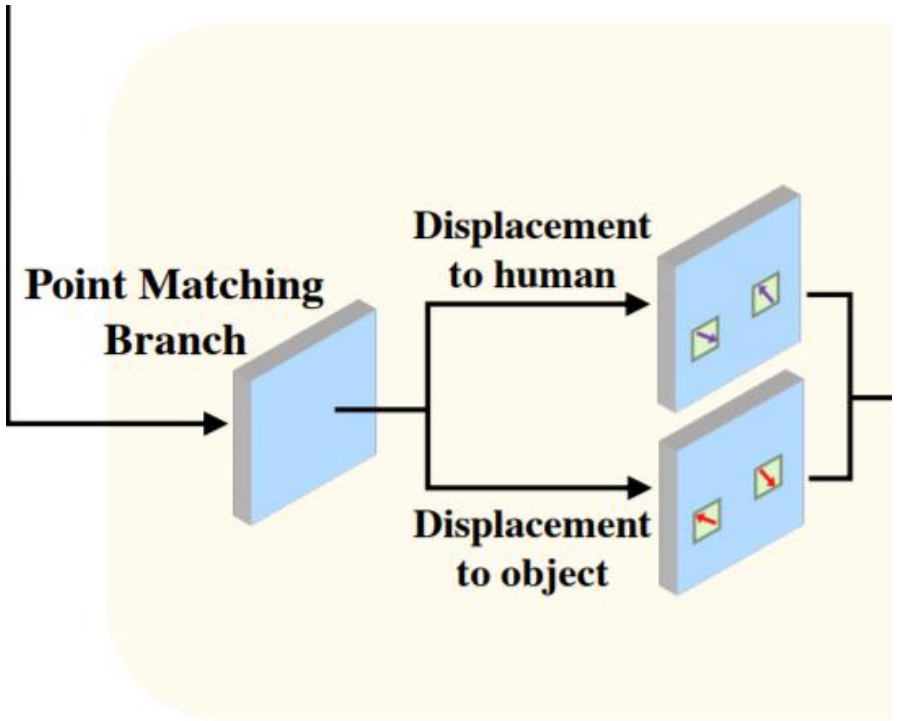
$$L^h_{off} = \sum_{(\tilde{x}^h,\tilde{y}^h)\in\tilde{S}^{\bar{h}}} (|\tilde{\delta}^x_{(\tilde{x}^h,\tilde{y}^h)} - \hat{\delta}^x_{(\tilde{x}^h,\tilde{y}^h)}| + |\tilde{\delta}^y_{(\tilde{x}^h,\tilde{y}^h)} - \hat{\delta}^y_{(\tilde{x}^h,\tilde{y}^h)}|, \tag{3}$$

$$L_{off} = \frac{1}{M+D}(L^h_{off} + L^o_{off}) \qquad M = |\tilde{S}^h| \text{ and } D = |\tilde{S}^o|$$



포인트 매칭

상호작용 점을 앵커로 하여 사람 쪽과 객체 쪽으로 변위를 추정



로스 ~(그라운드트루), ^(예측된), L_{ao}

$$(\tilde{d}^{hx}_{(\tilde{x}^a,\tilde{y}^a)}, \tilde{d}^{hy}_{(\tilde{x}^a,\tilde{y}^a)}) = (\tilde{x}^a - \tilde{x}^h, \tilde{y}^a - \tilde{y}^h)$$

