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Vehicle Detection in High-Resolution Satellite Images

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Outline of presentation

- Background
- Methodology
- Results
- Summary

Background

- Goal: generate traffic information
  - Road segment counts
  - Queue indicator
  - Parking overview
  - Overview of heavy vehicle traffic

Overview of approach

- Available data:
  - multispectral image (Quickbird, resolution 2.4m, 4 bands)
  - panchromatic image (Quickbird, resolution 0.6m)
  - road network from GIS data
- Main steps: (2-5 only panchromatic, resolution, time delay)
  1) presegmentation
  2) object segmentation
  3) feature extraction
  4) object preclassification
  5) object classification

Multispectral image

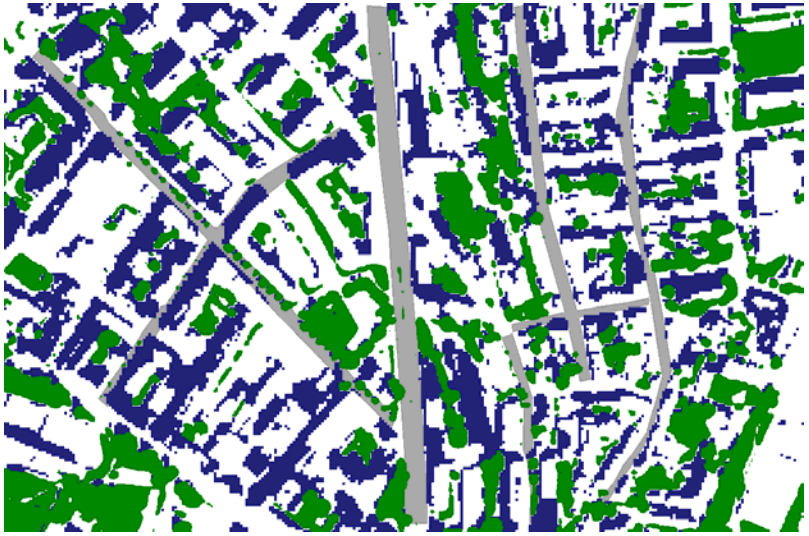
Panchromatic image

Presegmentation

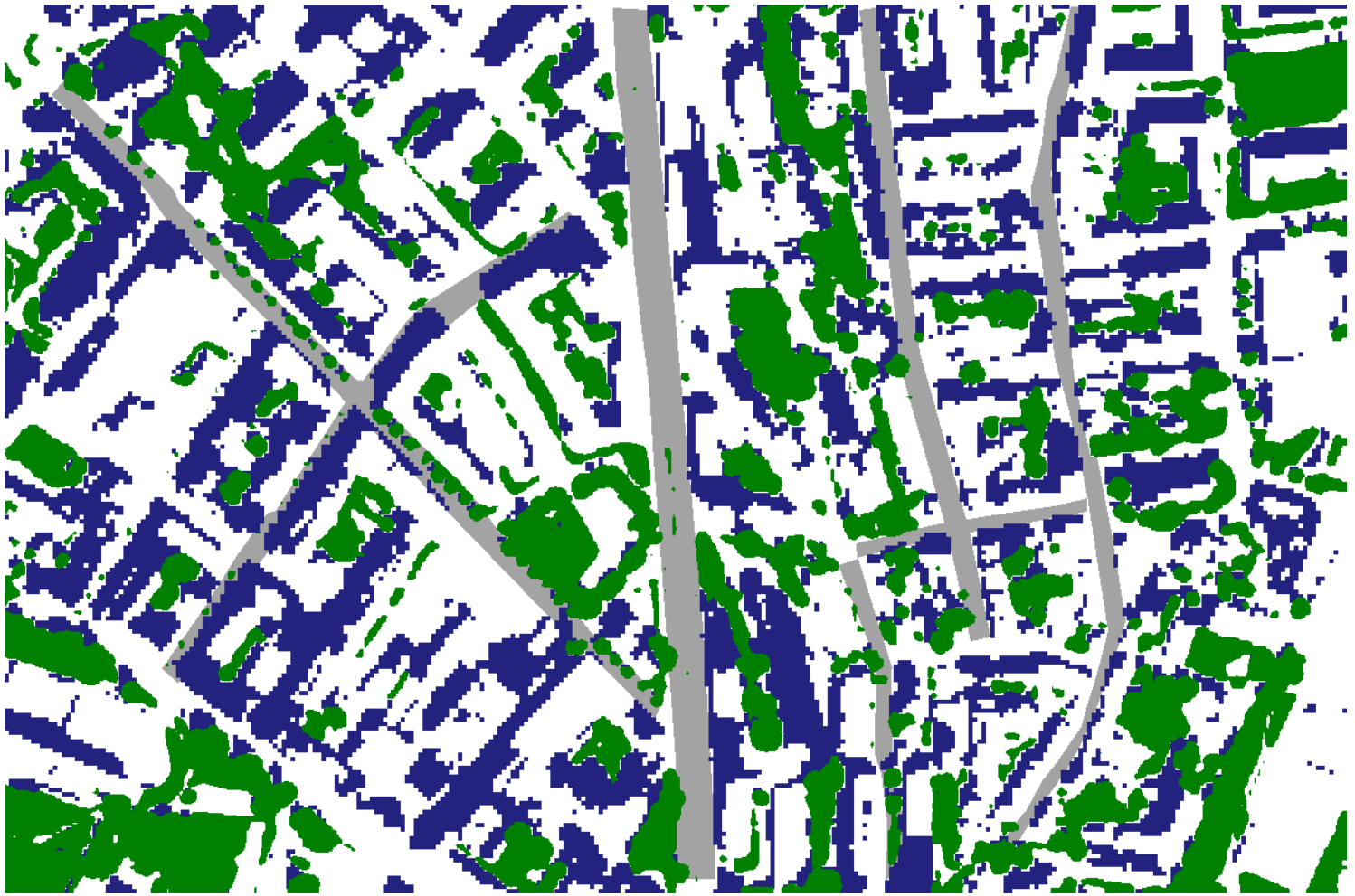
- Identify vegetation
  - Vegetation may cover vehicles (segmentation does not help)
  - Vegetation may be confused with vehicles
  - Computes normalized difference vegetation index (NDVI) from the multispectral data
  - Select subimage with NDVI > threshold
- Identify shadows from tall buildings
  - These areas should be analysed differently
  - Cluster multispectral image into three clusters using K-means
  - Select cluster with the darkest pixels in the panchromatic image
- Consider only the area within a road mask

