Deblurring Low-light Images with Light Streaks

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6th December 2018

Introduction

Background

Most recent approaches rely on salient image features such as edges for blur kernel estimation, however in low-light images the amount of salient image features that can be extracted is often limited. **Furthermore, low-light images often have gone through heavy in camera non-linear tone mapping, which breaks the linear blur model that most approaches assume.**

What we do

In this work, we propose a new deblurring framework that properly uses light streaks as an additional cue for blur kernel estimation. We extend the widely-used linear blur model by explicitly modeling point light sources and light streaks, resulting in a non-linear model that more accurately describes the formation of low-light images that contain light streaks. We then formulate a kernel estimation energy function that takes into account light streaks as well as other image structures.

Light Streak Detection

Algorithms

Blur Kernel Estimation using Light Streaks

$$B^p = \sum c\left(\hat{P}_i\right) = \sum c\left(K * D_i + N\right) \tag{1}$$

$$\begin{aligned} f_K(K) = & \sum_{x \in M^r} \left|\partial_h B(x) - \left(K * P_h\right)(x)\right|^2 \\ & + \sum_{x \in M^r} \left|\partial_v B(x) - \left(K * P_v\right)(x)\right|^2 + \lambda \|K\|_1 \\ & + \mu \sum_{P_i \in \mathbb{P}} \sum_{x \in P_i} \left|\left(D_i * K\right)(x) - \hat{P}_i(x)\right|^2 \end{aligned} \tag{2}$$

Algorithms

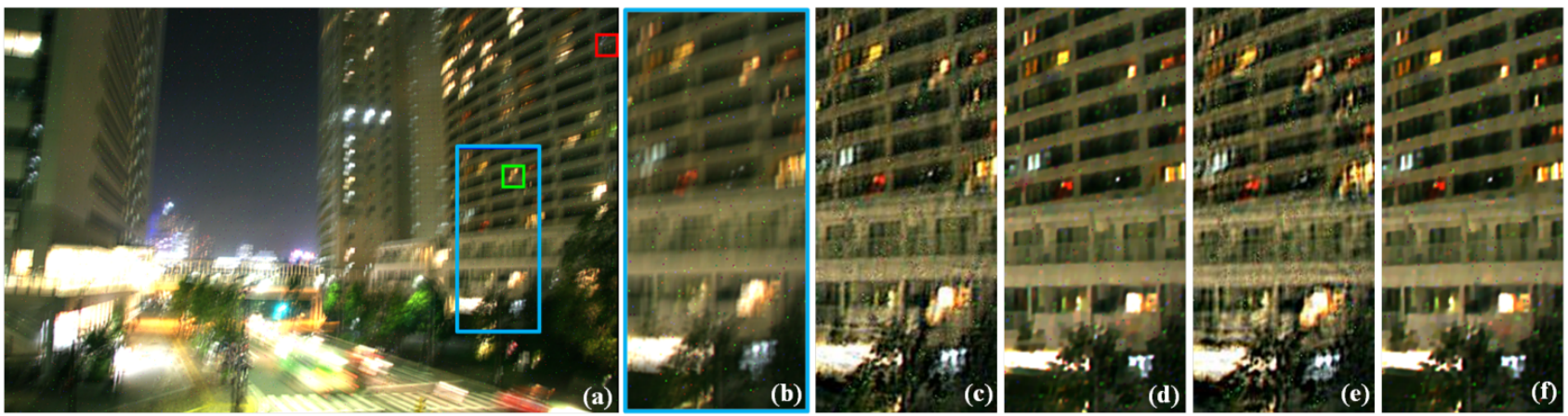
Blur Kernel Estimation using Light Streaks

$$f_{D_i}(t_i, r_i) = \left\| D_i(t_i, r_i) * K - \hat{P}_i \right\|^2 + \left\| D_i(t_i, r_i) - I_i \right\|^2 \tag{3}$$

$$f_I(I) = \sum_i \mu \left\| D_i - I_i \right\|^2 + \sum_x |B(x) - c(K * I)(x)|^2 + \gamma \sum_x \left(|\partial_h I(x)|^\alpha + |\partial_v I(x)|^\alpha \right) \tag{4}$$

