Active Covariance Scaling for Feature Tracking Through Motion Blur

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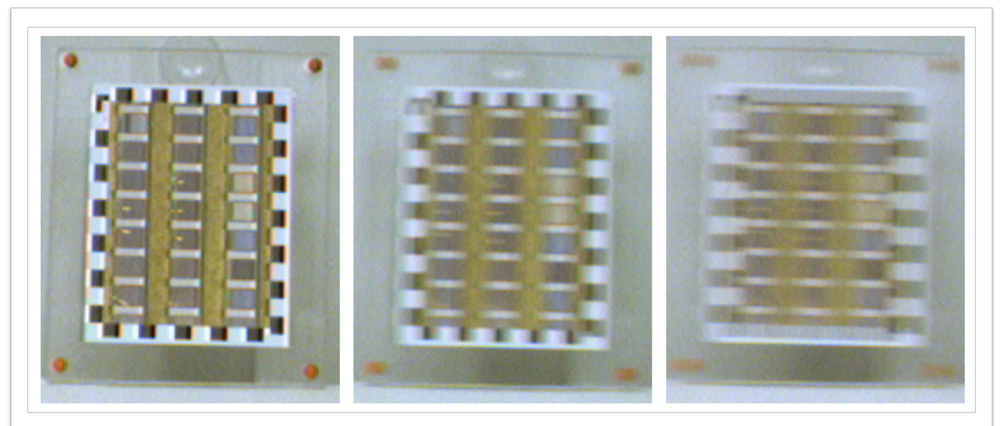
Introduction

For rapidly moving platforms such as micro aerial vehicles, legged robots, and human first responders, it is important to track visual features through fast motions with **substantial motion blur**.



Low blur Medium Blur High blur

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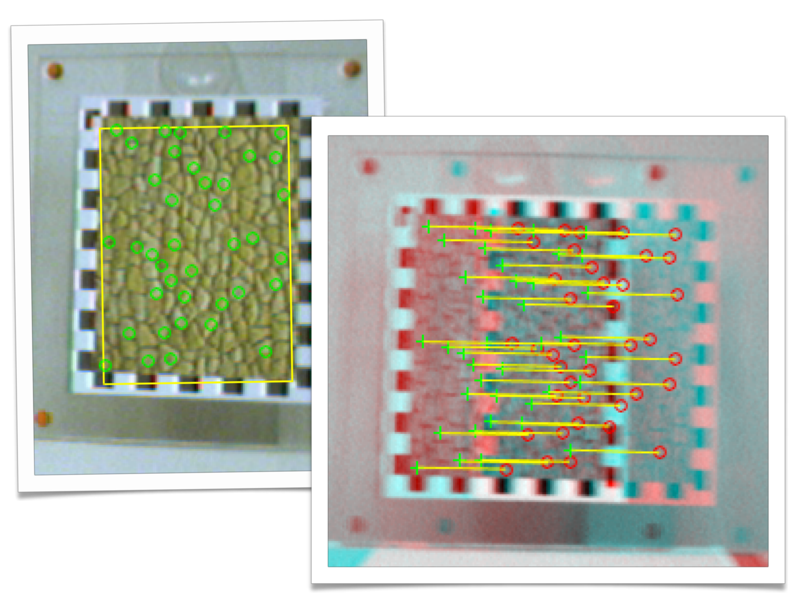
1. How does **feature tracking error** respond to varying levels of motion blur? How do we identify motion blur?
2. Can we account for blur by **actively scaling feature covariance**?

Method



1. **Feature Extraction**

   Extract point features from the textured region in the first image of the sequence.

