Cross-Correlation Based Velocity-Independent Residual Time Correction

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1. Summary

In this study, a cross-correlation based residual time correction was developed to overcome the "hockey stick" effect due to incorrect velocity in pre-stack migrated data. We then applied this correction to pre-stack time migrated data from the Barnett Shale.

3. Methodology

For a given time window centered at a certain time, cross-correlation is calculated for every two traces in a group of six traces. The time lag $t_{m,n}$ corresponding to the maximum absolute correlation coefficient is recorded for each trace pair, based on which relative time shift t^p of a trailing trace against the pilot trace (inner most in the group) is obtained (Figure 1). We generate the pilot trace by reverse flattening the adjacent inner four traces then stacking them and the original pilot trace together (Figure 2). For each CRP gather, this process is repeated from near offset to far offset, then from shallow part to deep part. The final residual time T^k for a point is the summation of its relative time shift to the pilot trace and the residual time of this pilot trace.

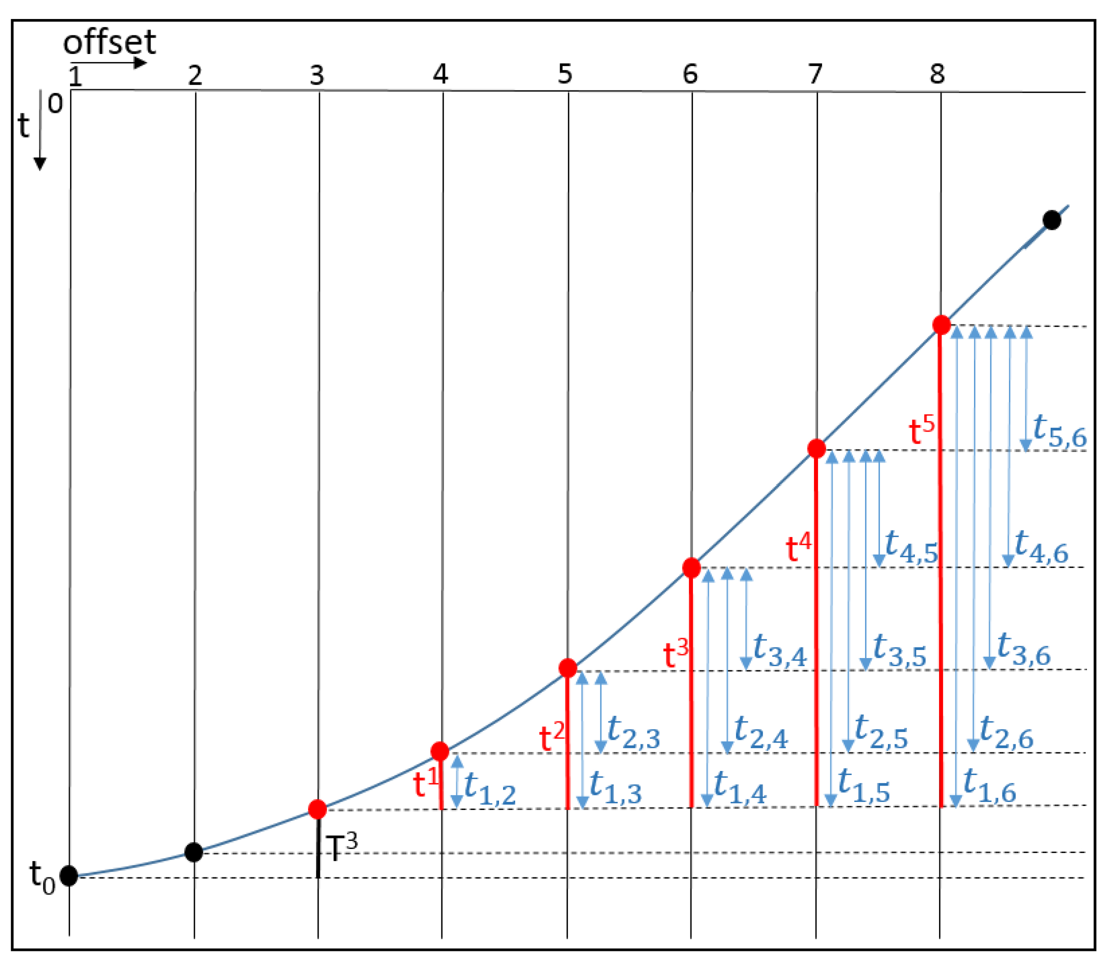

Figure 1. Cartoon illustration of a trace group. Six traces are in this group and trace 3 is the pilot trace. T^3 is the residual time of the pilot trace. t^1 to t^5 are the relative time shifts against the pilot trace. These relative shifts are least-square solutions solved from $t_{m,n}$, which are the time lags between each two traces.

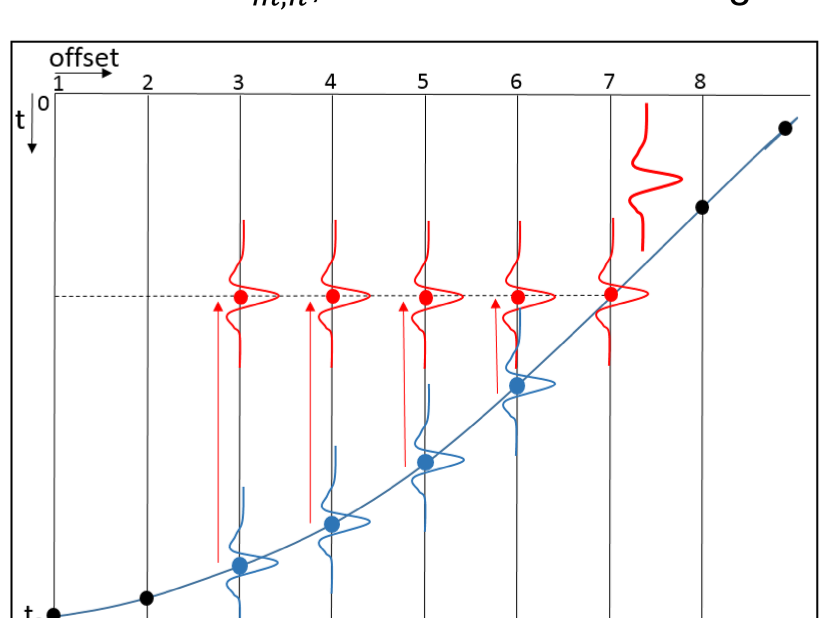