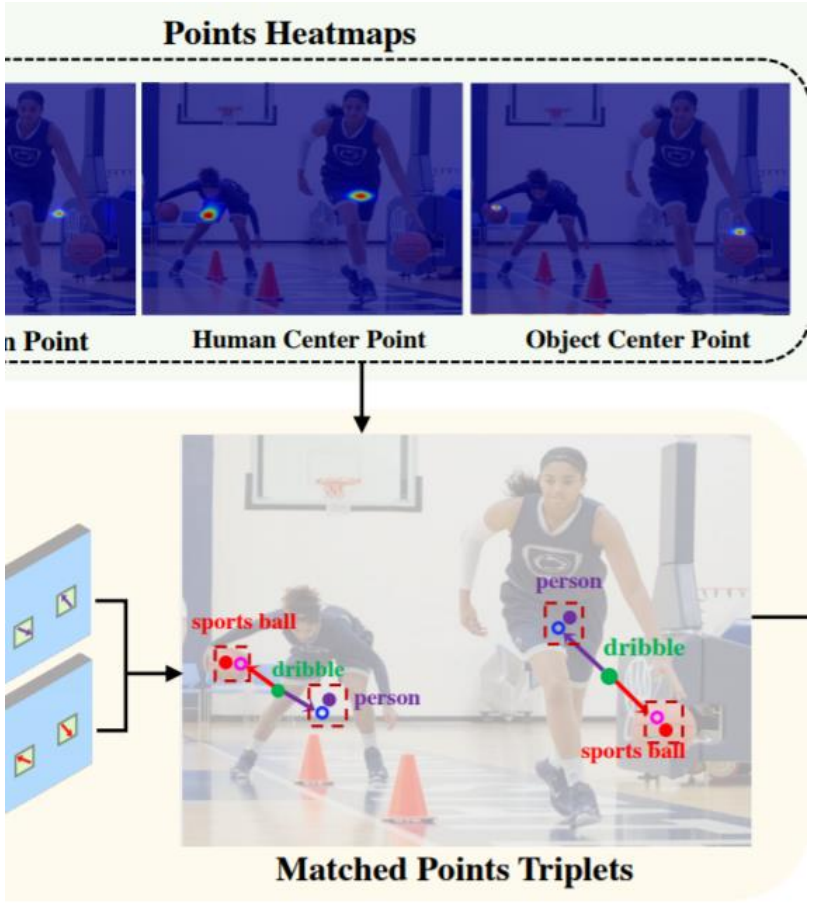
$$L_{ah} = \frac{1}{N} \sum_{(\tilde{x}^a,\tilde{y}^a)\in\tilde{S}^a} |\hat{d}^{hx}_{(\tilde{x}^a,\tilde{y}^a)} - \tilde{d}^{hx}_{(\tilde{x}^a,\tilde{y}^a)}| + |\hat{d}^{hx}_{(\tilde{x}^a,\tilde{y}^a)} - \tilde{d}^{hy}_{(\tilde{x}^a,\tilde{y}^a)}|, \quad (4)$$