2. **KLT Tracking**

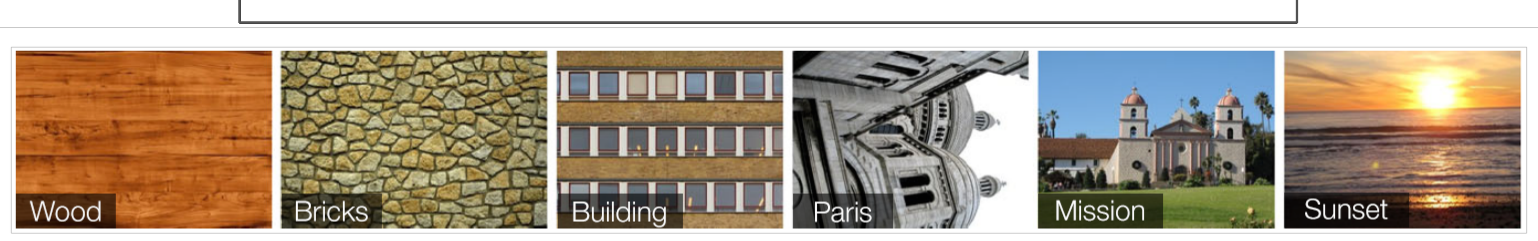
   Track features from frame to frame with Kanade–Lucas–Tomasi tracker.

3. **Error Computation**

   Compute frame-to-frame tracking error using ground-truth homographies.

$$\mathbf{e}_n = \mathbf{p}_n - \hat{\mathbf{p}}_n = \mathbf{H}_{n,n-1}\mathbf{p}_{n-1} - \hat{\mathbf{p}}_n$$

