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BOTDR Denoising by Sparse Representation Algorithm with Preformed Dictionary

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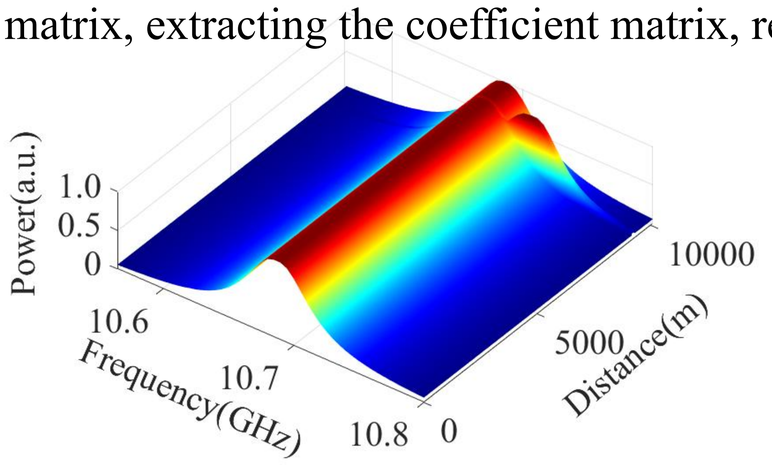
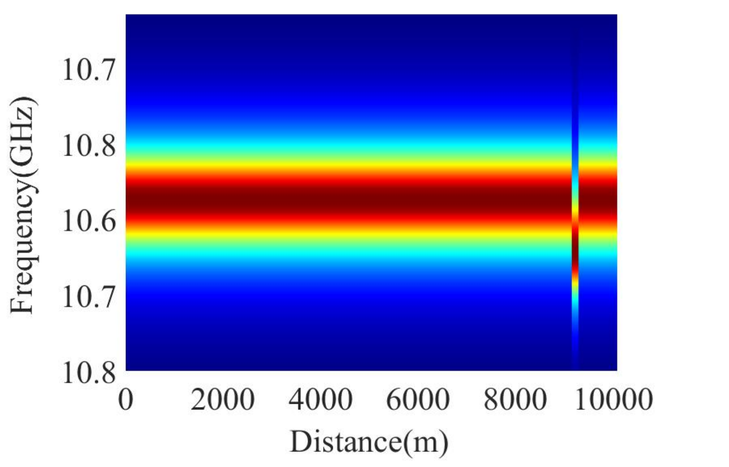
As the threshold limit and attenuation of the optical pulse, BOTDR sensor has the problem of low SNR. This limits the dynamic range of the BOTDR sensor. Improving SNR is very important for BOTDR sensor. In this paper, a sparse representation algorithm with preformed dictionary is used to suppress the random noise introduced by the sensor in the actual environment.

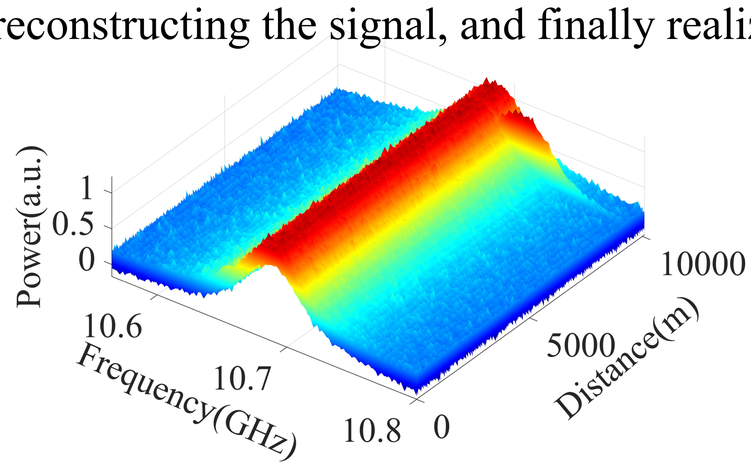
Unlike valid signals, random noise cannot be sparsely represented by dictionary atoms. Using this difference, the sparse representation algorithm can denoise the top view of 3D-BGS image of the BOTDR sensor.
In this paper, the discrete cosine transform algorithm is used to design a preformed dictionary. By designing the dictionary matrix, extracting the coefficient matrix, reconstructing the signal, and finally realizing noise reduction.