Figure 2. Cartoon illustration of generating a pilot trace. Four inner adjacent traces of trace 7 are reverse flattened towards trace 7. The stacking trace of these five traces is then used as the pilot trace of the group which starts at trace 7.

2. Introduction

Long offset seismic data are routinely acquired and processed for unconventional reservoirs. Traditional residual time correction that based on hyperbolic NMO is incapable of flattening seismic gathers in far offset, which compromises stacking and pre-/ post-stack migration quality, and may further lead to ambiguity and mistakes in interpretation.

Jumping out of the hyperbolic assumption would be a nice try, and some researchers have already successfully developed and implemented gather flattening techniques based on cross-correlation (Hinkley et al., 2004; Gulunay et al., 2007, 2008). In this study we also followed this idea, flattening seismic gathers by cross-correlating traces within a dynamic temporal and spatial window. However, before calculating cross-correlation and time shifts within each group, a pilot trace which is a stacking of some inner side reverse flattened traces is generated. Such noise depressed pilot traces are then used as references in each spatial window (trace group), and therefore provide a more stable benchmark to correlate with instead of simply using every first trace in a group as reference.

4. Application

We applied this residual time correction algorithm to a time migrated CRP gather from the Barnett Shale (Figure 3). The correction was run in two stages. In the first stage, correlation window was 40ms for shallow part and 80ms for deep part, with a correlation rejection threshold of 0.6. In the second stage, these numbers were 20ms, 40ms and 0.8, respectively. Events are flattened after each stage.

