Towards Cautious Collective Inference for Object Verification.

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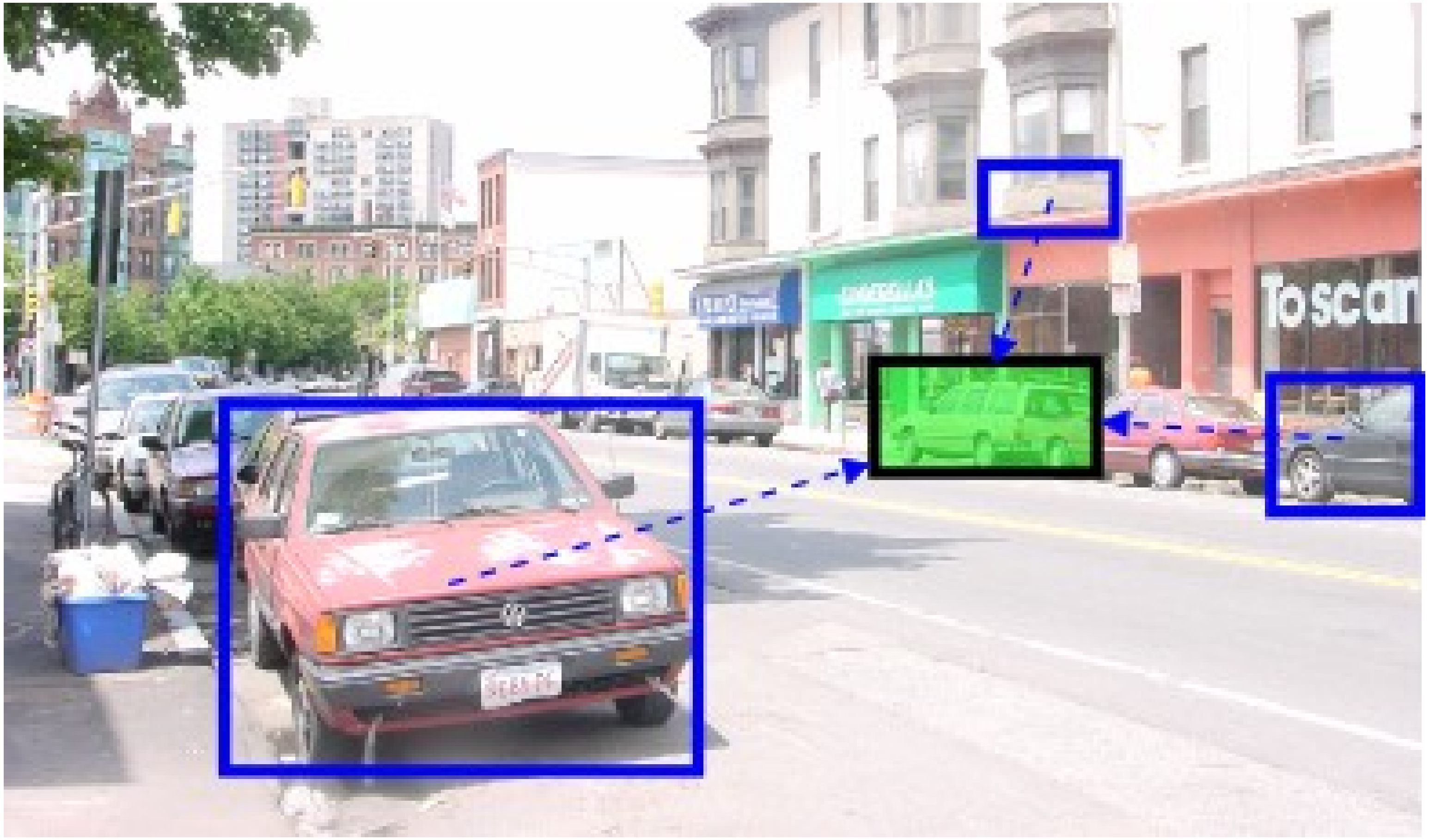
KU Leuven
March 24th 2014

