Homography from a Vanishing Point in Urban Scenes

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Problem statment

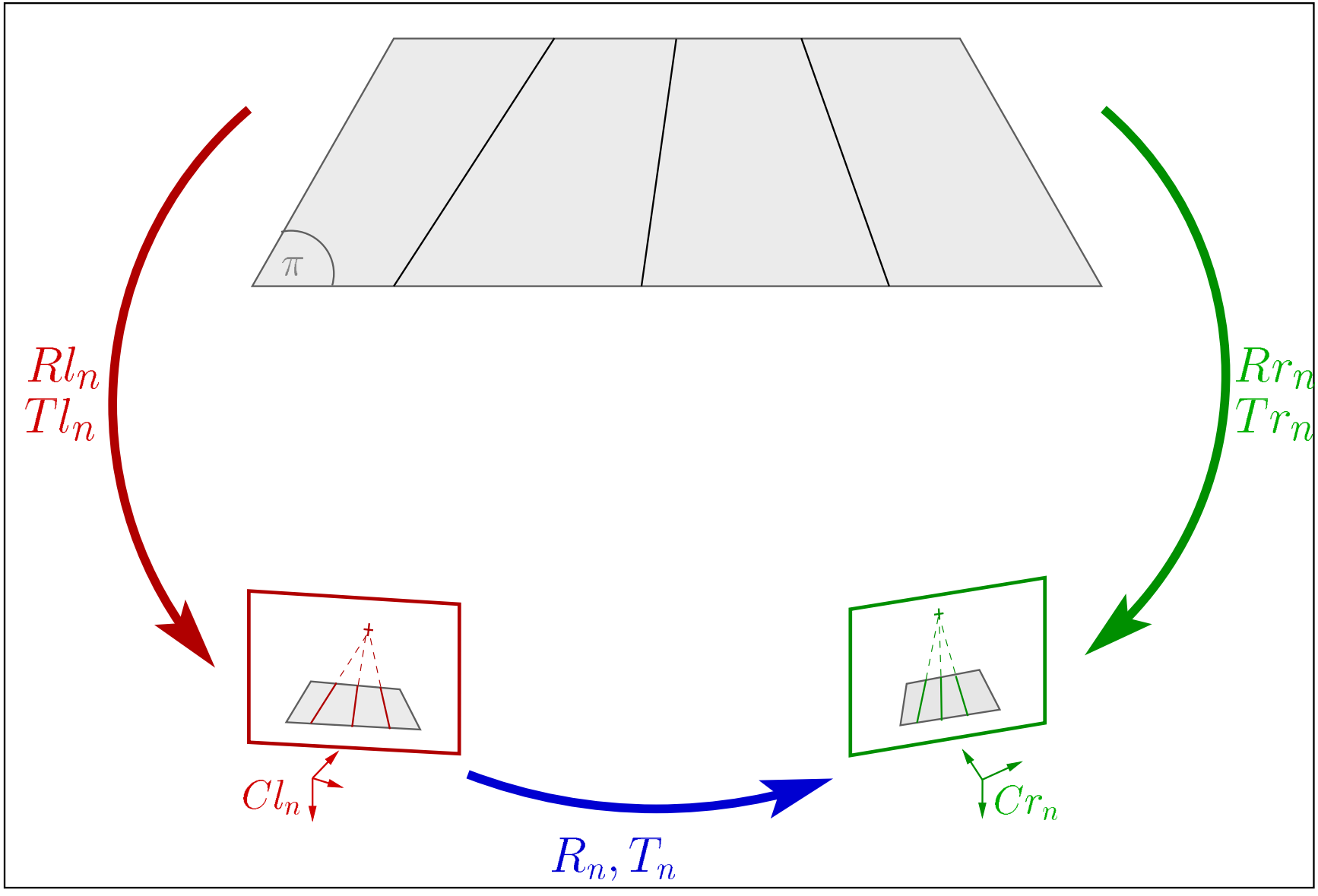
- The localization of vehicle in outdoor environments are mainly based on GPS system.
- **But**, the data quality of such systems highly depends on the clear view the receptor has.
- **In the same way**, the façades which corrupt the GPS signals could be viewed as parts of an “urban canyon”.

$\Rightarrow$ the use of an on-board vision system for improving the localization process.

