Fig. 4 The reconstructed image of scene1 using two methods at sampling rate 30%. (First row: Original image; Second row: Reconstruct images.) Reconstruct image PSNR: 2DCS (left): 24.7726 dB, 3DCS (right): 34.0355 dB)

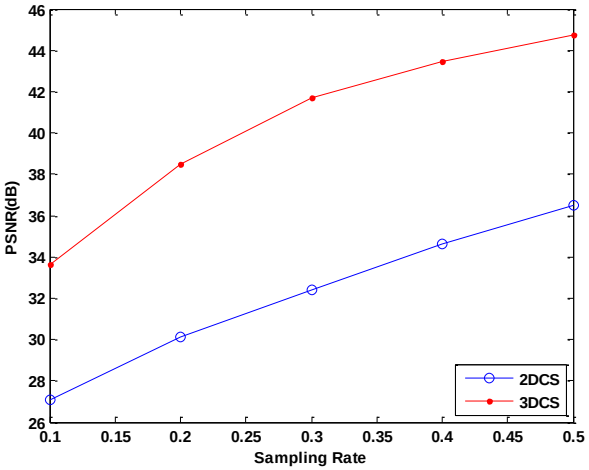

Fig. 5 Average recovery PSNR of all bands at different sampling rate for scene2.

IV. Conclusion

In this paper, a three-dimensional compressed sampling (3DCS) method has been proposed to compress a hyperspectral data cube to meet the need of real-time process at a very low sampling rate，which consists of 3D circulant sampling and an efficient reconstruct algorithm with convergence guarantee. There are two major contributions in the paper. Firstly, circulant sampling is extended from 2D to 3D, utilizing the spectral correlation of HSI between the adjacent bands in the sampling process directly. Secondly, three-dimensional total variation (3DTV) is used as the regularization term to reconstruct HSI from the incomplete sampled data by taking advantage of the highly spatial and spectral correlation of HSI.

Experimental results demonstrate that our proposed 3DCS has a huge advantage on improving the image quality of reconstruct images. Even when the sampling rate decreases to a lower level, the method 3DCS can also give a better reconstruct image than 2DCS. The method presented here can be used widely in Hyperspectral CS techniques to reduce the measurement number and reduce the transmission and storage difficulties to meet the needs of real-time processing. Therefore, the method has a great significance on the design of the hyperspectral imaging spectrometer with a simpler hardware and a higher processing velocity.

Acknowledgment

The author thanks Prof. Feng for her constructive suggestions and would like to express her gratitude to all those who helped her during the writing of this thesis.

References

[1] D.Donoho, “Compressed sensing”, IEEE Trans. Inform. Theory, vol. 52, no. 2, pp. 489-509, 2006.

[2] R. Baraniuk, “A lecture on compressive sensing”, IEEE Signal Processing, vol.24, no.1, pp. 118-221, 2007.

[3] E Candès, J Romberg, Terence Tao, “Robust uncertainty principles: exact signal reconstruction from highly incomplete frequency information”, IEEE Transaction on Information Theory, vol. 52, no.2, 489-509, 2006.

[4] J. Romberg, “Compressive sensing by random convolution”, SIAM J. Imaging Sciences, 2009.

[5] W. Yin, S. P. Morgan, J. Yang, and Y. Zhang, “Practical compressive sensing with toeplitz and circulant matrices”, Rice University CAAM Technical Report TR10-01, 2010.

[6] M. Lustig, D. Donoho, J. Santos, and J. Pauly, “Compressed sensing mri”, IEEE Signal Processing Magazine, vol.25, no.2, pp.72–82, 2008.

[7] Q. Du and J. E. Fowler, “Hyperspectral image compression using jpeg2000 and principal component analysis”, IEEE Geosci. Remote Sens. Lett., vol.4, no.4, pp.201–205, 2007.

[8] J. E. Fowler and Q. Du, “Reconstructions from compressive random projections of hyperspectral imagery”, Optical Remote Sensing: Advances in Signal Processing and Exploitation Techniques, S. Prasad, L. M. Bruce, and J. Chanussot, Eds. Springer, pp.31-48, 2011.

[9] Mohammad Golbabaee, Simon Arberet and Pierre Vandergheynst, “Distributed compressed sensing of hyperspectral images via blind source separation”, 978-1-4244-9721-8/10, IEEE, pp.196-198, 2010.

[10] Haiying Liu, Chengke Wu, Lv Pei and Song Juan, “Compressed hyperspectral image sensing reconstruction based on interband prediction and joint optimization”, Journal of Electronics & Information Technology. vol.33, no.9, pp. 2248-2252, 2011.

[11] J Yang, Y Zhang, and W Yin, “A fast alternating direction method for TVL1-L2 signal reconstruction from partial fourier data”, IEEE journal of selected topics in signal processing, vol.4, no.2, pp.288-297, 2010.

[12] Yilun Wang, Junfeng Yang, Wotao Yin, and Yin Zhang, “A new alternating minimization algorithm for total variation image reconstruction”, SIAM J. Imaging Science, vol.1, no.3, pp. 248-272, 2008.

[13] X. Shu and N. Ahuja, “Hybrid compressive sampling via a new total variation tvl1”, Proc. of European Conference on Computer Vision, pp.393-404, 2010.

[14] M. Afonso, J. Bioucas-Dias, and M. Figueiredo, “Fast image recovery using variable splitting and constrained optimization”, IEEE Trans. Image Process., vol.19, no.9, pp. 2345–2356, 2010.