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Visual Odometry

Application of Computer Vision to Trajectory Estimation

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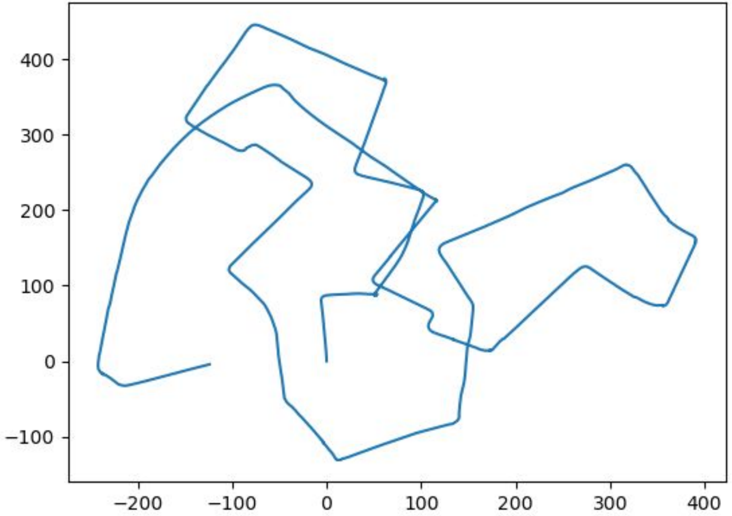
Visual odometry

Determining the position and orientation of a vehicle based on camera images

Video



Trajectory

Applications

Autonomous vehicles

Drones

Robotics

Rough terrain

Space exploration

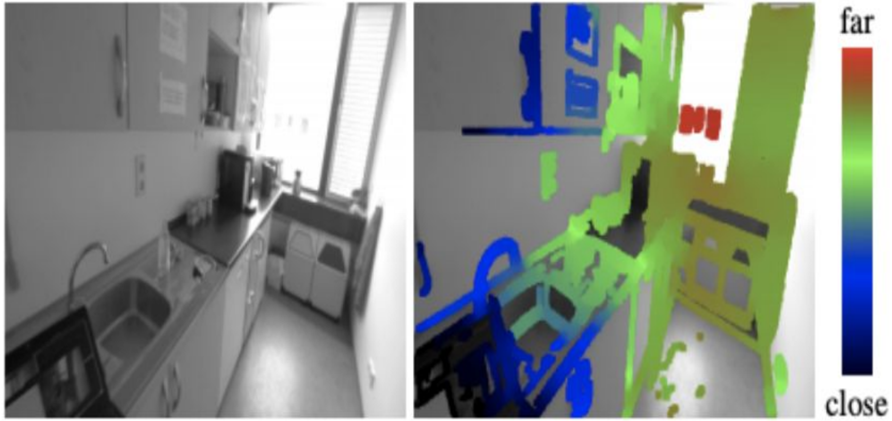
Agriculture

Types of cameras

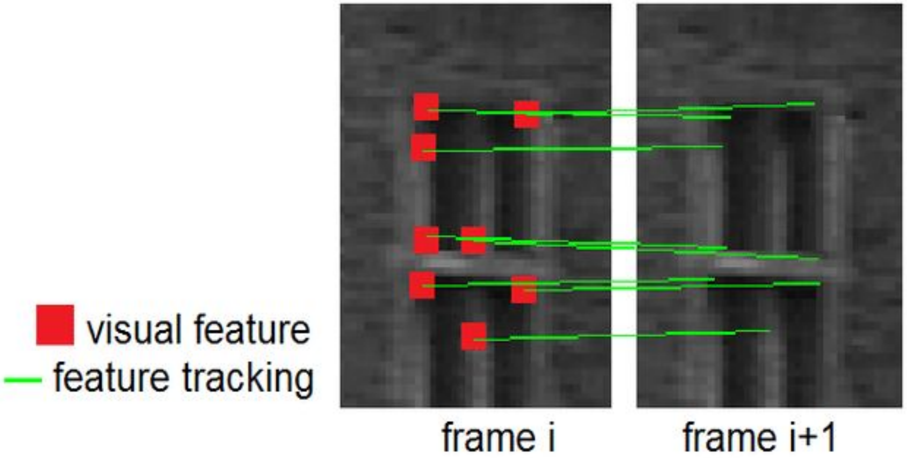
Stereo cameras allow to determine depth

Approaches

Direct methods



Feature-based methods



Limitations and risk analysis of the problem

- Bad weather or lighting conditions
- Requires good image quality
- Needs a fast CPU/GPU
- Might be inaccurate
- Difficult to use in real time

Why not traditional odometry?