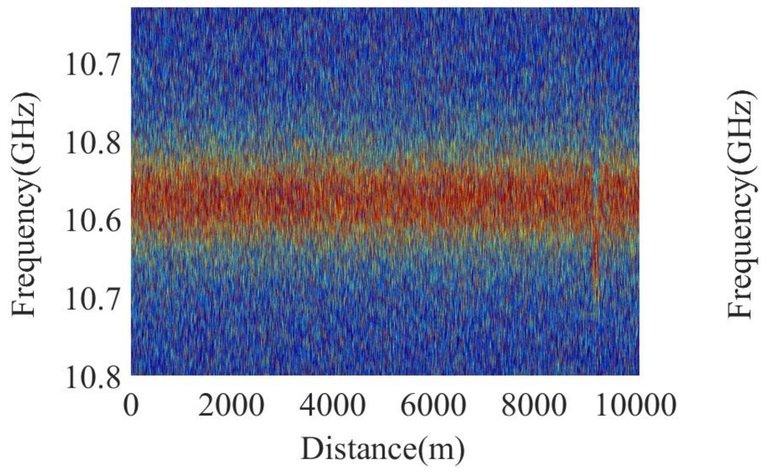
(a) Ideal 3D-BGS image



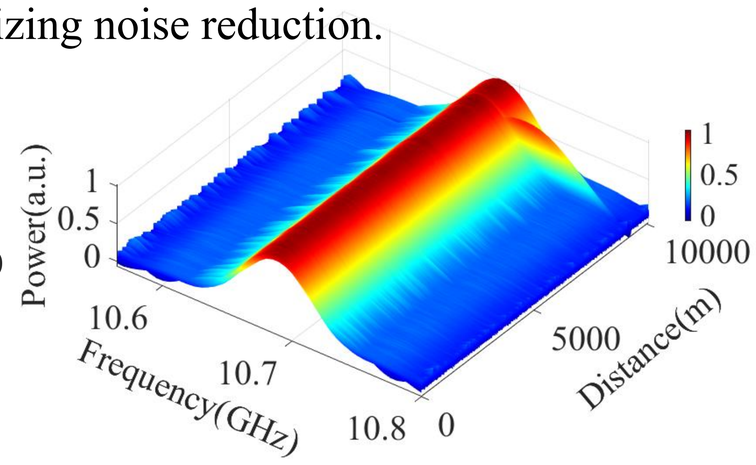
(b) The top view of ideal 3D-BGS image



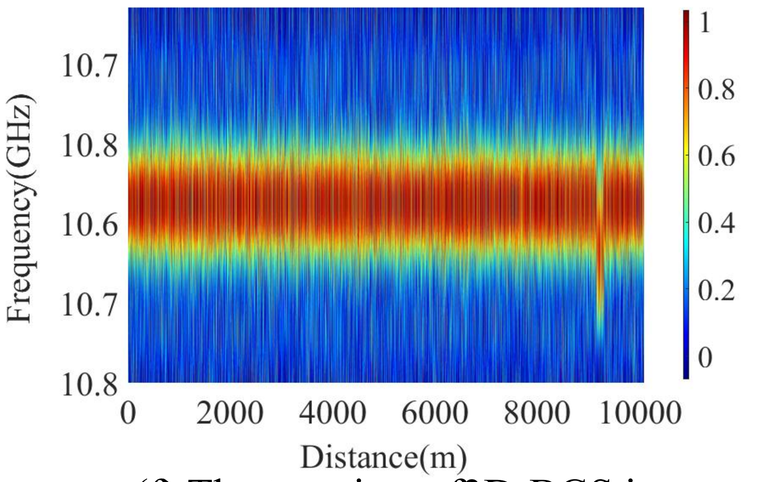
(c) 3D-BGS image before noise reduction



(d) The top view of 3D-BGS image before noise reduction

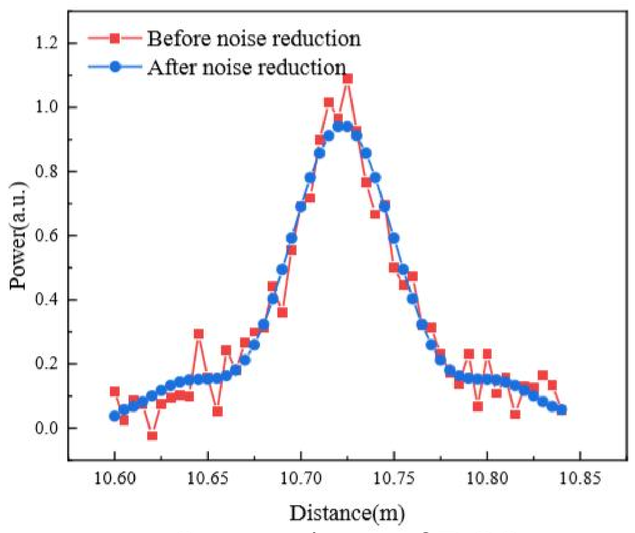


(e) 3D-BGS image after noise reduction

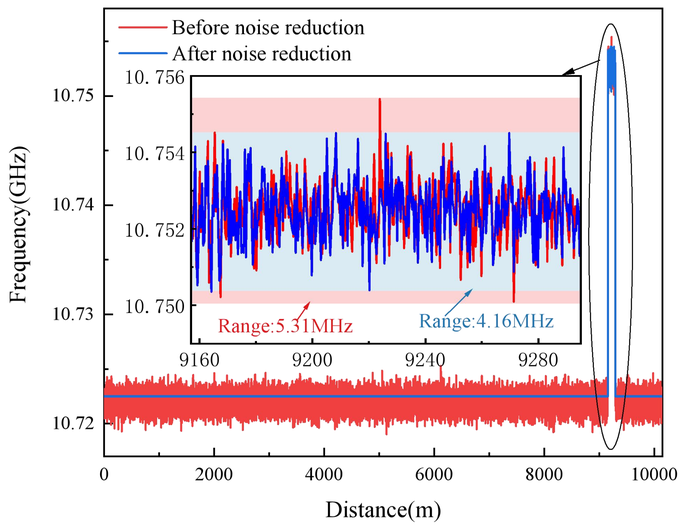


(f) The top view of3D-BGS image after noise reduction

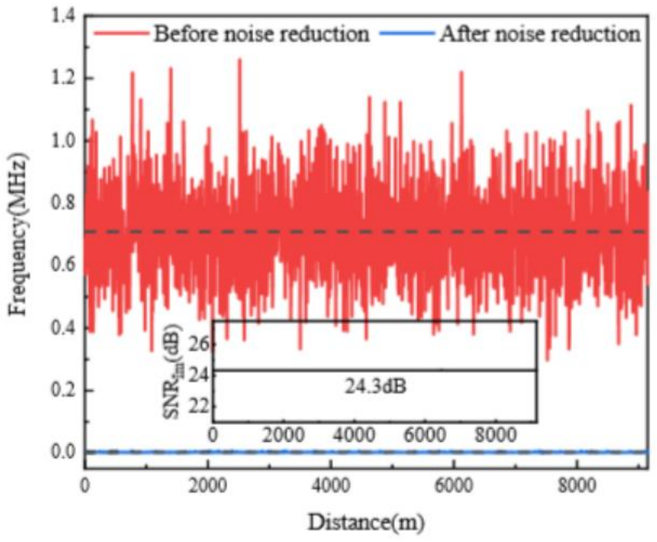
The BOTDR simulation signal is constructed by superimposing random noise on an ideal signal. Then use the algorithm to process the simulated signal to verify the performance of the algorithm.



Comparison of BGS



Comparison of BFS



Comparison of RMSE

Compared with the signal before denoising, the BGS curve after denoising is smoother. The fluctuation range of BFS curve after noise reduction in the non-temperature-change region is greatly reduced, and in the temperature-change region is also narrowed, from 5.31MHz to 4.16MHz. The SNR is improved by 24.3dB, which proves the effectiveness of the algorithm proposed in this paper.

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