

Outlier Rejection

Course 3, Module 2, Lesson 4



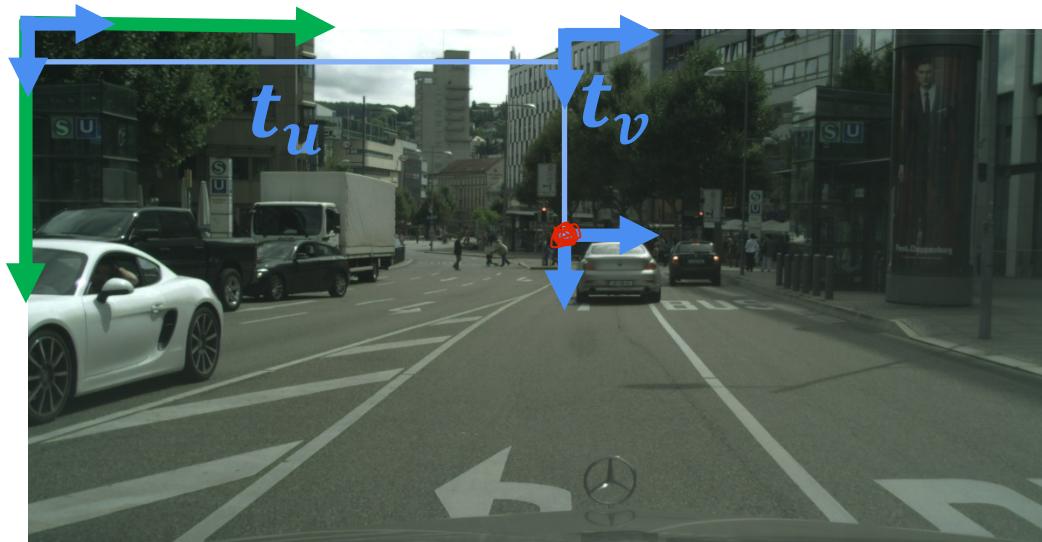
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Learning Objectives

- Learn the definition of outliers, and how outliers interfere with model estimation that rely on image feature matchers
- Learn how to handle outliers through the RANSAC algorithm

Image Features: Localization

- Problem: Find translation $T = [t_u, t_v]$ in image coordinate system between image 1 and image 2.



