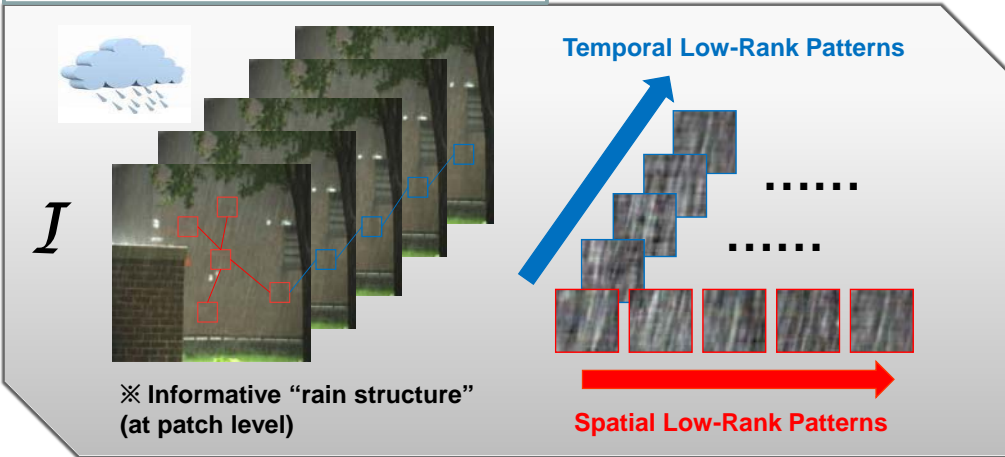# A Generalized Low-Rank Appearance Model for Spatio-Temporally Correlated Rain Streaks

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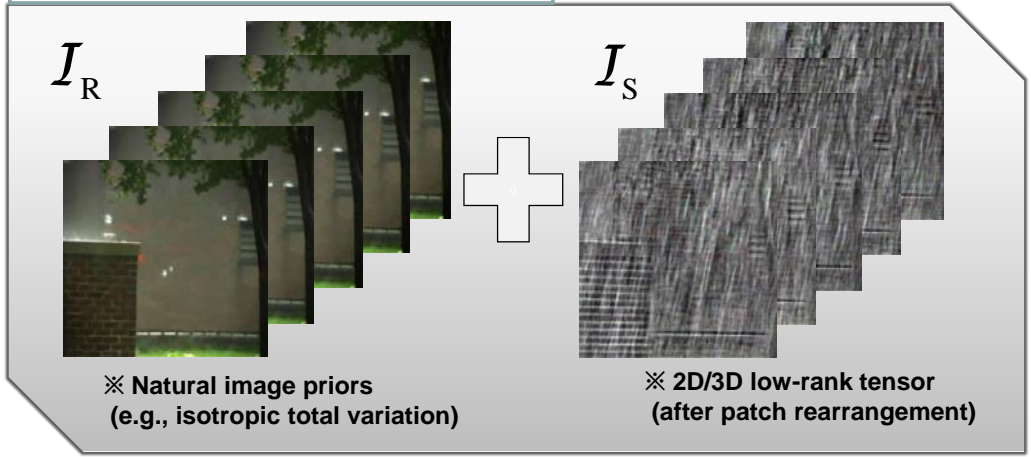
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To characterize rain streaks, just exploit the repeatability/similarity of rain steaks taken in the same scene!

Low-Rank Appearance Model

Temporal Low-Rank Patterns

I

※ Informative "rain structure" (at patch level)

Spatial Low-Rank Patterns

Image/Video Decomposition

I_R

I_S

※ Natural image priors (e.g., isotropic total variation)

※ 2D/3D low-rank tensor (after patch rearrangement)

Our advantages: **(1) no pre-processing (e.g., rain detection); (2) training-free (e.g., dictionary learning); and (3) feasible to any source input (e.g., monochromatic/chromatic image/video)**

Problem Formulation

$$I_R, I_S = \arg\min \alpha\, \mathrm{rank}(\mathrm{P}(I_R)) + \beta\|I_S\|_{TV} + \frac{1}{2}\|I - I_S - I_R\|_F^2$$

※ relaxed by tensor trace norm [LWY09]

$$\mathrm{rank}(\mathcal{X}) \approx \|\mathcal{X}\|_* = \frac{1}{n}\sum_{k=1}^{n}\|\mathbf{X}^{(k)}\|_*$$
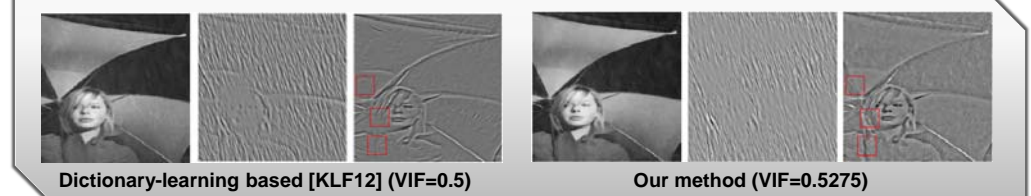
※ extended to temporal TV [CKGGN11]

$$\|\mathcal{X}\|_{TV} = \sum_{i,j,t}\sqrt{(x_{i,j,t}-x_{i-1,j,t})^2 + (x_{i,j,t}-x_{i,j-1,t})^2 + (x_{i,j,t}-x_{i,j,t-1})^2}$$

※ Gaussian noise reused by Guided Image Filtering [HST10]

$$\hat{I} = I_S + \tau\, \mathrm{GDF}(I - I_S - I_R, I - I_R)$$

[LWY09]   J. Liu, P. Wonka, and J. Ye, "Tensor completion for estimating missing values in visual data." in *Proc. ICCV*, 2009.
[CKGGN11] S. H. Chan, R. Khoshabeh, K. B. Gibson, P. E. Gill, and T. Q. Nguyen, "An augmented Lagrangian method for total variation video restoration," *IEEE Trans. on Image Processing, vol. 20, no.*11, pp. 3097-3111,2011.
[HST10]   K. He, J. Sun, and X. Tang, "Guided image filtering," in *Proc. ECCV*, 2010.
[KLF12]   L.-W. Kang, C.-W. Lin, and Y.-H. Fu, "Automatic single-image-based rain streaks removal via image decomposition," *TIP*, 21(4):1742-1755, 2012.
[GN04]   K. Garg and S. K. Nayar, "Detection and removal of rain from videos," in *Proc. CVPR*, 2004.

Image Rain Removal

Dictionary-learning based [KLF12] (VIF=0.5)   **Our method (VIF=0.5275)**

Video Rain Removal

Detection based [GN04]   **Our method**