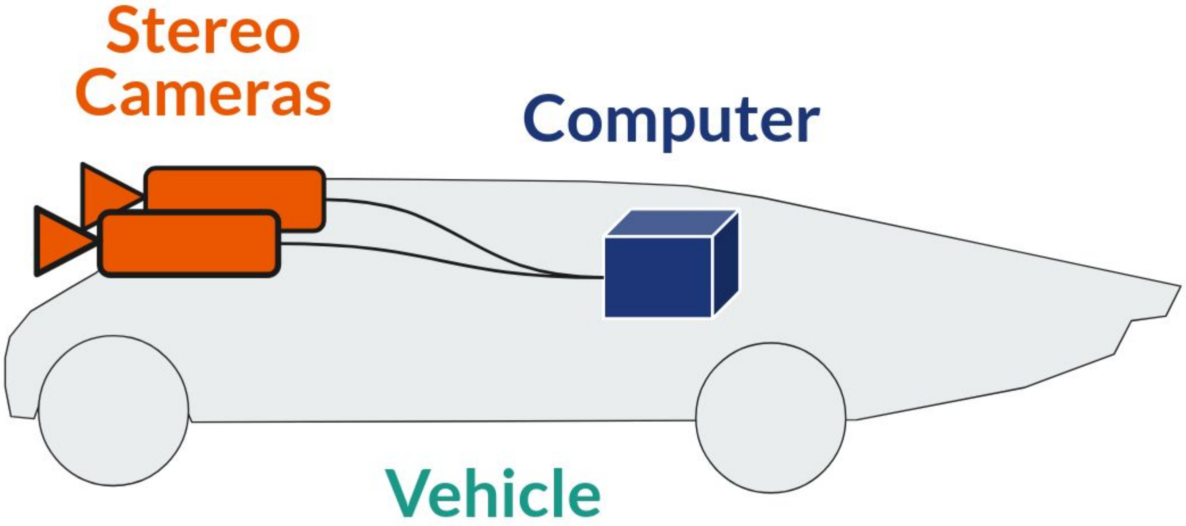
- Does not provide full trajectory, just the distance from the beginning.
- Cannot detect loops in the trajectory.
- Has less research value.