Images from CITYSCAPES dataset: <https://www.cityscapes-dataset.com/>

Image Features: Localization

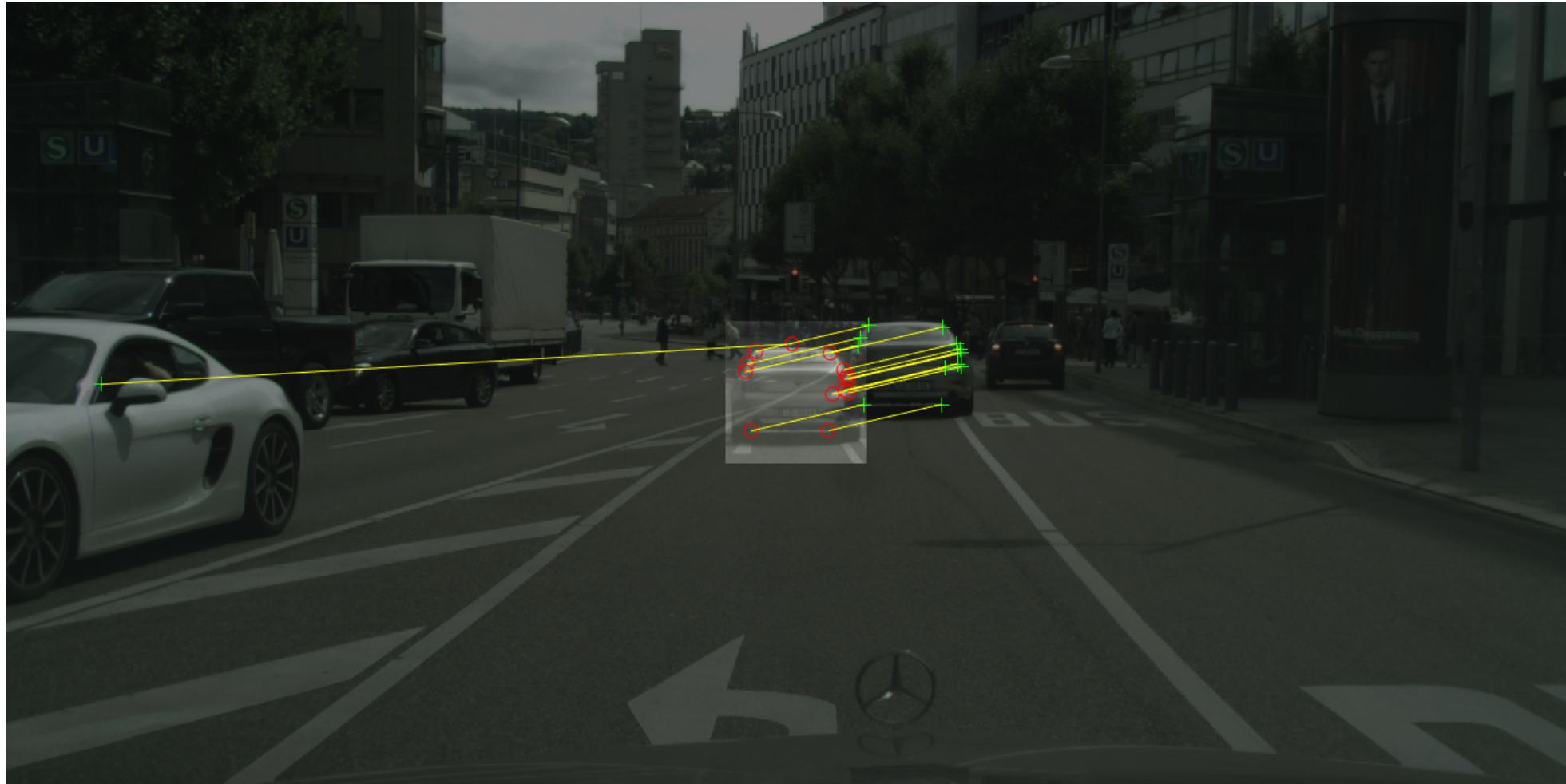


Image Features: Localization

- Matched feature pairs in images 1 and 2:

- $f_i^{(1)}, f_i^{(2)} \mid i \in [0, \dots, N]$

- $\underline{f_i^{(1)}} = (u_i^{(1)}, v_i^{(1)})$

- **Model:**

- $u_i^{(1)} + \underline{t_u} = u_i^{(2)}$

- $v_i^{(1)} + \underline{t_v} = v_i^{(2)}$

*rigid body motion:
same for all feature pairs*

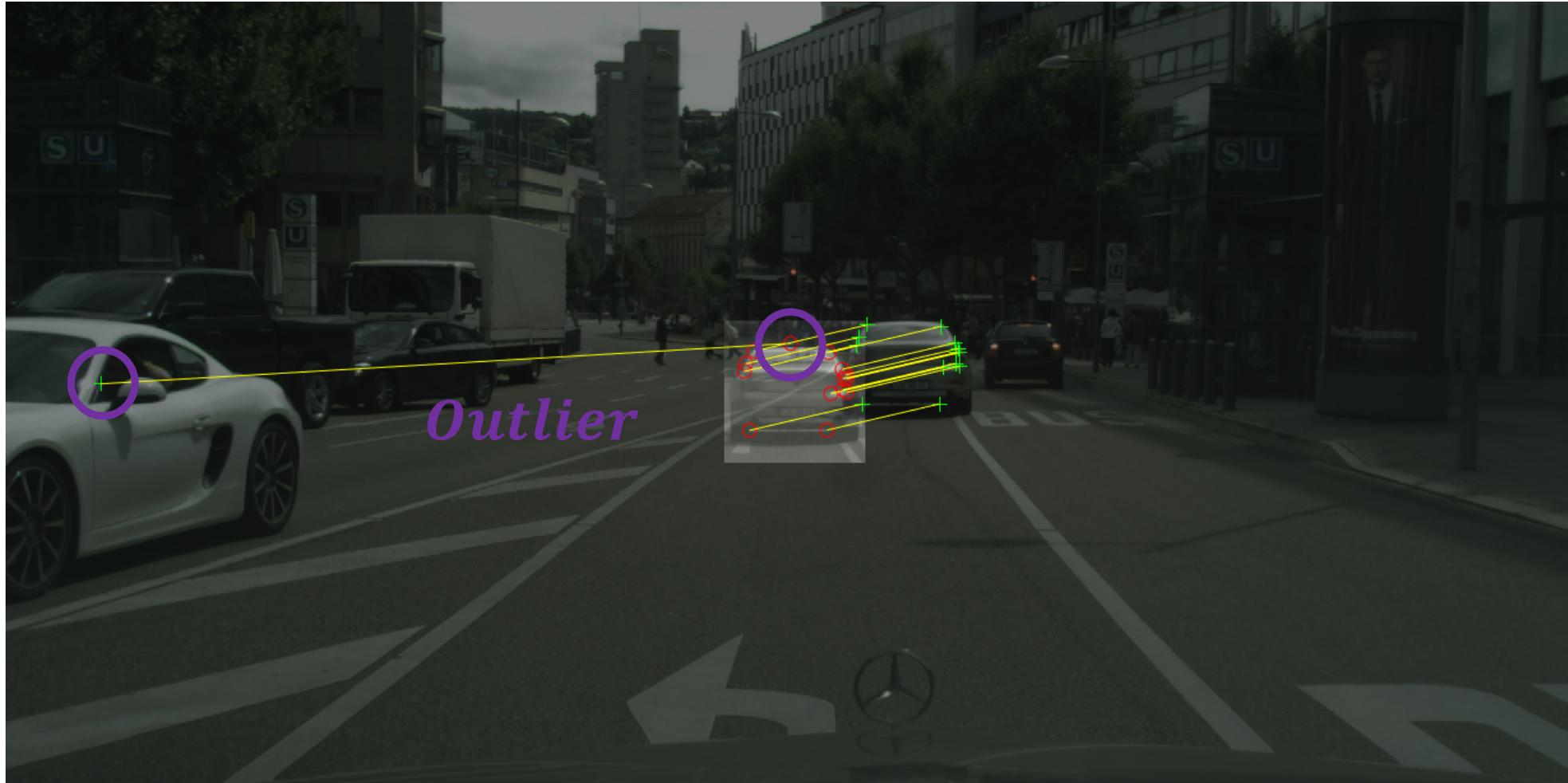
Image Features: Localization

- Problem: Find translation $\mathbf{T} = [\mathbf{t}_u, \mathbf{t}_v]$ in image coordinate system between image 1 and image 2
- Solve using least squares:

$$t_u = \frac{1}{N} \sqrt{\sum_i (u_i^{(1)} - u_i^{(2)})^2}$$

$$t_v = \frac{1}{N} \sqrt{\sum_i (v_i^{(1)} - v_i^{(2)})^2}$$

Outliers



Random Sample Consensus (**RANSAC**)

- Fischler & Bolles 1981.
- **RANSAC Algorithm:**

Initialization:

1. Given a **Model**, find the smallest number of samples, M , from which the model can be computed

Main Loop:

2. From your data, randomly select M samples
3. Compute model parameters using the selected M samples
4. Check how many samples from the rest of your data actually fits the model. We call this number the number of **inliers C**
5. If $C >$ **inlier ratio threshold** or **maximum iterations reached**, terminate and return the best inlier set. Else, go back to step 2

Final Step:

6. Recompute model parameters from entire best inlier set

Image Features: Localization

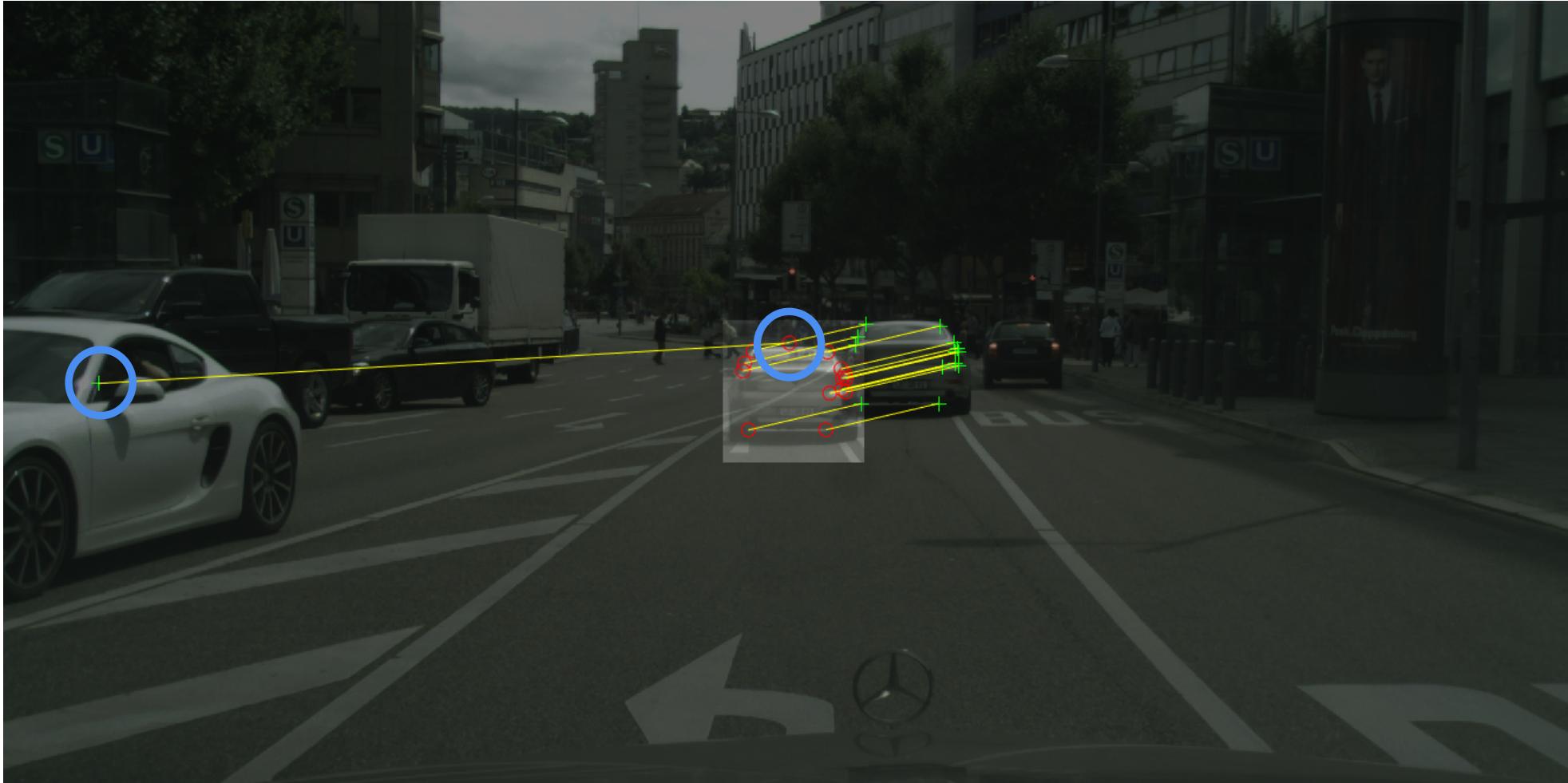
Ex,

- Model:

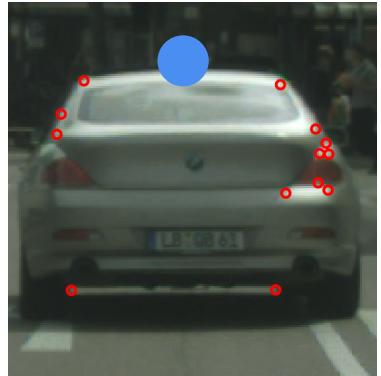
$$\begin{aligned} u_i^{(1)} + t_u &= u_i^{(2)} \\ v_i^{(1)} + t_v &= v_i^{(2)} \end{aligned}$$