The task at hand

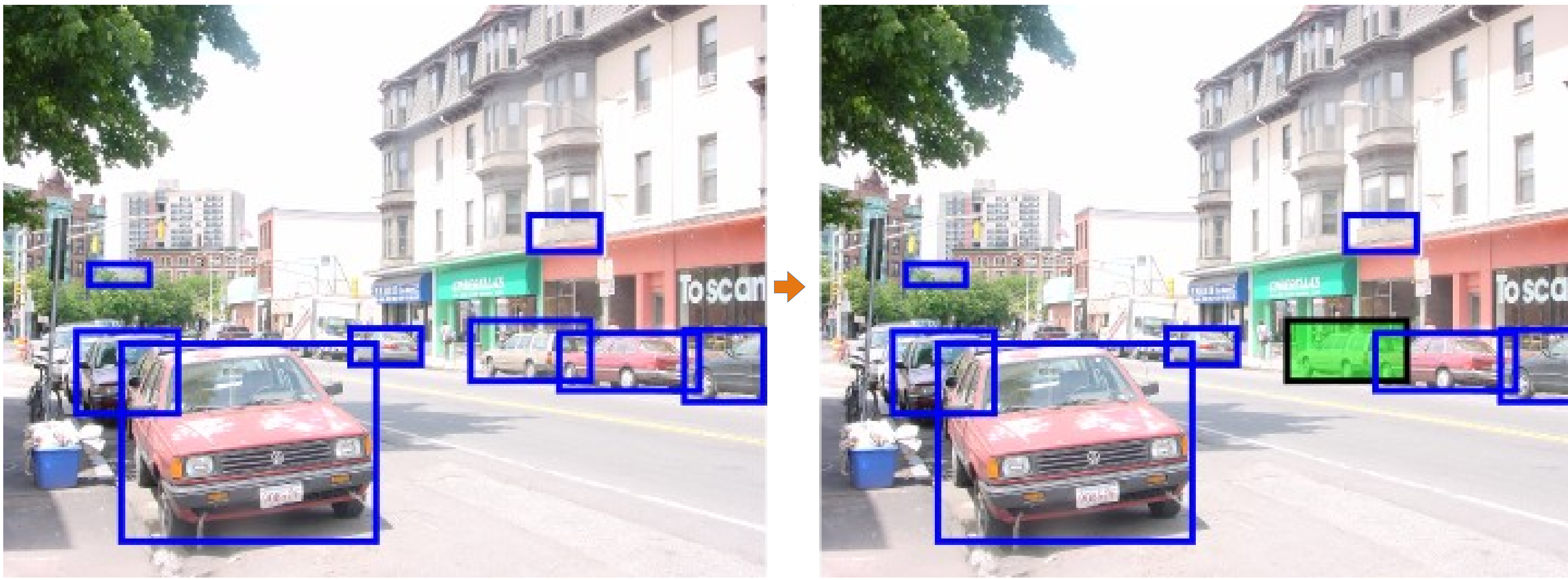
Object Verification

(Context-based Object Detection)



