Detecting planes and estimating their orientation from a single image

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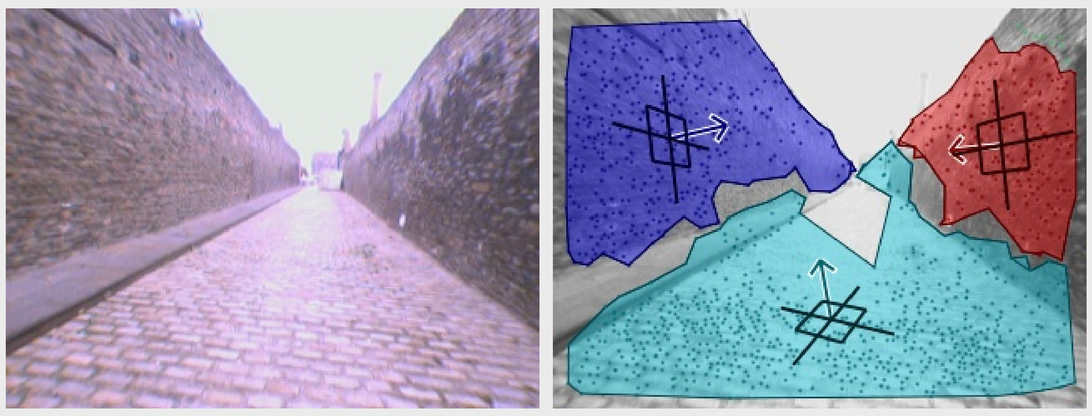
Introduction

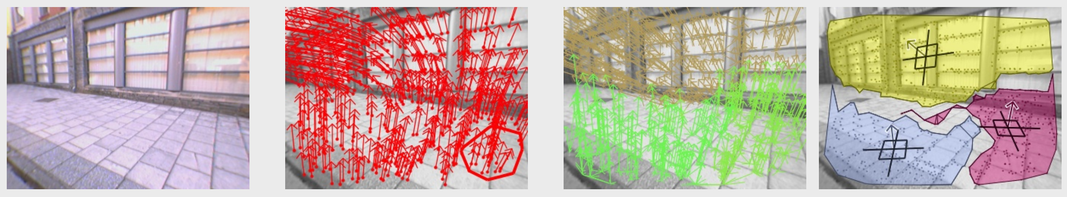
We propose an algorithm to detect planes in a single image, in outdoor urban evnrionments. We use machine learning methods, to learn from a labealled training set the relationship between appearance and structure, and show that this can work in a variety of scenes.



- Aim to detect planes in a single image
- Does not rely on geometric information
- Inspired by human perception – based on prior experience

Overview

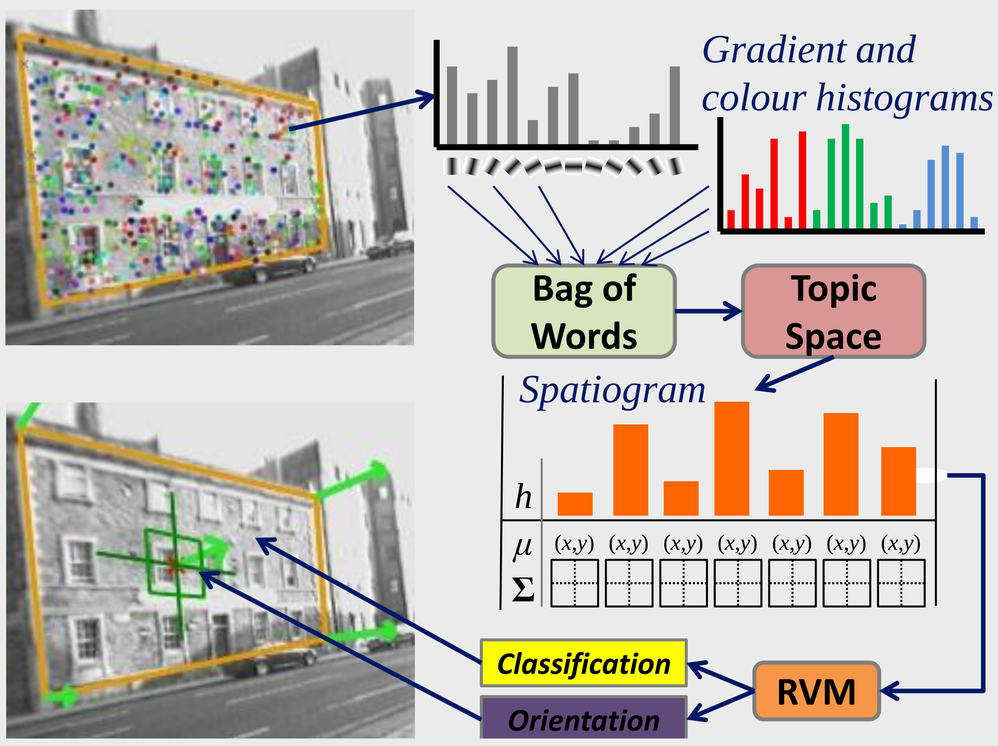
- Represent salient points using gradient and colour features
- Use *plane estimation* [2] on multiple overlapping windows
- Robust estimate of planarity and orientation at each point
- Segment into distinct planar regions