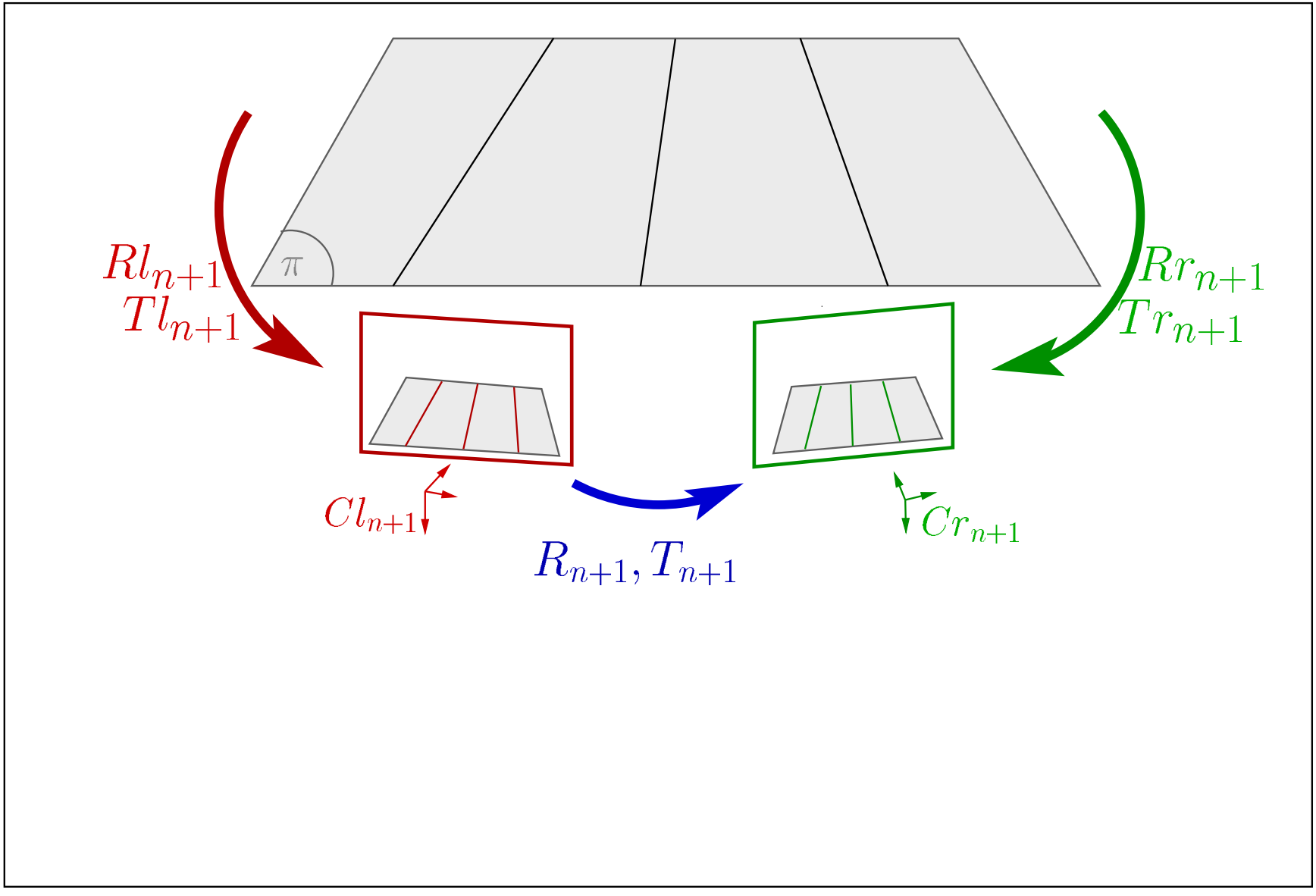
A vision system in urban environments

Could a vision system be considered as a localization sensor to estimate the ego-motion of a vehicle in urban environments ?

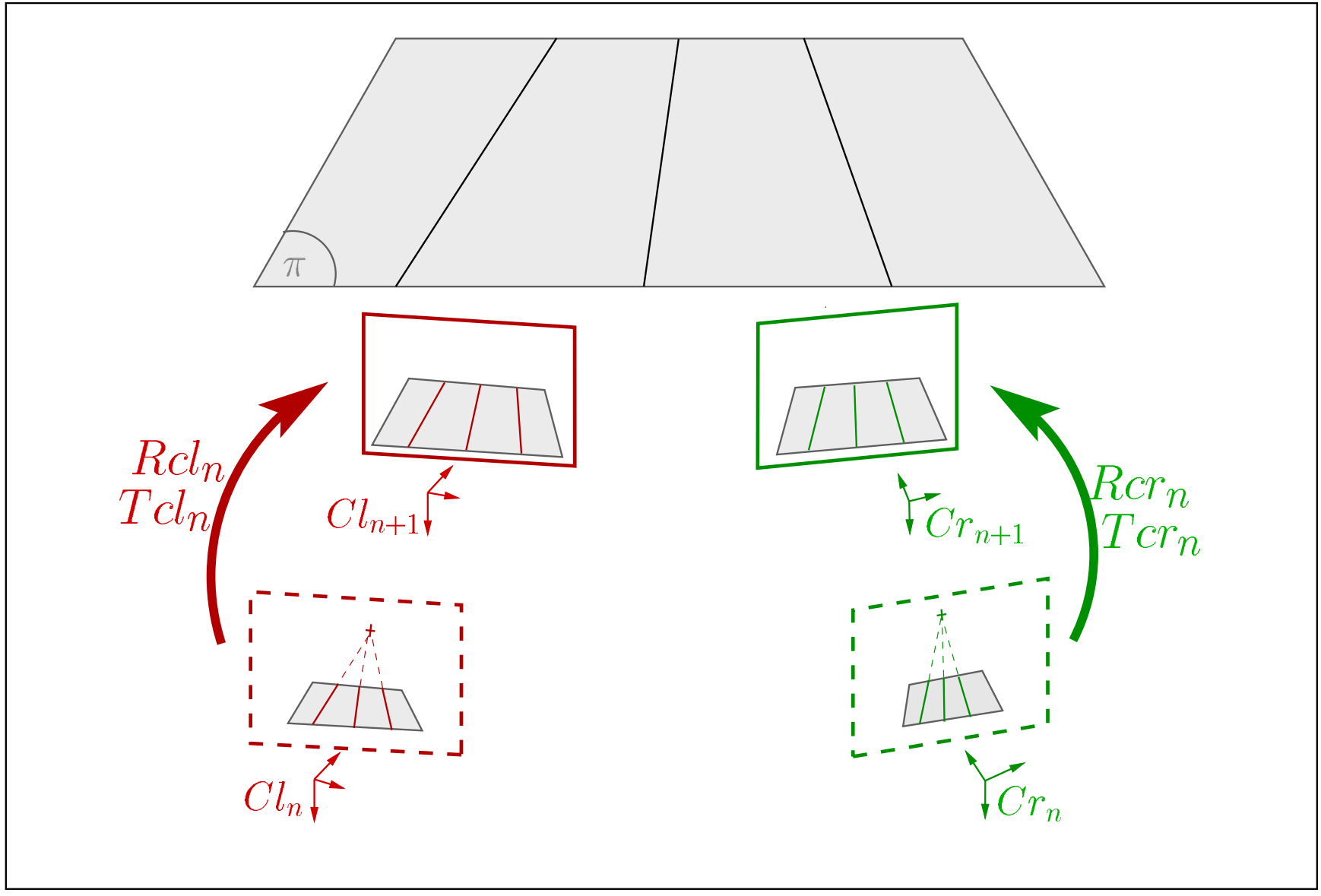
Motion viewed from a stereo pair



Motion viewed from a stereo pair



Motion viewed from a stereo pair



Coplanar Features

Features lying on the π plane have projections in 2 images constrained by the **planar homography** H_π:

for $\mathsf{k} \in [1, 2]$,

$$\mathbf{l_k} \propto \mathsf{H}_\mathsf{k}^{-\mathsf{t}}.\mathbf{L}$$

$$\mathbf{p_k} \propto \mathsf{H}_\mathsf{k}.\mathbf{P}$$

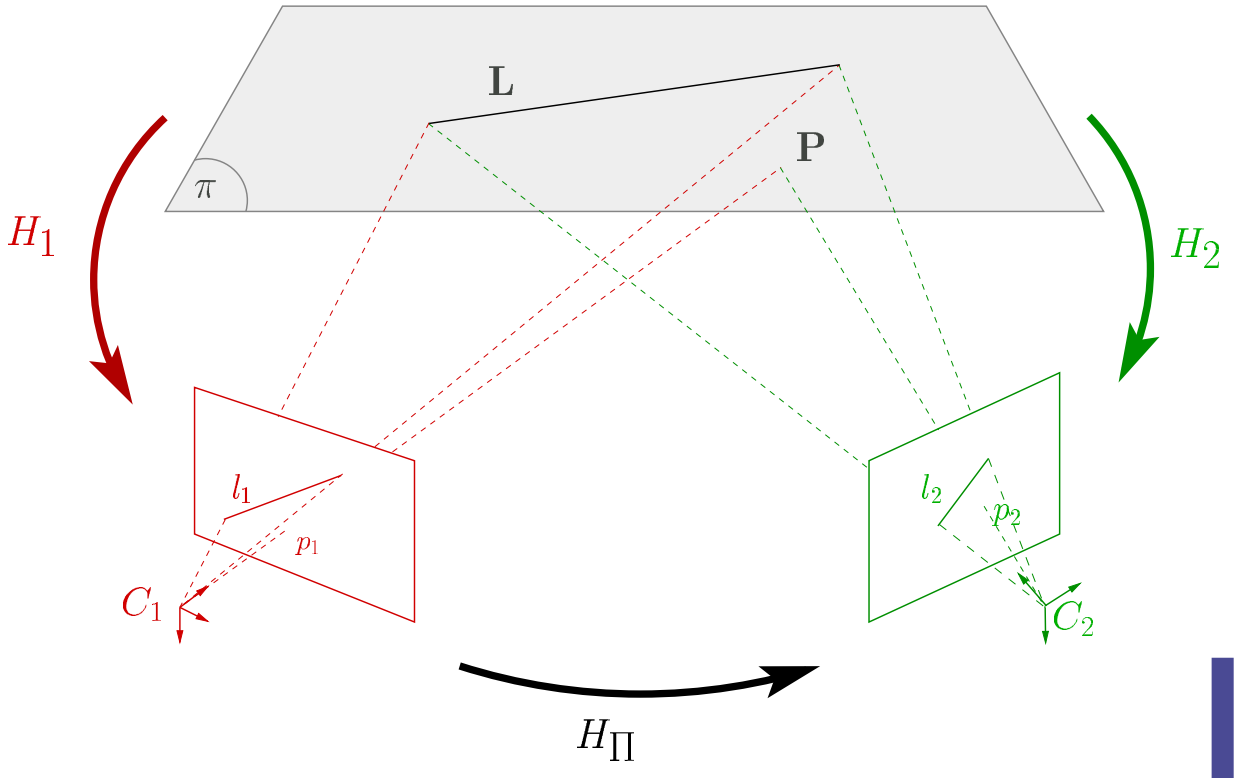
then

$$\mathbf{l_2} \propto \mathsf{H}_\pi^{-\mathsf{t}}.\mathbf{l_1}$$

$$\mathbf{p_2} \propto \mathsf{H}_\pi.\mathbf{p_1}$$

with

$$\mathsf{H}_\pi = \mathsf{H}_2.\mathsf{H}_1^{-1}$$



Assumptions

- the road is locally planar with parallel boundaries;
- the structured environment contains edges aligned with the 3 orthonormal directions;
- the geometry of the stereo pair is rigid;
- the cameras are un-calibrated with fixed intrinsic parameters;
- the video sequence is recorded at a high frame rate.

Algorithm overview

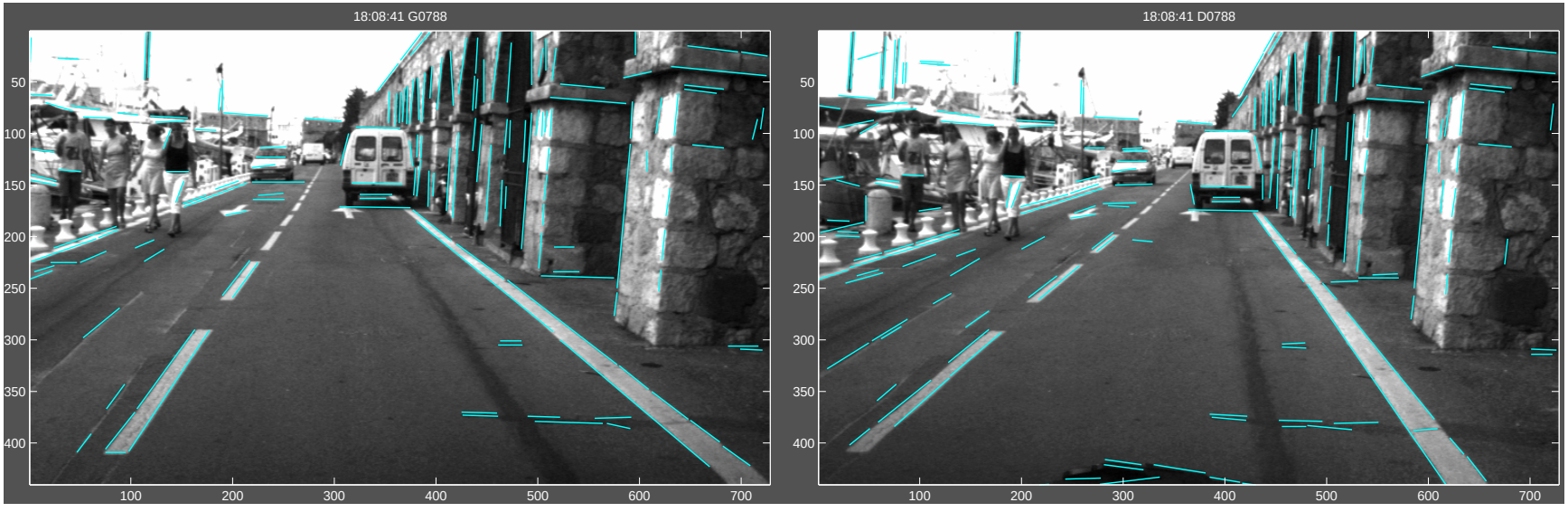
The two-stage algorithm supplies:

1. the segmentation of the road plane in images:
   - the Vanishing Lines (VLs);
   - the Dominant Vanishing Point (DVP).
2. the estimation of the vehicle ego-motion:
   - the coplanar Feature Points (FPs);
   - the homography of the road plane between images of the stereo pair.