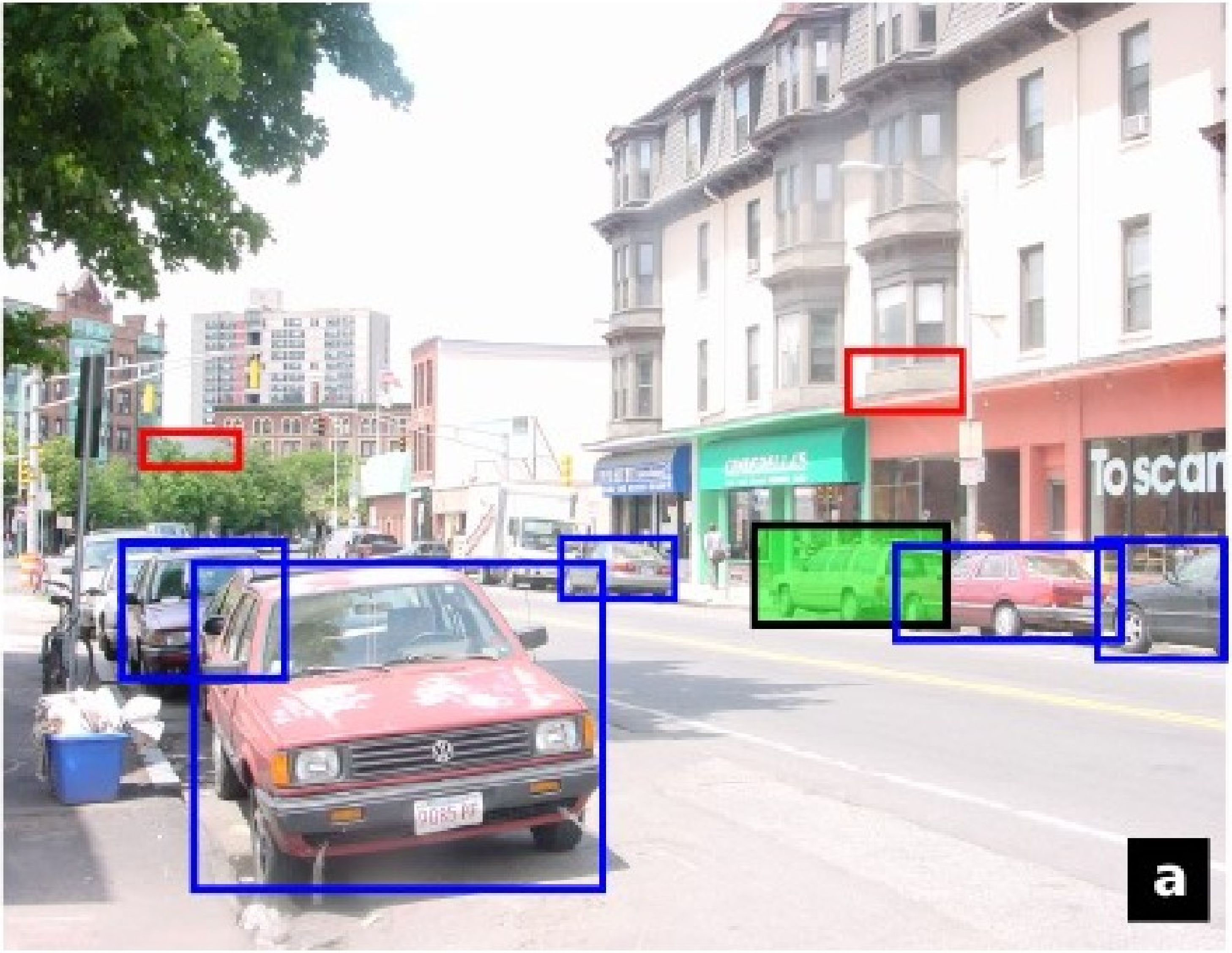
Object Verification

A traditional pipeline



Problem Statement

(Q) How to properly use relations between objects?