Assumptions

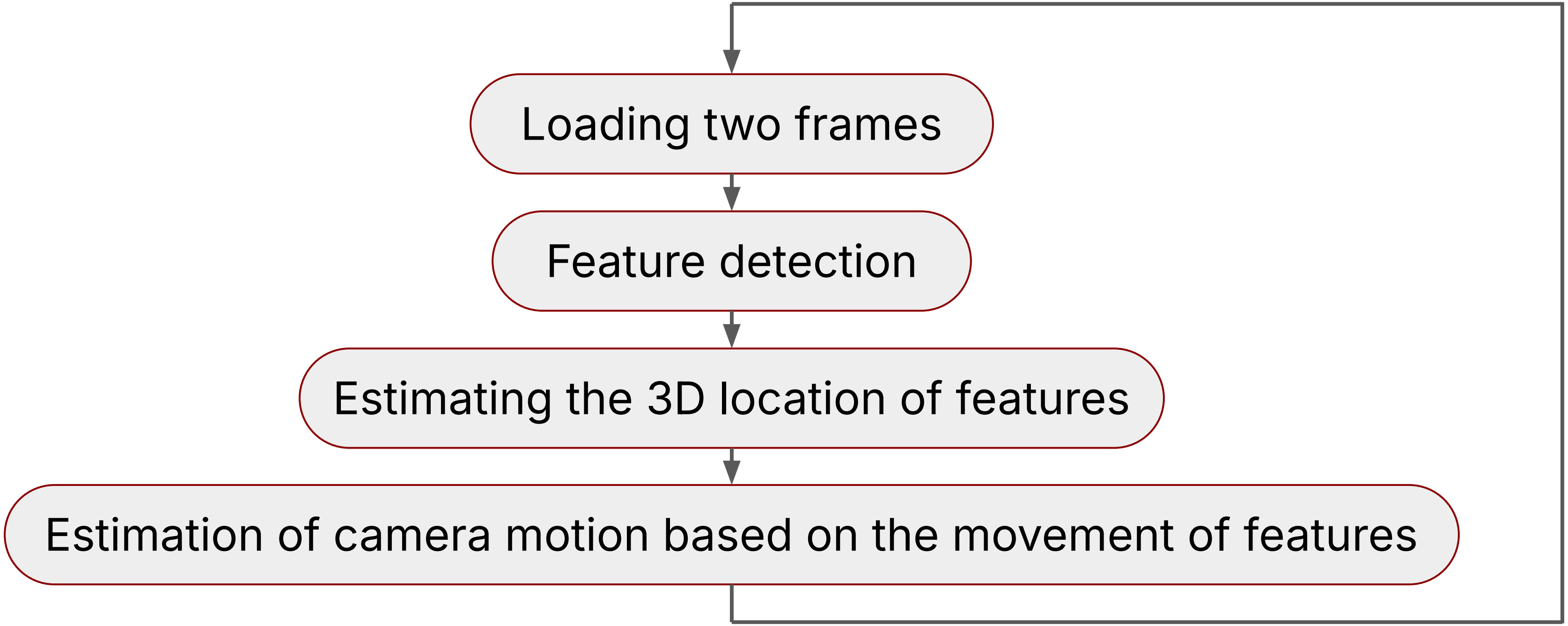
Adequate lighting

Stable image

Similarity between frames



Outline of the algorithm

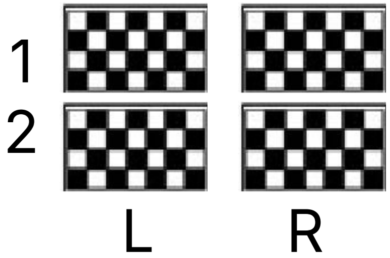


Camera calibration and image preparation

Internal parameters

Image distortion

Relative position of both cameras



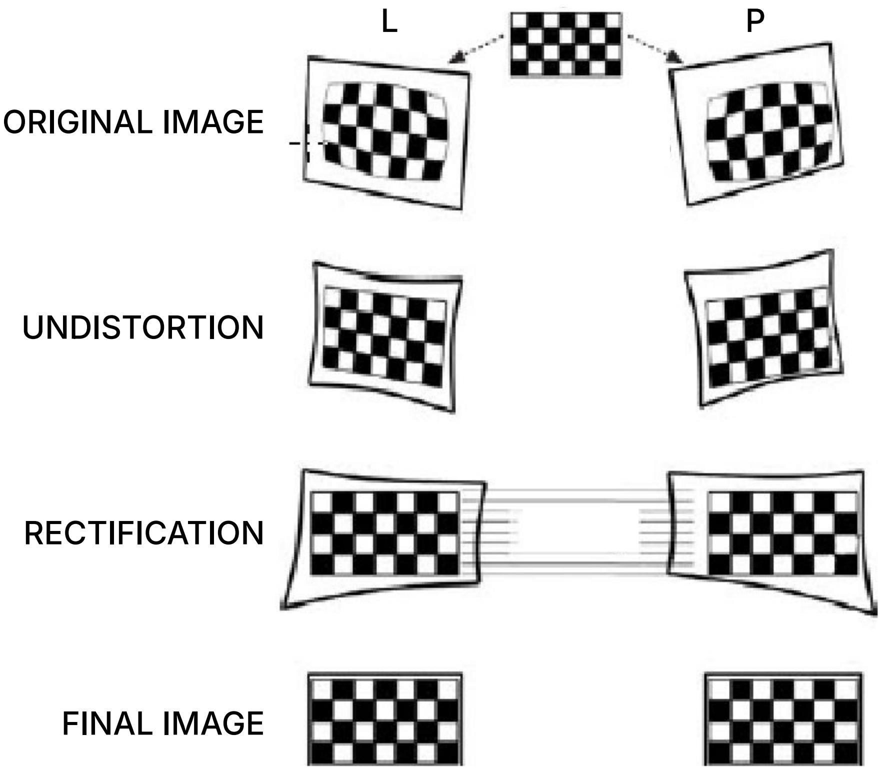
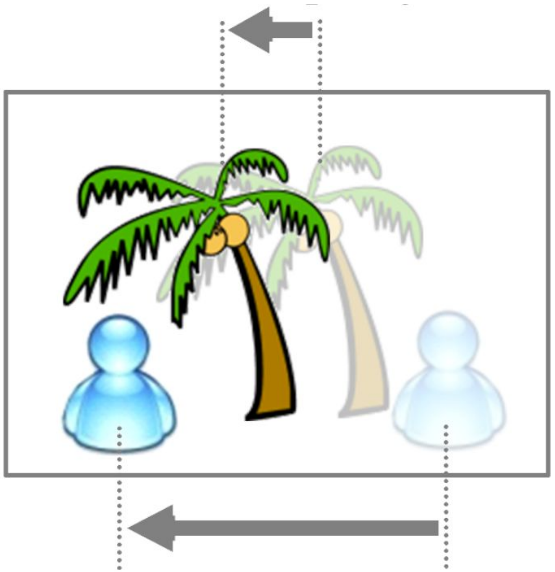