Vegetation and shadow masks

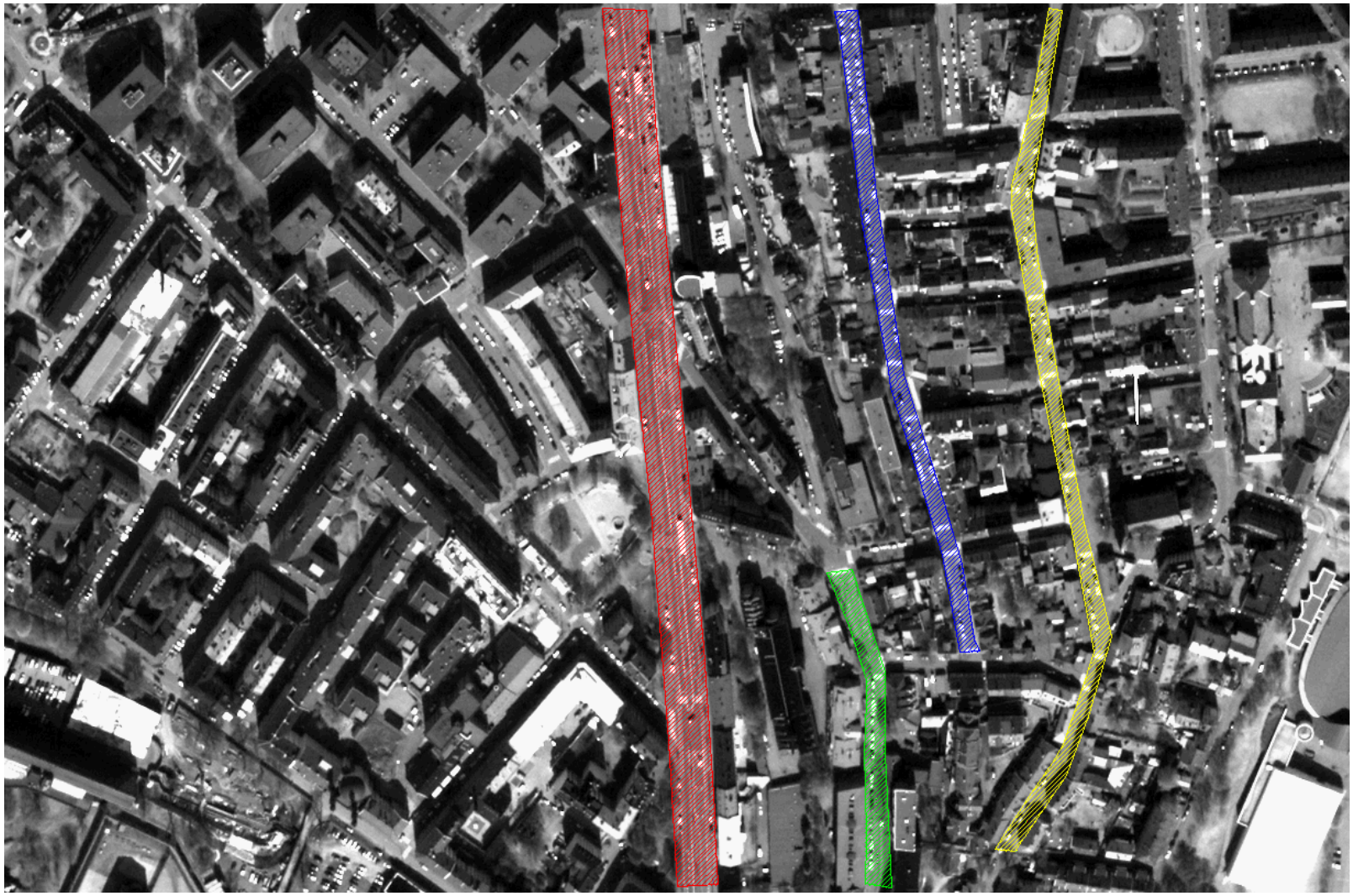
shadow (blue) and vegetation (green)