- $M = 1$ pair of feature matches

RansaC: Iteration 1



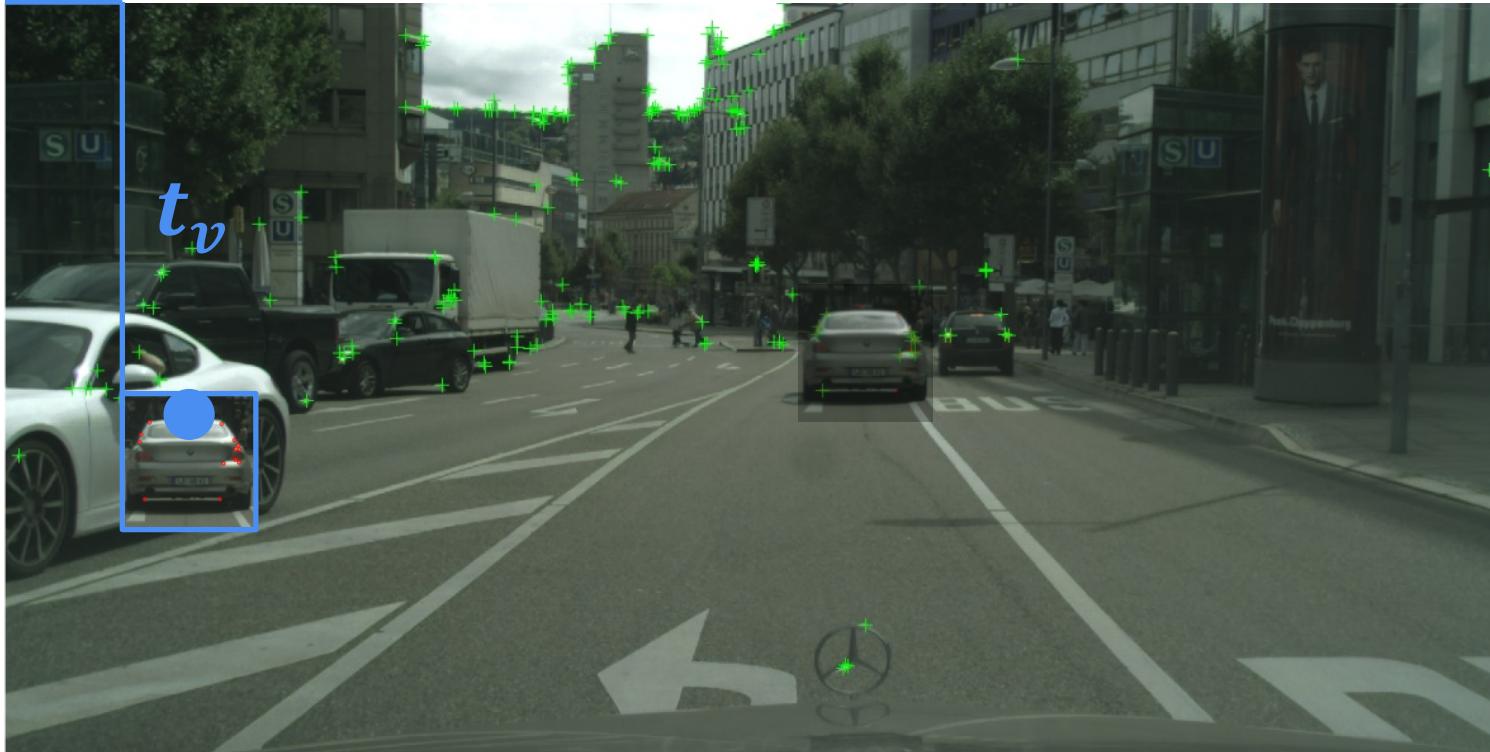
RansaC: Iteration 1