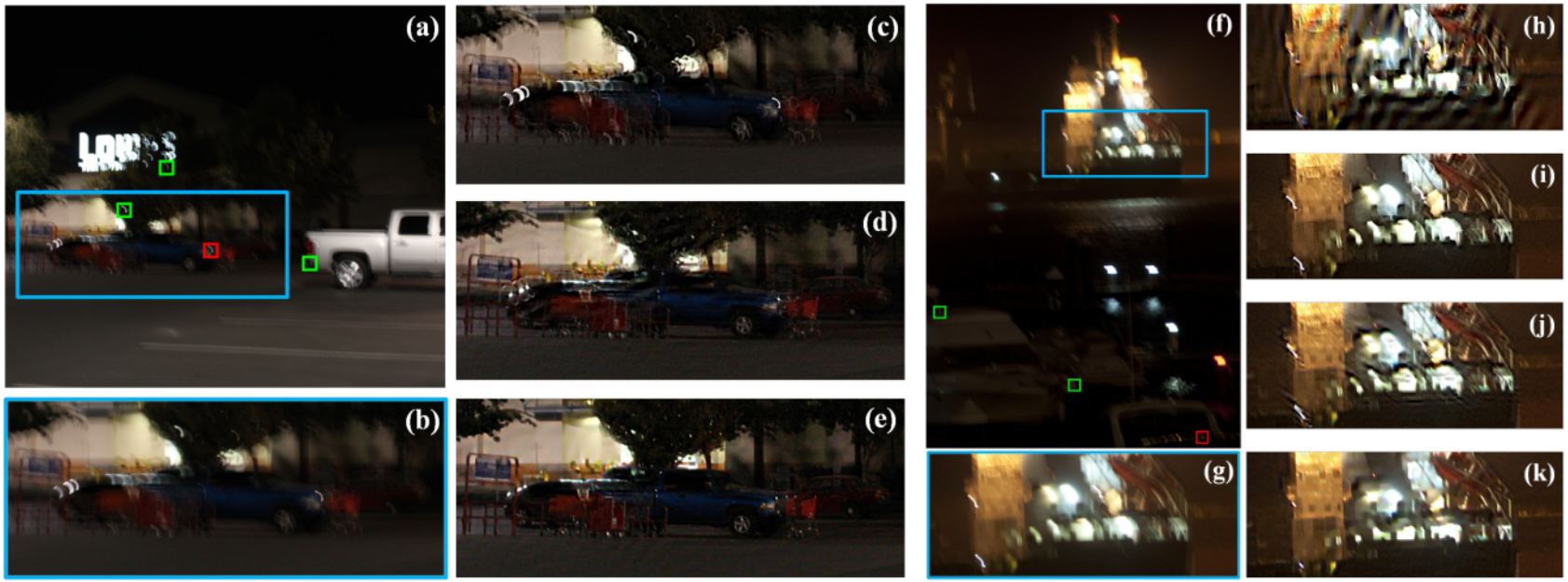
Experiments

A comparison with Hua and Low' s approach. The red box indicates our selected light streak patch and the green box is a manually selected patch. (a) Input image; (b) cropped regions from (a); (c) & (e) cropped results by Hua and Low [8], using the red and green light streak patches, respectively; (d) & (f) cropped results by our method. Please refer to the supplementary material for complete results.