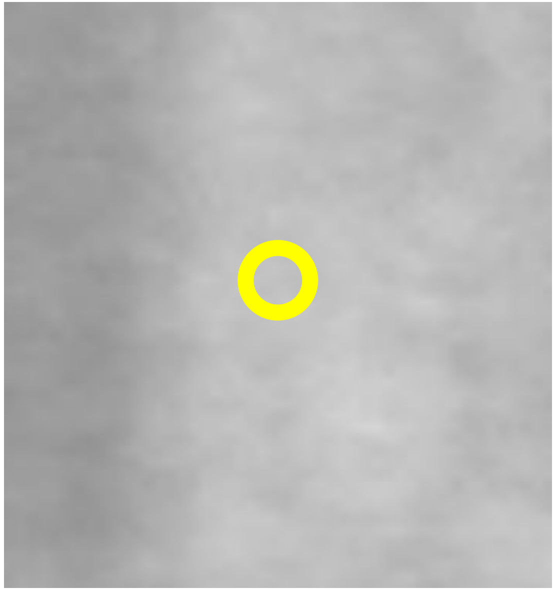
Image depth determination



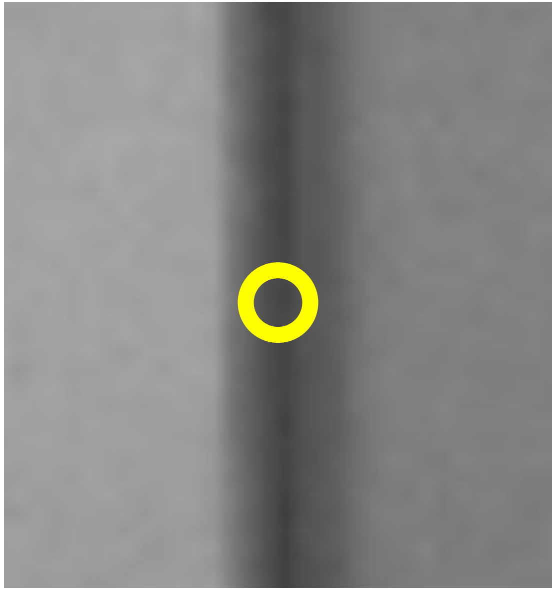
Disparity

The distance between corresponding pixels in the left and right images.