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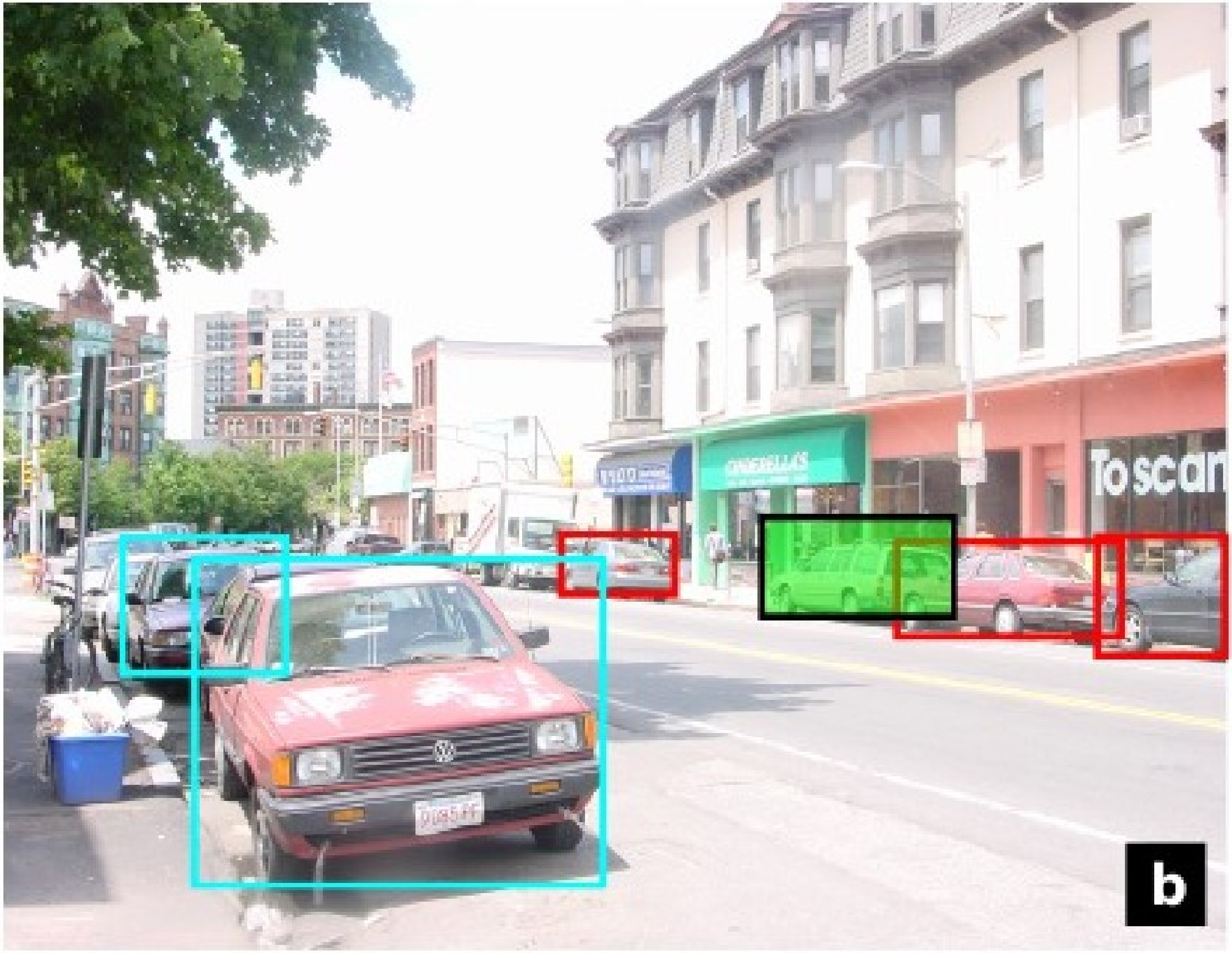
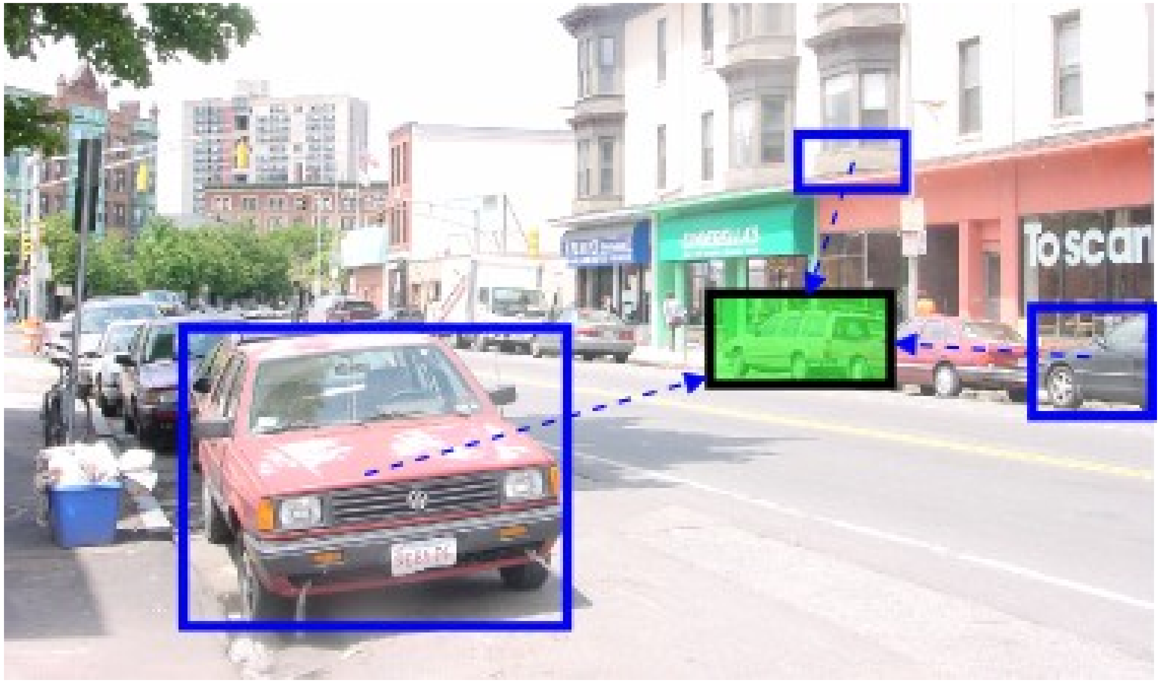


Proposed Method

Defining Pairwise Relations between Objects

Derived from the features of the bounding boxes



Relations :

$$r_{ij}^{(RF1)} = (\Delta x_{ij}, \Delta y_{ij}, \Delta\theta_{ij})$$

$$r_{ij}^{(RF2)} = (rx_{ij}, ry_{ij}, r\rho_{ij}, ra_{ij})$$ (based on Li et al's, CVPR 2012)

$$r_{ij}^{(RF3)} = (\Delta x_{ij}, \Delta y_{ij})$$ (based on Perko et al's, CVIU 2010)