$$\boldsymbol{d^{ah}} = (d^{ah}_x, d^{ah}_y)$$

$$\boldsymbol{d^{ao}} = (d^{ao}_x, d^{ao}_y)$$

포인트 매칭

트리플넷 매칭
가우시안 분포인 C점수가 크고, 예측된 값의 차이가 가까운 것들중 최적의 것을 선택
객체상자도 같은 식으로 선택

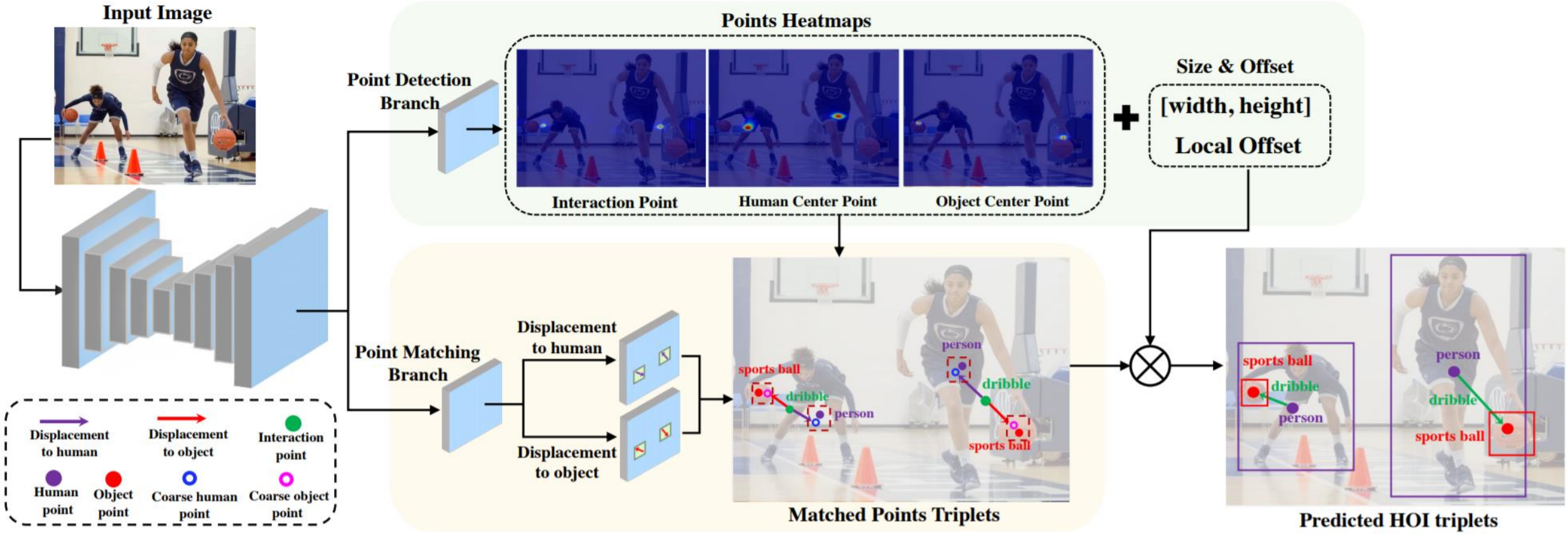


$$(\hat{x}^h_{opt}, \hat{y}^h_{opt}) = \underset{(\hat{x}^h,\hat{y}^h)\in\hat{S}^h}{\arg\min} \frac{1}{C^h_{(\hat{x}^h,\hat{y}^h)}} \cdot (|(\hat{x}^a,\hat{y}^a) - (\hat{d}^{hx}_{(\hat{x}^a,\hat{y}^a)}, \hat{d}^{hy}_{(\hat{x}^a,\hat{y}^a)}) - (\hat{x}^h,\hat{y}^h)|) \quad (5)$$

최종 손실

$$\hat{x}^h_{ref} = \hat{x}^h_{opt} + \hat{\delta}^x_{(\hat{x}^h_{opt},\hat{y}^h_{opt})} \quad (\hat{x}^h_{ref} - \frac{\hat{w}_{(\hat{x}^h_{opt},\hat{y}^h_{opt})}}{2}, \hat{y}^h_{ref} - \frac{\hat{h}_{(\hat{x}^h_{opt},\hat{y}^h_{opt})}}{2},$$

