NON-LOCAL KALMAN: A RECURSIVE VIDEO DENOISING ALGORITHM

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Contributions

We suggest a video denoising pipeline with the following advantages:

- Particularly suited for real-time processing
- Produces temporally consistent videos, which are much better visually
- Competitive with current state-of-the-art denoising methods

Non-local denoising method

Non-local Kalman

Patch trajectories

Spatial denoising

$\hat{p} = \mu + C(C + \sigma^2 I)^{-1}(q - \mu)$. $\hat{\mu} = \frac{1}{N}\sum_{i=1}^{N} q_i$ and $\hat{C} = \frac{1}{N}\sum_{i=1}^{N} \overline{q}_i \overline{q}_i^T - \sigma^2 I$,

Temporal filtering

$$p_{t+1,i} = p_{t,i} + w_{t,i} \text{ with } w_{t,i} \sim \mathcal{N}(0, C_t) \quad (1)$$

$$q_{t,i} = p_{t,i} + n_{t,i} \text{ with } n_{t,i} \sim \mathcal{N}(0, \sigma^2 I). \quad (2)$$

Experiments

Quantitative evaluation

Our algorithm is compared against VBM3D and VBM4D, two current state-of-the-art methods

σ	Method	Bus	Foreman	Pedestrian_area	Crowd_run	Touchdown_pass	Station2	Average
10	VBM3D	33.32/.7824	37.40/.6681	40.78/.6577	35.62/.8017	39.08/.6103	38.92/.7266	37.52/.7078
	VBM4D	33.39/.8237	37.39/.6871	40.56/.7463	35.69/.8457	39.60/.6752	39.93/.7746	37.76/.7588
	NL-Kalman	33.34/.8502	36.16/.6782	38.67/.7420	34.29/.8383	38.82/.6940	39.91/.7916	36.86/.7657
	NL-Kalman (oracle)	*33.87/.8713*	*36.93/.7230*	*39.23/.7592*	*34.64/.8514*	*39.58/.7433*	*40.50/.8059*	*37.46/.7923*
20	VBM3D	29.57/.6064	34.60/.5763	36.93/.5579	32.22/.7122	36.09/.4703	35.45/.5689	34.14/.5820
	VBM4D	29.55/.6856	34.61/.6073	36.75/.6468	32.07/.7439	36.41/.4795	36.23/.6395	34.27/.6338
	NL-Kalman	29.58/.7291	33.19/.5844	35.61/.6444	30.89/.7478	35.91/.5181	36.81/.6868	33.66/.6518
	NL-Kalman (oracle)	*30.43/.7752*	*34.18/.6301*	*36.45/.6738*	*31.44/.7746*	*36.99/.6135*	*37.46/.7116*	*34.49/.6965*
30	VBM3D	27.59/.4995	32.77/.5224	34.44/.4869	30.14/.6394	34.55/.3906	33.36/.4536	32.14/.4987
	VBM4D	27.53/.5988	32.91/.5612	34.45/.5745	29.95/.6704	34.76/.3801	34.14/.5420	32.29/.5545
	NL-Kalman	27.30/.6327	31.27/.5335	33.27/.5680	28.64/.6708	33.91/.4034	34.73/.5986	31.52/.5678
	NL-Kalman (oracle)	*28.48/.6993*	*32.50/.5802*	*34.43/.6102*	*29.44/.7078*	*35.20/.5186*	*35.46/.6338*	*32.59/.6250*

Qualitative evaluation

Remarks

References

[1] Barnes et al. "PatchMatch: a randomized correspondence algorithm for structural image editing". *ACM Transactions on Graphics-TOG*, 2009.

[2] Korman and Avidan "Coherency sensitive hashing". *IEEE ICCV*, 2011.

[3] Arias et al. "Analysis of a variational framework for exemplar-based image inpainting". *SIAM*, 2012.

[4] Kaiming and Sun "Computing Nearest-Neighbor Fields via Propagation-Assisted KD-trees". *IEEE CVPR*, 2012.