Proposed Method

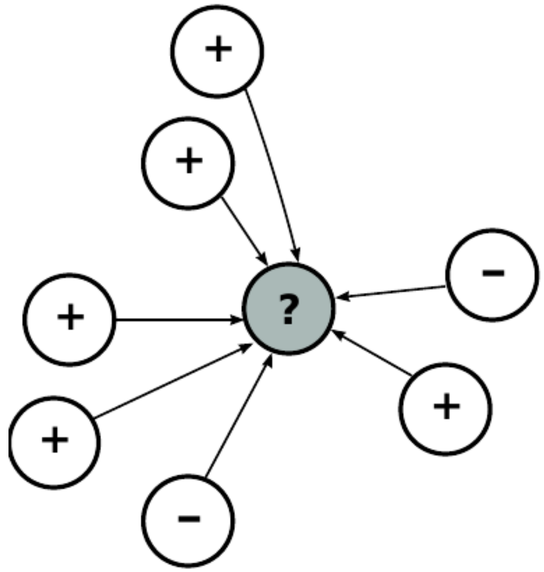
Aggressive Inference

$$wvRN(o_i|N_i) = \frac{1}{z}\sum_{o_j \in N_i} p(o_i|o_j).w_{ij}$$

(Mackassy et al., JMLR 2007)

$$p(o_i|o_j) = p(o_i|r_{ij}) = \frac{p(r_{ij}|o_i)p(o_i)}{p(r_{ij}|o_i)p(o_i) + p(r_{ij}|\neg o_i)p(\neg o_i)}$$

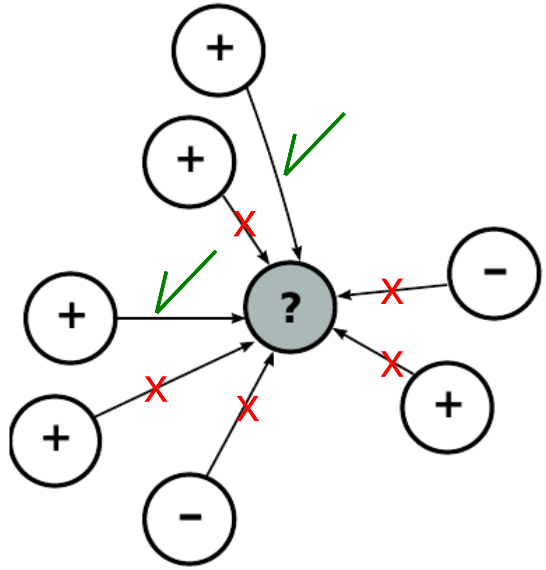
$$w_j = p(o_j|s_j) = \frac{p(s_j|o_j)p(o_j)}{p(s_j|o_j)p(o_j) + p(s_j|\neg o_j)p(\neg o_j)}$$



