Robust Feature Detection Using Particle Keypoints and Its Application to Video Stabilization in a Consumer Handheld Camera

Semi Jeon, Inhye Yoon, Seungji Yang, Bongmo Kim, Jisung Kim, and Joonki Paik

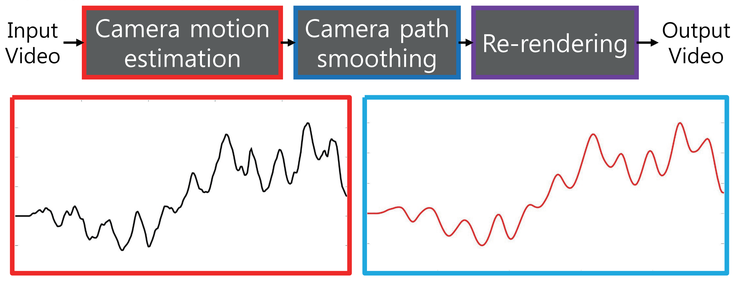
Image Processing and Intelligent Systems Laboratory, Graduate School of Advanced Imaging Science, Multimedia, and Film, Chung-Ang University, Seoul, Korea

Introduction

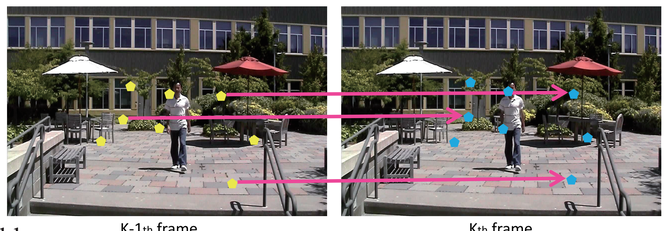
- Handheld cameras
  - Mobile cameras, digital camcorders, drone, action cameras.
  - Increasing attention because of compact size and easy handling.
- Problem of handheld cameras
  - Image sequences acquried by the handheld cameras have undesired motions due to rolling shutter distortion and camera shaking.
- Video stabilization
  - The proposed method is suitable for enhancing the quality of video acquried by consumer handheld image devices.

Background

- The traditional video stabilization method



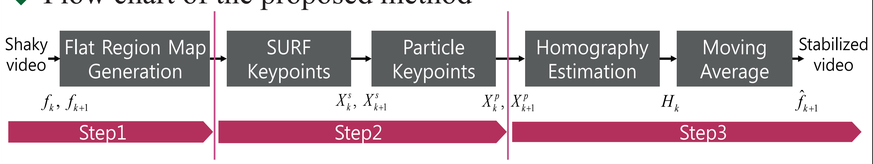
- Video stabilization using feature points



- Problem
  : feature detection failures in flat regions.

Proposed Method

- Flow chart of the proposed method

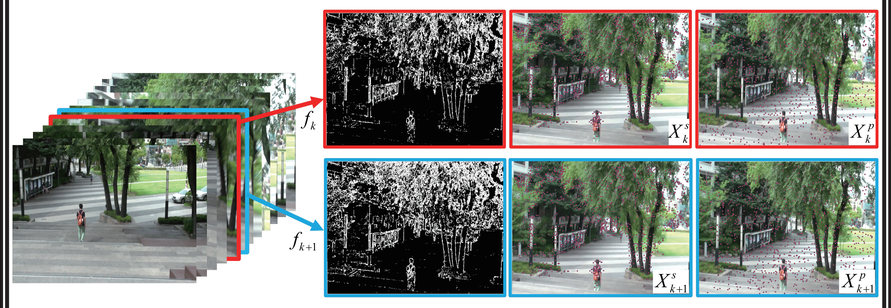


Step1: Flat region map generation
- Generating a spatially smoothed frame by convolving the original shaky frame with a 3x3 Gaussian lowpass filter.
- Absolute difference between the original and smoothed frames.
- Expanding the sharp region using morphological dilation.

Step2: Robust feature detection
1. Extract SURF keypoints

$$X_k^s = \{(x_1^k, y_1^k), \cdots, (x_M^k, y_M^k)\}, \quad X_{k+1}^s = \{(x_1^{k+1}, y_1^{k+1}), \cdots, (x_M^{k+1}, y_M^{k+1})\}$$

2. Randomly generate particle keypoints X_k^p, X_{k+1}^p in the flat region.
   - characterized as Gaussian function $G(\bar{X}_k^s, \Sigma_k)$, $G(\bar{X}_{k+1}^s, \Sigma_{k+1})$
3. Obtain descriptor by distance between SURF and particle keypoints.
4. Extract optimal feature keypoints of each frames using RANSAC to eliminate outliers.



Step3: Camera paths estimation for video stabilization
- Estimate the optimal homography H_k by robust feature points that uniformly distributed in the **entire image**.
- Estimate the global camera path C_k using H_k.
- The global camera path is updated as

$$C_{k+1} = C_k + (Q_k - P_k)$$

- Smooth the estimated original camera path by a moving average filter using the mean of adjacent left- and right-side in the original camera paths.
- Transform the original shaky frame using the smoothed camera path.
- Generate stabilized video frame $\hat{f}_{k+1}$.

Experimental Results

(a) shaky frames (b) stabilized frame using feature points based on **SURF** (c) stabilized frame using **proposed method**

- In comparison, the proposed method has less geometric distortions than traditional method based on SURF keypoints.

Conclusion

- The proposed video stabilization method provides significantly improved video quality using a novel robust feature detection algorithm.
- This work redefines the feature points using the particle keypoints in the region to solve the problem of incorrect feature detection in the flat region.
- Video taken by consumer handheld camera is successfully stabilized.

References

[1] L. Xu and X. Lin, "Digital image stabilization based on circular block matching," IEEE Trans. Consumer Electronics, vol. 52, no. 2, pp. 566-574, May 2006.

[2] A. Litivin, J. Konarad, and W. Karl, "Probabilistic video stabilization using kalman filtering and mosaicing," Proc. Image Video Commun. IS&T/SPIE Symp. Electronic Imaging, vol. 5022, pp. 663-674, May 2003.

[3] S. Battiato, G. Gallo, G. Puglisi, and S. Scellato, "SIFT features tracking for video stabilization," Int. Conf. Image Analysis and Processing, pp. 825-830, September 2007.

[4] B. Pinto and P. Anurenjan, "Video stabilization using speed up robust features," Int. Conf. Communications and Signal Processing, pp. 527-531, February 2011.

2016 IEEE International Conference on Consumer Electronics (ICCE)