Fusing color and range data for improved car detection in aerial imagery

Stefan Kluckner, Georg Pacher and Horst Bischof
{kluckner,pacher,bischof}@icg.tugraz.at

Microsoft®

TU Graz
Graz University of Technology

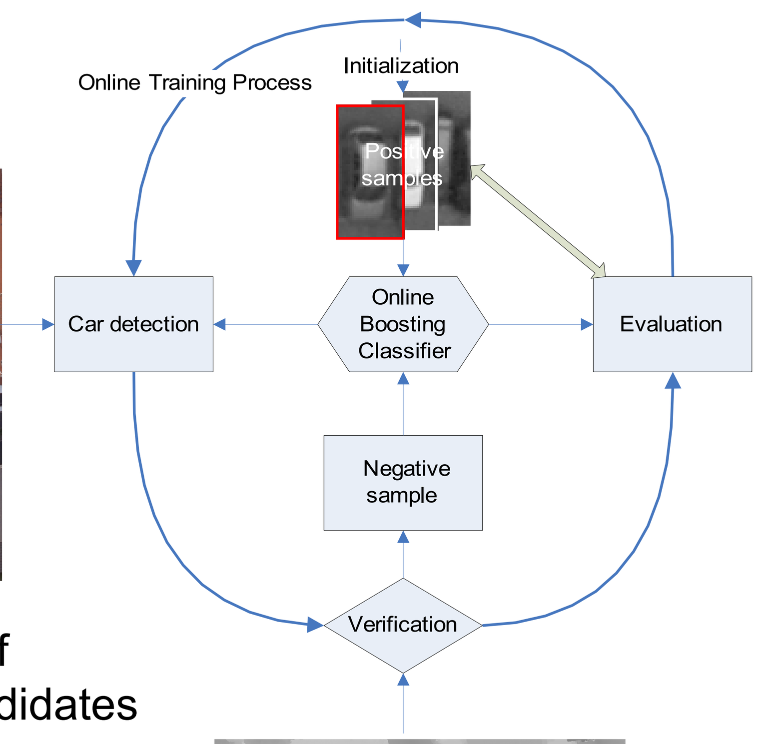
Institute for Computer Graphics and Vision, Graz University of Technology, Austria

Abstract

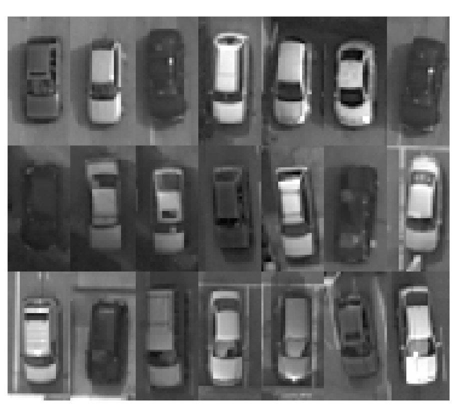
Automatic 3D modeling of urban environments has become a hot research topics since location aware applications (e.g. Virtual Earth, Google Earth) on the Internet aim for detailed models of the earth. In large scale 3D city models, moving objects, such as cars usually bear errors and distract the automatic reconstruction process. Therefore, it is desirable to detect these objects. In this work, we present a method to train a car detector for high resolution aerial images with a minimum amount of hand labeling, making use of range and color information. We further show, that the performance of the detector can be significantly improved by including context information, such as a street layer.

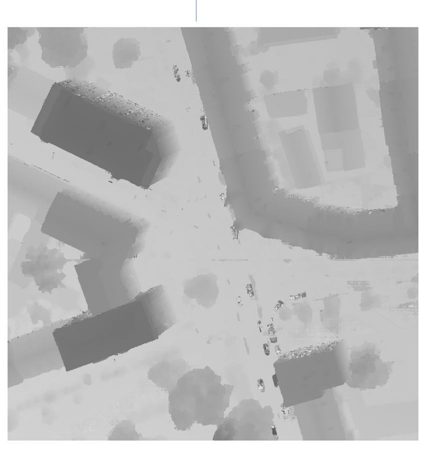
Autonomous Learning a Car Detector

Proposed idea:



Sample collection of positive update candidates

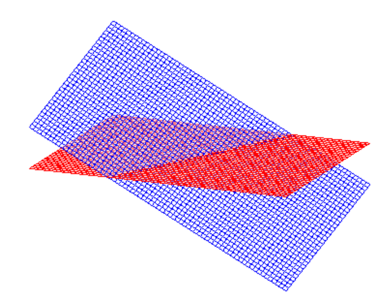




Goal: Autonomous learning the classifier
Reduce hand labeling effort

Assumption: Detected cars must appear on the ground

Verification: Use range data for plane estimation
Consider current detection as negative update