Cautious Inference

- McDowel et al., JMLR 2009
- Neville et al, SRL ws@AAAI 2000

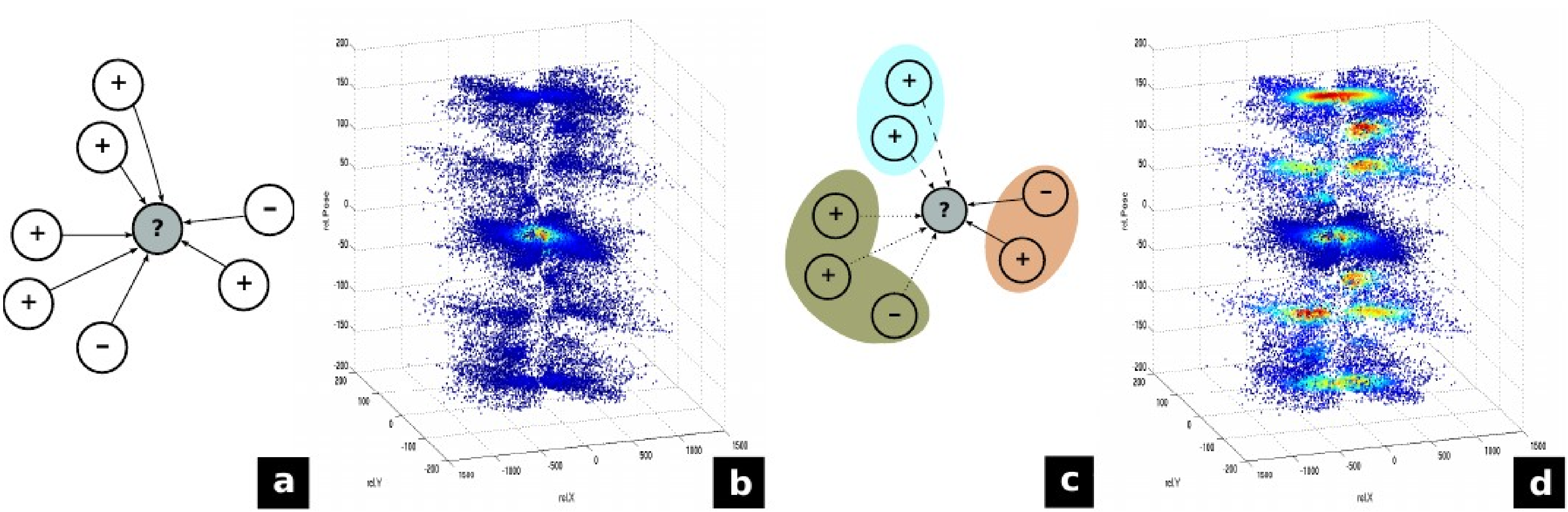
$$wvRN(o_i^u|N_i) = \frac{1}{z}\sum_{o_j^k \in (N_i \cap O^k)} p(o_i^u|o_j^k).w_{ij}$$



Proposed Method

How objects associate to each other ?

Class-based Homophily | **Relationship-based Homophily**

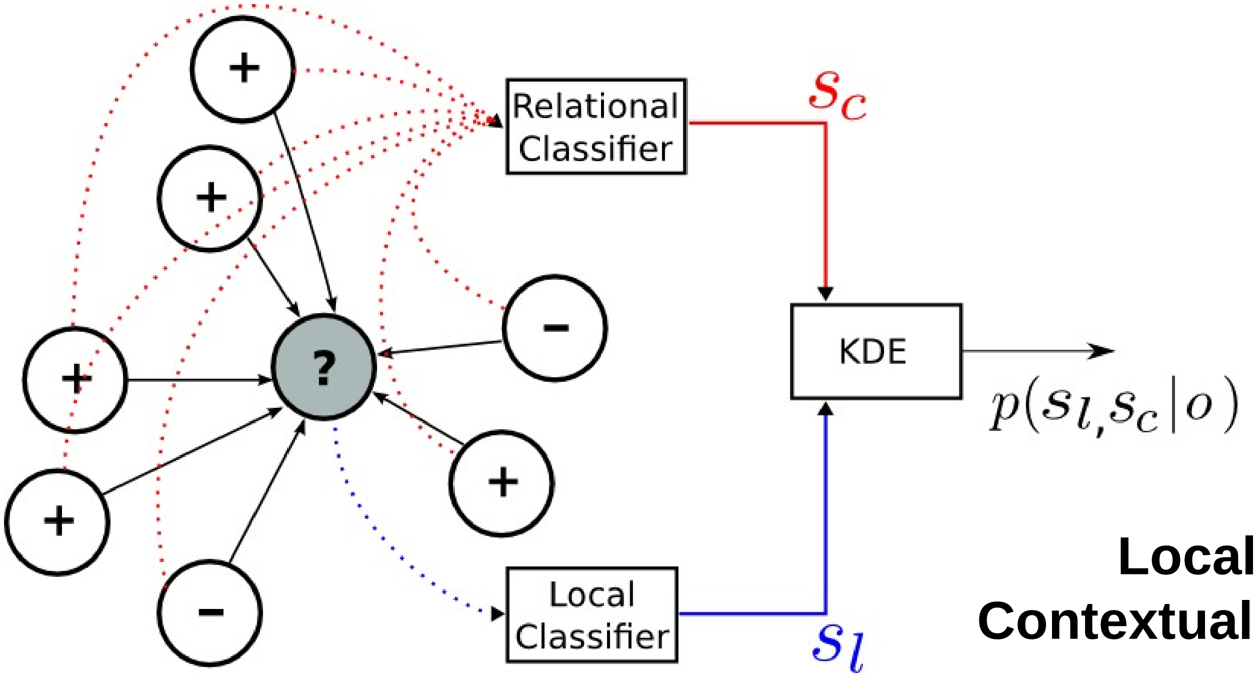


$$wvRN(o_i|N_i) = \frac{1}{z} \sum_{o_j \in N_i} p(o_i|o_j).w_{ij}$$

Proposed Method

Combining local and contextual sources of Information

Inspired by the score combination method of Perko et al., CVIU 2010.



