Image Restoration Based on 3-D Autoregressive Model via Low-Rank Minimization

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Due to all kinds of need of customers and the complicated transmitting environment of digital image and video resources, numerous practical applications emerge, *e.g.* image inpainting, interpolation, super-resolution and the removal of salt and pepper noise. One thing these cases all have in common is that there are plenty of missing pixels randomly distributed in an image.

Existing image restoration methods aiming at solving this problem include kernel regression [1], matrix completion [2] and total variation (TV) model [3]. The 3-D AR model has also been proposed to detect and interpolate the missing data in video sequences. However, the missing rate or missing region in these papers is usually small. With the missing rate increasing, known pixels in a local neighborhood are not going to be enough to form a solvable linear system. Thus, generally speaking, AR model is not suitable for image restoration from high missing rates. Nevertheless, with proper preliminary processing as proposed in this paper, AR models can be well utilized and present good results even in high missing rates.

In this paper, we propose a novel method for image restoration. For the first time, the 3-D AR model is utilized in a single image to simultaneously measure correlation within and between similar patches. 2-D AR model combining with a multiscale structure reconstruct the image using its low-resolution versions to preserve important perceptual statistics such as edges. After obtaining the preliminary reconstruction of the reconstructed full size image, similar patches are collected and the 3-D AR model is applied to form a more local-consistent patch set. Then, an iterative singular value thresholding (SVT) method is utilized to solve the low-rank minimization problem. Instead of aggregating all the overlapped patches after each patch set is processed, we perform SVT for each patch set and aggregate all the overlapped patches into an intermediate image, then the iterative regularization is carried out on the image to produce the newly output for next iteration. Experimental results demonstrate that the proposed method achieves higher PSNR and SSIM than state-of-the-art methods [1-3] and the processed images possess a better visual quality especially in edge structures and texture regions.

References

[1] H. Takeda, S. Farsiu, and P. Milanfar, "Robust kernel regression for restoration and reconstruction of images from sparse noisy data," in *Proceedings of IEEE International Conference on Image Processing*, October 2006, pp. 1257-1260.

[2] Y. Chen, C. Hsu, and H. Liao, "Simultaneous tensor decomposition and completion using factor priors," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 36, no. 3, pp. 577-591, March 2014.

[3] J. Zhang, D. Zhao, R. Xiong, S. Ma, and W. Gao, "Image restoration using joint statistical modeling in a space-transform domain," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 24, no. 6, pp. 915-928, June 2014.

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