Segmentation of the road area in images

The road segmentation requires 5 steps:

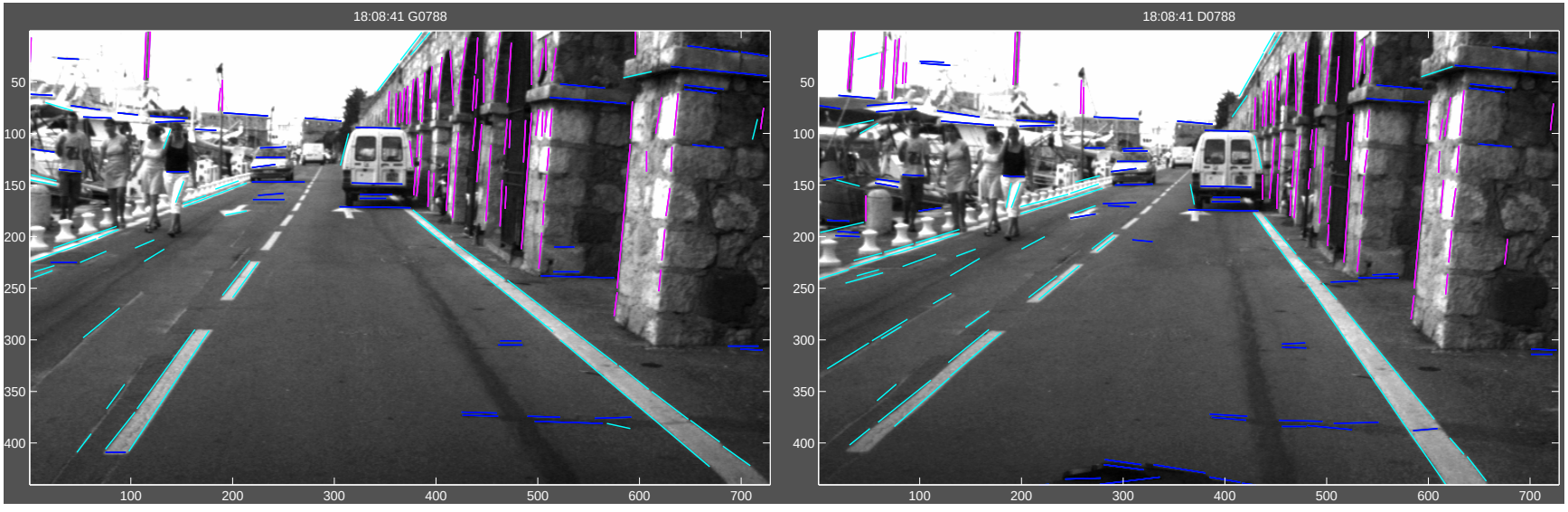
1) a Canny edge detection;



Segmentation of the road area in images

The road segmentation requires 5 steps:

2) an edge classification;



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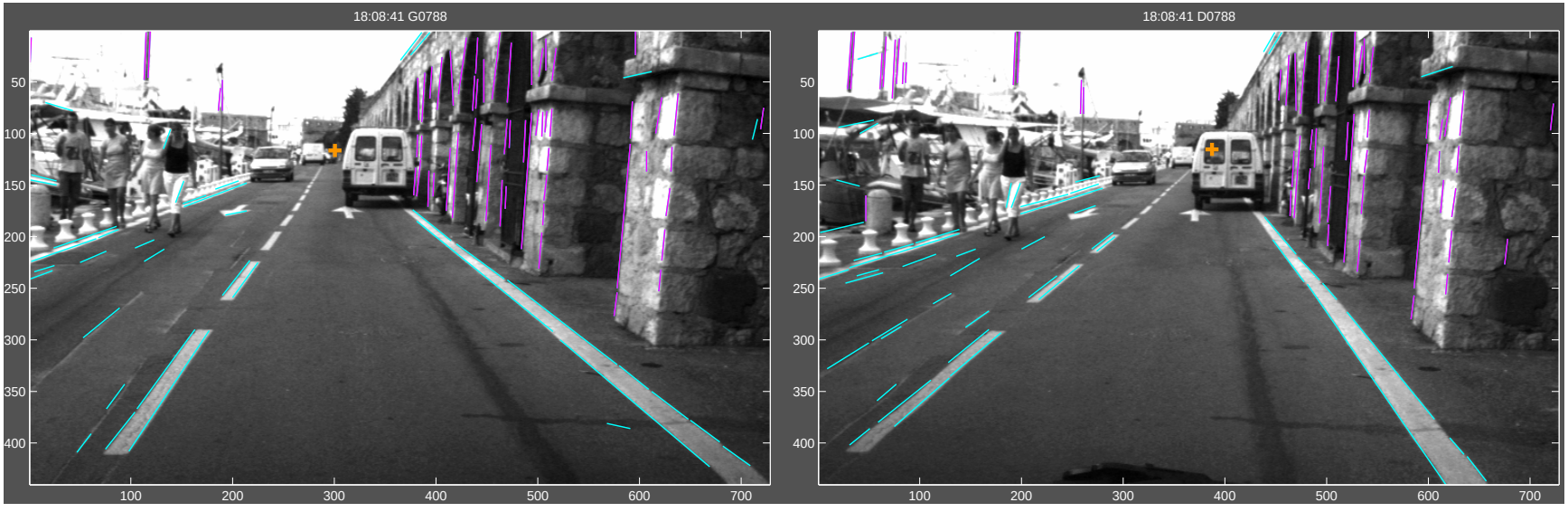
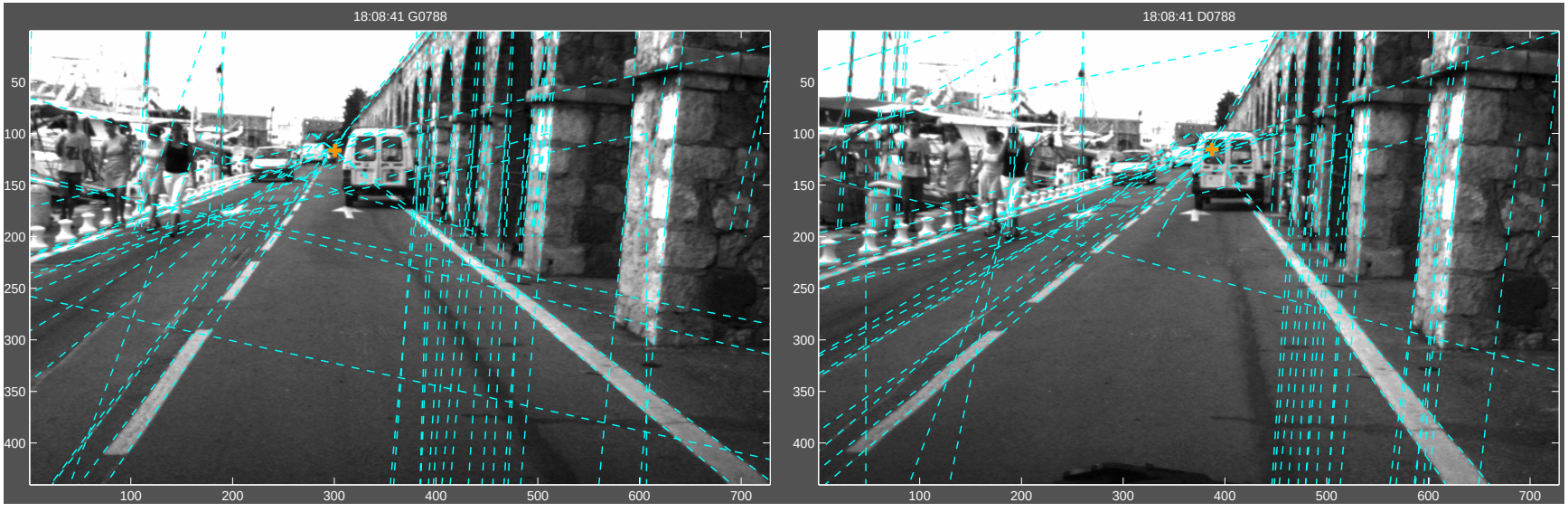