Local Support : $s_l = p(\hat{o}_i)$

Contextual Support : $s_c = wvRN(o_i | N_i)$

- Score Combination

$$p(o|s_l, s_c) = \frac{p(s_l, s_c|o)p(o)}{p(s_l, s_c|o)p(o) + p(s_l, s_c|\neg o)p(\neg o)}$$

Evaluation

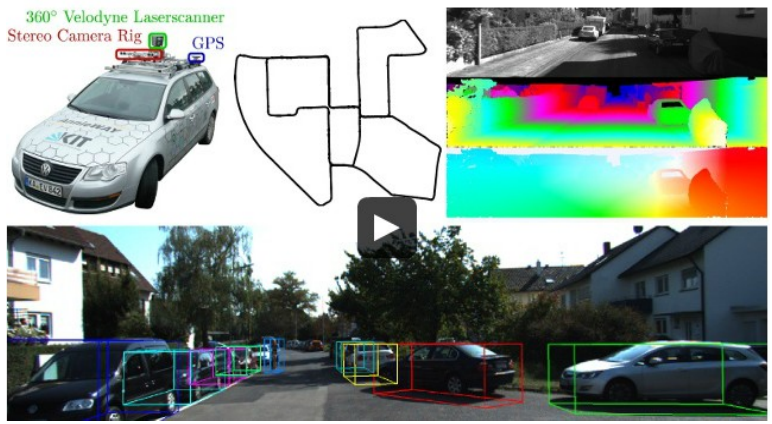
Experimental details

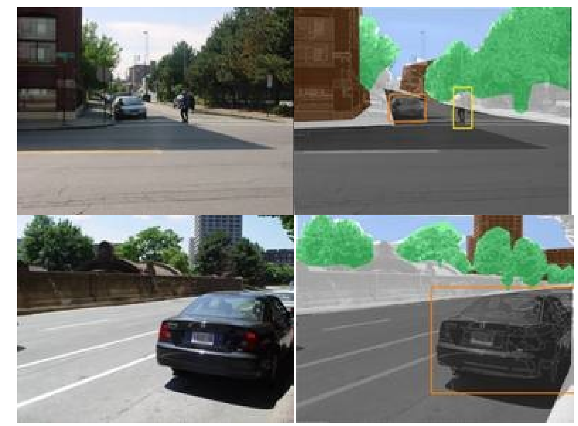
Datasets:

KITTI benchmark
(Geiger et al, CVPR 2012)

MIT StreetScenes
(Bileschi et al)

- Class of Interest : **car**
- Focus on Images with more than 2 objects





Object Localization:

Object Detection (2D)

[1] López et al. ,ws@ICCV 2011.

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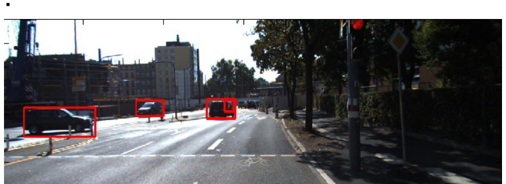

Parameters:

- **Inference Type:** *Aggressive* | *Cautious .*
- **Homophily Type:** *class-based* | *relation-based .*

Evaluation

Only using contextual information

Dataset **KITTI benchmark**	**Relations Representation : RF1**				**Relations Representation : RF2**			
	Class-based Hom.		Relation-based Hom.		Class-based Hom.		Relation-based Hom.	
	Global		Global		Global		Global	
Set	aggre.	caut.	aggre.	caut.	aggre.	caut.	aggre.	caut.
all	0.29	***0.38***	0.28	***0.37***	0.32	0.40	0.41	***0.50***

Dataset **MIT StreetScenes**	**Relations Representation : RF3**				**Relations Representation : RF2**			
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all	0.54	***0.63***	0.51	0.59	0.51	***0.56***	0.49	0.55

Combination of Local and Contextual Information

Dataset **KITTI benchm**[1]		**RF1**		**RF2**	
		Class-based Homophily		Relation-based Homophily	
		Global		Global	
Set	Detector [14]	aggre.	caut.	aggre.	caut.
all	0.61 ± 0.011	0.61 ± 0.009	0.63 ± 0.007	0.65 ± 0.011	$\boldsymbol{0.68\pm0.003}$

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Collecting Hypotheses using DPM

Dataset **KITTI benchmark**		**RF3**		**RF2**	
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[2] Felzenszwalb et al. ,TPAMI 2010.

