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Automotive AI Powered by Knowledge

KI Wissen Final Event | 21-22 March 2024

Knowledge-augmented Pedestrian Detection

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Attention is all you need!

1.1 Poster

1.6 Poster

Motivation, Concepts and Goals

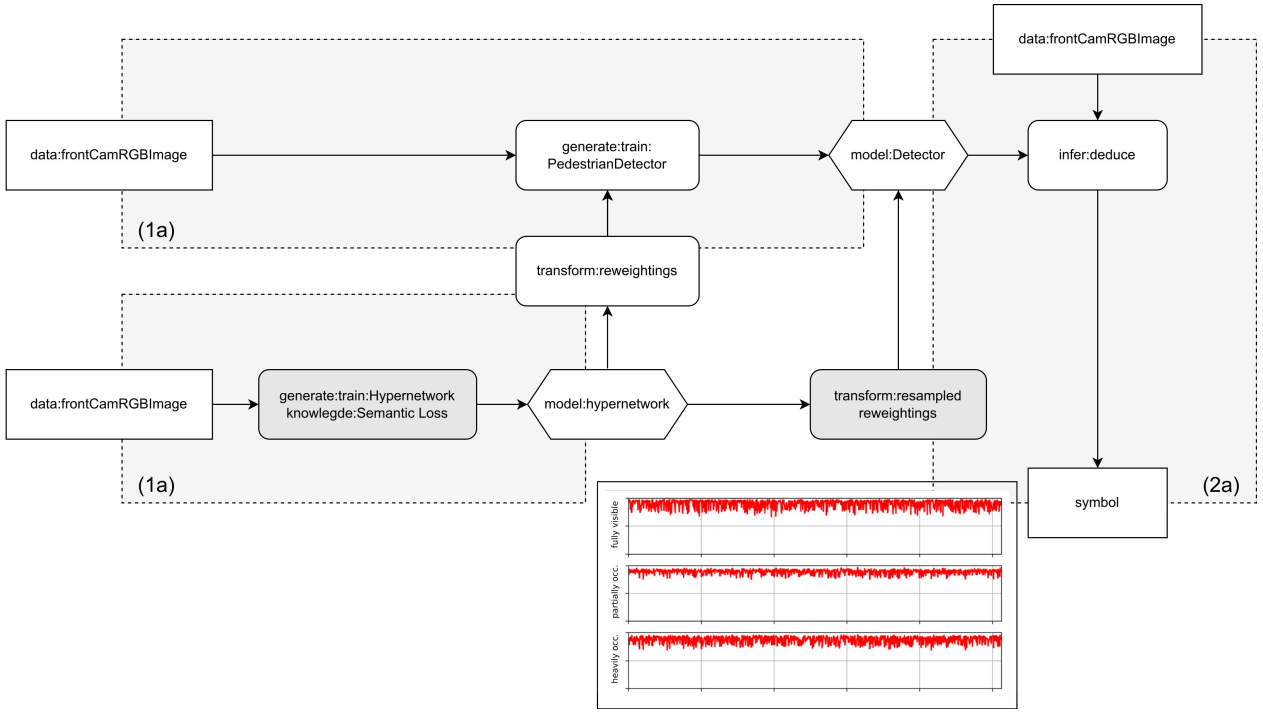
- Guide existing models towards reliable features for visual pedestrian detection
- Disentanglement of features; Association of semantics
- Utilization of concept activations extracted from support images
- Robust and explainable detection of occluded pedestrians from limited data

Knowledge Guided YOLO Detector

Training stage

- Query image is complemented with support images from sub-classes.
- Parallel hypernetwork determines reweighting coefficients

‘fully visible’
‘partially occluded’
‘heavily occluded’



Knowledge Guided YOLO Detector

Training stage

- Query image is complemented with support images from sub-classes.
- Parallel hypernetwork determines reweighting coefficients
- Semantic loss enforces activations across sub-classes

$$\min_{\theta,\psi,\eta} \sum_i \left[L_d(I_i, \mathcal{S}_i) + \lambda \sum_l L_s(\alpha, \Omega_i^l) \right]$$