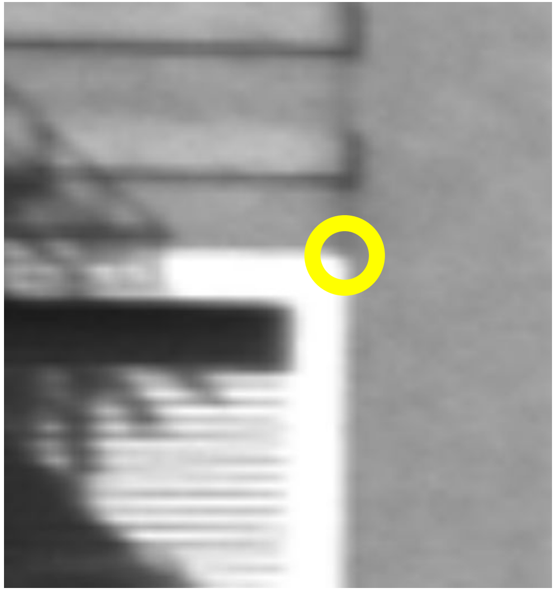
Feature (corner) detection



❌ Wall

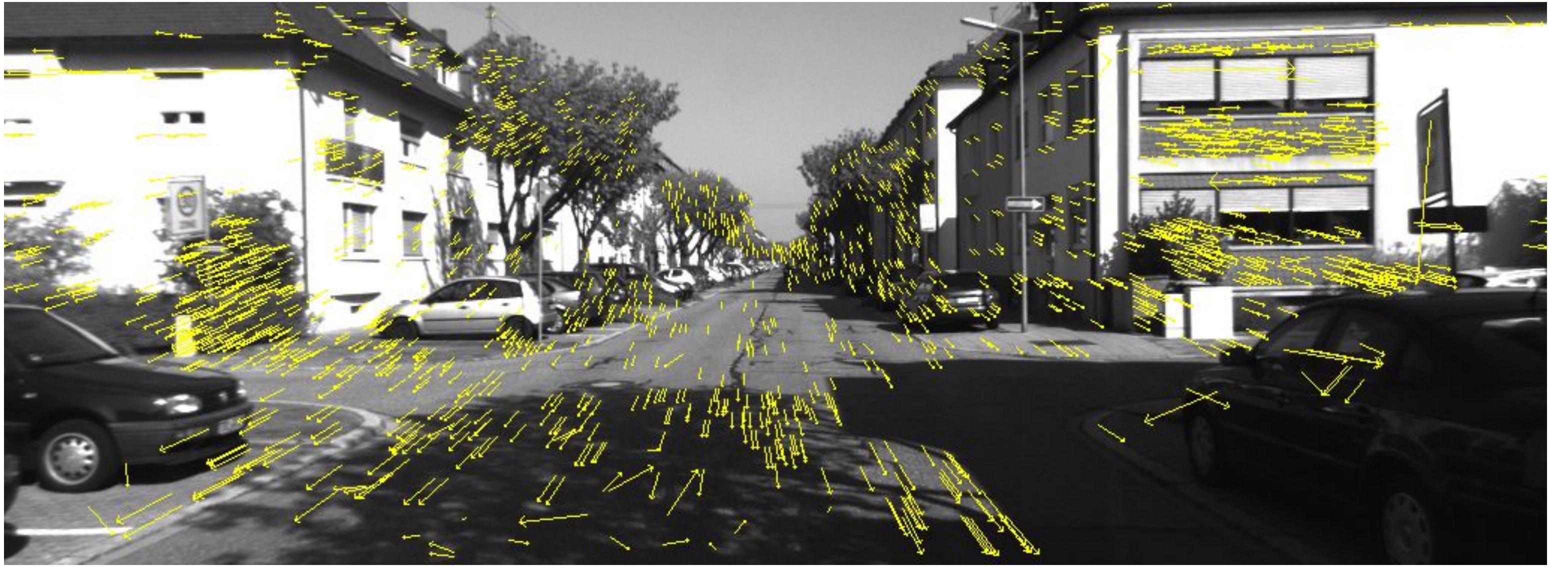


❌ Edge of a building



