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Sparse Scene Flow Segmentation for Moving Object Detection in Urban Environments

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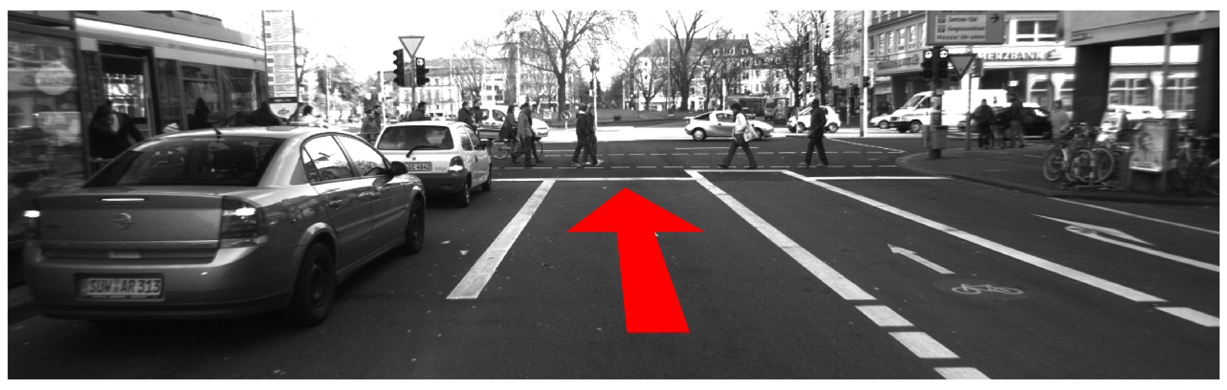
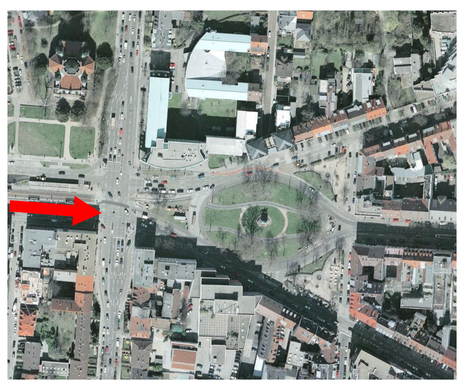
Motivation

Inner city intersections are a very demanding scenario for modern driver assistance systems.

Goal

- Perception and understanding of highly dynamic traffic scenes.
- Class-independent detection of moving object for inner city traffic scenarios.





Stereo Reconstruction

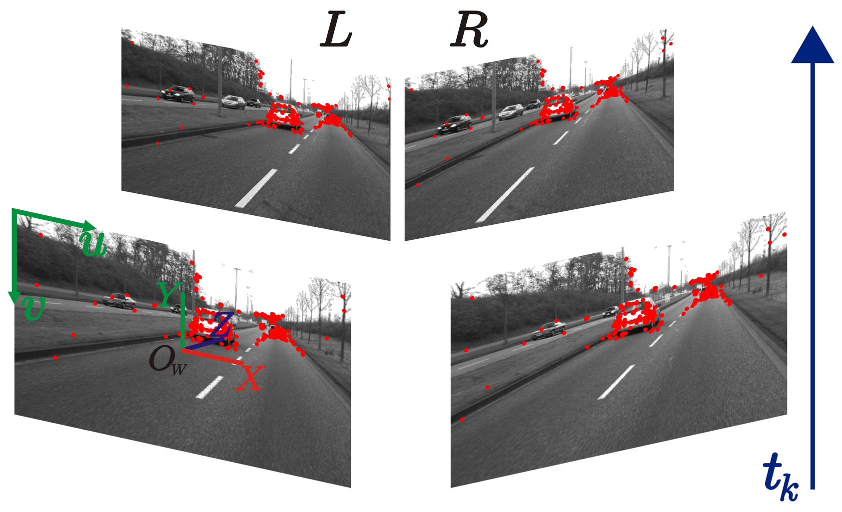
Interest points $\mathbf{x}=[u,v]^T$ are detected in two consecutive stereo image pairs.

