1.8 Geo-Informed Conformity Check of Pedestrian Detection Models

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Detection

Motivation

The goal of pedestrian detection models is to miss no or as few pedestrians as possible, i.e., to have a low miss rate. However, a low miss rate often comes at the cost of having many false positive predictions.
We propose a knowledge conformity algorithm for pedestrian detections by using spatial knowledge to identify false predictions [1].

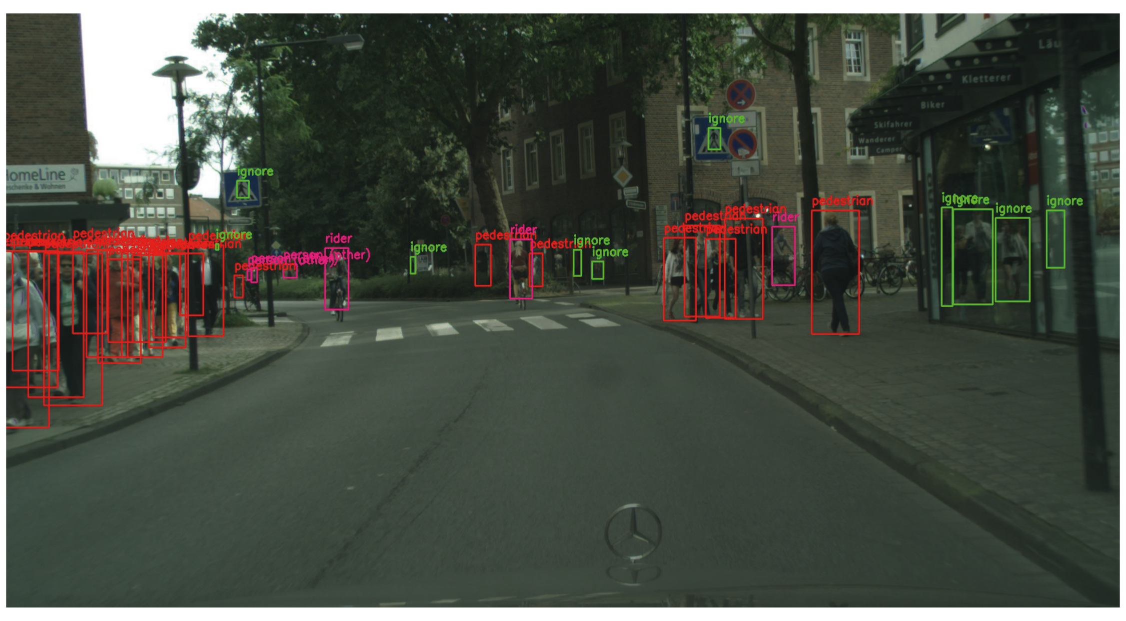

Figure 1: Example image from CityPersons Dataset with ground truth bounding boxes for pedestrian detection [2]

Knowledge Modules

We have developed three modules for our *Geo-Informed Conformity Checks:*

1. Spatial perspective (Conformity of pedestrian sizes)
2. Street map (Conformity of pedestrian positions)
3. Spatial perspective + street map (Conformity of heights + positions)

Module 1: Spatial Perspective

The perspective transformation of a bird's eye view into the camera view depends on the extrinsic and intrinsic camera parameters. *We use this knowledge to compute how tall a pedestrian can be depending on its position in the camera image.*

Figure 2: Spatial perspective (Module 1) - informs about potential pedestrian sizes

Module 2: Street Map

We use geographical knowledge in terms of street maps. We query OpenStreetMap for the road network graph and the building polygons around the current position and project them into the camera perspective.

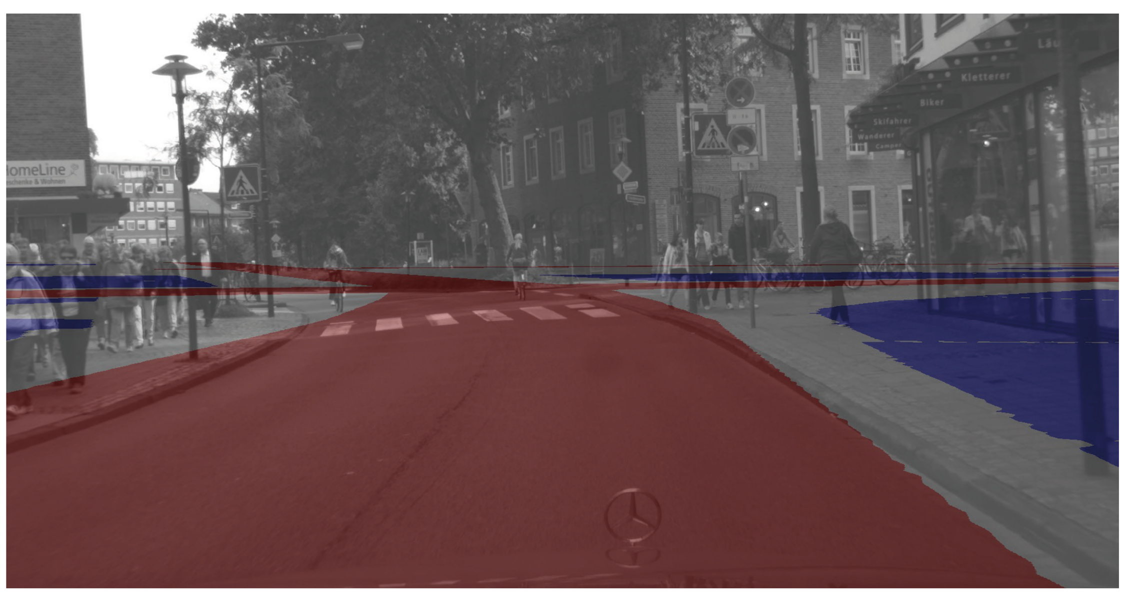

Figure 3: Street map (road + building) projected into camera perspective (Module 2) - informs about potential pedestrian positions.

We use the knowledge from the street map to compute possible positions of pedestrians. We assume that they can generally occur everywhere in the map, but not on the footprints of buildings.

Module 3: Spatial Perspective + Street Map

Both knowledge modules can be combined so that we get information about the maximum pedestrian heights at their possible positions.

Evaluation of Knowledge Modules

	Pedestrian	Ignore
Module 1	82.07%	41.90%
Module 2	81.87%	27.47%
Module 3	72.32%	26.76%

Table 1: Conformity scores of GT bounding boxes (evaluation of knowledge modules): for the Pedestrian subcategory, a higher conformity score is better, for the ignore subcategory, a lower conformity score is better

Conformity Check of Model Predictions

Our algorithm goal is to verify predictions from pedestrian detection models. The example in Figure 4 shows that most bounding boxes are consistent, but those at the right (on the window of the building) are inconsistent with geospatial knowledge. This is the desired result and means that our conformity algorithm can filter out false predictions.

Figure 4: Geo-informed conformity check of model predictions

References:

[1] L. von Rueden et al.: "Street-Map Based Validation of Semantic Segmentation in Autonomous Driving". IEEE ICPR. 2021
[2] S. Zhang et al.: "Citypersons: A diverse dataset for pedestrian detection." IEEE CVPR. 2017
[3] L. von Rueden: „Informed Machine Learning: Integrating Prior Knowledge into Data-Driven Learning Systems". PhD Thesis, 2023

Partners

External partners

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