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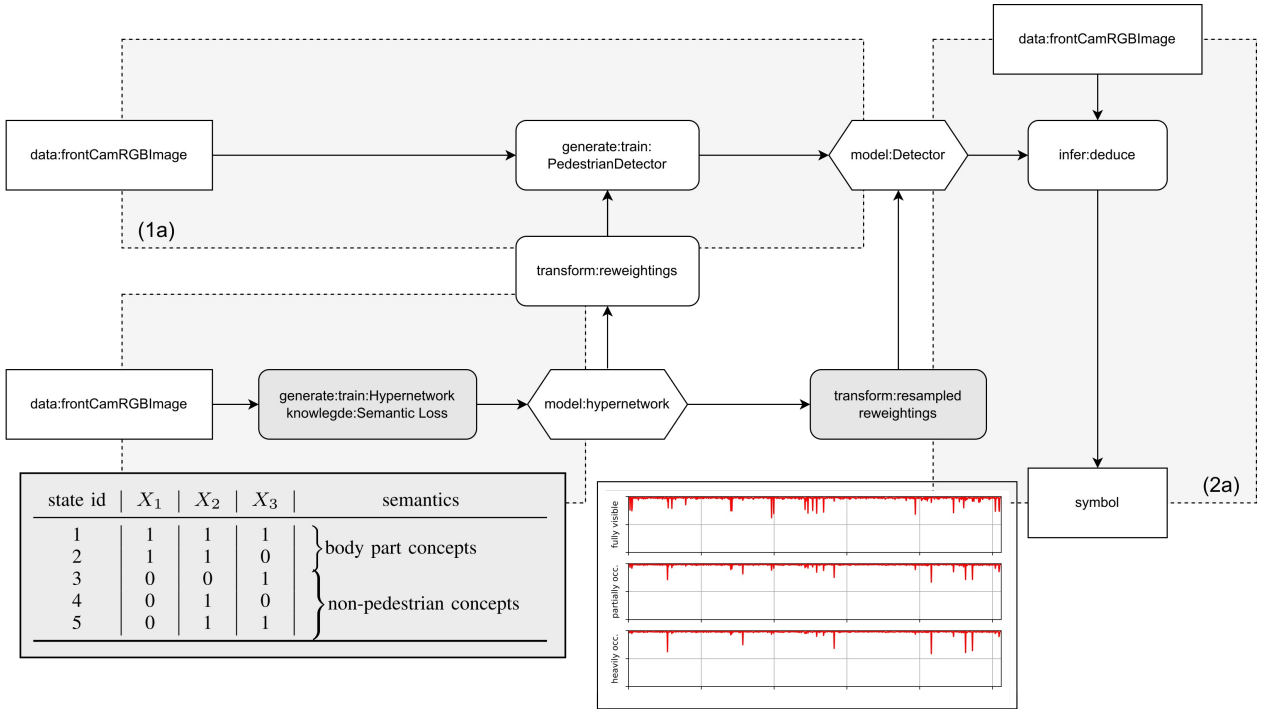