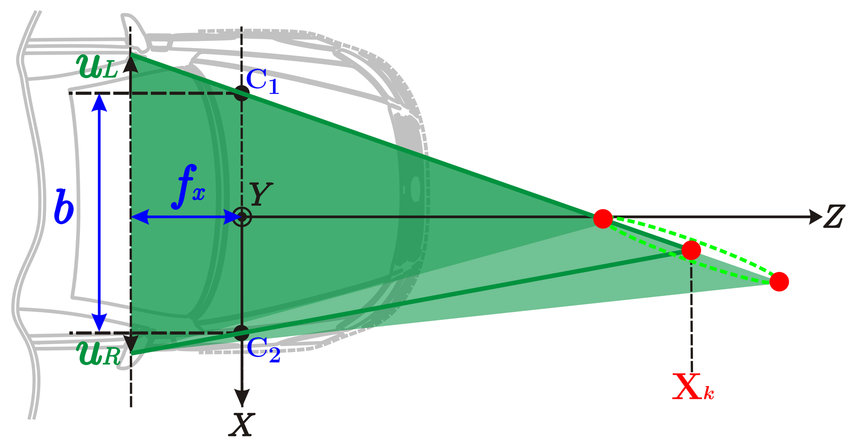
Disparities are estimated at sub-pixel accuracy for rectified images.

Error propagation leads to the quadratically growing error of the **3D position** $\mathbf{X}=[X,Y,Z]^T$ given by

$$X = \frac{(u_L - c_{u,L}) \cdot b}{d} \qquad Z = \frac{b \cdot f}{d}$$

$$Y = \frac{(v_L - c_{v,L}) \cdot b}{d}$$





System Overview

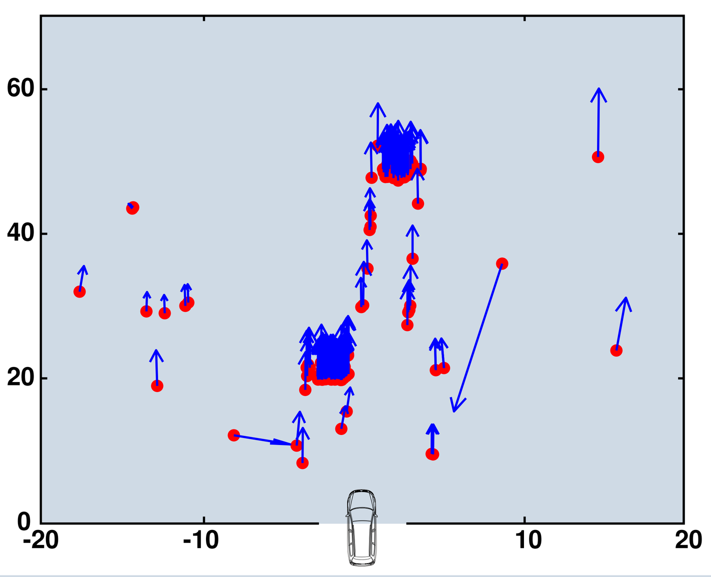
Scene Flow Description → Scene Flow Clustering → Geometry Check → Object Association → Final Detection

Scene Flow Description

Interest points are stored as tracklets.