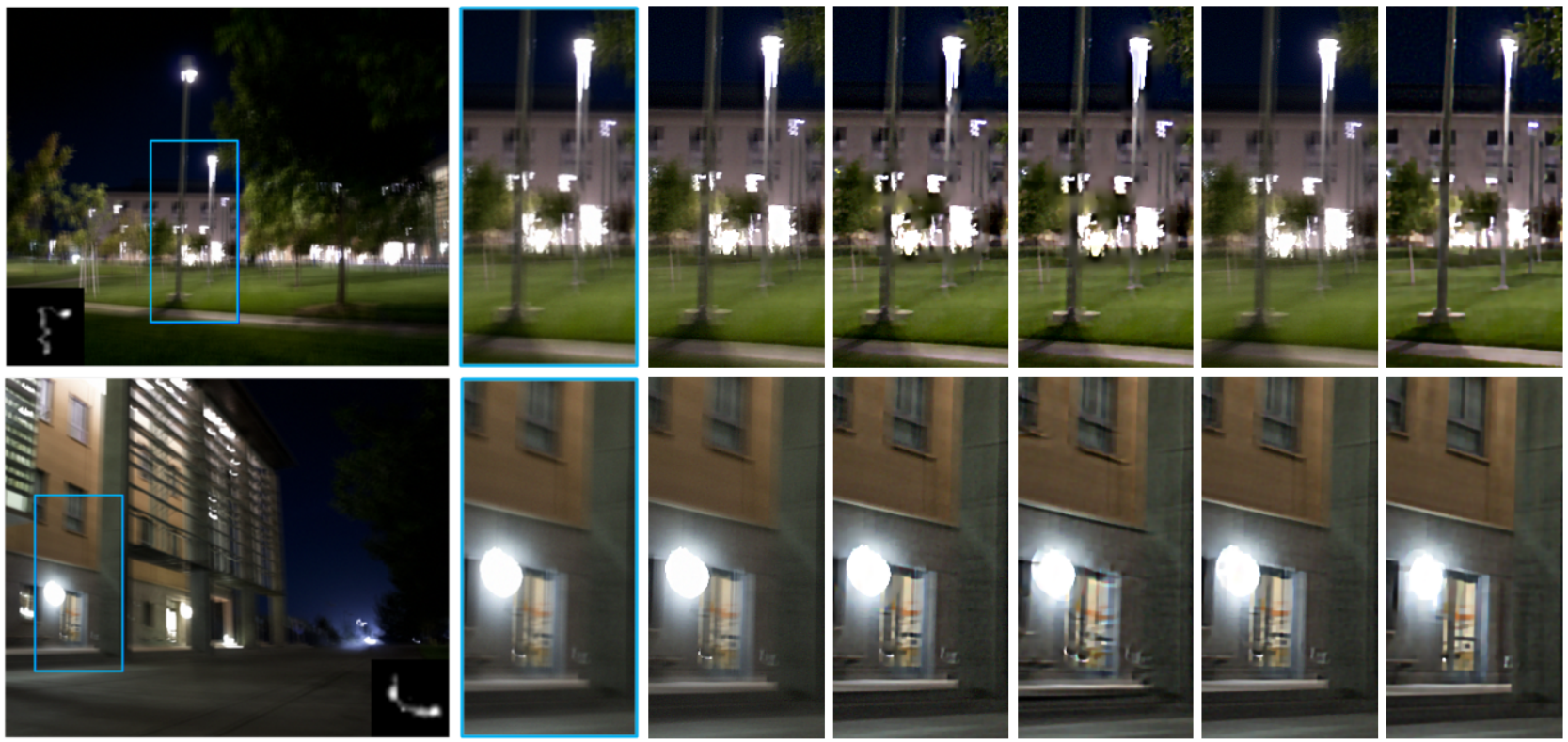
Experiments

Comparisons with state-of-the-art methods on real examples. (a)(f) Input image; (b)(g) cropped regions from (a) and (f); (h) cropped results by Cho and Lee ; (c)(i) cropped results by Krishnan et al. ; (d)(j) cropped results by Hua and Low; (e)(k) cropped results of our approach. Please refer to the supplementary material for complete results.



Experiments

Comparisons on synthetic examples. (a) Input image with ground truth kernel; (b) cropped region from (a); (c)-(g) cropped results by Cho and Lee, Levin et al. , Krishnan et al. , Xu et al. and our approach, respectively. Please refer to the supplementary material for complete results.



Further

Ongoing Optimization

- cnn ?

References

- Zhe Hu, Sunghyun Cho *Deblurring Low-light Images with Light Streaks*