Flexible Data-dependent Alpha-trimmed Stacking for Random and Interference Noise Attenuation in Seismic Data from the Alaska, USA

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Abstract: The introduction of multiple coverage, currently called common midpoint (CMP) stacking technique, has improved the way in which seismic data are acquired and processed more than most other advancements in the community of seismic exploration. The most important reason for the wide spread of CMP stack is its distinctive capability in attenuating random noise in seismic data, especially in the case that noise falls in the same frequency range of seismic signal.

Alpha-trimmed stack (ATS) has a great capability of discrimination against not only random noise, but also against interference noise from other crews in marine seismic data acquisition (Haldorsen et al., 1989). ATS is one of the proven effective weighted stacking methods, however, still has two major drawbacks. These drawbacks are the experience-based selection of an appropriate trimming value and the utilization of the fixed alpha-trimming value to the entire dataset regardless of data time-variant nature. First, the trimming process is operated empirically, as the trimmed percentage is decided based merely on the experience and personal judgment of the processor. This inevitably reduces the fold, most of the time unnecessarily, and consequently has a large portion of human error, which likely results in losing some useful signal. The second shortcoming of ATS is applying a fixed trimming value to the whole seismic dataset (Rashed, 2008; Deng et al., 2017). Given the temporal and spatial variant nature of nonstationary seismic data, there is no single trimming value that can be appropriate for the entire dataset (Rashed et al., 2014; Rashed, 2018).

This study presents an adaptable version of ATS called flexible data-dependent alpha-trimmed stack (FATS), in which a flexible trimming percentage value dependent on statistical measures of amplitude dispersion is calculated for each time sample of the data. In this way, the variant nature of seismic data is taken into consideration, i.e. only dispersed amplitudes are trimmed off, and the processor’s capability to manipulate the output towards the mean stack or median stack is also preserved. Common statistical measures of dispersion can be used that include range, variance, standard deviation, and median absolute deviation. Our experience in the present study shows that selecting different measures of data dispersion has almost a negligible effect on the final stacking output. The following is the workflow of implementing the FATS method:

- For each NMO-corrected CMP gather, sort amplitudes at each time sample from smallest to largest.
- Calculate dispersion for each time sample.
- Divide the dispersion at each time sample by the maximum dispersion within this CMP gather.
- Calculate discrete trimming percentage parameters for each time sample on this CMP gather.
- Optionally, smooth the calculated trimming parameters.
- Apply the trimming parameters and stack the trimmed CMP gather.

A field example of simultaneous multi-source land seismic data from the Alaska, USA is used to show an intuitive view on interference and random noise attenuation by FATS. In order to better show the distinct improvement in the lateral continuity and smoothness of the events in the target area around 2 s, zoomed-in sections of the data from CDP 600 to 700, time 1.5 to 2.5 s are displayed in Figures 1. It's observed that remaining strong noise still exists in the mean stack and ATS sections in Figures 1(a) and 1(b). Even worse, signal events are damaged in Figure 1(b) due to the single trimming value. In Figure 1(c), noise gets completely attenuated meanwhile signal gets carefully protected thanks to the adaptability of FATS, which is especially distinct in the right half part of the sections. More practically meaningful, noise elimination in the stack sections contributes substantially to more accurate seismic interpretation for the ultimate purpose of lowering the risk cost of dry drilling in oil and gas reservoir exploitation.

In this study, a new stacking method named FATS has been proposed and tested with field land data. It is clear that FATS result achieves overall the highest SNR, temporal resolution and spatial coherence after attenuating interference and random noise compared to the results of other stacking methods. Finally, future research can be focused on the influence of wavelet frequency on FATS algorithm and on the application of the proposed approach to marine datasets, where simultaneous multi-source acquisition has been operated widely around the world.

Key words: weighted stack, amplitude dispersion, interference, random noise, Alaska

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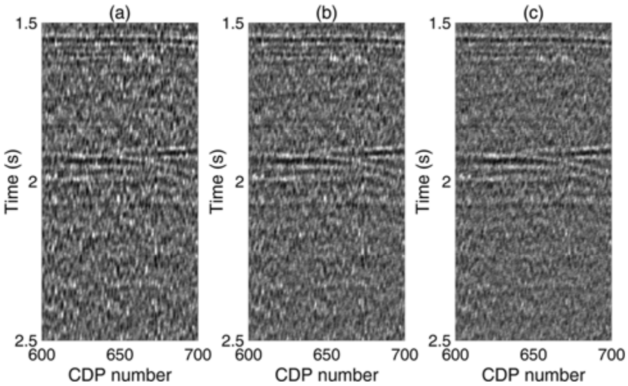

Fig. 1. Stacking test of the simultaneous multi-source land seismic data from the Alaska, USA.
(a) Image by mean stack; (b) Image by ATS; (c) Image by FATS.

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