The **velocity** $\mathbf{V}$ is computed as the first order derivative of the world points $\mathbf{X}$.

$$\mathbf{V} = \frac{\Delta \mathbf{X}_{k-\Delta t_i}}{\Delta t}$$



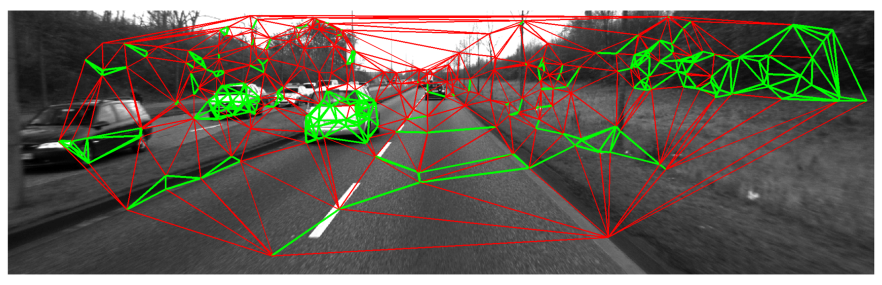
Scene Flow Clustering

Scene flow clusters describe a **similar motion**.

Removed edges of the graph exceed a threshold of the Mahalanobis distance Δ:

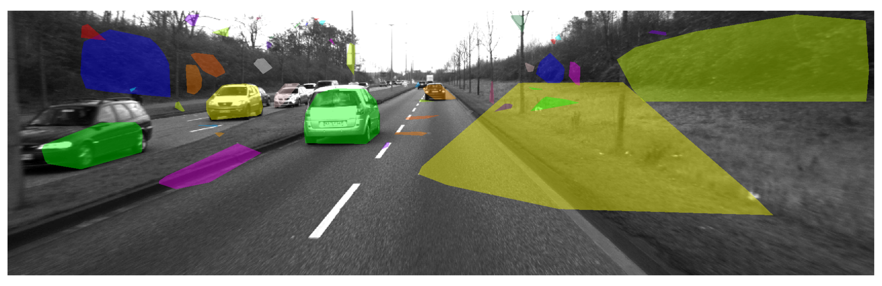
$$\Delta(\mathbf{V}_i, \mathbf{V}_j) = \sqrt{(\mathbf{V}_i - \mathbf{V}_j)\ \Sigma_{i,j}^{-1} (\mathbf{V}_i - \mathbf{V}_j)}.$$

The covariance Σ is obtained by error propagation of the 3D reconstruction.



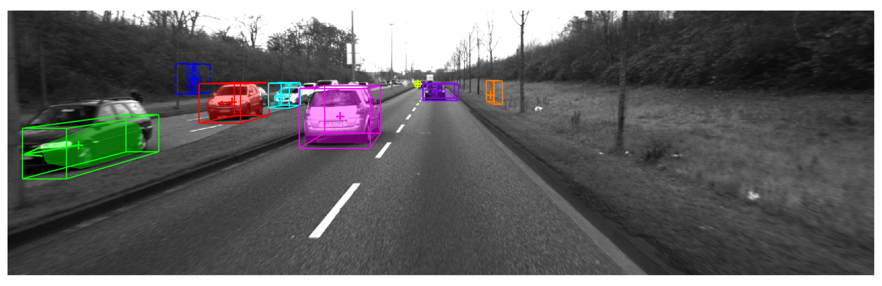
Geometry Check

Connected components describe detected objects.



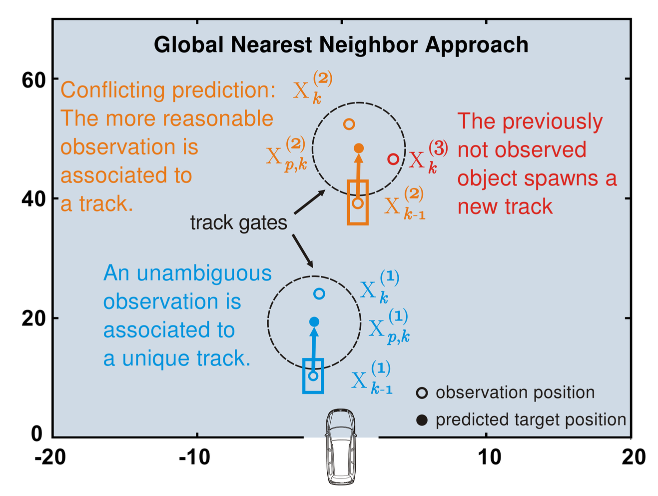
Neglected Objects:

- Exceeding reasonable dimensions.
- Not standing on the ground plane.

