Stanford Exploration Project, Report 61, January 13, 1998, pages 1–11

Stanford Exploration Project, Report 61, January 13, 1998, pages 1–11

A truncation effect in velocity analysis

Josef Jedlička[1]

keywords: *velocity, amplitudes*

ABSTRACT

A set of parabolas that is due to the truncation effect can be seen in velocity stacks. A velocity stack that uses uncertain velocities attenuates the truncation effect.

INTRODUCTION

When a velocity stack is performed with even sampling in the sloth domain (first introduced by Francis Muir), a disturbing feature of parallel lines can be observed (Figure **??**c). At the first glance they seem to be straight lines, but a closer inspection shows that they are curved. It will be shown in this paper that they are parabolas.

The nature of these lines is studied in this paper and I suggest a way of attenuating this feature.

STRUCTURE OF A VELOCITY ANALYSIS PANEL

Image of a point

A velocity analysis panel is obtained by transformation of a CMP gather. In this paper an operator of summation will be used. This operator $\mathbf{S}$ transforms (t, x)-space into (τ, m)-space; i.e., it is an operator of transformation from the time-offset domain into the time-sloth domain. We are interested in the image in (τ, m)-space of a point in (t, x)-space.

Let a gather G_{tx} contain only one non-zero amplitude that is located at time t of a trace with the offset x (Fig. **??**a). Let us apply the operator $\mathbf{S}$ on the gather G_{tx}. The operator $\mathbf{S}$ gives non-zero results only for hyperbolas passing through the point (T, X) (Fig. **??**). Each hyperbola is determined by the time τ and the sloth m, which satisfy the equation

$$T^2 = \tau^2 + X^2 m, \tag{1}$$

[1] **email:** not available

which can be written

$$\tau^2 = -X^2 m + T^2. \tag{2}$$

This is the equation of a parabola, so we have

$$\mathbf{S}(point) = parabola. \tag{3}$$

A parabola corresponding to the point (T, X) is shown in Figure **??**b.

Representation of a velocity analysis panel

The CMP gather G can be viewed as a sum of gathers G_{tx}, each containing only one non-zero amplitude:

$$G = \sum_{t,x} A(t,x) G_{tx}, \tag{4}$$

where G_{tx} is a gather containing a spike at (t, x) and $A(t, x)$ is the amplitude of a trace with offset x at time t.

Because the image of G_{tx} is a (τ, m)-space containing a parabola, we can write

$$V = \sum_{t,x} A(t,x) V_{tx}, \tag{5}$$

i.e., the (τ, m)-space can be viewed as a sum of panels, each containing one parabola. For a constant offset x, the resulting sets of parabolas are shown in Figure **??**.

Let us denote as V_x the panel that we get for one offset x:

$$V_x = \sum_{t} A(t,x) V_{tx}. \tag{6}$$

V_x is an image of a trace with offset x. Finally we have

$$V = \sum_{x} V_x. \tag{7}$$

V_x consists of horizontal lines for $x = 0$. For increasing offset V_x consists of parabolas with increasing slopes (Figure **??**).

The slopes of the parabolas

Let us calculate the slope of the parabolas:

$$\frac{d\tau}{dm} = \frac{X^2}{2\sqrt{X^2 m + T^2}}. \tag{8}$$

The slope at $m = 0$ is

$$\frac{d\tau}{dm} = \frac{X^2}{2T}. \tag{9}$$

The distance between two adjacent hyperbolas when the sloth space is evenly sampled is

$$\Delta t = \frac{x^2}{t} \Delta m. \tag{10}$$

Hence the slope of parabolas at $m = 0$ is proportional to the distance between hyperbolas passing through the corresponding points. From Figure **??** we can see that at higher times the slopes are nearly the same (the lines appear to be parallel); this conclusion corresponds to the fact that hyperbolas divide the gather quite evenly.

TRUNCATION EFFECT

We can see that the slopes of the lines on Figure **??**c correspond to the slopes corresponding to the last trace of the gather (Fig. **??**d). It suggests that the lines are due to the truncation effect and that they are parabolas. If they are parabolas they should turn into straight lines in (τ^2, m)-space. The result is shown in Figure **??**b. In the upper right part of the figure are lines dipping less steeply. This is due to the fact that truncation at low times occurs at lower offset (Figure **??**).

A velocity stack made with half of the marine gather is shown in Figure **??**a. The slope is less steep and corresponds to that in Figure **??**b.

Attenuation of truncation effect

In Jedlička, 1989, I introduced a velocity analysis using stochastic normal moveout (SMOC). Let us briefly review the basics. A sampling interval Δm is chosen in the sloth domain, but instead of a sum along hyperbolas, a sum is made from all amplitudes lying between adjacent hyperbolas. In other words a histogram is created (Figure **??**). This operation is equivalent to the filtering of (τ, m)-space with a boxcar filter over the sloth domain. A spectrum of the triangular filter

$$\triangle = \square * \square \tag{11}$$

has lower sidelobes than the spectrum of the boxcar filter and therefore it causes less overlapping (Figure **??**). Furthermore it can be viewed as an approximation to a Gaussian. This is the initial idea of Francis Muir that led to the concept of SMOC.

From Figure **??**b we can see that the truncation effect is strongly attenuated. For comparison, a velocity analysis panel shown in Figure **??**c was filtered over the sloth domain; the result should be equivalent to the velocity stack produced with SMOC. However, the result shown in Figure **??**a is not so clean. This comparison shows the advantage of using SMOC over the filtering in the sloth domain. The length of the filter should not be chosen to be too small, otherwise the truncation effect is not attenuated (Figure **??**c). Choosing the length of the filter to be too big leads to a fuzzy appearance of the velocity analysis panel.

CONCLUSIONS

An interesting feature of lines in a velocity analysis panel was explained as a truncation effect. Velocity analysis using SMOC can be used for attenuating this effect.

ACKNOWLEDGEMENTS

I would like to thank Francis Muir for drawing my attention to the truncation effect.

REFERENCES

Jedlička, J., 1989, Stochastic normal moveout: SEP-**60**,165-178.