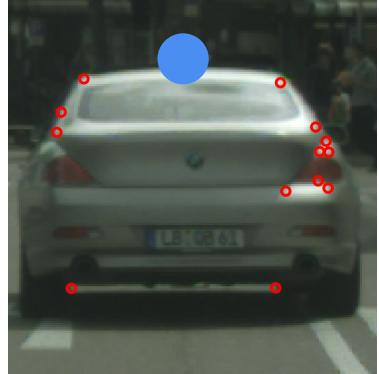
t_u



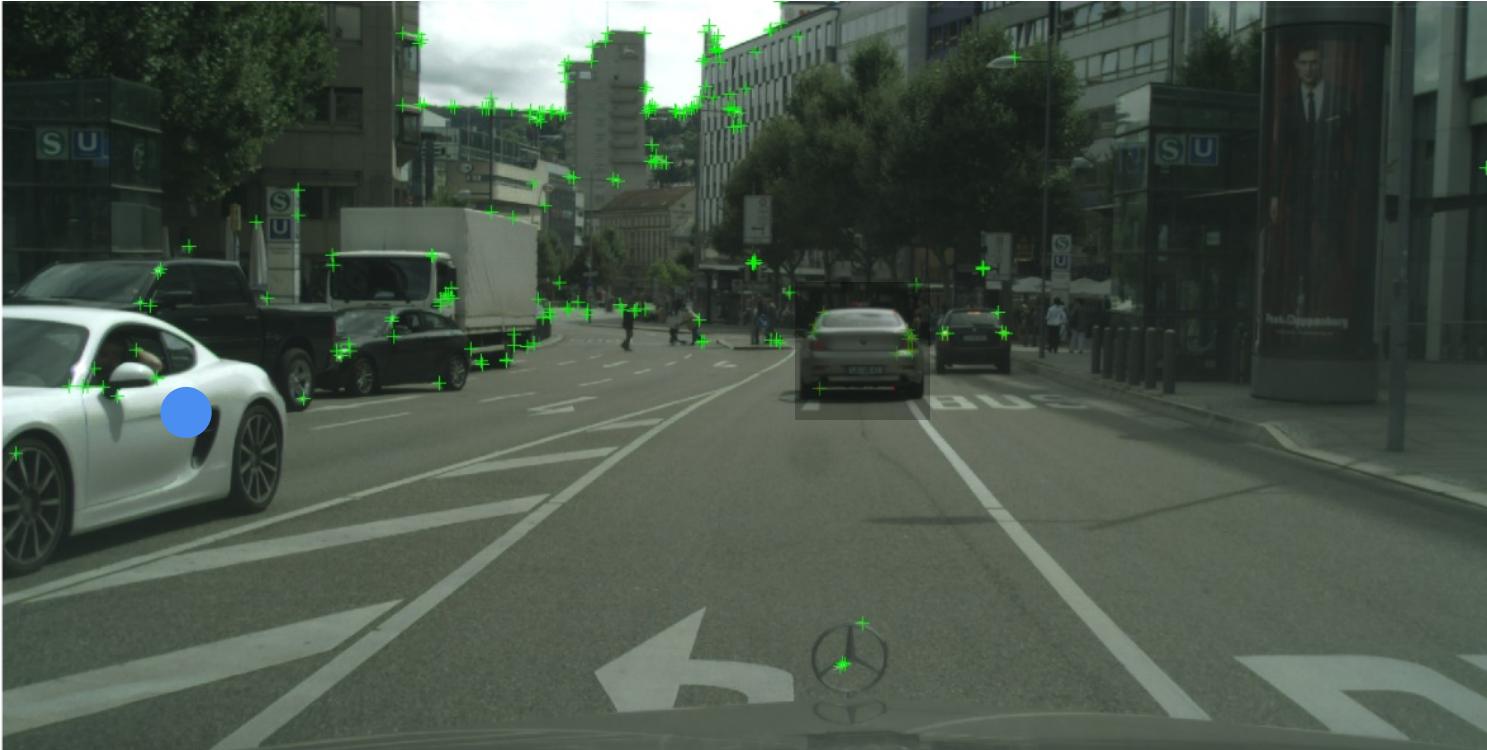
t_v



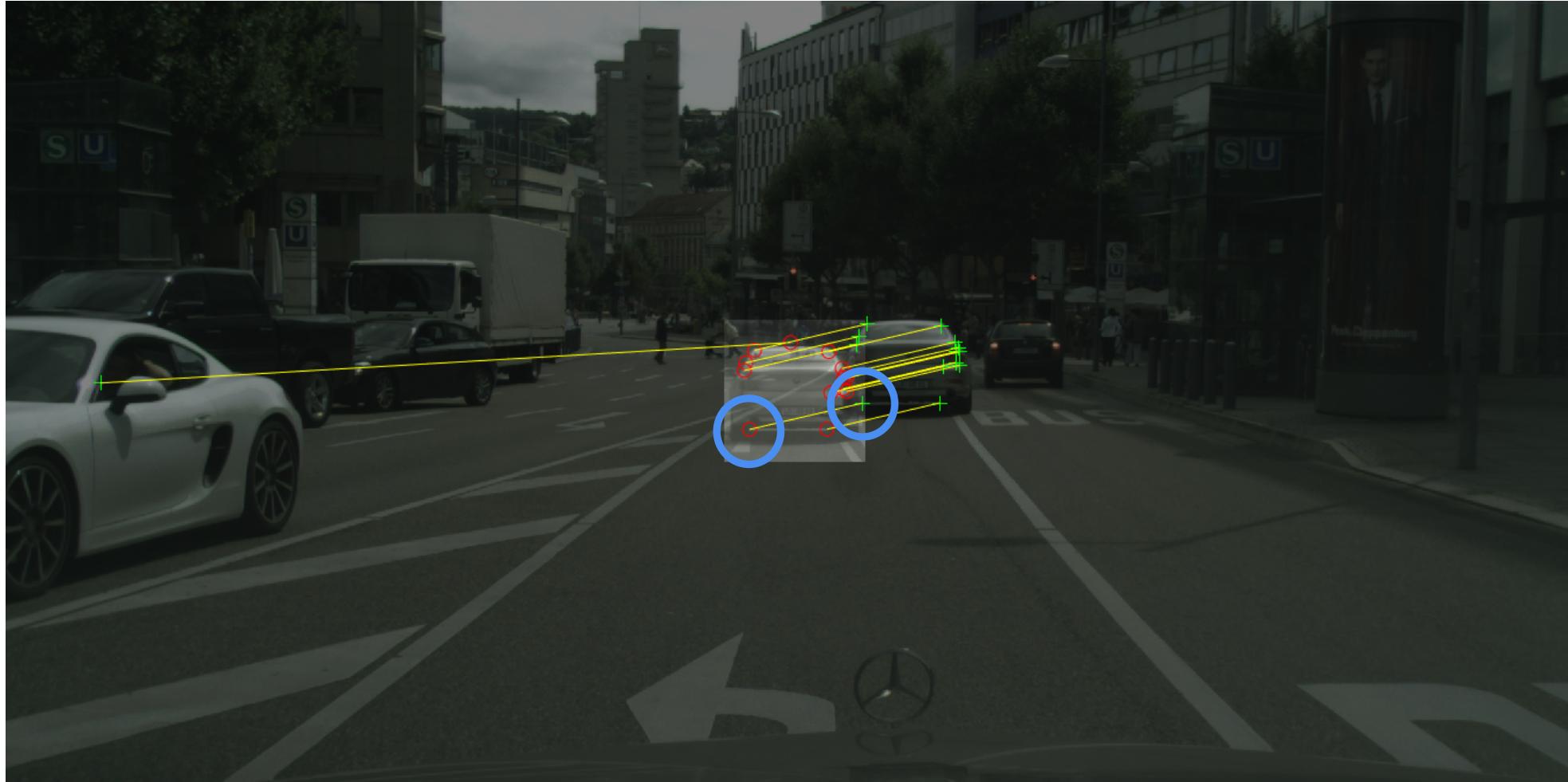
