Supervised learning and evaluation of KITTI's cars detector with DPM

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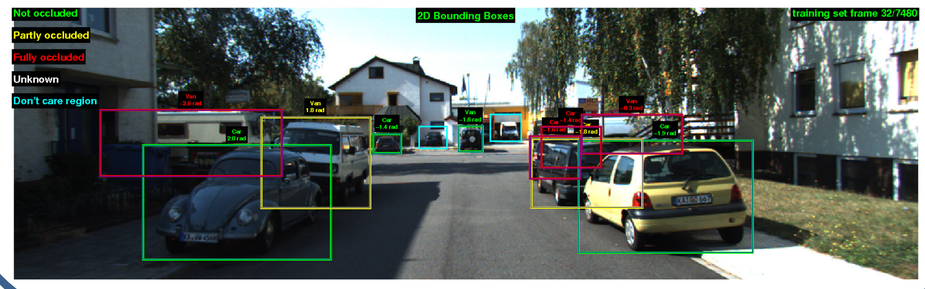
Problem description

- **Image understanding** for autonomous vehicles and ADAS
- Naturalistic **urban scenes** and common evaluation protocol
- **Object detection and orientation estimation** challenge
- **KITTI** Vision Benchmark

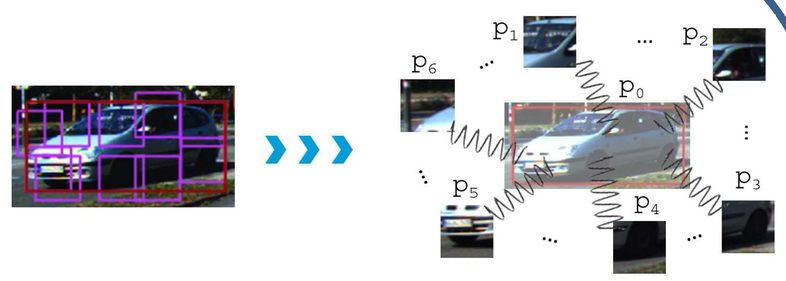


Evaluation protocol

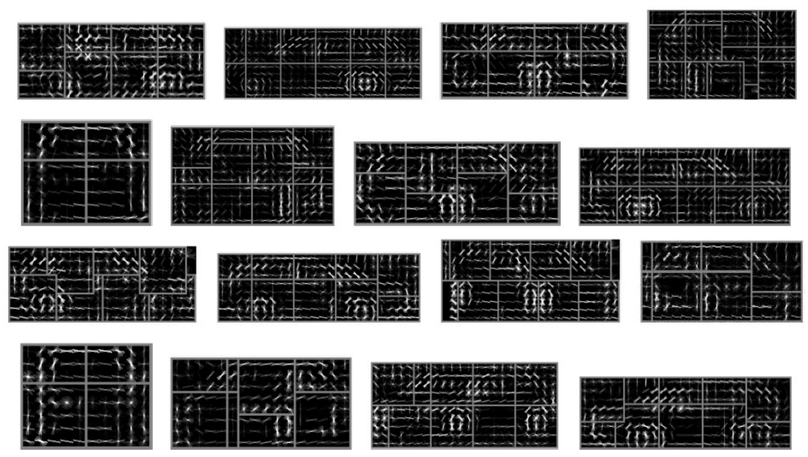
- **Metrics:** TPs, FPs, FNs sorted by score -> **precision-recall** curves
- **AP** and **AOS** figures computed as the Area under the Curves
- **Algorithm:** PASCAL vs **KITTI evaluation** algorithms
- Overlap between detected and ground-truth 2D boxes. **IoU > 70%**
- Three difficulty levels: **easy, moderate, hard**
- ***Ignored* samples**: 'Don't care', neighboring classes, upper levels

Overview of the DPM part-based object detector

- Scale pyramid of **HOG features** from color images
- **Star topology** connecting root bounding box and object parts



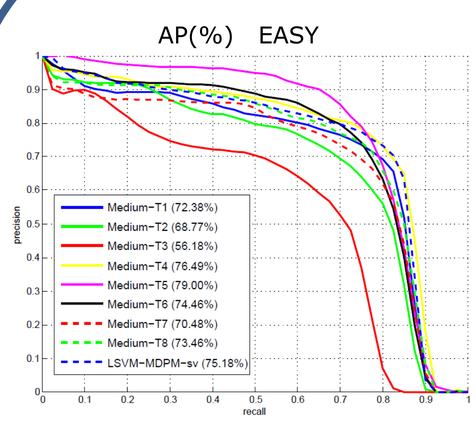
- **Mixture of components**. One object model for each orientation/viewpoint