Vegetation and shadow masks



Road masks



Object segmentation

- Only the panchromatic image is used (resolution, time delay)
- Find bright and dark objects
- Otsu's method used twice
  - below and above the peak of the histogram
  - finds the optimum threshold separating two classes so that their combined spread (within-class variance) is minimal
- Resulting connected components:
  - vehicles (bright and dark)
  - smaller shadows
  - road markings
  - ???

Feature extraction

- Gray level features
  - region mean, region standard deviation, region gradient mean, boundary gradient, local contrast, smoothness contrast ratio
- Spatial features
  - area, compactness, angle deviation, spatial spread, Hu moments, height and width of bounding box, elongation, rectangularity

Object preclassification

- Obvious non-vehicles removed
- Simple rule based classifier
- Based on:
  - width
  - elongation
  - rectangularity
  - compactness
  - angle deviation

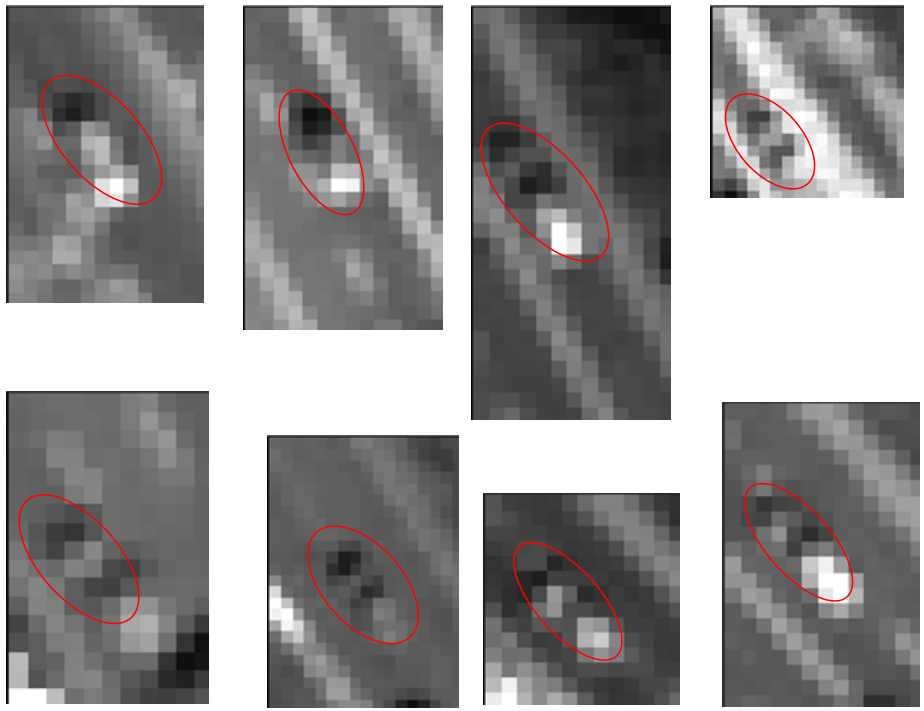
Object classification

- Four classes:
  - dark vehicle
  - bright vehicle
  - dark noise
  - bright noise
- Statistical classification
  - quadratic discriminant analysis
  - based on the extracted features
  - training is needed

Results – Vehicle positions

Results – Vehicle positions

Sources of error



Manually identified vehicle objects that are not properly segmented. These objects have a low contrast to the background and are therefore fragmented into several very small parts.

Manual and automatic results

Total manual vehicle count			Vehicles missed before classification according to manual counts	
P1	P2	Consensus	P1	P2
396	387	362	73	69

Manual and automatic results

	Total number of objects classified	Number of objects manually classified as vehicles			Percentage overlap between P1 and P2
		P1	P2	Consensus	
Total	**499**	**296**	**305**	**257**	**83%**

	Objects classified as vehicles by the automatic approach	Correctly classified as vehicles		Correct classification rates according to P1 and P2	
		P1	P2	P1	P2
Total	**303**	**256**	**252**	**82.8%**	**79.2%**

Summary

- A future system for automatic road traffic counts is feasible.
- Improvement on the methodology is an ongoing project.

Acknowledgement

- This work has been supported by ESA.