Automated Camera Stabilization and Calibration for Intelligent Transportation Systems

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1. Approach

In this paper we propose two algorithms to solve distinct problems that arise from the real-world disturbances that act upon the Intelligent Transportation System.

1.1. Dynamic stabilization

The gantry bridges to which the cameras are mounted are prone to environmental influences. These influences include, but not exclusively, wind and vibrations from passing vehicles. These external influences bring the cameras into a swinging state which introduces jittery motion in the video feeds.

Although the displacements of the camera only span a small range around its resting position, the influences in on the images amplify by the huge distances the cameras overview.

To mitigate the noise added by the jittery motion we propose the pipeline displayed in Figure 1.

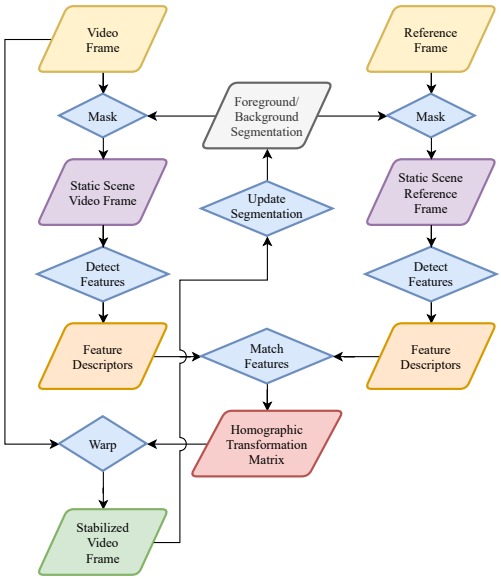

Figure 1.

Frame retrieval The first step in the algorithm is to retrieve the current frame from the camera.

Removing dynamic foreground scene We only want to find features on the non-moving static scene objects, *e.g.* the road, poles, guardrails and bridges. As these features are expected to not move between frames, aligning these during image warping ensures that the scene stays static. Moving vehicles are thus excluded from the detection and do not contribute in the algorithm.

Hence, we mask the current video frame and the stable reference frame using a background segmentation based on the *Improved Adaptive Gaussian Mixture Model for Background Subtraction* proposed by Zoran Zivkovic *et al.* [10, 11, 4].

Additionally it speeds up the algorithm.

Maybe append more about warmup for MOG2.

Feature detection We are looking for specific patterns or specific features which are unique, can be easily tracked and can be easily compared. (Taken from OpenCV)

Hence, on the static scene of the video frame and reference frame we perform feature detection to retrieve the descriptors and pixel locations of prominent image parts.

There exists many different implementations of feature detectors and descriptors as described by Kumar *et al.* [7]. We mainly focus on the implementations of SIFT [8], SURF [3] and ORB [9] feature detectors and descriptors, Fast [6] feature detector with FREAK [2] feature descriptors and Star [1] feature detector with BRIEF [5] feature descriptors coming from the OpenCV library [4].

Feature matching Feature matching compares the features of one frame to the features of the other frame. A match is reported if the feature descriptors of two compared

features surpass a specific dynamic threshold [8] regarding some feature dependent metric [7]. These feature matches establish a spatial relationship in pixel space between the two frames.

Frame warping

1.2. Static calibration

- HD map based approach
- Optimization algorithm, reprojection error between map and video
- Landmark extraction, mapping, pose estimation
- Watersheder for pixel marking

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