Ultrasensitive denoising imaging

Guang-Jie Zhai[1,*], Wen-Kai Yu[1,2], Qing Zhao[2]
[1] Key Laboratory of Electronics and Information Technology for Space System,
Center for Space Science and Applied Research, Chinese Academy of Sciences, Beijing 100190, China
[2] College of Physics, Beijing Institute of Technology, Beijing, 100081, China
[*] E-mail: gjzhai@nssc.ac.cn

Abstract: Traditional methods in remote spectral imaging usually cannot obtain images and spectra simultaneously, either rely on scene raster scanning or use an array sensor. Thus it is inevitable that the flux will be distributed evenly to the pixel dimension, resulting in a decline in the imaging sensitivity. To solve the problems, we proposed a compressive spectral imaging scheme with dual spatial light modulation. With the information of spectra and space both compressed, the spectral image of a colored object can be obtained by a single-photon point detector. Objects with both continuous and discrete spectrum are used to demonstrate the performance, which shows wide-spectrum and high efficiency in spectral imaging. Since this approach is based on the technique of single-pixel imaging, we have found a correlation between the samplings in both reflection arms of the digital micro-mirror, in view of which we propose a complementary way of double-pixel compressive imaging on denoising. In a telescopic system, this method can be used to retrieve images of a target with 20 cm resolution, obtaining an image in a higher quality of 1~2 orders than that acquired by the conventional single-pixel imaging scheme under the same sampling rate. Our results have shown that the above method has strong ability in producing high-quality images with fewer measurements, which leads to a broader prospect of applications in the remote-sensing area.
Keywords: computational imaging and display, multispectral imaging

1. Introduction

Obtaining a three-dimensional spectral image in one measurement, which has great importance in both physics and biology, seems impossible. As an alternative, the detection of spatial image or spectrum is usually performed by mechanical scanning, which will decrease the stability of imaging. Recently, a single-pixel camera [1] based on compressed sensing is derived. CS makes it possible to reduce the detection dimensions and the sampling number. Building upon on the idea of high-flux measurements, we combine such method with single-photon detection technique to obtain ultrasensitive multispectral imaging through only a single-photon point detector with position-fixed. As for image denoising, we propose a complementary measurement strategy and apply it in remote sensing.

2. Optical experiments and results

Here we present a compressive spectral imaging scheme with dual spatial light modulation and a single-photon point detector, as well as a complementary double-pixel compressive imaging system for remote sensing. The experimental apparatuses and results are given as follows.

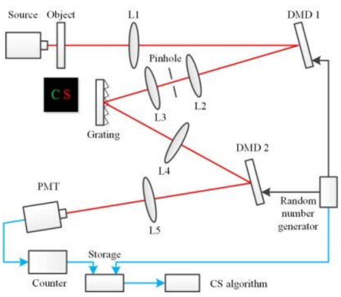

Fig. 1 Experimental setup for spectral imaging. L1-L5: lens; DMD: Digital micromirror device; PMT: Photomultiplier tube.

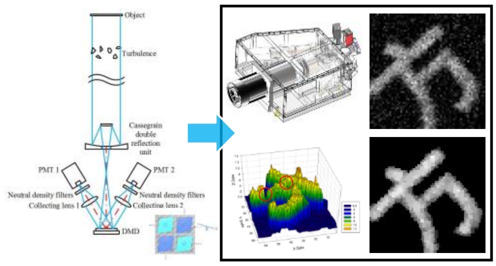

Fig. 2 Experimental apparatus for complementary compressive remote imaging, and results of a natural target at 2 km range [2].

3. Conclusion

In summary, we propose an ultrasensitive compressive spectral imaging scheme with a photon-counting-type PMT, acquiring images and spectrums simultaneously without scanning. For image denoising, we present a complementary measurement method for 2.0 km remote sensing, with the variance of the noise decreasing by half. It is a leap forward for improving the image quality of traditional single-pixel cameras, opening up possibilities for new applications.

Acknowledgements

Authors acknowledge the research team. National Key Scientific Instrument and Equipment Development Project of China (Grant No. 2013YQ030595); National High Technology Research and Development Program of China (Grant No. 2013AA122902).

References

[1] M. F. Duarte, M. A. Davenport, D. Takhar, J. N. Laska, T. Sun, K. F. Kelly, and R. G. Baraniuk. IEEE Signal Process. Mag. **25** (2008) 83–91.
[2] W. K. Yu, X. F. Liu, X. R. Yao, C. Wang, Y. Zhai, and G. J. Zhai. Sci. Rep. **4** (2014) 5834.