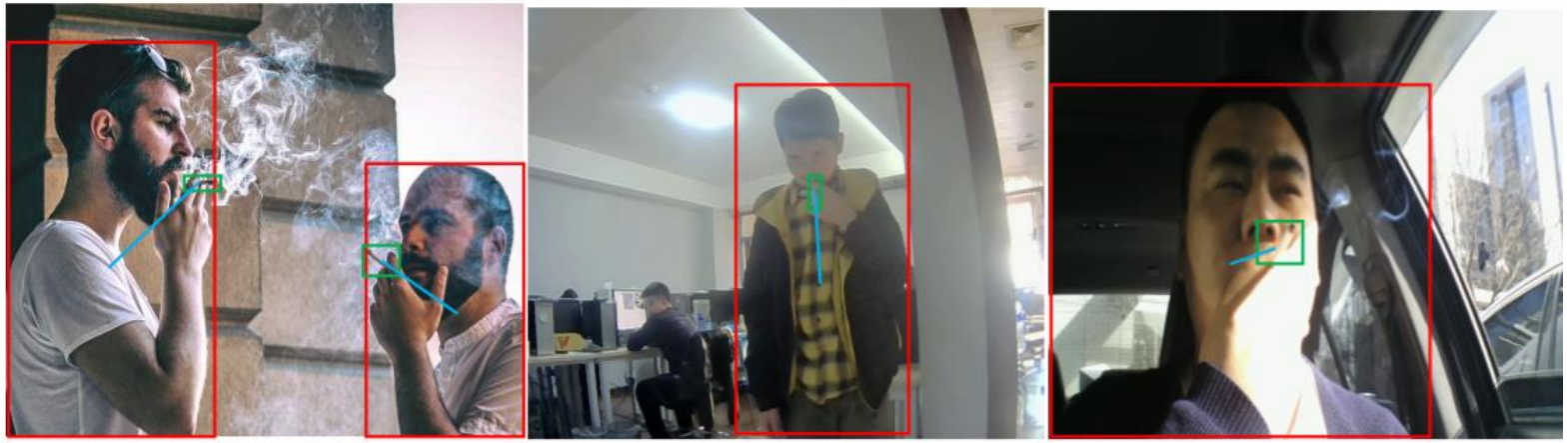
$$\hat{y}^h_{ref} = \hat{y}^h_{opt} + \hat{\delta}^y_{(\hat{x}^h_{opt},\hat{y}^h_{opt})} \quad \hat{x}^h_{ref} + \frac{\hat{w}_{(\hat{x}^h_{opt},\hat{y}^h_{opt})}}{2}, \hat{y}^h_{ref} + \frac{\hat{h}_{(\hat{x}^h_{opt},\hat{y}^h_{opt})}}{2}. \quad (7)$$



$$L = L_a + L_h + L_o + \lambda(L_{ah} + L_{ao} + L_{wh}) + L_{off} \quad (6)$$

$$\hat{C}^p_{\hat{x}^h_{ref}\hat{y}^h_{ref}} \hat{C}^o_{\hat{x}^o_{ref}\hat{y}^o_{ref}} \hat{C}^a_{\hat{x}^a_{ref}\hat{y}^a_{ref}}.$$

HOI-A Dataset(Human-Object Interaction for Application)



a. <human, smoke, cigarette>
outdoor

b. <human, smoke, cigarette>
indoor

c. <human, smoke, cigarette>
in car & intense illumination

d. <human, smoke, cigarette>
in dark scene

e. Attacking smoke: no cigarette
negative sample

f. no predefined interaction
negative sample

HOI를 위한 긍정적인 이미지와 부정적인 이미지를 모아 훈련할때 더 효과적으로 할 수 있도록 하는 데이터셋
38,668 이미지, 11개 객체, 10개 액션

43,820 휴먼 등장, 60,438개 오브젝트 등장, 96,160개 상호작용 등장

Dataset

HICO-DET
Images 47,776 (38,118, 9,658)
Objects 80 (airplane, apple…)
Verbs 117 (carry, catch…)
HOI 600 (airplane – board, direct, exit, fly…)

HOI Remark >= 150k

HOI-A

평가지표

mAP

실험 (HICO-DET)

Method	Feature	Full(mAP %) ↑	Rare(mAP %) ↑	Non-Rare(mAP %) ↑	Inference Time (ms) ↓	FPS ↑
Shen *et. al* [23]	A + P	6.46	4.24	7.12	-	-
HO-RCNN [2]	A + S	7.81	5.37	8.54	-	-
VSRL [10]	A	9.09	7.02	9.71	-	-
InteractNet [8]	A	9.94	7.16	10.77	145	6.90
GPNN [21]	A	13.11	9.34	14.23	197 + 48 = 245	4.08
Xu *et. al* [27]	A + L	14.70	13.26	15.13	-	-
iCAN [6]	A + S	14.84	10.45	16.15	92 + 112 = 204	4.90
PMFNet-Base [25]	A + S	14.92	11.42	15.96	-	-
Wang *et. al* [26]	A	16.24	11.16	17.75	-	-
No-Frills [11]	A + S + P	17.18	12.17	18.68	197 + 230 + 67 = 494	2.02
TIN [15]	A + S + P	17.22	13.51	18.32	92 + 98 + 323 = 513	1.95
RPNN [32]	A + P	17.35	12.78	18.71	-	-
PMFNet [25]	A + S + P	17.46	**15.65**	18.00	92 + 98 + 63 = 253	3.95
PPDM-DLA	A	19.02	12.65	20.92	**27**	**37.03**
PPDM-Hourglass	A	**21.10**	14.46	**23.09**	71	14.08

