Point in, Box out: Beyond Counting Persons in Crowds

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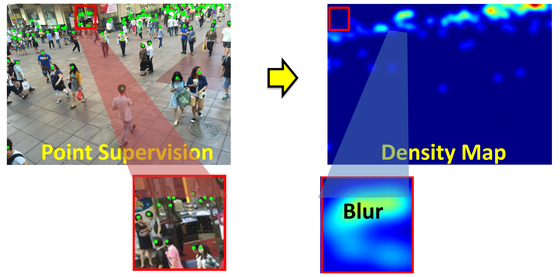
Motivation

➢ **Regression-based Counting**



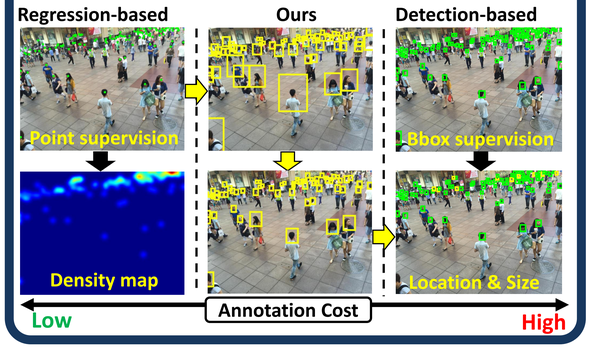
Missing **location & size** information

➢ **Detection-based Counting**

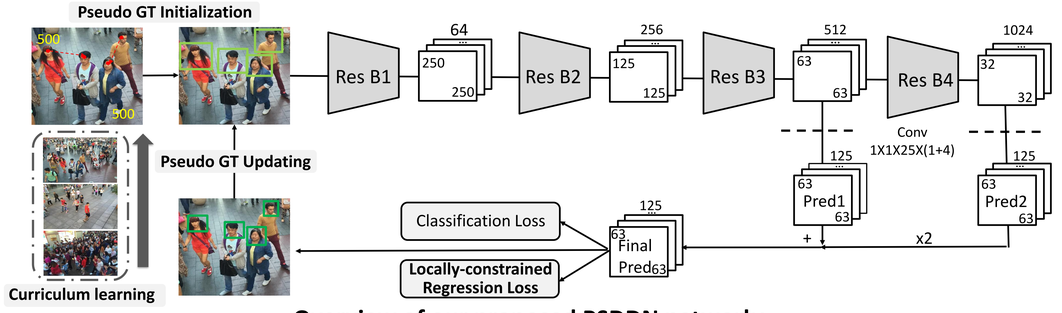
Annotation cost: **high** fine output information

➢ **Ours: Point in, Box out**

Mine latent information from point annotations



Method



Overview of our proposed PSDDN network:
One-shot anchor-based detection network (multi-scale Training & testing scheme)

➢ **Pseudo ground truth initialization**

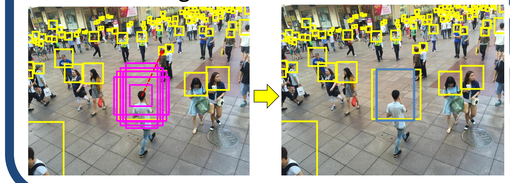
Box initialization : $h(g^0) = w(g^0) = d(g, NN_g)$

➢ **Online pseudo ground truth updating**

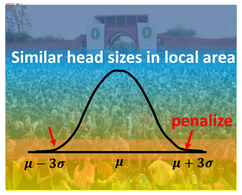
1) Select positive anchors:

$$IoU(pos(g^t)) > 0.7 \;\&\&$$
$$size((pos(g^t)) < d(g, NN_g)$$

2) g^{t+1} is from those $pos(g^t)$ that has the highest score



➢ **Locally-constrained regression loss**



$$\mu w_i = \frac{1}{|G_i|}\sum_{mn\in G_i} gw_{mn}$$

$$\sigma w_i = \sqrt{\frac{1}{|G_i|}\sum_{mn\in G_i}(gw_{mn} - \mu w_i)^2}$$

$$lw_{ij} = \begin{cases} \left(\widehat{gw_{ij}} - (\mu w_i + 3\sigma w_i)\right)^2 & \widehat{gw_{ij}} > \mu w_i + 3\sigma w_i \\ \left((\mu w_i - 3\sigma w_i) - \widehat{gw_{ij}}\right)^2 & \widehat{gw_{ij}} < \mu w_i - 3\sigma w_i \\ 0 & otherwise \end{cases}$$