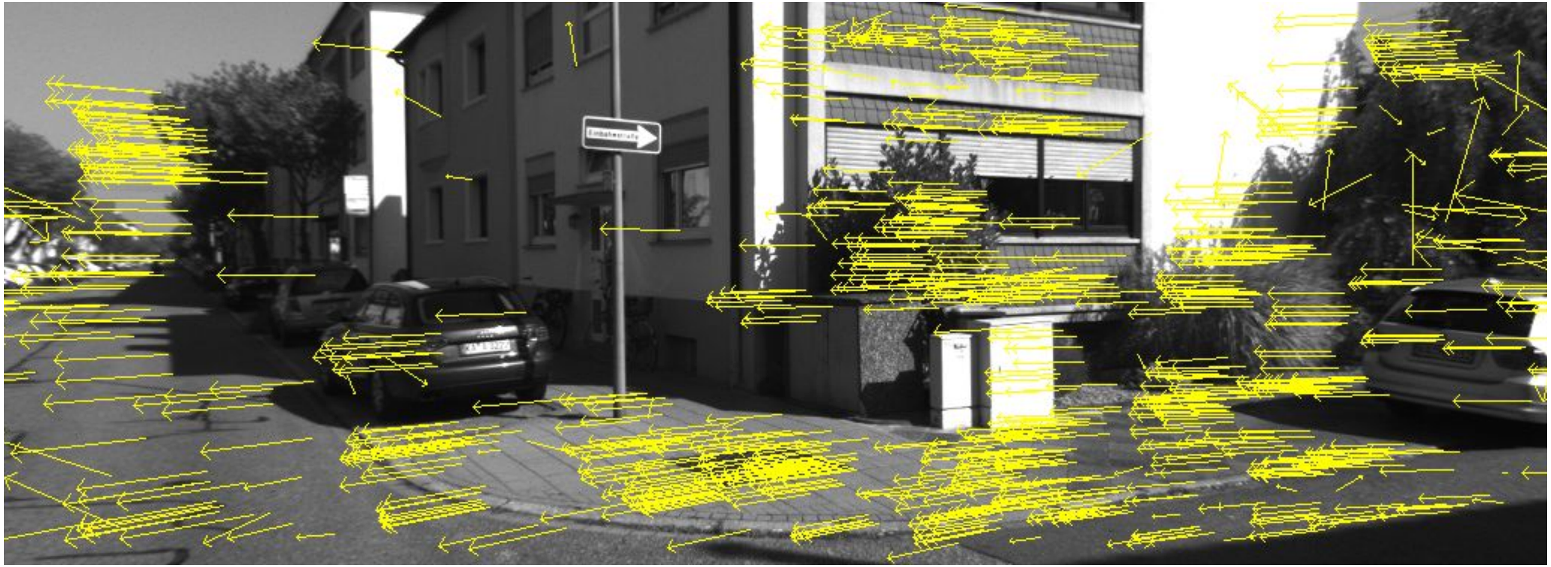
✔ Corner of a window

Feature tracking



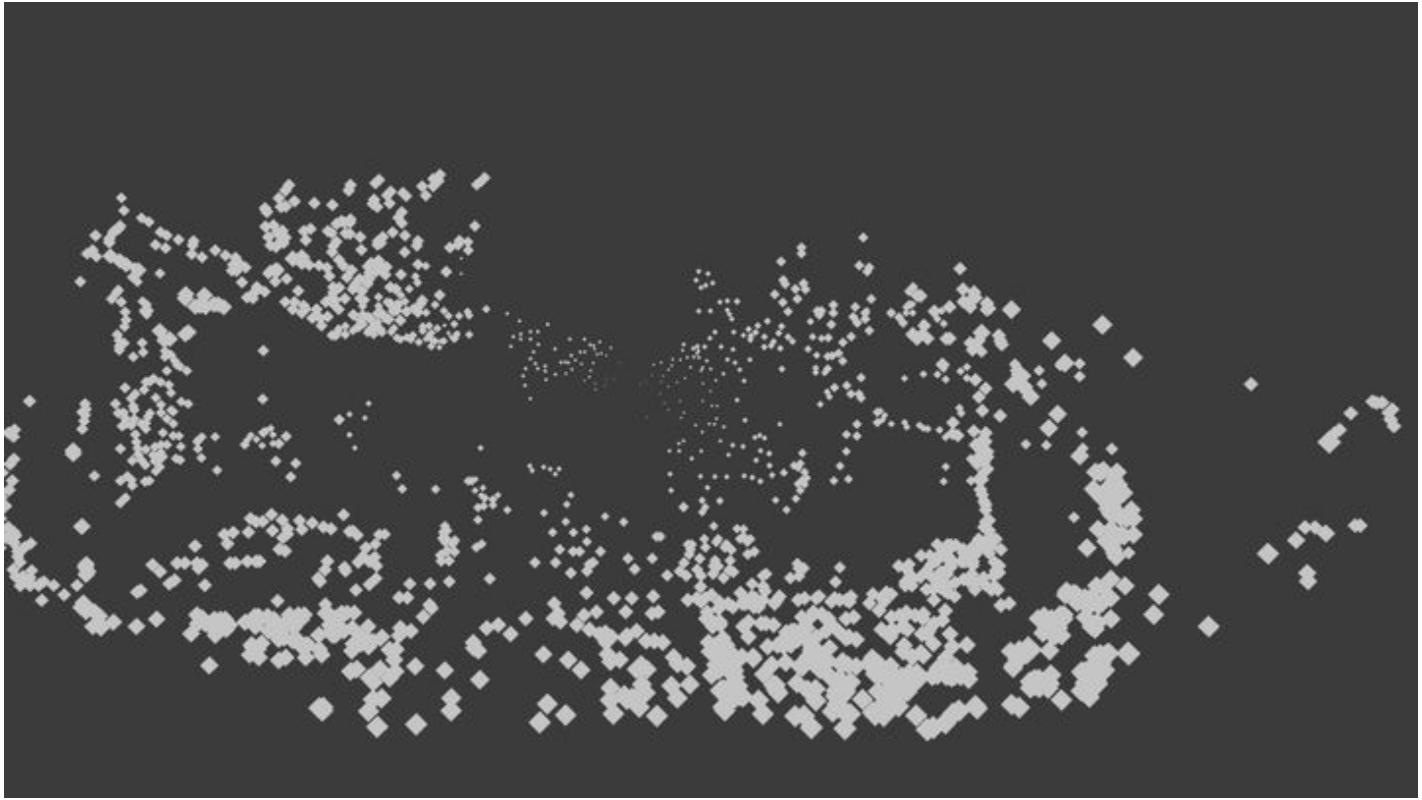
Displacement of features compared to the previous frame