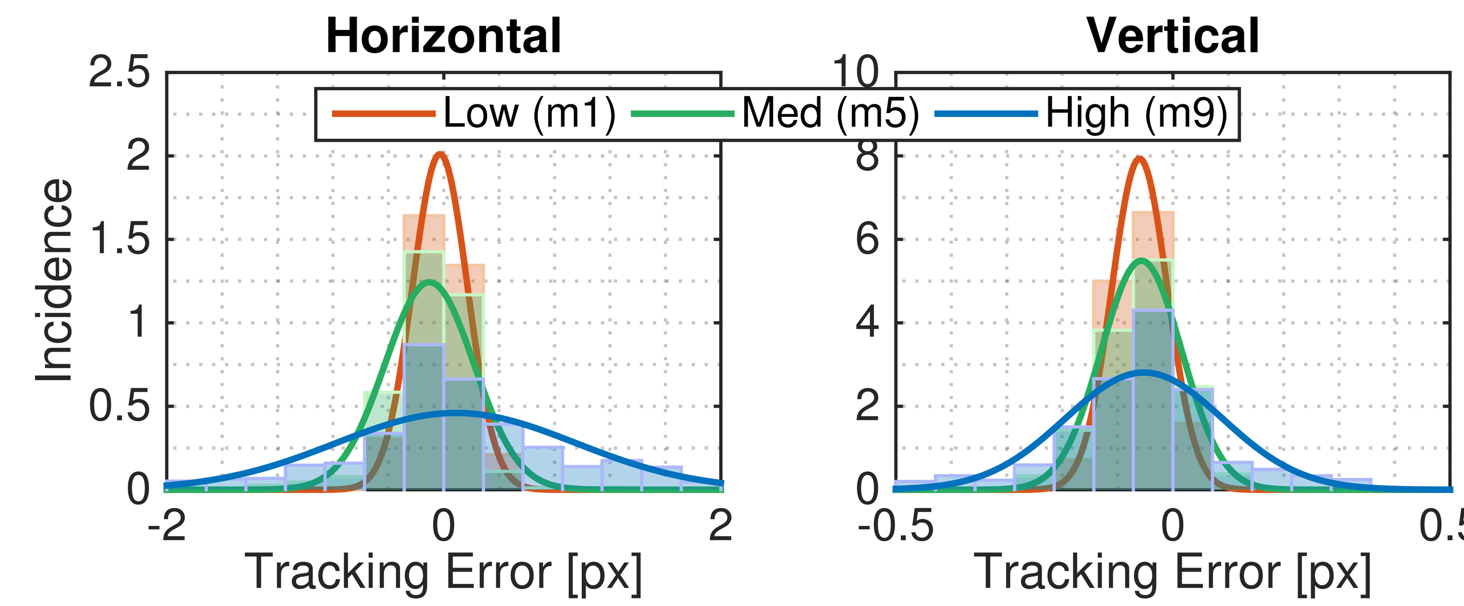
Dataset



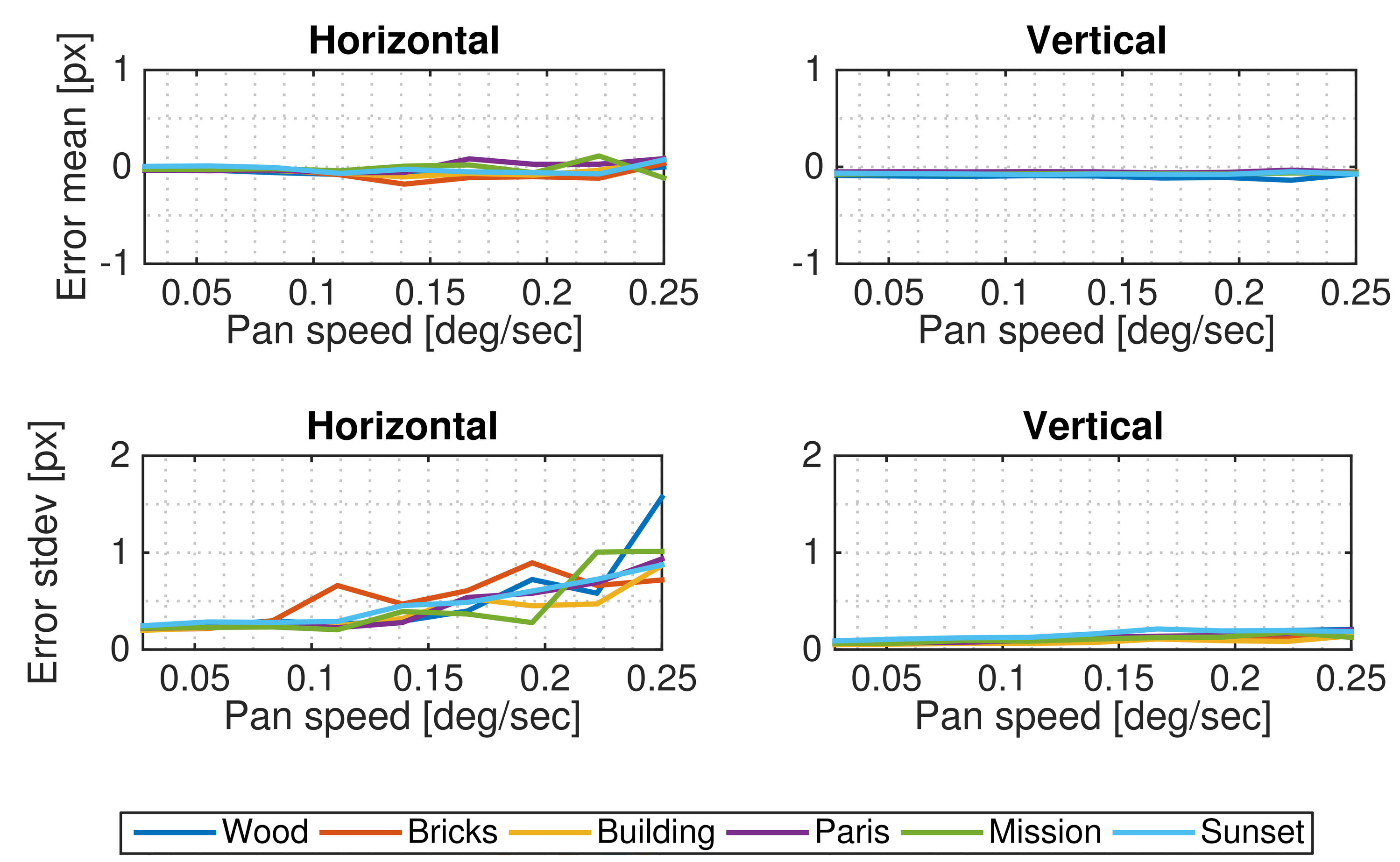
We use the dataset of Gauglitz et al.[1], in which a camera on a pan-tilt head observes one of **six textures** while panning at **nine angular rates**.