Knowledge Guided YOLO Detector

Inference stage

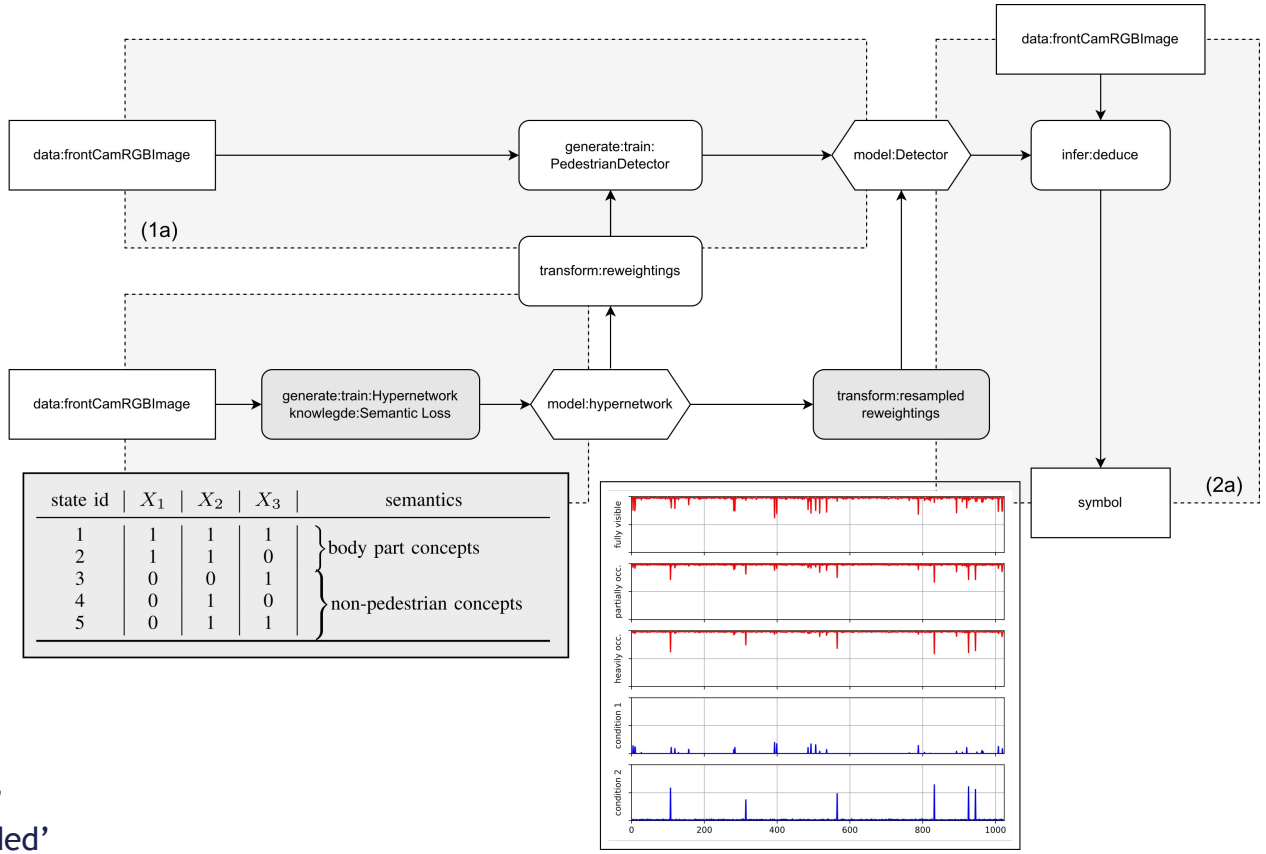
- Attenuation of feature maps based on conformance to semantics

$$c_1^l = \max\left(0, (1 - \bar{\omega}_1^l) + \min\left(\bar{\omega}_2^l + \bar{\omega}_3^l, 1\right) - 1\right)$$
$$c_2^l = \max\left(0, \bar{\omega}_1^l + \min\left((1 - \bar{\omega}_2^l) + (1 - \bar{\omega}_3^l), 1\right) - 1\right)$$

- Determine attenuated reweightings via

$$\hat{\omega} = \mathbb{1} + \gamma_1 \mathbf{c}_1 + \gamma_2 \mathbf{c}_2.$$

‘fully visible’
‘partially occluded’
‘heavily occluded’



Knowledge Guided YOLO Detector

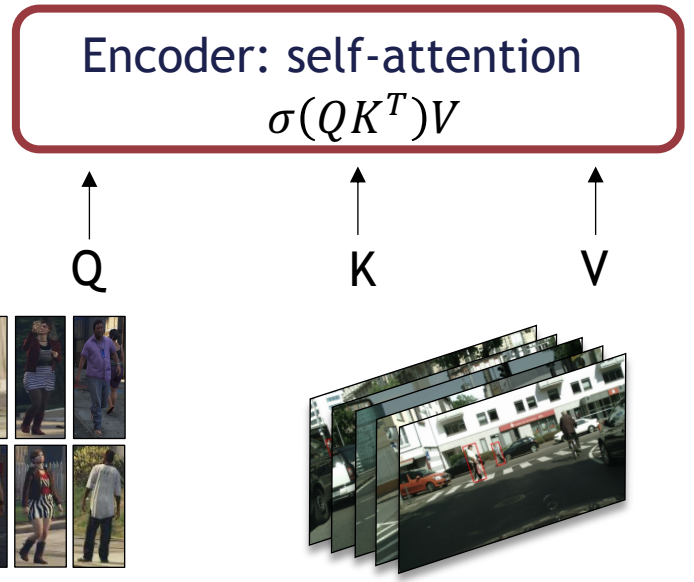
- During inference, model can be used with single image input, i.e., no computational overhead
- Depending on occlusion level, attenuation factors can be adjusted