RansaC: Iteration 1



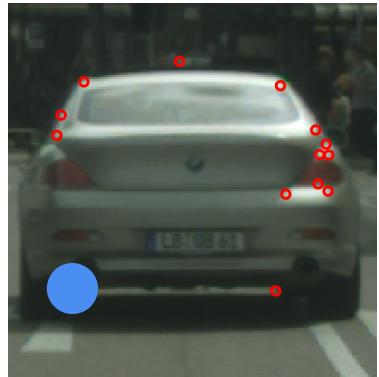
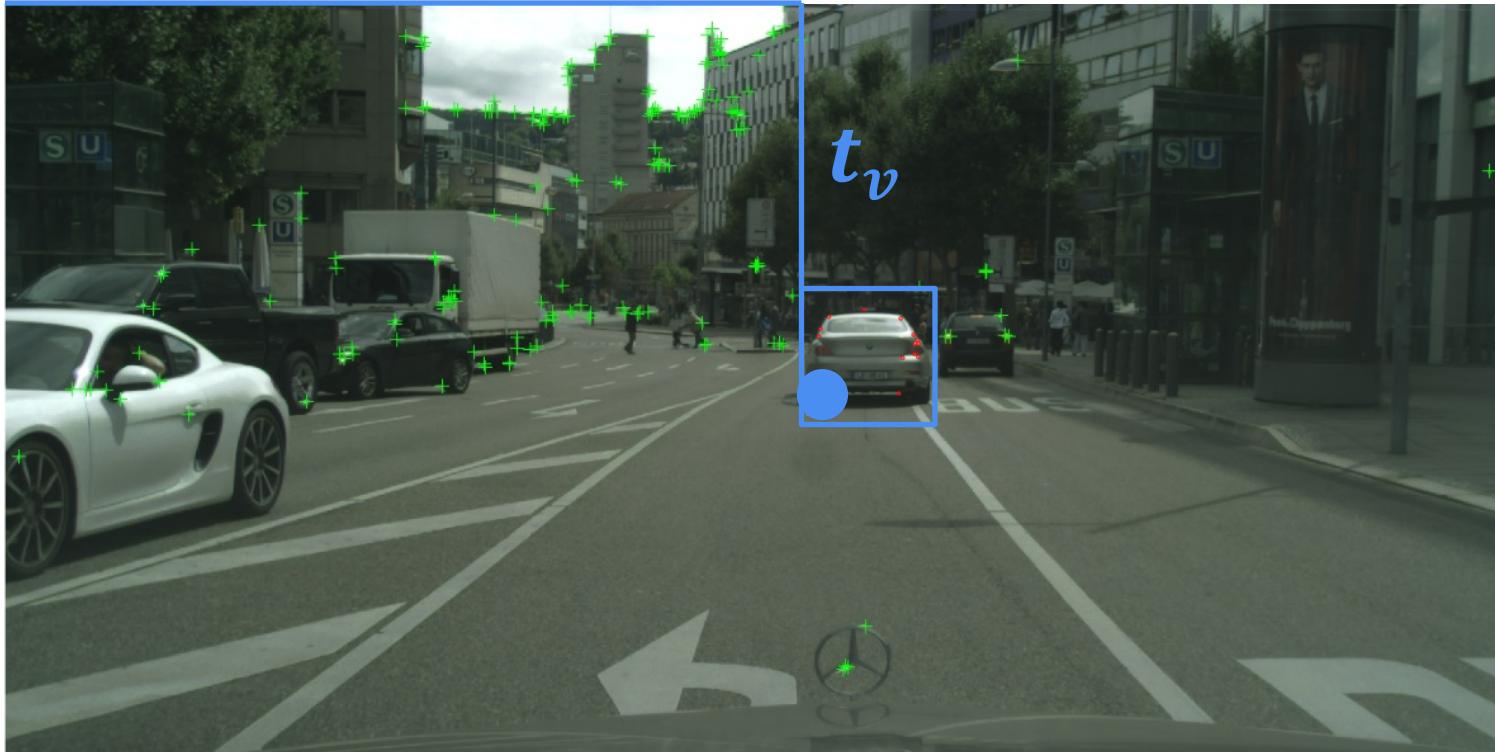
$$C = 0$$