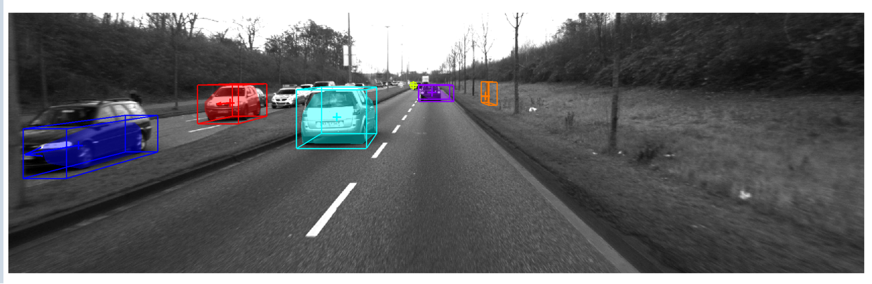


Object Association

Observation-to-Track association for unambiguous and conflicting prediction.



Final Detection



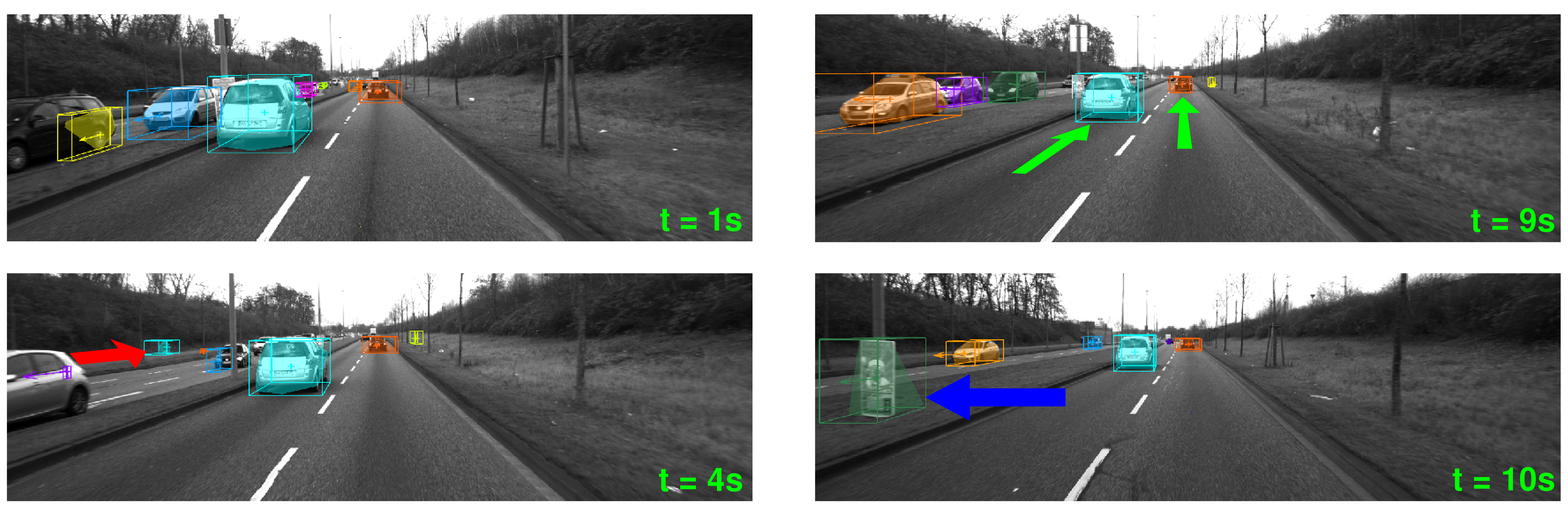
Results

Rural Road Sequences

- Continuous tracking of the **cars in front** within 15 s (10 fps).
- Detection of uncommen classes such as the **wheelchair user**.
- **Static objects** are detected since egomotion is not compensated.