- Potential for ensemble methods for addressing different levels of occlusion

Dataset	Split	Baseline	Knowledge Guided		
γ_2			0.0	−1.0	−2.0
Citypersons	vis + occ	**0.4350**	0.4065	0.3874	0.2723
	part. occ	0.3428	0.3035	**0.3445**	0.2953
	heavy occ	0.1362	0.1219	0.1935	**0.2761**
JAAD	vis + occ	**0.5081**	0.4963	0.3945	0.1853
	part. occ	0.2129	0.1968	**0.2598**	0.1964
	heavy occ	0.0897	0.0529	**0.1303**	0.1297
SHIFT	vis + occ	**0.3153**	0.2905	0.1815	0.1122
	part. occ	**0.2057**	0.1513	0.1712	0.1196
	heavy occ	**0.1322**	0.0595	0.0987	0.1006

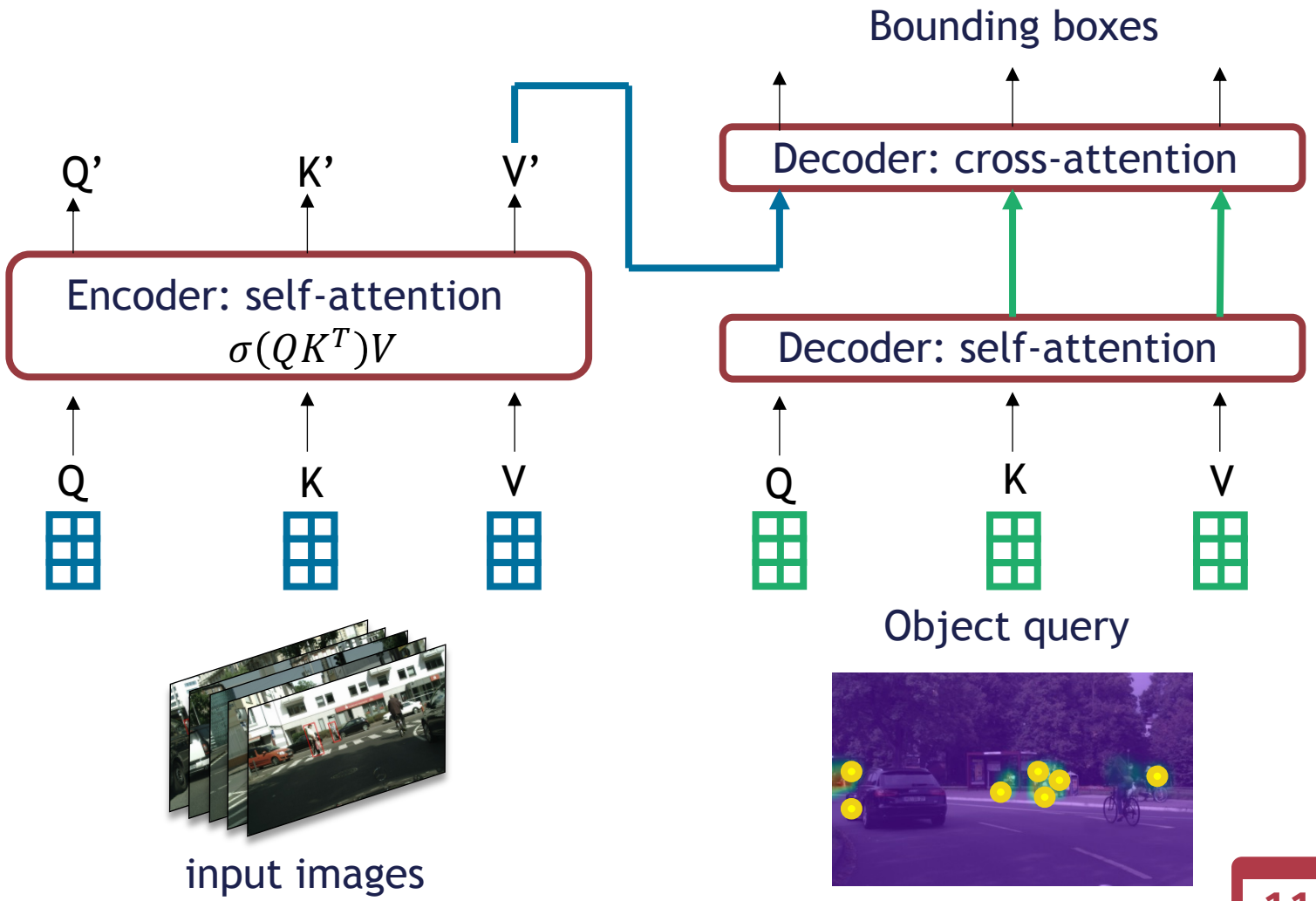
Knowledge-augmented Detection with Transformer

