Going Unconstrained with Rolling Shutter Deblurring

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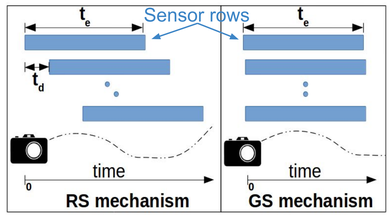
1 Problem description

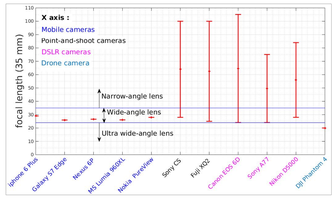
a. Most present-day cameras employ rolling shutter (RS) as opposed to global shutter (GS) (see Fig.).

Traditional deblurring works that assumes GS model *fails* in RS.

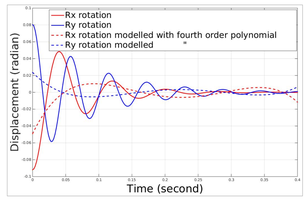


b. Existing RS deblurring models are *ineffective* for

1. **Wide-angle systems** or in-plane camera rotations (its relevance is shown in the right).



2. **Irregular camera motion,** common in drones, street-view cars, *etc*. (Right gives a vibratiory motion & its approximation by existing works).



c. Existing RS methods are *computationally intensive.*

2 Central theme

GS model (*i.e.,* a *single* ego-motion for *all* image rows) include

(+) *both* wide- and narrow-angle systems (by considering full 3D camera-rotation pose).

(+) *both* regular and irregular ego-motion (by considering non-parametric motion model).

(+) efficient FFT-based algorithms (by modelling blur in small image patches as convolutions).

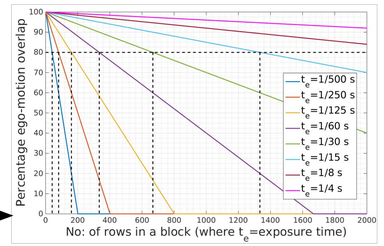
(-) But ***not*** suitable for RS (since RS ego-motion varies per row).

"Can we have a GS-like model suitable for RS, thereby removing constrains of existing RS methods."

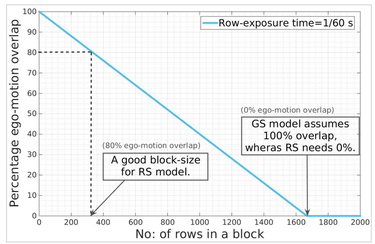
3 A GS-like RS model

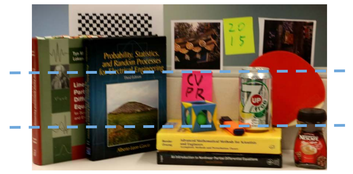
Observation: *RS images can be segregated into blocks, each having a dominant ego-motion.*

Segregation with 80% ego-motion dominance for different exposure settings.



A segregation example: A 2240 X 1680 image with exposure time 1/60 s and inter-row delay 1/100 ms.



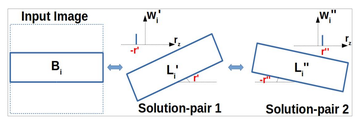


RS as block-wise GS

We automatically segregate these blocks *sans* sensor timings.

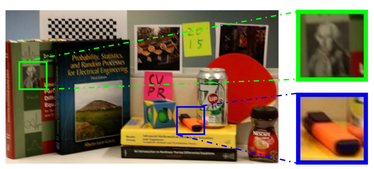
4 Challenges in RS deblurring

Claim: *There exist a 'random' offset for each deblurred block. These blocks incoherently combine to form a distorted image (Fig. gives an example for in-plane rotation).*

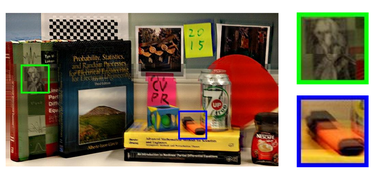


Blurred-block B_i = Camera undergone -r' rotation with the latent image-block being L_i' or rotation r'' with image-block being L_i''.

Implication:

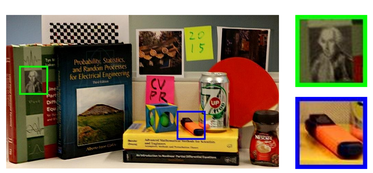


Input RS-blurred image



Output of block-wise GS deblurring

Solution: Imposing a prior that nearby blocks have overlapping ego-motion (which reduces the offset between adjacent blocks).

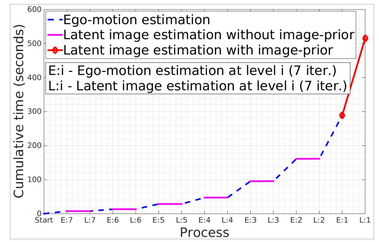


Deblurring result with prior

5 Analysis and Results

Computational analysis

Time profiling for an image-size 800X800

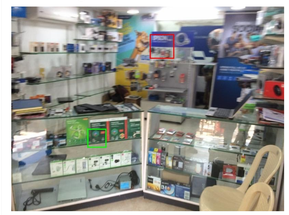


Computational gain over state-of-the-art

Image dimension	Ego-motion estimation time (s)		Latent image estimation time (s)	
ht. × wd.	[Su, CVPR15]	Ours	[Su, CVPR15]	Ours
800×800	216.01	**29.58**	258.65	**1.44**
450×800	122.28	**22.48**	44.23	**1.30**
400×400	73.26	**10.34**	23.82	**0.62**

Qualitative analysis

Wide-angle system



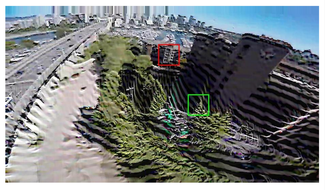
Input

State-of-the-art GS deblurring [Xu, CVPR13]

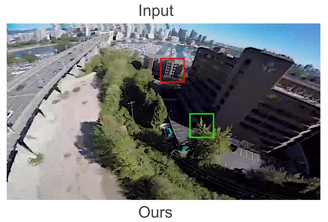
Ours

Irregular ego-motion (drone image)

Input



State-of-the-art RS deblurring [Su, CVPR15]



Ours

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