Approaching cars are detected

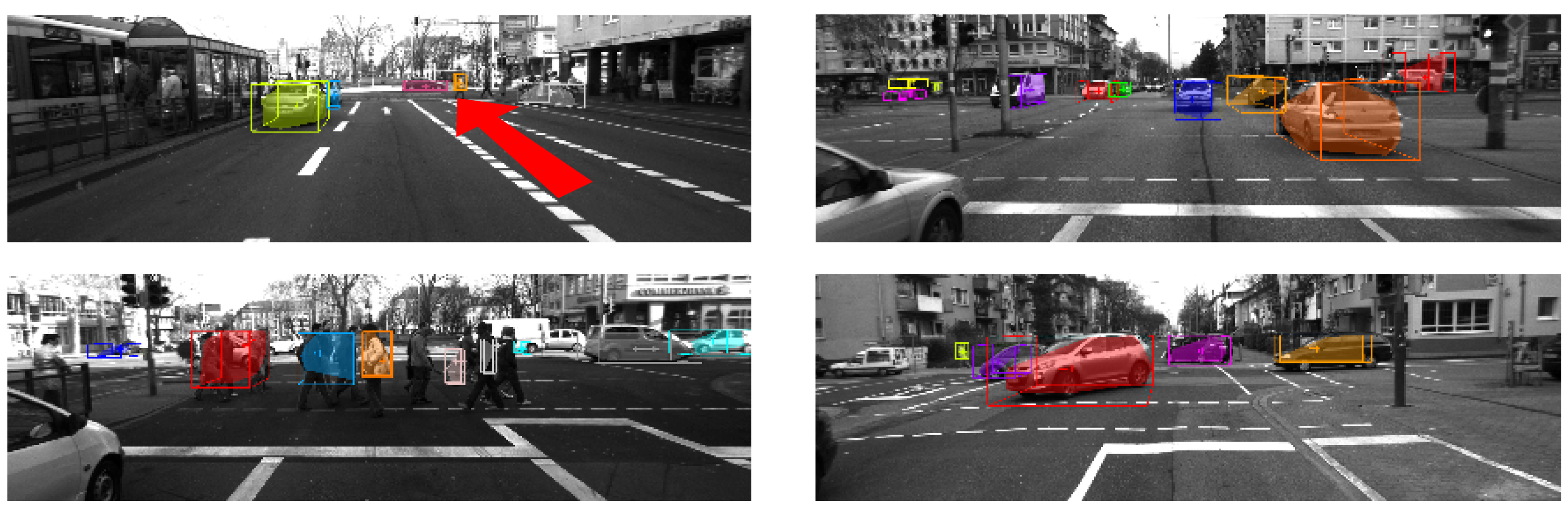
- within 3 time steps at a distance up to 25 m.
- within 5 time steps for a greater range of up to 60 m.



Inner City Intersection Scenarios

- **Pedestrians** are detected in a range up to 30 m.
- For the far range up to 60 m larger objects are detected as well.
- Turning or partly occluded cars are detected in a single frame.

- Similarly moving groups of pedestrians are detected as one object.
- Observation-to-Track association fails for sharply turning objects.



Conclusion

We presented a novel approach for object detection for challenging inner city traffic scenarios.

- Computationally sparse interest points.
- 3D description of moving objects in the current environment.
- Class-independent detection also of uncommon objects.

Future Work

Future work will include:

- More sophisticated multiple target tracking to reduce false detections and handle (partly) occluded objects.
- Egomotion compensation using visual odometry.
- Inclusion of a motion model to consider object rotations.

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