- Synthetic pedestrian or vehicle image patches support sequence of input images
- The same backbone is used to extract features from synthetic support image patches and input images
- Goal: Generate attention heatmaps between support images and input images. The heatmap contains knowledge of positions of objects of interest



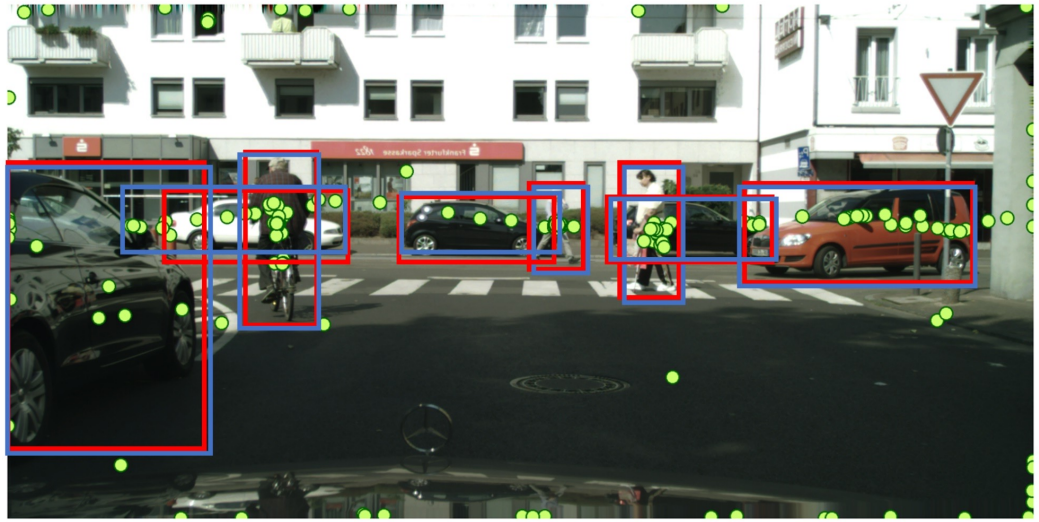
Knowledge-augmented Detection with Transformer

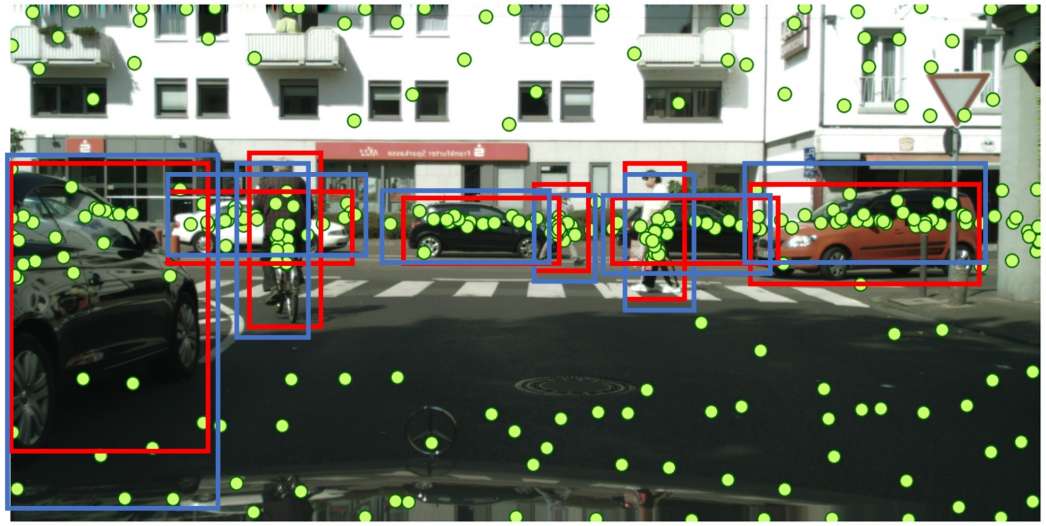
- Transformer-based detection uses object queries in decoder part for bounding box prediction.
- Instead of random initialized positional encoding in object queries, we add positional encoding based on attention heatmaps from encoder.