Criterion: Dihedral angle between ground and currently estimated plane

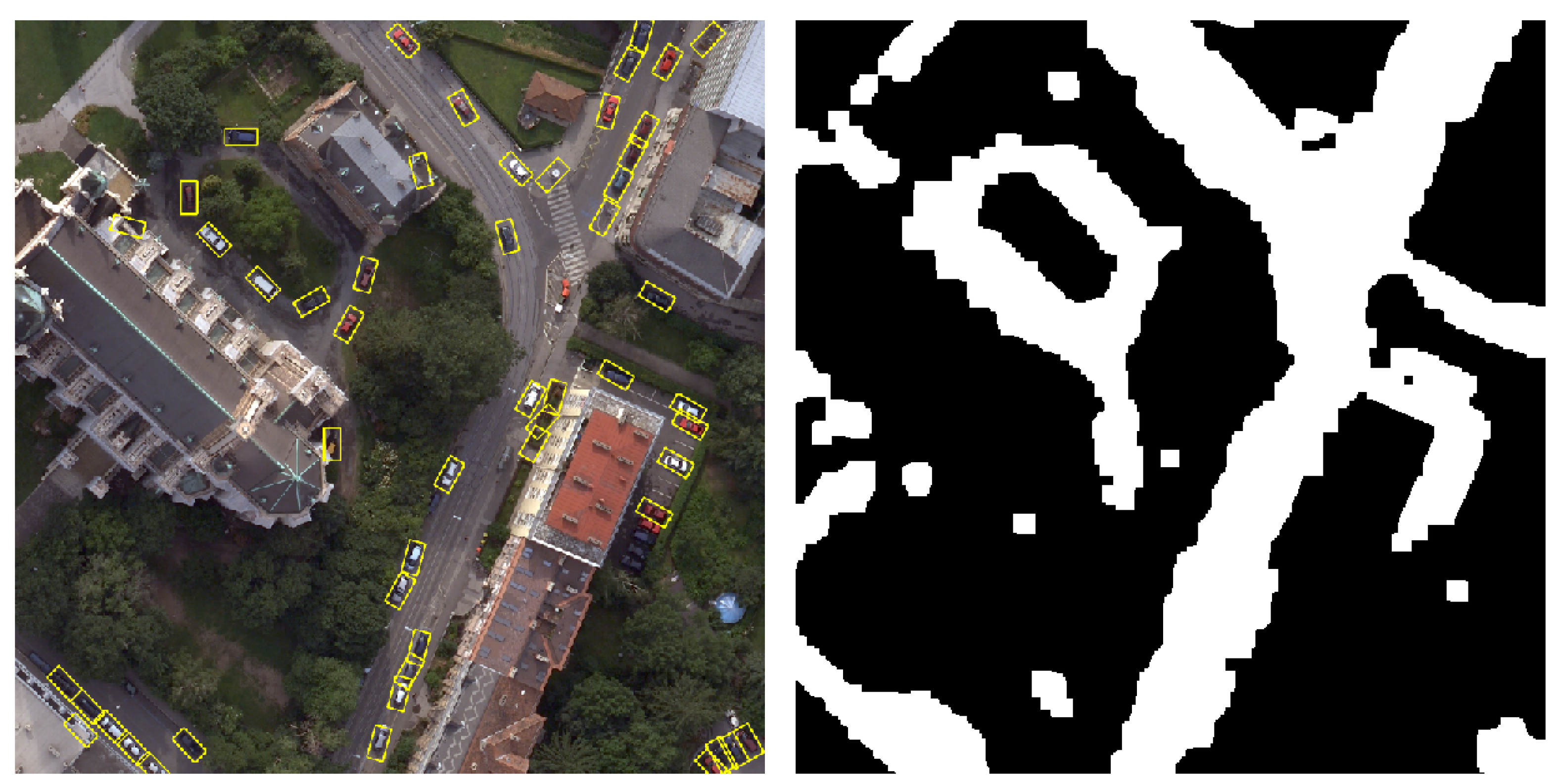
Car detection: Online Boosting for Feature Selection [1] with Haar-like and orientation histogram features

Extracting the Streetlayer as Context Information

- Confident car detections serve as seed points
- Height data and color driven graph-based grouping
- Utilize the high image redundancy
- Extract the streetlayer using a TPS representation
- Reduction of false positive detections