Feature tracking



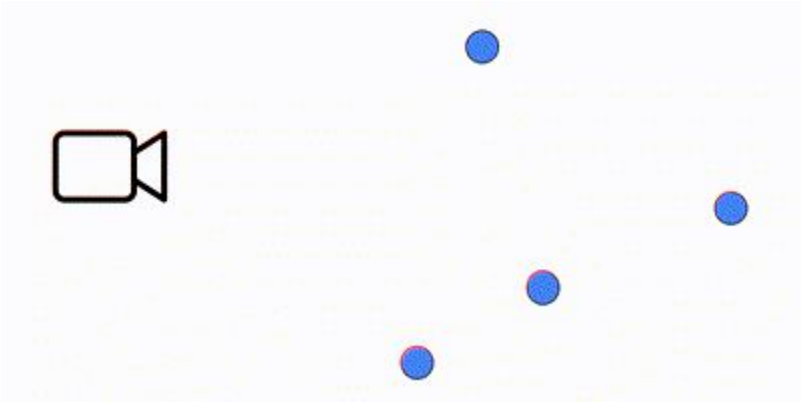
Displacement of features compared to the previous frame

Determining the 3D location of features

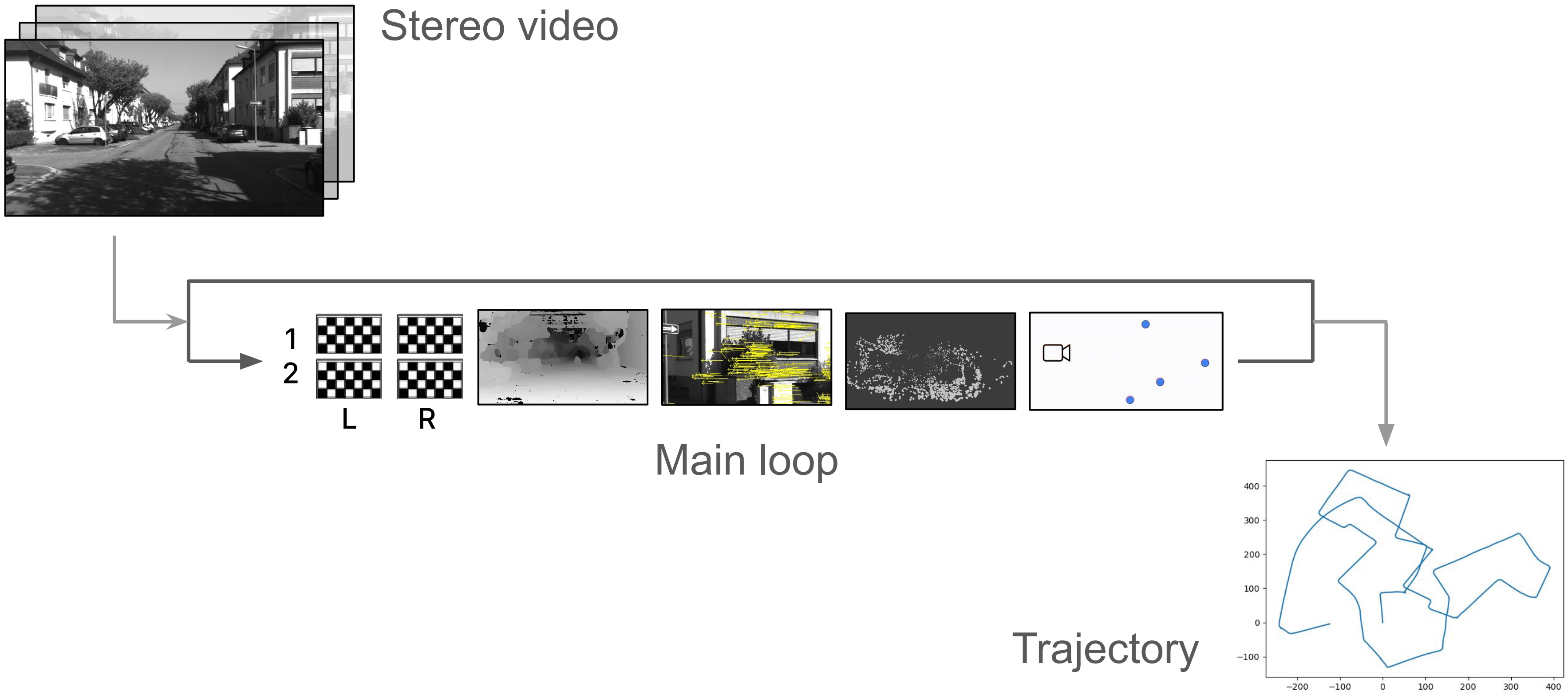


What movement caused this impression?

- We compare the 3D positions of the features in two consecutive frames
- We determine the approximate transformation of the camera (translation + rotation) that explains these displacements



Complete algorithm



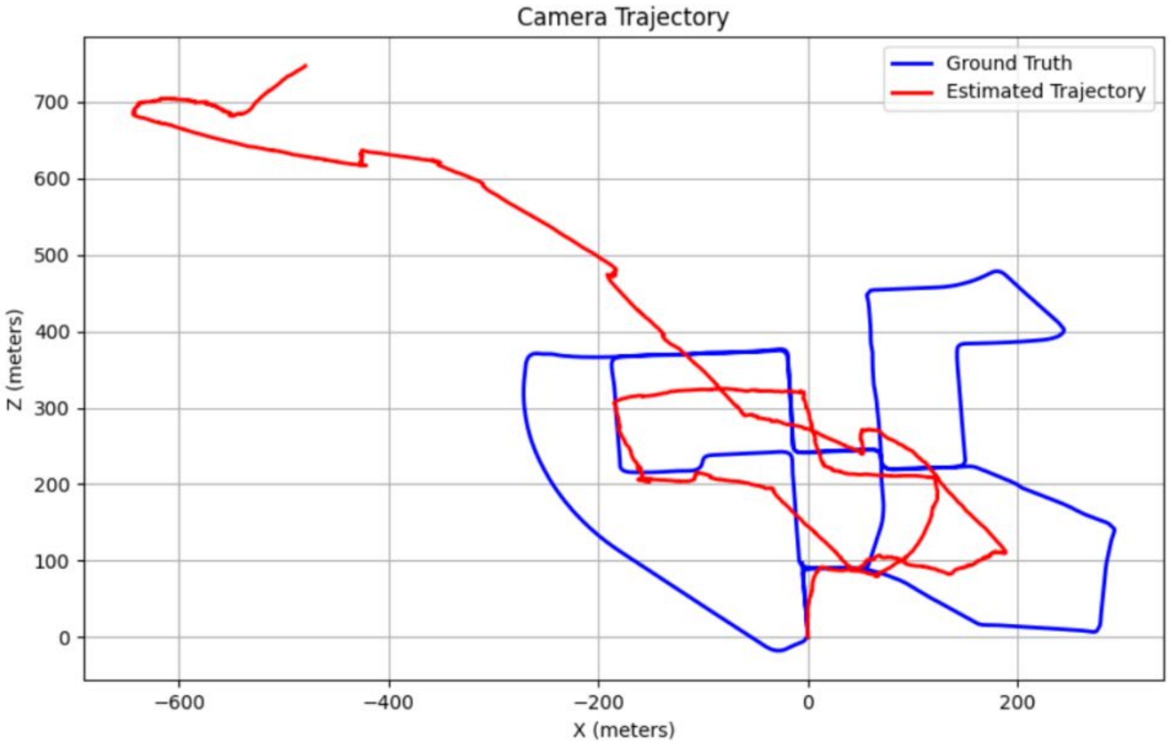
Testing and evaluation

Evaluation of our System

KITTI Visual Odometry Dataset

Tests with our Data (ZED 2i)