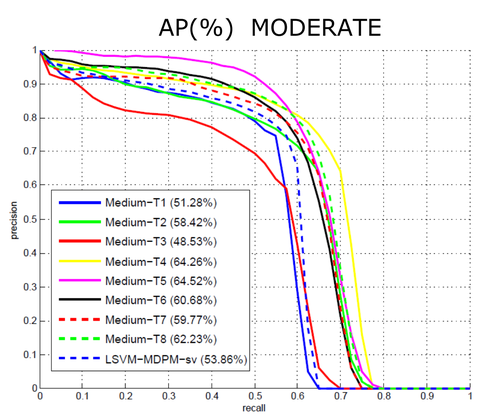


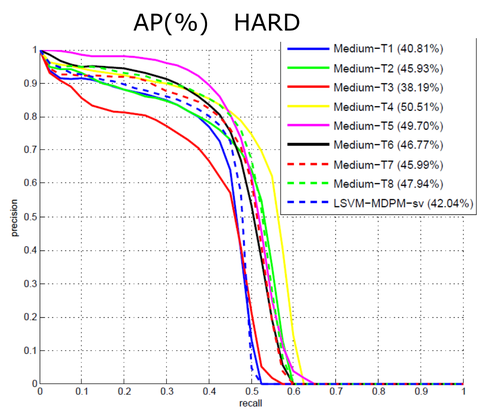
- **Latent-SVM classifier**. Latent variables: model component, part locations and scale
- **Detection**: scoring function and non-maximum suppression filter

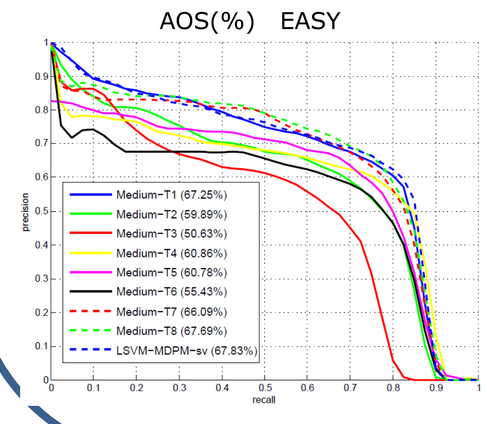
$$s(z) = \sum_{i=0}^{144} F_i \cdot \phi_v(H, z) - \sum_{i=17}^{144} d_i \cdot \phi_d(dx_i, dy_i) + bias$$

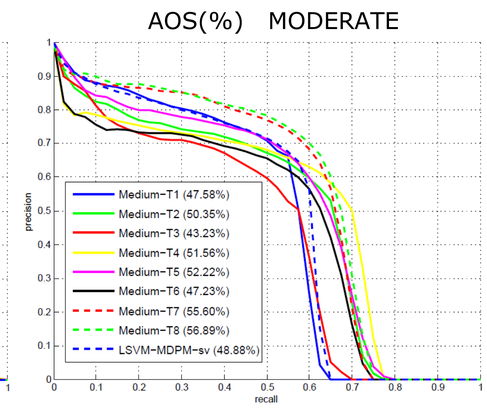
Supervised learning and evaluation. Experimental results based on 5-fold cross-validation

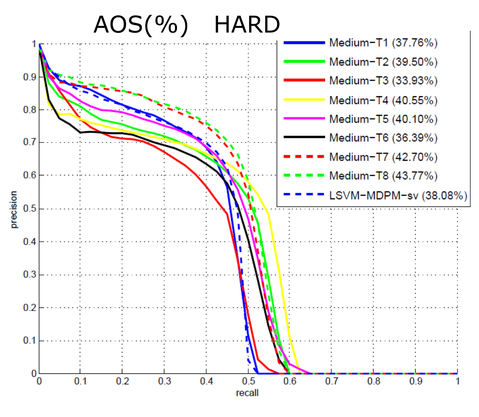












DPM training pipeline aspects considered

- Data cleanliness
- Minimum latent overlap requirement
- Filters area initialization
- Mirroring of positive samples
- Bootstrapping: harvesting negative samples from positive and negative images
- Fix latent components to ground-truth orientation during mixture models merging
- Reference baseline: MDPM-LSVM-sv [Geiger et al., CVPR 2012]

False positive examples

(a) Too tight bounding box (b) Part of a car (c) Multiple cars (d) Side view mirror (e) Too wide bounding box

(f) Loose fitting (g) Multiple cars (h) Background (i) Background

Conclusions and Future Works

- Comparison **PASCAL vs KITTI** evaluation protocols: same metrics, but different algorithms
- Tested 3 training modalities regarding the **cleanliness** of the data
- Supervised DPM training: latent overlap requirement (75%), harvesting negatives, no latent viewpoint
- The above main features produced a precision boost: **up to 10% in AP and 5% in AOS**.
- **Future guidelines**: DPM extension to 3D data and models, special treatment for occluded samples

Acknowledgments

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