Knowledge-augmented Detection with Transformer

- Prior knowledge directs queries to focus more on targeting objects over baseline models. This results in increased accuracy in the positions of bounding boxes.

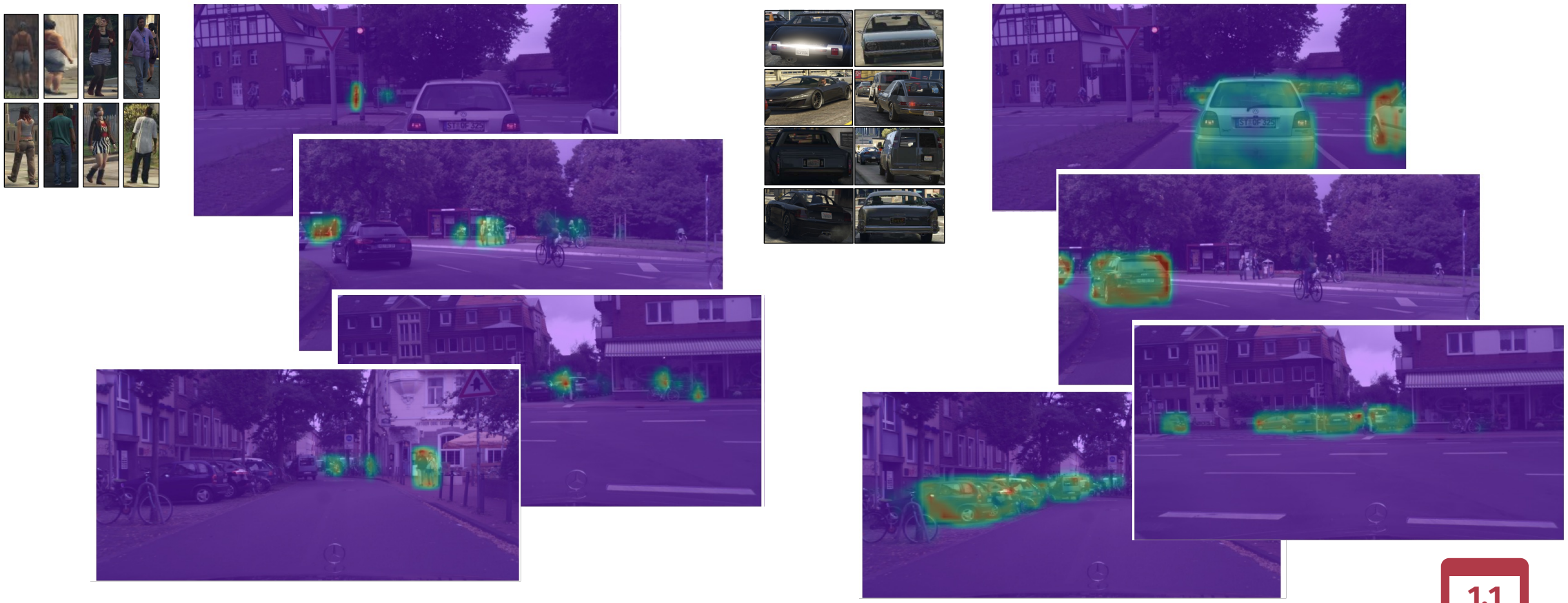




Left: our method; Right: baseline model
Red bounding box: ground-truth; Blue bounding box: predicted results

Knowledge-augmented Detection with Transformer

- With different support images, we can disentangle high-level semantics:



Knowledge-augmented Detection with Transformer

- Full Data Training: Utilizing the entire KITTI or Cityscapes dataset for training.
- Limited Data Training: Employing only a quarter of the original training data size.
- Despite observing a decrease in performance compared to training with the full dataset, we experience a mitigated decline.

	KITTI (AP)		Cityscapes (AP)	
	Full	Limited	Full	Limited
DETR	57.7%	52.0%	44.8%	40.1%
Ours	**66.3%**	**60.6%**	**51.4%**	**49.0%**

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KI FAMILIE

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