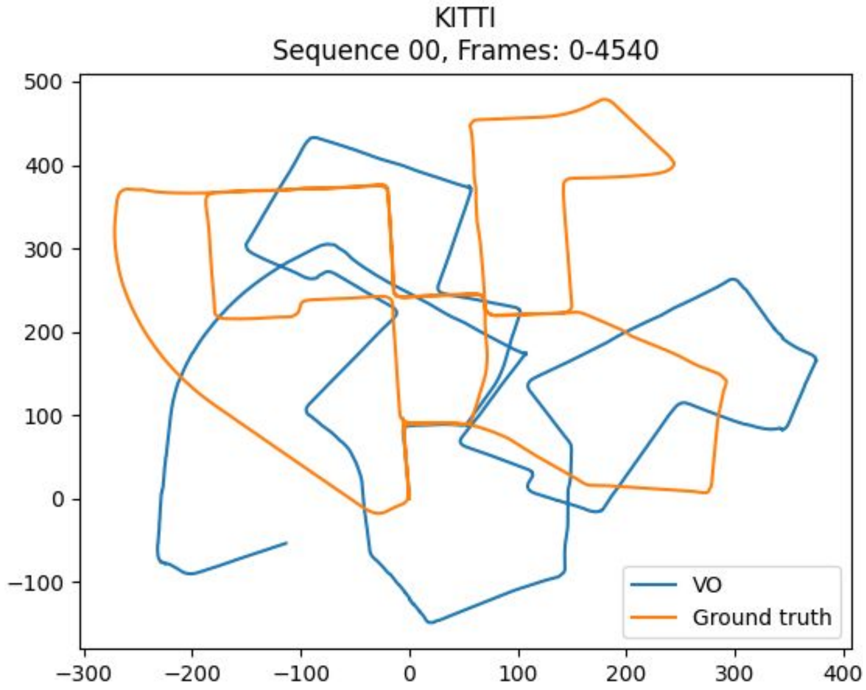
Results



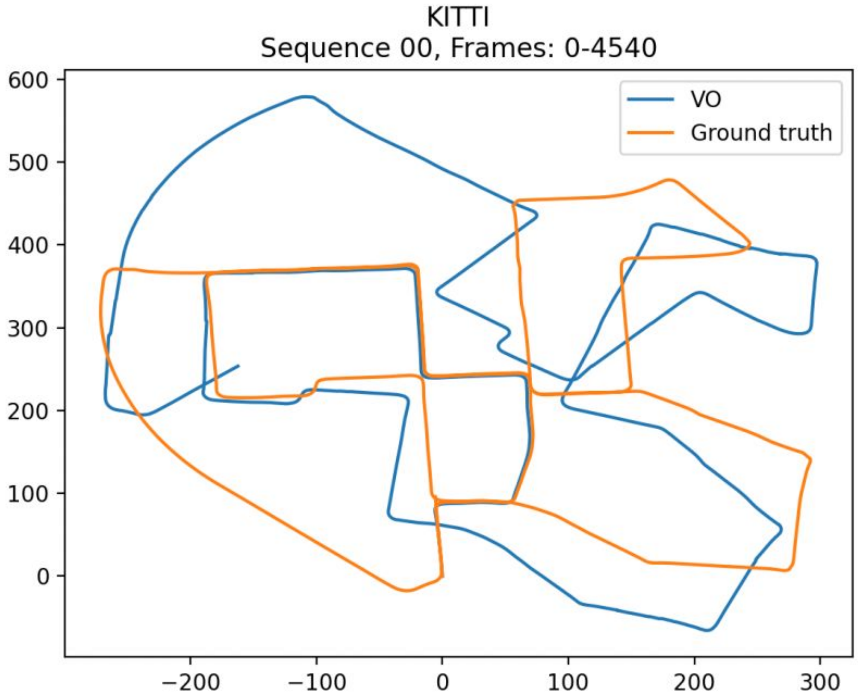
Camera Trajectory
Ground Truth
Estimated Trajectory
700
600
500
400
300
200
100
0
Z (meters)
−600
−400
−200
0
200
X (meters)

V1

Results



V2

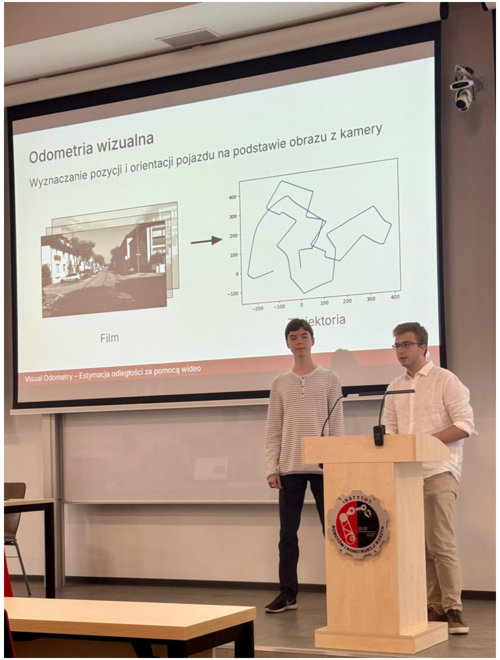


V3

Further development

- Development of real-time capabilities (integration with ROS2)
- Improvement of the algorithm
- Optimisation of the algorithm
- Combining data from other sources (GPS, IMU, wheel odometry, steering wheel angle)
- Extension to SLAM (Simultaneous Localization and Mapping)

Recognition of our work and inter-university collaboration



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Images

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