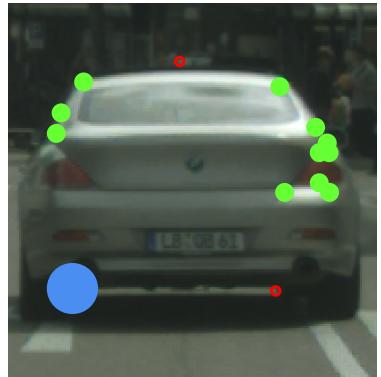
RansaC: Iteration 2



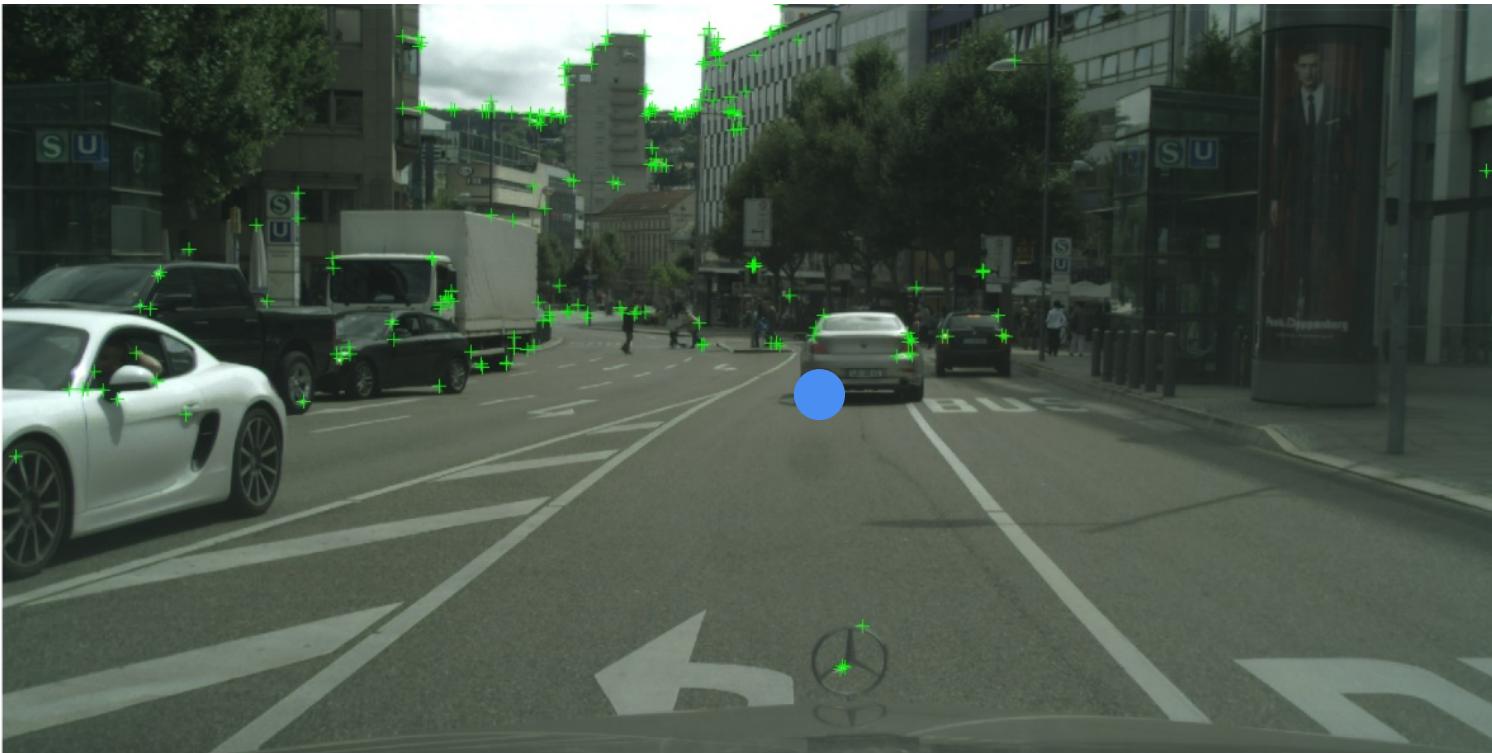
RANSAC: Iteration 2

 t_u  t_v

RANSAC: Iteration 2



$C = 11$



Summary

- Outliers are wrong feature matching outputs, that can occur due to errors in any of the three stages of feature usage
- RANSAC can be used to efficiently arrive to a good model even when outliers are among the matched features
- **Next: Visual Odometry**