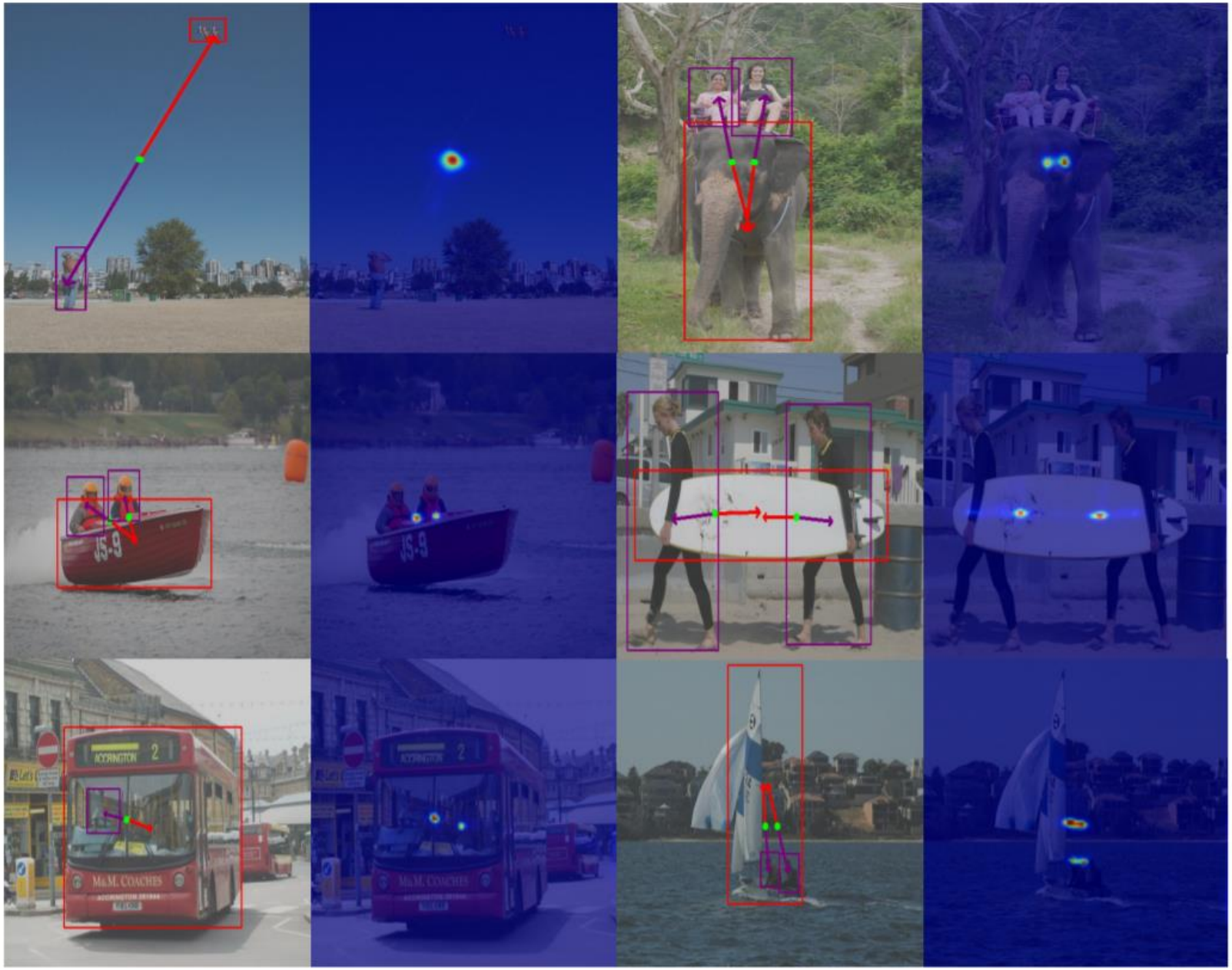
	Method	Full	Rare	Non-Rare	Time
1	Basic Model	18.46	11.97	20.40	24
2	+ Feature Fusion	18.66	11.86	20.69	26
3	+ Global Reasoning	18.63	12.61	20.42	26
4	Union Center	18.07	11.53	20.02	27
5	PPDM-DLA	19.02	12.65	20.92	27