➢ **Curriculum learning**

Train the model from images of relatively accurate and easy pseudo ground truth first

$$\mathrm{TL} = 1 - \frac{1}{|G_i|}\sum_{g\in G}\Phi(d_g|\mu,\sigma)$$

Training difficulty is defined according to image density

Results

➢ **Counting Performance (MAE & MSE)**

Dataset	SHA		SHB	
Measures	MAE	MSE	MAE	MSE
Pv0	168.6	268.3	69.8	98.1
Pv1	104.7	193.8	41.7	66.6
Pv2	89.8	169.5	19.1	42.4
Pv3(PSDDN)	85.4	159.2	16.1	27.9
PSDDN + [20]	**65.9**	**112.3**	**9.1**	**14.2**
Li et al. [20]	**68.2**	115.0	**10.6**	**16.0**
Ranjan et al. [31]	68.5	116.2	10.7	16.0
Liu et al. [24]	73.6	112.0	13.7	21.4
Liu et al. [22]	-	-	20.7	29.4
DetNet in [22]	-	-	44.9	73.2
Sindagi et al. [41]	73.6	**106.4**	20.1	30.1
Sam et al. [35]	90.4	135.0	21.6	33.4

Different variants of PSDDN:
Pv0: Training with initialized fixed pseudo Gt;
Pv1: Pv0 + pseudo Gt updating;
Pv2: Pv1 + proposed regression loss;
Pv3: Pv2 + Curriculum learning;
[20]: Csrnet: regression-based method

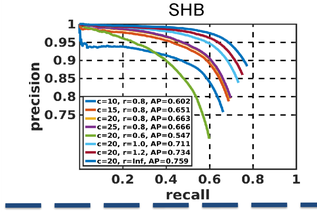
Counting	UCF		
Measures	MAE	MSE	AP
Li et al. [20]	**266.1**	**397.5**	-
Liu et al. [24]	279.6	388.9	-
Sindagi et al. [41]	295.8	320.9	-
Sam et al. [35]	318.1	439.2	-
PSDDN	359.4	514.8	0.536

➢ **Detection Performance (AP)**

True positives: IoU / if no GT BB:

- $d(g, \hat{g}) < c$
- $size(\hat{g}) < r \times d(g, NN_g)$

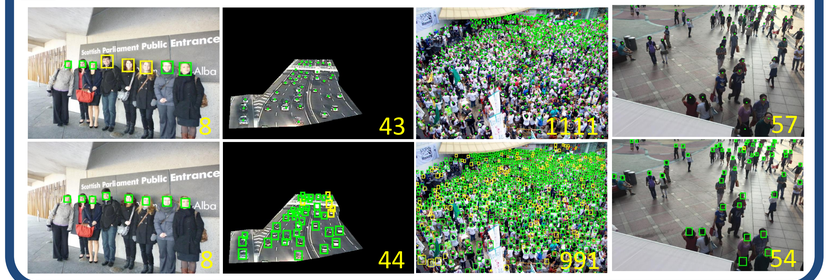
Effects of different c and r



Dataset	Pv0	Pv1	Pv2	Pv3 (PSDDN)
SHA	0.308	0.491	0.539	0.554
SHB	0.015	0.241	0.582	0.663

Methods	Annotations	WiderFace		
		easy	medium	hard
Avg. BB	points(test)+ mean size	0.002	0.083	0.059
FR-CNN (ps)	points(train) + mean size	0.008	0.183	0.108
FR-CNN (fs)	bounding boxes (train)	**0.840**	**0.724**	0.347
PSDDN	points(train)	0.605	0.605	**0.396**

Methods	GAME0	GAME1	GAME2	GAME3	AP
Victor et al. [19]	13.76	16.72	20.72	24.36	-
Onoro et al. [27]	10.99	13.75	16.09	19.32	-
Li et al. [20]	3.56	5.49	8.57	15.04	-
PSDDN	4.79	5.43	6.68	8.40	0.669



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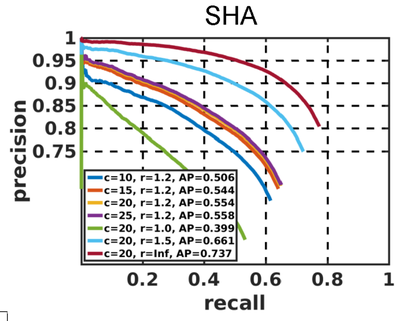

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