The Adaptive Complex Shock Diffusion for Seismic Random Noise Attenuation

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Introduction

- Seismic images always have low signal-to-noise ratio (SNR), especially under complex acquiring conditions.That makes it difficult to suppress random noise and extract seismic signals simultaneously.
- The diffusion filtering based on partial differential equations has great potential capacities in texture protection and noise attenuation of seismic images .
- An adaptive complex shock diffusion (ACSD) method is proposed to preserve the seismic textures by combining the CSD and the structure tensor. A texture detection function is constructed based on the eigen values of the Hessian matrix, which contains seismic texture structure information. The proposed texture detection function provides a tool to adjust the threshold function of the diffusion coefficient in the gradient direction.

Methods

- we utilize the structure tensor to get the texture information of the seismic images,The texture detection function D is obtained by the two eigenvalues μ1 and μ2 of the strucure tensor.

$$D=(\mu_1-\mu_2)^n$$

where the parameter n can be adjusted according to the various images in order to highlight the edges of the seismic images.

- After obtaining the texture detection function D, we make it be the independent variable of the threshold detection function K, and the formula is defined as:

$$K=ke^{-D}$$

where is a weight factor for adjusting the value of K.

- we get the diffusion coefficient in the gradient direction defined as:

$$C_\eta=\frac{\alpha e^{i\theta}}{\exp(\mathrm{Im}(I)/(K\bullet\theta\bullet t))}$$

The ACSD can be stated as:

$$I_t=-\frac{2}{\pi}\arctan(a\,\mathrm{Im}(\frac{I}{\theta}))|\nabla I|+C_\eta I_{\eta\eta}+\tilde{\lambda}I_{\xi\xi}$$

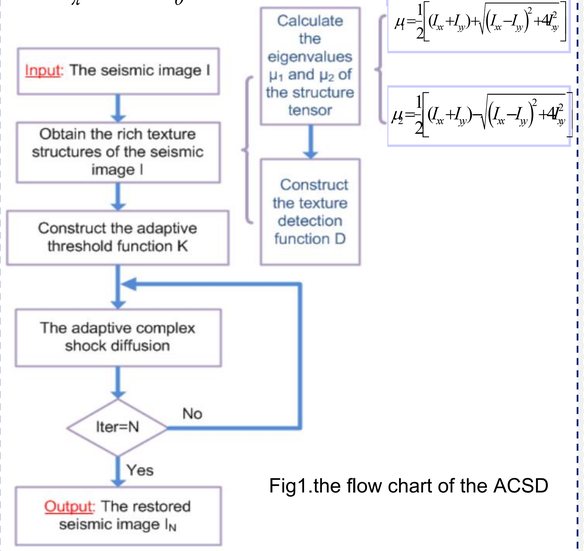

Fig1.the flow chart of the ACSD

Results

TABLE I SNR AND MSE OF THE FILTERING RESULTS

Original (dB)	CSD		ACSD	
	SNR(dB)	MSE	SNR(dB)	MSE
5	9.88	0.0017	**18.46**	**0.0002**
0	9.38	0.0019	**15.40**	**0.0005**
-5	7.89	0.0027	**11.08**	**0.0013**
-10	5.25	0.0050	**6.47**	**0.0037**

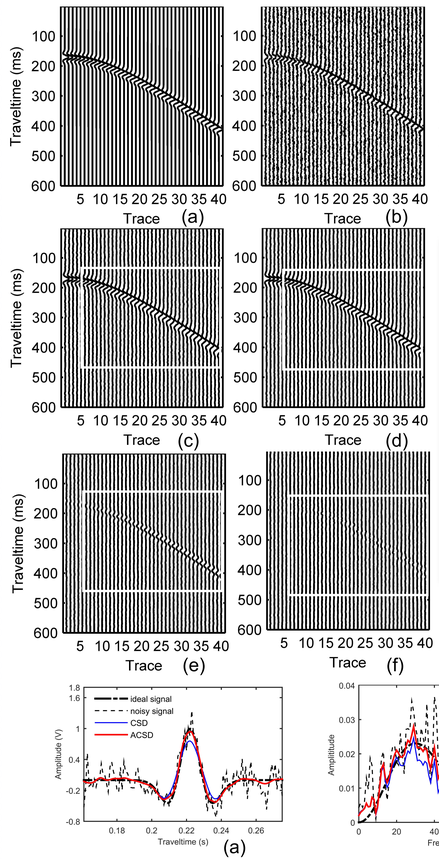

Fig. 2. Results of a synthetic seismic record. (a) Pure record. (b) Noisy record. (c) Result of CSD. (d) Result of the ACSD. (e) The difference of CSD and pure record. (f) The difference of the ACSD and pure record.

From Fig. 2(c) and (d), we find that the CSD and the ACSD both work well in random noise attenuation. In contrast with Fig. 2(e), Fig. 2(f) indicates that the seiemic event which has large slope is well preserved by the ACSD.

Fig. 3. (a) Waveform and (b) Spectrum of the signal in the15th channel

Through comparisons in Fig. 3, we can observe that the ACSD recovers the amplitudes and the phase of the seismic events more completely.

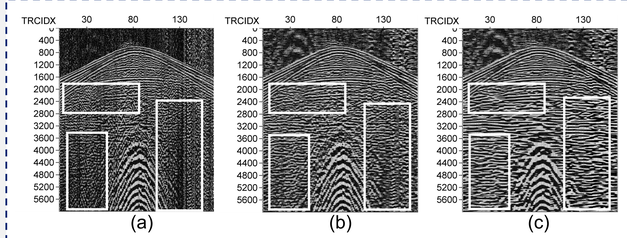

Fig. 4. Results of a field seismic image. (a) Noisy image. (b) Result of CSD. (c) Result of the ACSD.

From figures we can see that there still is strong residual random noise in Fig. 4(b) after using the CSD. On the contrary, some seismic events contaminated by random noise are easier to identify after using the ACSD. To highlight this, we mark certain regions with rectangles. The ACSD is better than the CSD in noise attenuation, details and coherence preservation of seismic events.

Conclusion

A texture detection function is constructed by using the structure tensor ,then we proposes an adaptive threshold function by utilizing the texture detection function to control the diffusion coefficient in the gradient direation according to the structure characteristics of seis mic images. The theoretical analysis and experimental results demonstrate that the ACSD has better capacities of seismic random noise attenuation and the seismic signal preservation compared to the original CSD.

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