실험 (HOI-A)

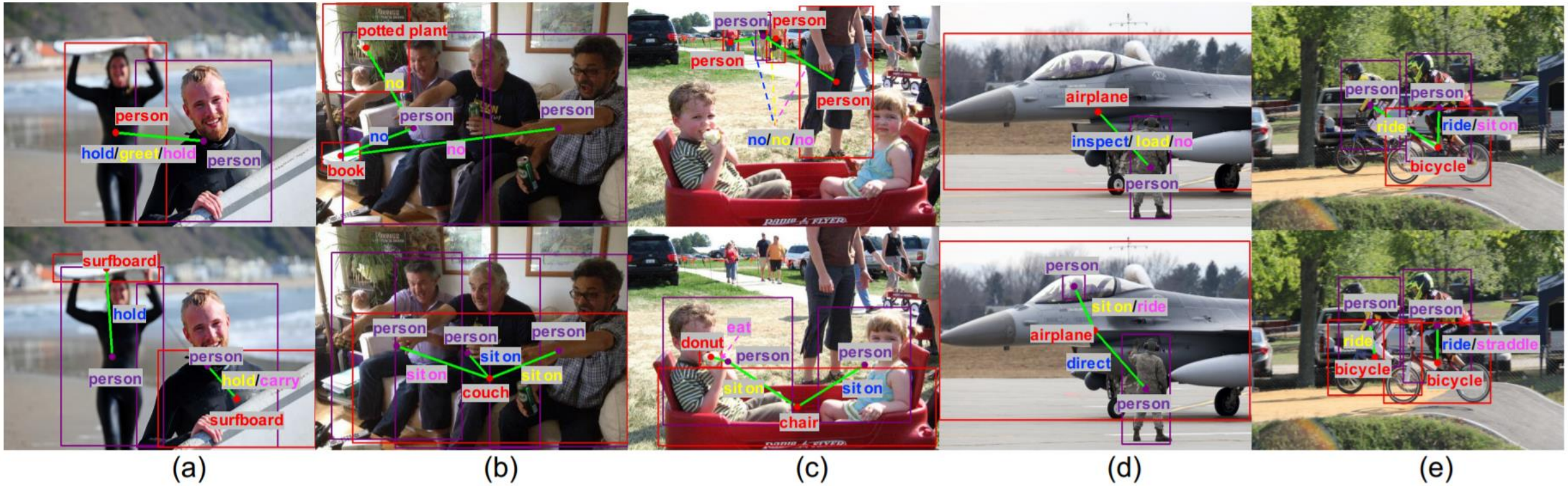
Method	mAP (%)	Time (ms)
Faster Interaction Net [1]	56.03	-
GMVM [1]	60.26	-
URNet [1]	66.04	-
iCAN [6]	44.23	194
TIN [15]	48.64	501
PPDM-DLA	67.03	**27**
PPDM-Hourglass	**71.45**	71

Table 3. Performance comparison on HOI-A test set.

실험 (인터렉션 포인트 히트맵)



실험 (iCAN 과 결과 비교)



Q & A