Results

Perceived motion blur can be clearly correlated to camera pan speed. As pan speed increases, KLT tracking error remains approximately zero mean and Gaussian, but with increasing variance.

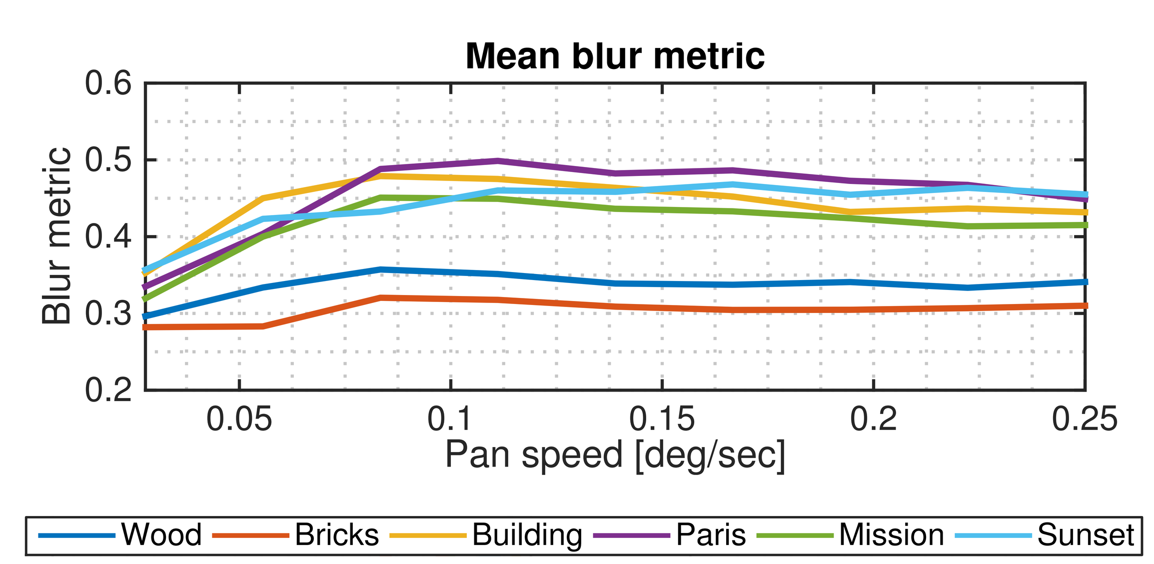


The motions in these sequences are almost purely horizontal, so horizontal motion blur dominates and we see larger tracking errors in this direction than in the vertical direction.



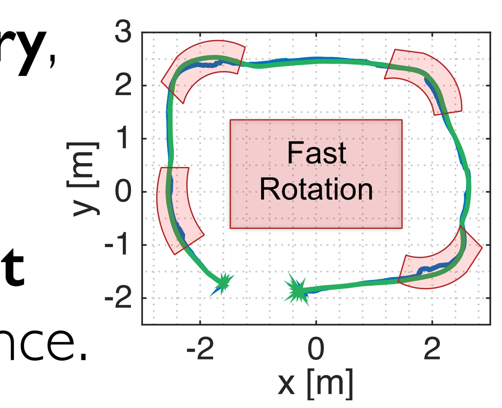
Vision-Based Blur Metric

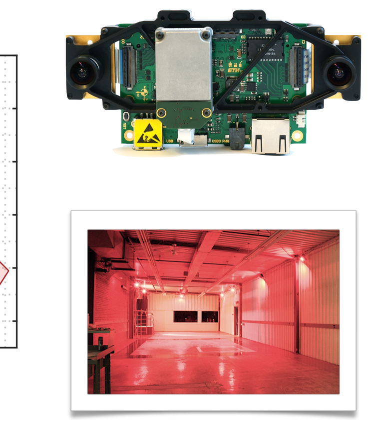
The blur metric of Crete et al.[2] varies with texture and does not correlate well with pan speed (and hence tracking error).

