Research on reconstruction of atmospheric turbulence wavefront compressed sensing measurement

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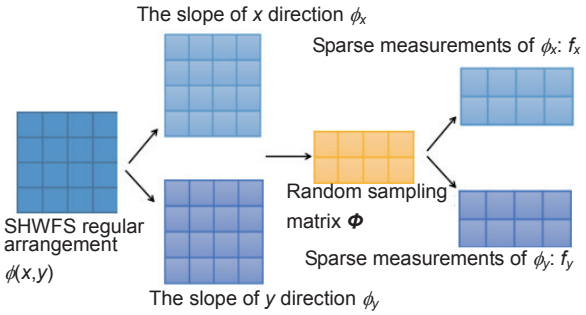

The measurement process of wavefront slope compressed sensing

Overview: Compressed sensing technology for atmospheric turbulence wavefront slope measurement can greatly improve the wavefront signal measurement speed, while reducing the pressure of wavefront measurement system hardware. Different from the existing wavefront slope measurement method, the compressed sensing wavefront measurement increase a process from sparse measurement of wavefront slope value to the reconstruction of the wavefront slope signal, which will increase the wavefront data processing time. So this means putting forward higher demands on the compressed sensing reconstruction algorithm. Therefore, it is necessary to reconstruct wavefront slope quickly and accurately with compressed sensing technology for wavefront measurement.

Smoothed L0 Norm (SL0) algorithm is an optimal iterative reconstruction algorithm with approximate L0 norm estimation. Compared with other algorithms, it does not need to know the sparsity of the signal in advance, and it has lower computational complexity and higher estimation accuracy. Because the SL0 algorithm is based on one-dimensional signal reconstruction, while the method of column by line serial reconstruction is used for two-dimensional signals such as wavefront slope. On the one hand, it belongs to serial operation and increases the reconstruction time, on the other hand, it destorys the relationship between the columns of the wavefront slope signal, which reduces the wavefront slope reconstruction precision.

Aiming at the shortcomings of its reconstruction accuracy and running speed, this paper implements a subregion parallel algorithm—Block-Smoothed L0 Norm (B-SL0), which can quickly and accurately reconstruct the signal by measuring the wavefront slope signal in subarea and parallel operations through theoretical analysis and simulation experiments based on the SL0 algorithm the wavefront derivative compressed sensing (DCS). The B-SL0 algorithm uses subregional parallel operation, which not only reduces the running time of the reconstruction algorithm, but also reduces the damage to the internal information of the wavefront slope signal and further improves the reconstruction accuracy of the wavefront phase.

The simulation results show that the B-SL0 algorithm is superior to the SL0 algorithm in terms of the running time of the wavefront slope reconstruction, and the wavefront phase accuracy restored by the reconstructed wavefront slope is better than that of the SL0 algorithm. In addition, compared with some classical algorithms, such as OMP, SP and BP, the B-SL0 algorithm in the same conditions not only greatly improves the running time of the wavefront slope reconstruction, and the reconstructed wavefront slope signal can restore the atmospheric turbulence wavefront phase better, which reflects the performance of the B-SL0 algorithm is good in reconstructing phase screen.

Citation: Li C, Cai D M, Jia P, *et al*. Research on reconstruction of atmospheric turbulence wavefront compressed sensing measurement[J]. *Opto-Electronic Engineering*, 2018, **45**(4): 170617.

Supported by Young Scientist Funds of National Natural Science Foundation of China (11503018) and Joint Research Fund in Astronomy (U1631133)

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