Segmentation of the road area in images

The road segmentation requires 5 steps:

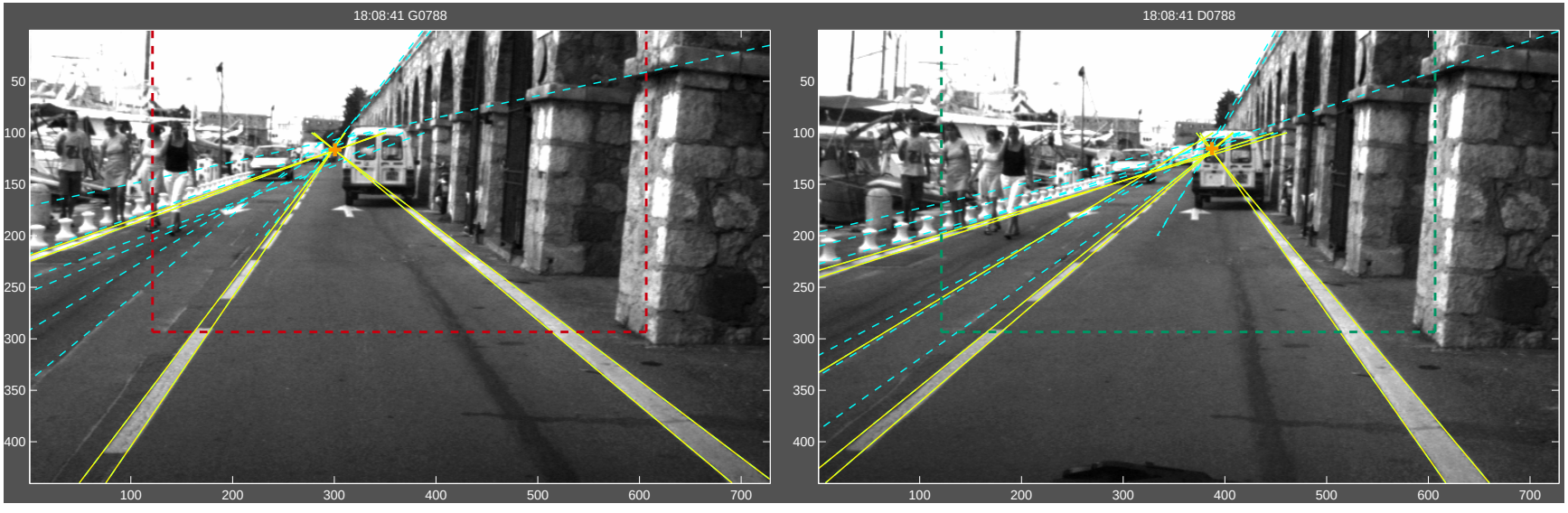
3) a clusterization of segments with fitting lines;



Segmentation of the road area in images

The road segmentation requires 5 steps:

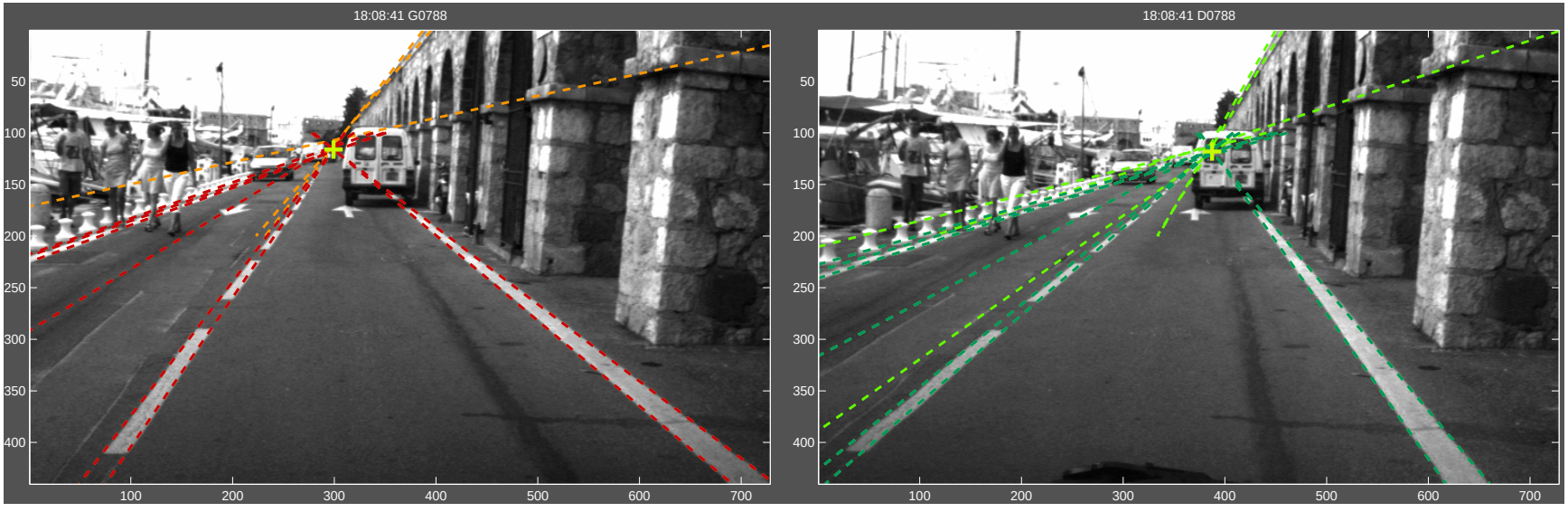
4) a selection of lines “near” the prediction of the DVP location;



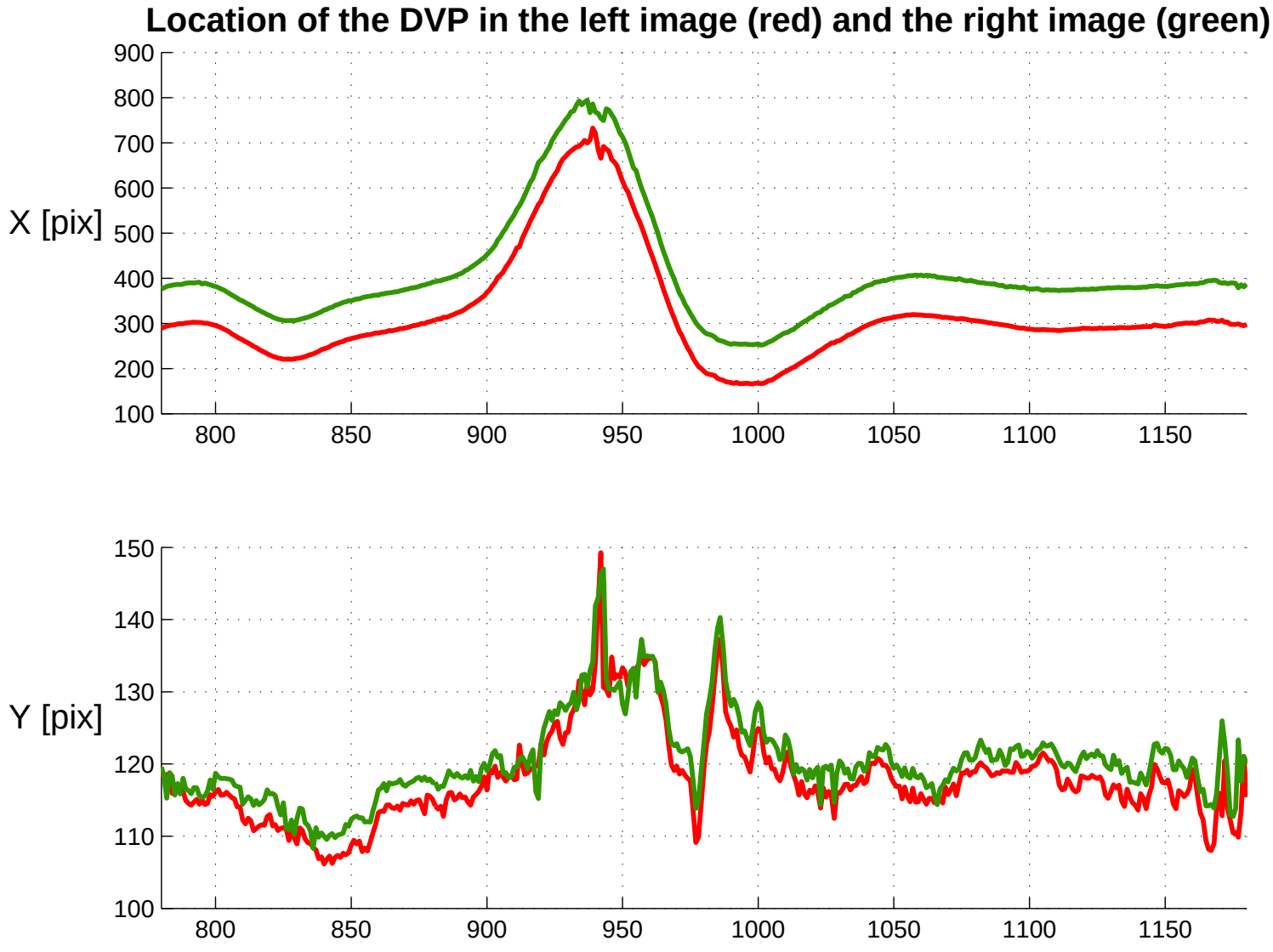
Segmentation of the road area in images

The road segmentation requires 5 steps:

5) a matching of coplanar lines by verifying the unicity of their cross-ratio.



