2011 Data Compression Conference

Adaptive Image Deblurring via Tanner Graph Representation and Belief Propagation

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Image deblurring aims to counteract the effect of *point spread function* (PSF) in imperfect image formation system. Conventional solutions include frequency-domain approaches (e.g. *Wiener filtering*) and spatial-domain iterative approaches (e.g. *Landweber* or *iterative back-projection*) [1]. The challenge is that this inverse problem can be ill-posed and may easily end up with amplified noises and serious ringing artifacts. To cope with this, *a priori* knowledge is incorporated in some algorithms to regularize the solutions. The difficulty, however, is then how to choose a proper image prior.

In this paper, we propose a deblurring framework based on a factor graph representation of the image and the image formation process. Each pixel is described by a variable node, while the statistical relation among pixels is formulated by two sets of check nodes, describing the local image structures and the image formation process, respectively. Belief propagation is employed to solve the pixel values and it is reduced to mechanisms to generate and fuse predictions for each pixel iteratively. A key work is that we analyzed the origin of ringing artifacts and found that it is due to the propagation of estimation error in previous iterations. We propose a method to estimate the uncertainty in each pixel of previous estimation, which is then used to adapt the generation and fusion of prediction in the next iteration. Experimental results in Fig. 1 show that the proposed solution can significantly eliminate ringing artifacts without employing any image priors. [1]

Fig. 1: Evaluation of the proposed method. From left to right: original image (cropped from 512×768 *Monarch*), blurred by Gaussian PSF ($\sigma = 2$, 5×5 window), deblurred by *iterative back-projection* (IBP), deblurred by the proposed method.

REFERENCES

[1] J. Biemond, R. Lagendijk, and R. Mersereau, "Iterative methods for image deblurring," *Proceedings of the IEEE*, vol. 78, no. 5, pp. 856–883, May 1990.

[1]This work was supported in part by the National Basic Research Program of China (973 Program) under Grant 2009CB320904 and the National Natural Science Foundation of China under Grant 61073083, 60803068 and 60833013.

1068-0314/11 $26.00 © 2011 IEEE
DOI 10.1109/DCC.2011.85

IEEE computer society