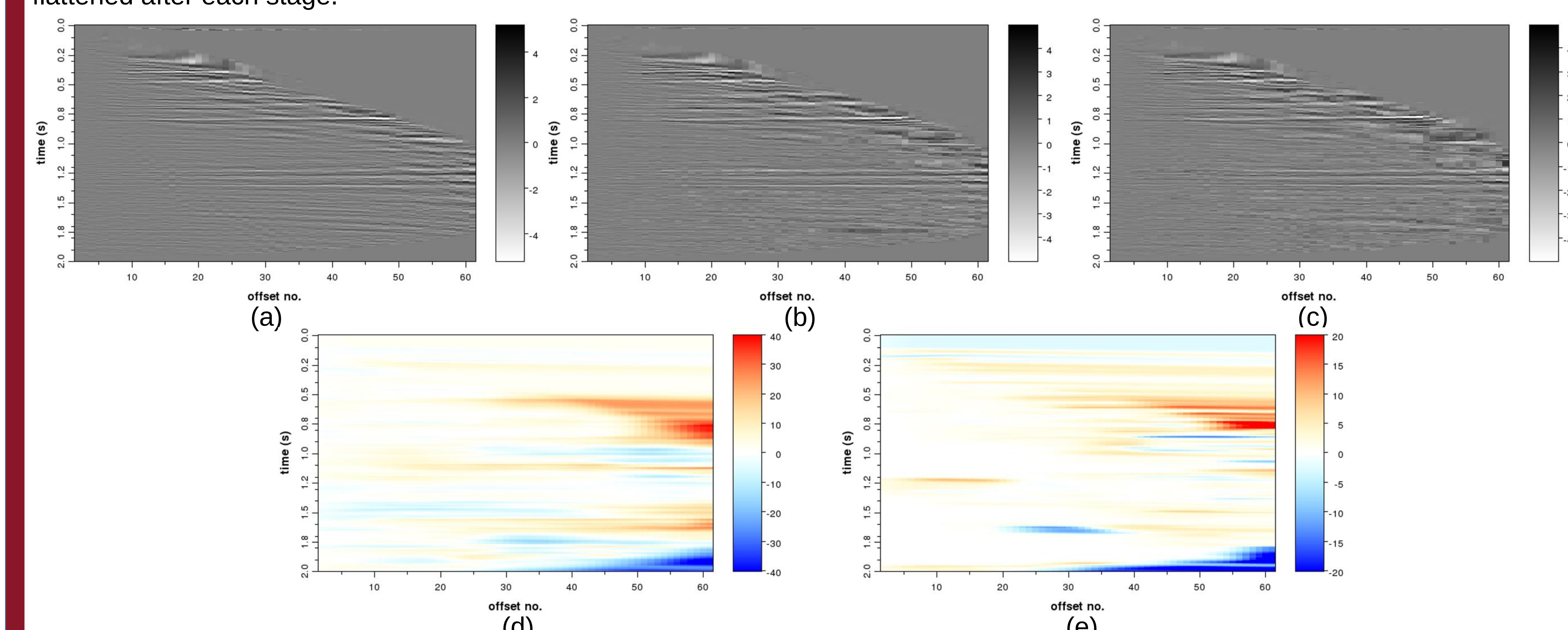

Figure 3. (**a**) Time migrated CRP gather. One can clearly identify the "hockey stick" effect caused by undercorrection in shallow part and overcorrection in deep part. (**b**) The same gather after stage 1 RMO. The "hockey stick" effect in far offset is depressed compared with in (a). (**c**) The same gather after stage 1 and stage 2 RMO. Events are further flattened. (**d**) Residual time applied in stage 1. Cold color indicates overcorrection and warm color indicates undercorrection. (**e**) Residual time applied in stage 2.

5. Conclusions

Such residual time correction method introduces a mathematical brute force that stands alone from velocity, therefore provides a more precise result as well as a cozier process than the usually tedious and laborious velocity picking procedure. However, due to its non-physical nature, parameter selecting should be done with caution to prevent artifacts.

6. Acknowledgements

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References

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