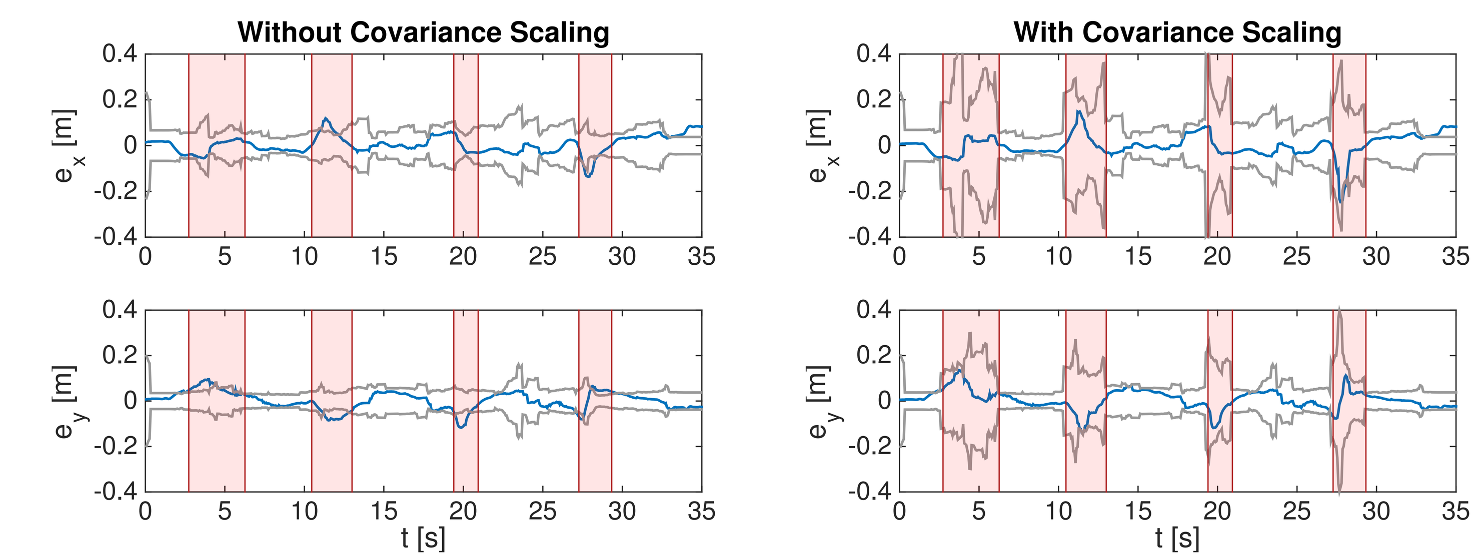


Visual Odometry Experiment

For stereo **visual odometry**, feature covariance scaling during fast turns makes the estimator **more consistent** compared to static covariance.







Discussion and Conclusions

When features are successfully tracked, KLT tracking error is zero-mean and approximately Gaussian.

The effect of motion blur on feature tracking accuracy can be captured by inflating the covariance of image reprojection error as a function of rotational speed.

Vision-based blur metrics are texture-dependent, but an IMU can be used to predict blur independent of texture.

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1. **Motion blur roughly preserves Gaussianity** of tracking error and correlates with rotational speed.
2. When motion blur occurs, KLT tracking error **covariance should be inflated** for consistency.

References

1. S. Gauglitz et al., "Evaluation of interest point detectors and feature descriptors for visual tracking," Int. J. Comput. Vision (IJCV), vol. 94, no. 3, pp. 335-360, Mar. 2011.
2. F. Crete et al., "The blur effect: Perception and estimation with a new no-reference perceptual blur metric," in Proc. SPIE Electron. Imaging Symp. Conf. Human Vision and Electron. Imaging, Feb. 2007, pp. 64 9201-64 9201-11

NCFRN NSERC Canadian Field Robotics Network
RCCRT Réseau canadien CRSNG pour la robotique de terrain
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