Fast Edge Preserving 2D Smoothing Filter Using Indicator Function

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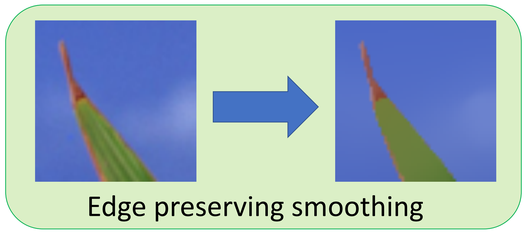
Introduction

▶ We proposed a new edge preserving smoothing method.

▶ Edge preserving smoothing is used in many image processing applications.



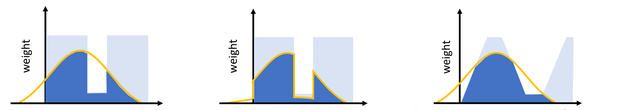
Edge preserving smoothing

● The smoothing effect and running time is said to be in a trade-off relationship.

● To improve the trade-off relationship, we adopted indicator function to 2D filter.

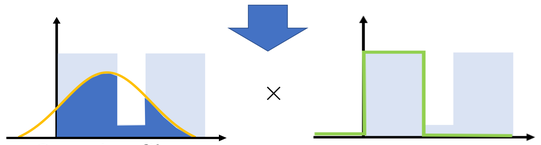
Example in 1D

Classical local smoothing filter smooths over edges.
→It deteriorates the sharp edge information.



Gaussian filter　Bilateral filter[1]　Domain transform[2]

The information over the edge should not be referred



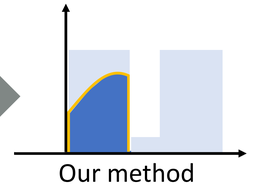
Gaussian filter
[Smooths image]

×

Indicator function
[indicates same region]

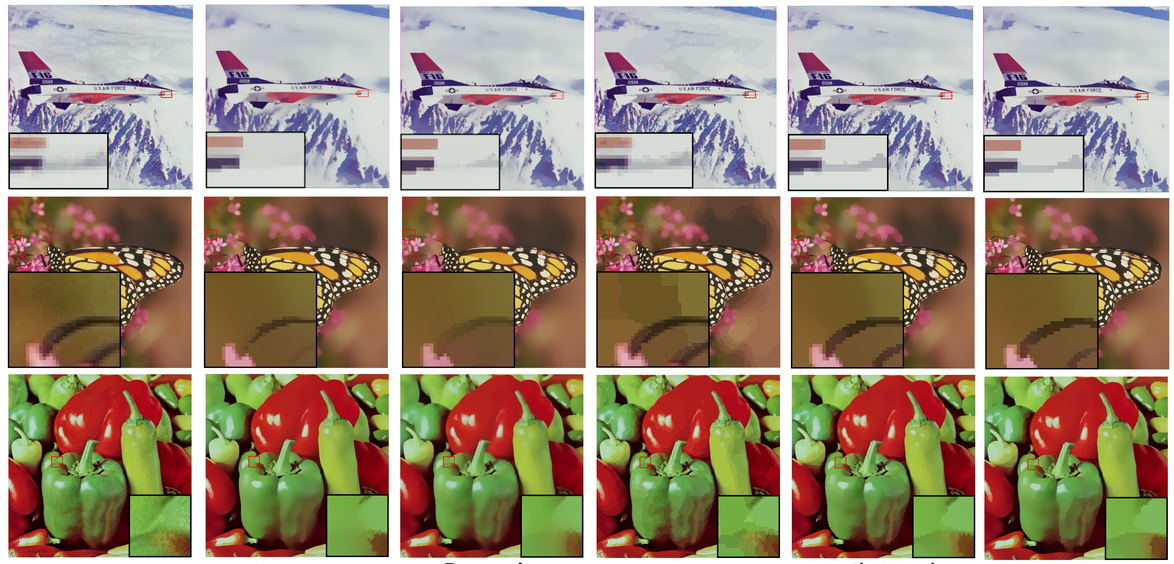
Our method

Smoothing filter
+
Indicator function



Our method

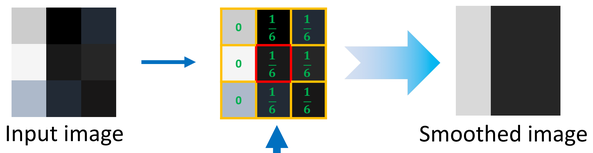
Experimental results



Input　Bilateral[1]　Domain Transform[2]　L0GP[3]　Bilateral & IF (ours)　IF (ours)