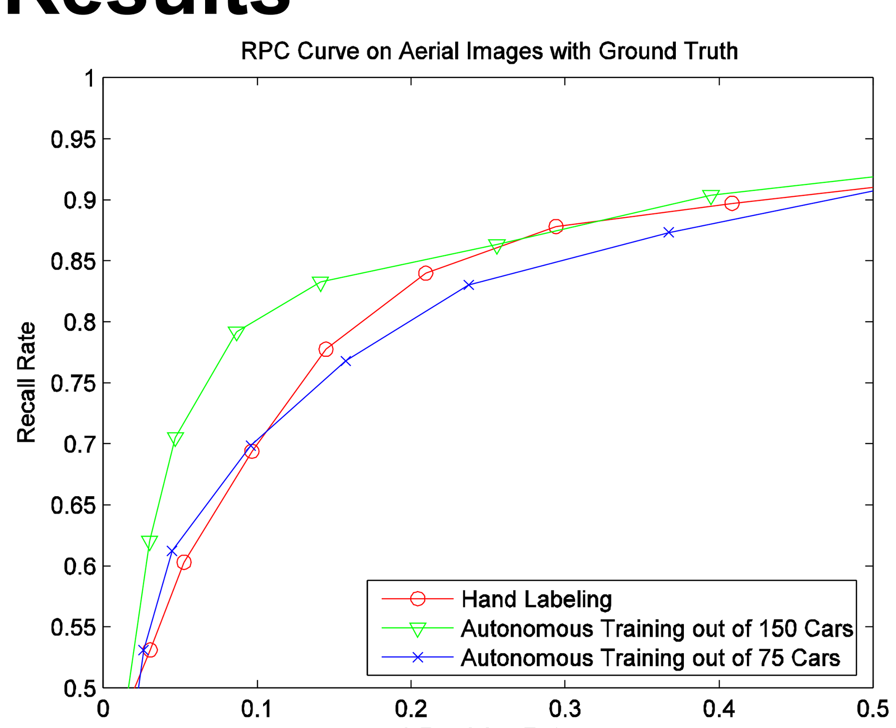
Graph edge weights:

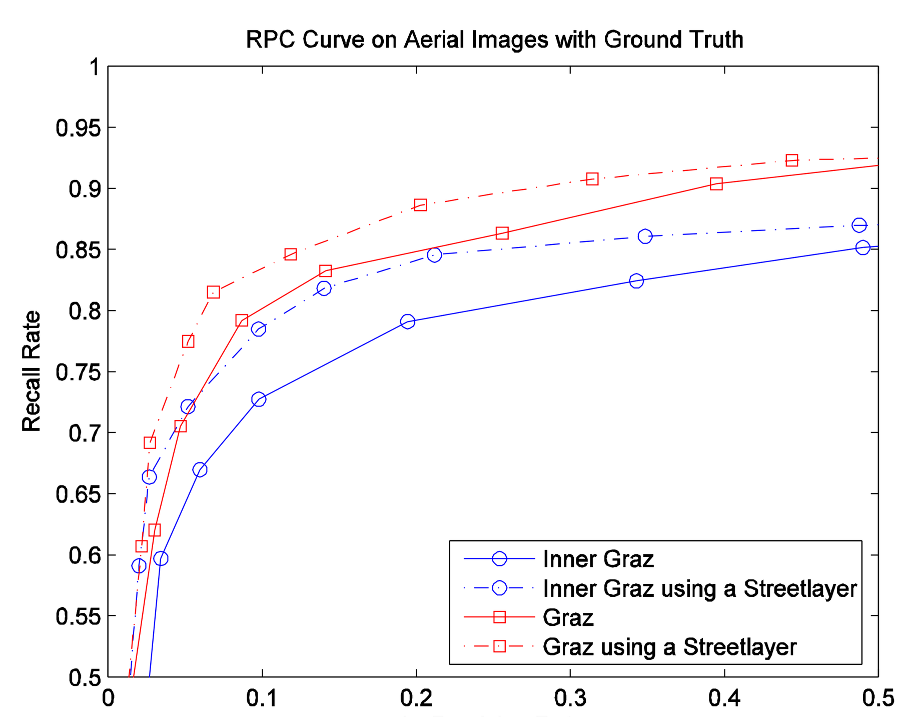
$$\omega_{n,n+1} = \begin{cases} \infty, \text{if } |(H_n - H_{n+1})| \geq 1.5m, \\ \max\left(\beta\left(\overline{N}, N_n\right), \beta\left(\overline{N}, N_{n+1}\right)\right), \text{otherwise} \end{cases}$$



Results

Detection rates on two *Graz* datasets





Streetlayer example *Graz*

Streetlayer example *San Francisco*

Conclusion

- Acceptable detection results
- Simple online learning strategy
- Autonomous generation of negative updates
- Fusion of color and height information

Future Work

- Exact terrain modeling
- Graph-based representation of the streetlayer
- Large scale testing

References

[1] H. Grabner and H. Bischof. On-line boosting and vision. In Proceedings CVPR, pages 260–268. 2006

[2] S. Kluckner, G. Pacher, H. Grabner, H. Bischof and J. Bauer. A 3D Teacher for Car Detection in Aerial Images. In Proceedings ICCV, 3d-RR. 2007

This work has been supported by the APAFA Project No. 813397, financed by the Austrian Research Promotion Agency and the Virtual Earth Academic Research Collaboration funded by Microsoft.