Location of the DVP in images



The Feature Points

The coplanar VLs converge to the DVP

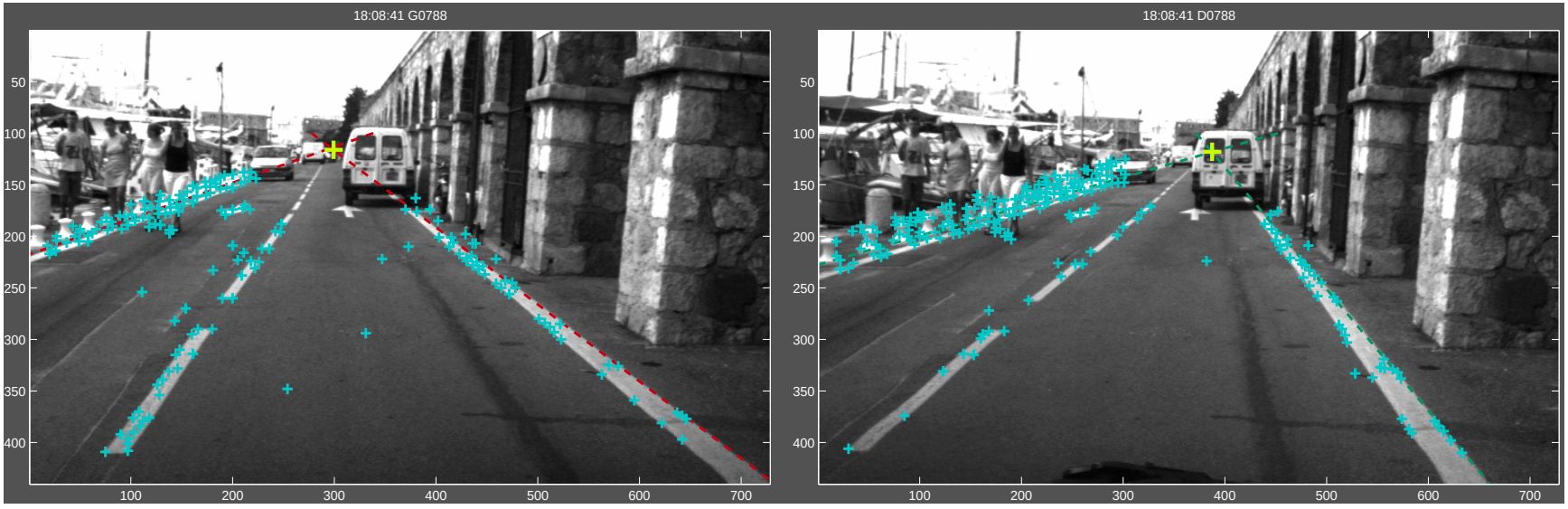
$\Rightarrow$ we detect, then match, FPs lying on the road plane.

- The extraction of FPs strongly depends on the road characteristics.
- The difficult cases are:
  - an unstructured road with a uniform texture;
  - dynamic obstacles (shadows, cars, pedestrians) which generate bad matches.

Extraction of coplanar Feature Points

The selection of coplanar Feature Points requires 3 steps:

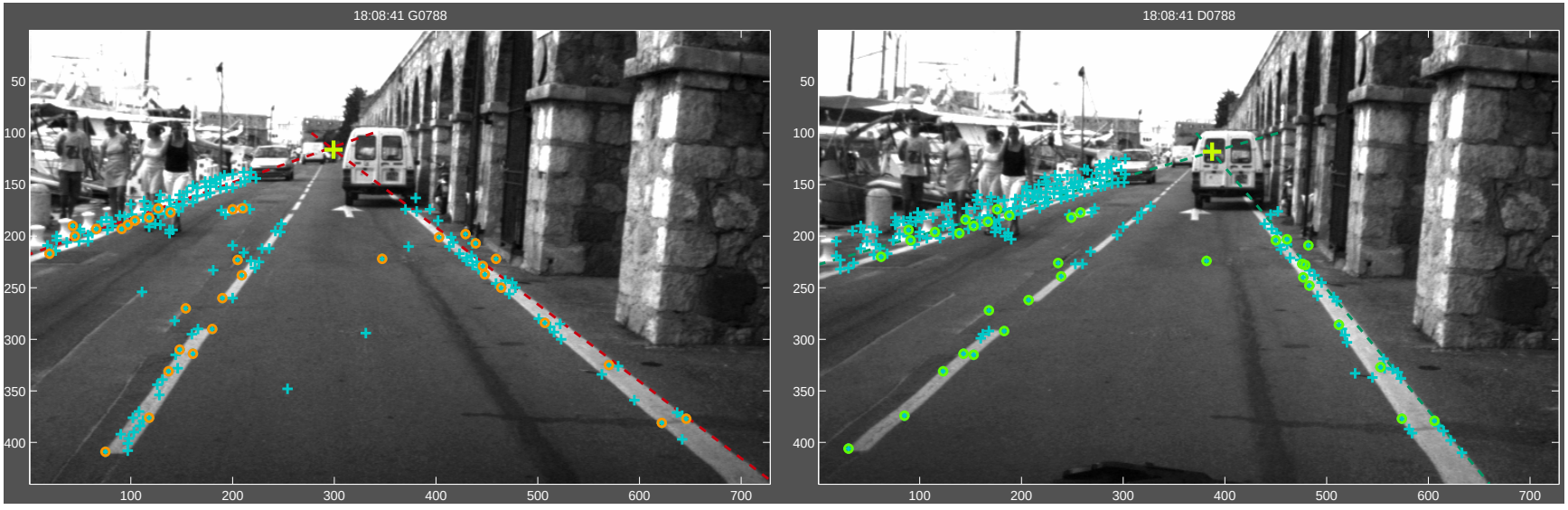
1) a Harris FP detection in the area of the road plane;



Extraction of coplanar Feature Points

The selection of coplanar Feature Points requires 3 steps:

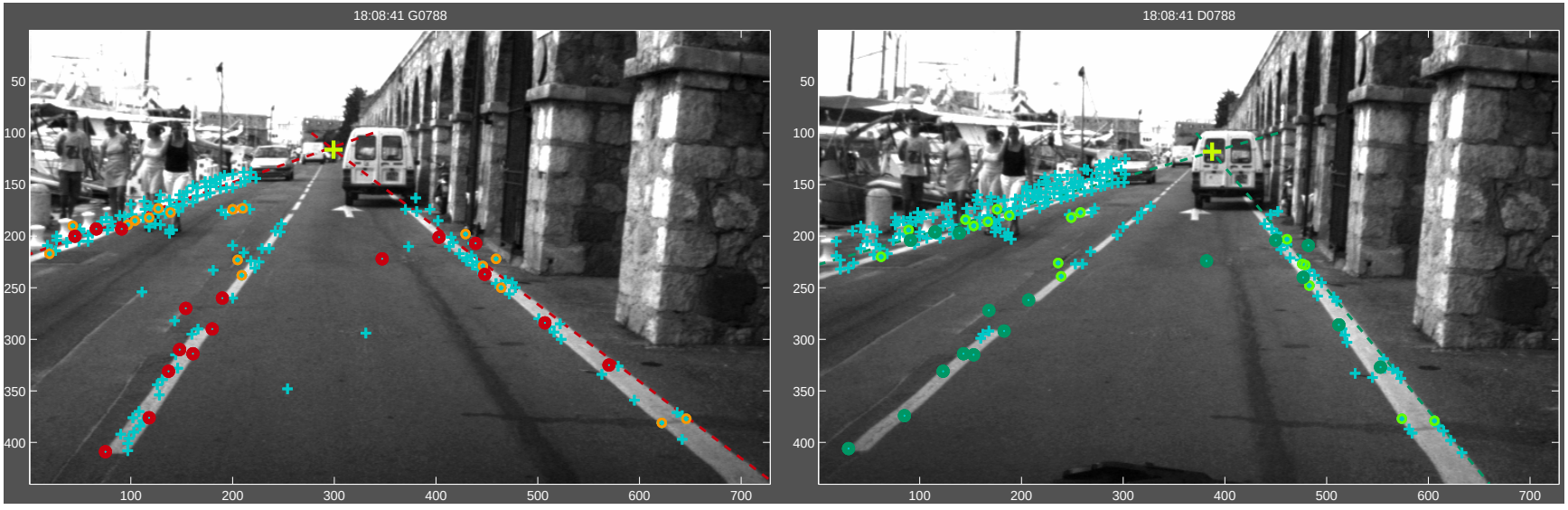
2) a matching between extracted FPs;



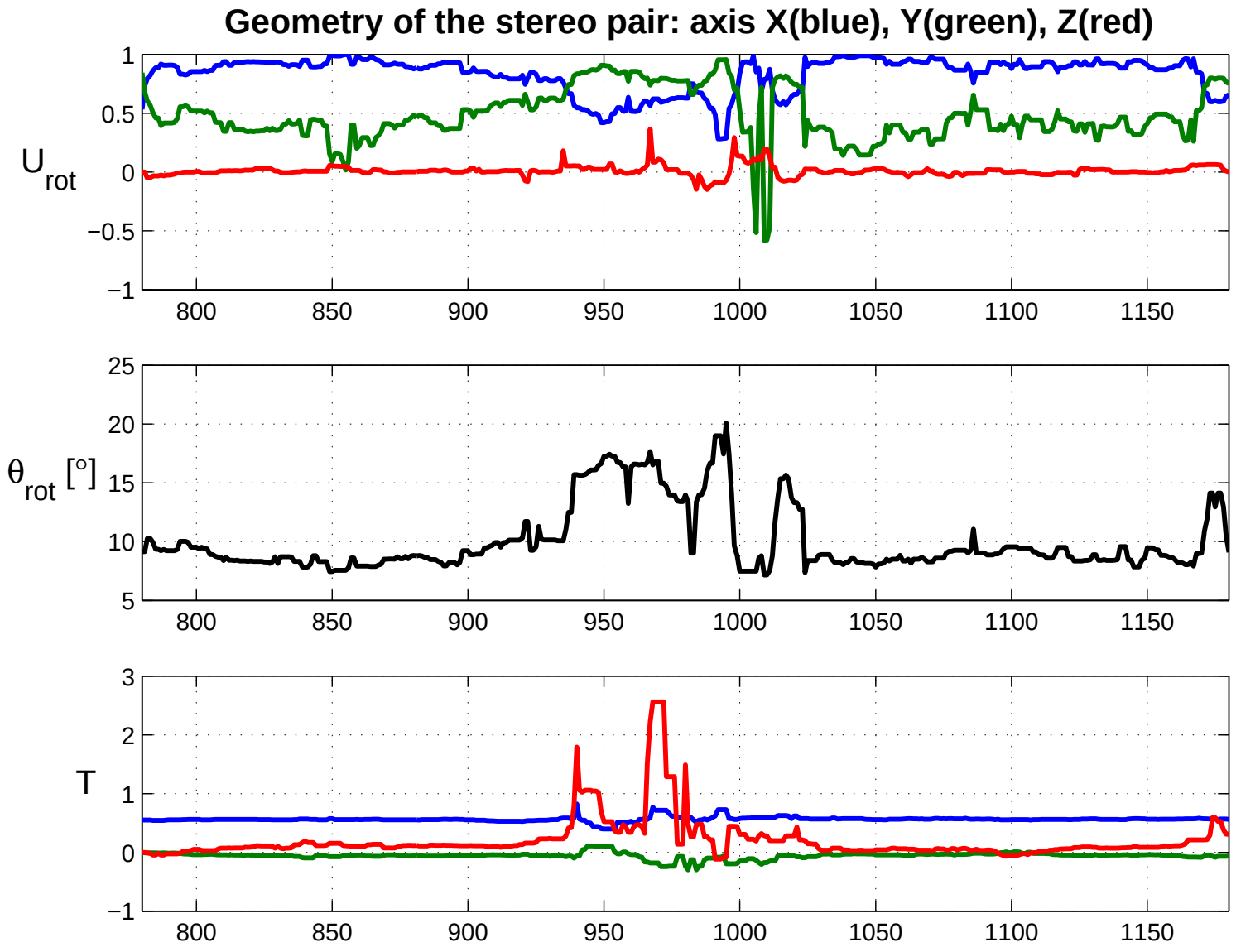
Extraction of coplanar Feature Points

The selection of coplanar Feature Points requires 3 steps:

3) a selection with the homography computation.



Geometry of the stereo pair



Future issues

- estimate the ego-motion of the vehicle considering the coplanar features matched in 2 stereo pairs;
- determine an affine auto-calibration of the stereo pair, using the structured environment;
- improve the robustness by introducing a filtering process.

Questions ?

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