Running time 512x512	1.52 s [MATLAB]	2.89 s [MATLAB]	102 s [MATLAB]	3.12 s [MATLAB] 0.19 s [C++]	2.78 s [MATLAB] 0.14 s [C++]

Indicator function



Input image　Smoothed image

Smoothing term

- Moving average filter
- Gaussian filter
- Bilateral filter　etc.

Any smoothing filter can be used.

×

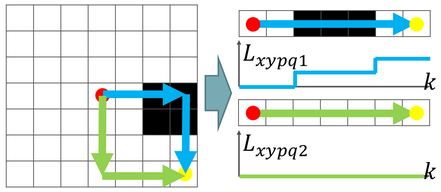
Indicator term

Indicates the pixels which are in the same region.

Expressed in 0 or 1.

$$J_{xy} = K_{xy} \sum_{(p,q)\in\Omega} I_{xypq} S_{xypq} H_{xypq}$$

Our proposed filter equation



$$L_{xypq1} = \int_0^p \left|\frac{\partial}{\partial x} I(x,0)\right| dx + \int_0^q \left|\frac{\partial}{\partial y} I(p,y)\right| dy$$

$$L_{xypq2} = \int_0^q \left|\frac{\partial}{\partial y} I(0,y)\right| dy + \int_0^p \left|\frac{\partial}{\partial x} I(x,q)\right| dx$$

$$r(x,p,y,q) = \min(L_{xypq1}, L_{xypq2})$$

$$H_{xypq} = \begin{cases} 1 & r(x,p,y,q) \le \sigma_i \\ 0 & otherwise \end{cases}$$

σ_i is a user-given parameter, which determines the actual size of filter.

Example of applications

Detail enhancement

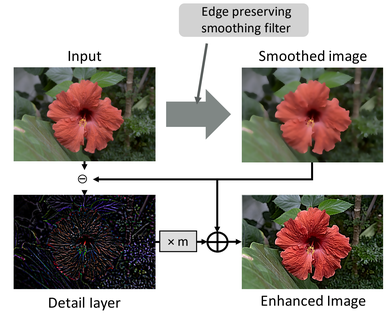
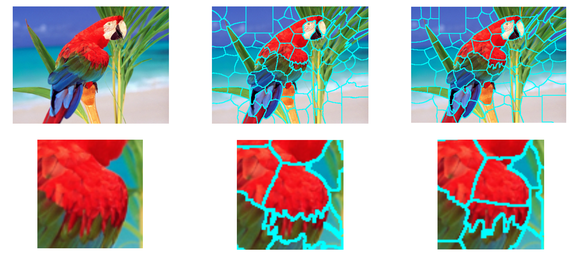


Image segmentation



Input　SLIC　Ours + SLIC

Conclusion

▶ Indicator function indicates the pixels in the same region. It improves the smoothing effect and the running time is still fast.

▶ Future research should be devoted to the development of the application of proposed method.

■ Source code is available at our website:　http://tkhm.elec.keio.ac.jp/achievement

[1] Tomasi, Carlo, and Roberto Manduchi. "Bilateral filtering for gray and color images." Computer Vision, 1998. Sixth International Conference on. IEEE, 1998.
[2] Gastal, Eduardo SL, and Manuel M. Oliveira. "Domain transform for edge-aware image and video processing." *ACM Transactions on Graphics (ToG)*. Vol. 30. No. 4. ACM, 2011.
[3] Ono, Shunsuke. "$ L_ {0} $ Gradient Projection." IEEE Transactions on Image Processing 26.4 (2017): 1554-1564.