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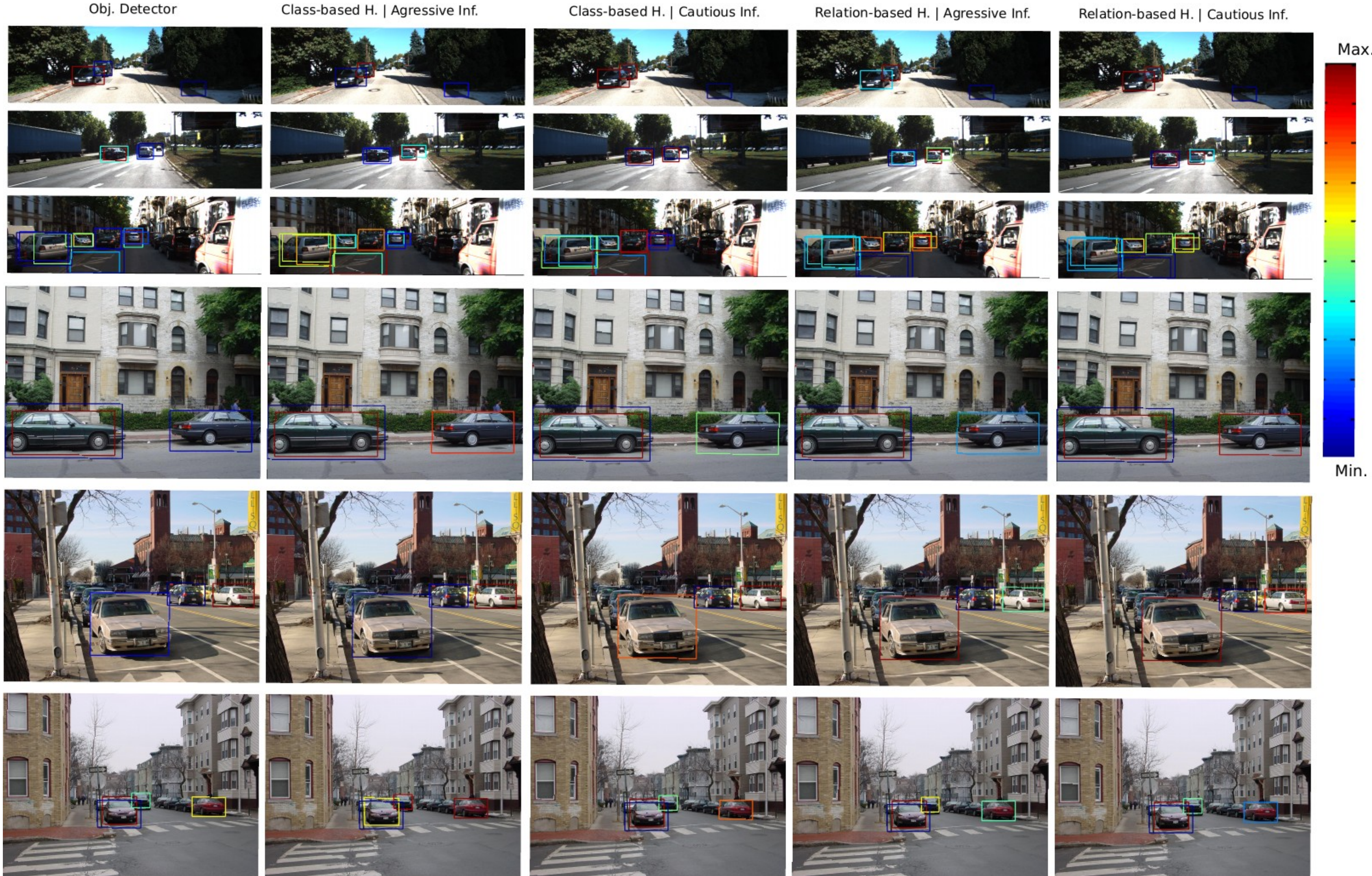
Qualitative Results



Conclusions

- **Cautious Inference about object relations outperforms traditional aggressive counterparts.**

- **Relation-based Homophily is good for scenarios where there is no local information about the unknown object.**
  (e.g. in an inpainting scenario)

- **Future Work**
  - Better representations for reasoning in 3D space.
  - Investigate methods to recover the underlying structures in the relational space.
  - Investigate the generality of the method in the context of other object categories or alternative applications.

Questions?

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