Input | Local plane estimate | Segmentation | Detected planes

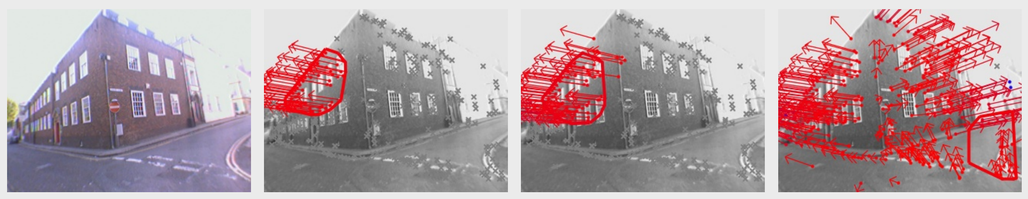
Plane Estimation

- For one image region: classify (plane or non-plane), and estimate 3D orientation
- Represent regions using bag of words
- Dimensionality reduction using latent semantic analysis
- Encode spatial distribution information with spatiograms [1]
- Relevance Vector Machine [3] for classification and regression

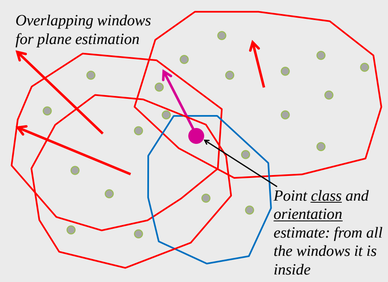


Local Plane Estimate

- Plane estimation (see bottom left) works for *one region*
- But cannot *detect* planes
- Apply plane estimation to overlapping windows

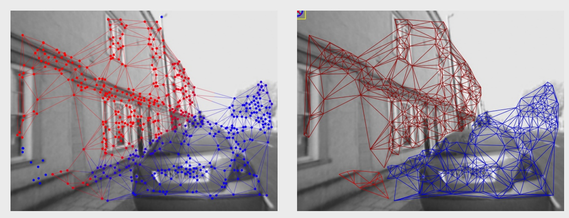


- Obtain local plane estimate for each point
- *Not* a plane detection – no boundaries
- Used for *segmentation*

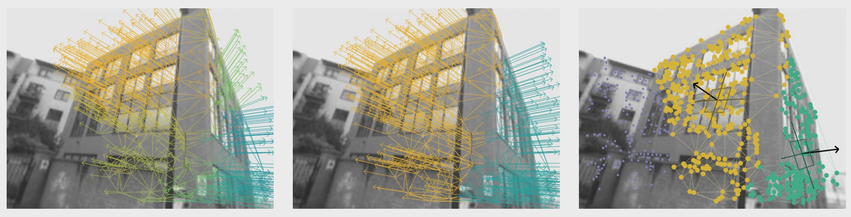


Segmentation

1. Segment planes from non-planes



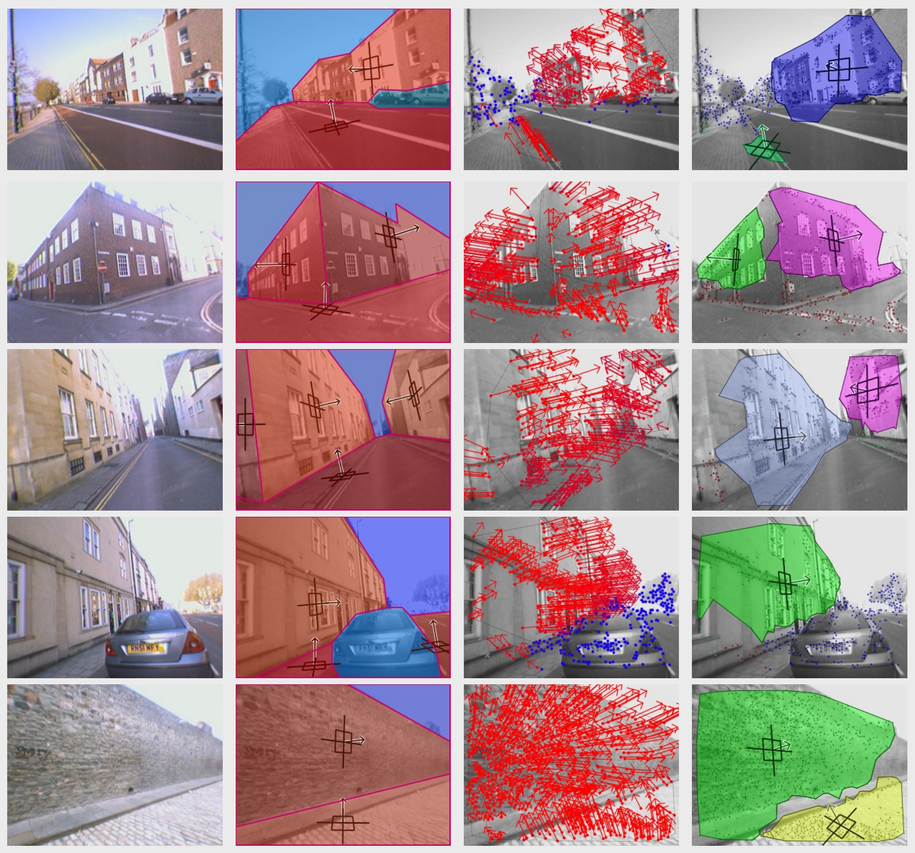
2. Find orientation of dominant planes (mean shift)
3. Segment planes by orientation



4. Apply plane estimation to plane segments: final plane detection

Results

- Tested on independent data set
- Point classification accuracy of **88%**, orientation error of **18°**



Example results (input, ground truth, local plane estimate, plane detection)

References

[1] Birchfield and Rangarajan. Spatiograms versus histograms for region-based tracking. In *Computer Vision and Pattern Recognitionn*, 2005.

[2] Haines and Calway. Estimating planar structure in single images by learning from examples. *International Conf. on Pattern Recognition Applications and Methods*, 2012.

[3] Tipping. Sparse bayesian learning and the relevance vector machine. *The Journal of Machine Learning Research*, 2001.