EE 367 Project Proposal: Evaluation of Temporal Coding Motion Deblurring Against Varying Noise Statistics

Ifueko Igbinedion Department of Electrical Engineering
Stanford University
ifueko@stanford.edu

MOTIVATION

Motion in scenes can cause blur artifacts that are often undesirable in images. Temporal coding of the motion in a scene can allow us to more accurately deconvolve a motion blurred image. By "fluttering" the camera shutter open and closed during the exposure time, we change the camera's blur kernel from a box filter to a broad-band filter. This preserves high spatial frequencies that are often lost due to motion and provides for more accurate estimation of the point spread function (PSF), improving deconvolution [6]. Moreover, utilizing multiple PSFs derived from sequential frames in the deconvolution process can result in deconvolution that is more robust to noise [2].

Considering noise during blind deconvolution can help modify the update rule of iterative deconvolution schemes [7], [3]. By applying a Gaussian or Poisson total variation prior, we can converge to a deconvolution result that is often better than with no priors. This project aims to implement a flutter shutter camera and deconvolution algorithms based on the temporal coding of motion in one or many frames, with Gaussian and Poisson total variation priors. Furthermore, it will evaluate the performance of these deconvolution schemes against varying Gaussian and Poisson noise.

RELATED WORK

Raskar et. al. [6] presented flutter shutter photography as a way of temporally encoding motion into the PSF and making deconvolution a well posed problem. They point out that the typical box filter that results from uniform light exposure over the exposure time destroys important high frequency information. The broad band filter that results from fluttering the camera shutter open and closed preserves thee high frequency spatial details. Additionally, they showed that manually specifying the direction of motion of the point spread function is sufficient enough to solve many challenging cases of motion. Ding et. al. [4] analyzed the flutter shutter camera over a range of nonlinear motions, and showed its robustness for constant velocity, and constant acceleration and harmonic motions. Sarker et. al [8] reduced the reconstruction noise by applying denoising algorithms to the flutter shutter captured exposures. Prior to reconstruction, a fourth order PDE is applied followed by a median fliter. Though reconstruction noise was reduced, sharpness of the image was also reduced.

Later, McCloskey [5] developed an algorithm to generate velocity-dependent fluttering patterns for the flutter shutter camera. If the velocity of a scene can be accurately estimated, an invertible PSF can also be estimated that results in low mean squared error in reconstruction. Agrawal et. al [1] showed that with the flutter shutter camera, motion blur can be used to enhance the spatial resolution of an image along the direction of blur during deconvolution. Cai et. al. [2] showed that the noise in PSFs can be reduced by utilizing PSFs from multiple, sequential frames, reducing the signal to noise ratio of the deconvolved image and the target image.

Richardson et. al. [7] proposed the bayesian iterative method of image deconvolution, showing that considering an estimation of the probability distribution of the image data can improve the results of iterative deconvolution. Dey et. all [3] adapted this iterative deconvolution scheme by incorporating a Poisson total variation prior, showing the success of this method assuming a Poisson noise distribution.

PROJECT OVERVIEW

This project aims to combine coded exposure photography with noise-aware deconvolution. After implementing a flutter shutter camera, I will implement deconvolution algorithms that incorporate Poisson and Gaussian total variation priors, in a similar fashion as described in [3] and [7]. These algorithms will support one frame and multiple frame PSF estimation. Then I will evaluate these algorithms on data captured with the flutter shutter camera and polluted with varying noise statistics. If time permits, I will apply this algorithm to deblurring a motion video.

MILESTONES, TIMELINE AND GOALS

A. Finalize hardware design

Deadline: 2/15

Decide on hardware implementation of flutter shutter camera. Options include a programmable remote shutter on a high speed DSLR camera or a camera module that supports flutter shutter, such as the Point Gray Flea3 camera.

B. Implement flutter shutter camera

Deadline: 2/24

Implement flutter shutter camera as designed. Capture images of scenes with varying motion.

C. Implement deblurring methods

Deadline 3/2

Implement deblurring methods incorporating TV priors for different noise distributions (Poisson, Gaussian, mixed Poisson/Gaussian) and for single and multiple frames.

D. Evaluate deblurring methods on varying noise statistics

Deadline: 3/7

Evaluate deblurring methods on images captured using the fluttered shuttered camera, modified with additive noise.

REFERENCES

[1] Agrawal, Amit, and Ramesh Raskar. "Resolving objects at higher resolution from a single motion-blurred image." Computer Vision and Pattern Recognition, 2007. CVPR'07. IEEE Conference on. IEEE, 2007.

[2] Cai, Jian-Feng, et al. "Blind motion deblurring using multiple images." Journal of computational physics 228.14 (2009): 5057-5071.

[3] N. Dey, L. Blanc-Feraud, C. Zimmer, Z. Kam, J. Olivo-Marin, J. Zerubia, 2004 ?A deconvolution method for confocal microscopy with total variation regularization?, In IEEE Symposium on Biomedical Imaging: Nano to Macro, 1223?1226

[4] Ding, Yuanyuan, Scott McCloskey, and Jingyi Yu. "Analysis of motion blur with a flutter shutter camera for non-linear motion." Computer Vision-ECCV 2010. Springer Berlin Heidelberg, 2010. 15-30.

[5] McCloskey, Scott. "Velocity-dependent shutter sequences for motion deblurring." Computer Vision-ECCV 2010. Springer Berlin Heidelberg, 2010. 309-322.

[6] Raskar, Ramesh, Amit Agrawal, and Jack Tumblin. "Coded exposure photography: motion deblurring using fluttered shutter." ACM Transactions on Graphics (TOG) 25.3 (2006): 795-804.

[7] W. Richardson, 1972 ?Bayesian-based iterative method of image restoration? J. Opt. Soc. Am. 62, 1, 55?59.

[8] Sarker, Abeed, and Leonard GC Hamey. "Improved reconstruction of flutter shutter images for motion blur reduction." Digital Image Computing: Techniques and Applications (DICTA), 2010 International Conference on. IEEE, 2010.