COMPUTATIONAL ASPECTS OF IMAGING WITH GAUSSIAN WAVE PACKETS

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In this paper we address some computational aspects related to a particular implementation of seismic imaging - the one based on a flow-out of Gaussian wave packets. Gaussian beams were used for modeling seismic wave propagation since early 80s while Gaussian wave packets introduced at the same time were not as popular in practical computations. Practical implementation of prestack migration with Gaussian beams was proposed by Hill (2001). Migration based on Gaussian packets was discussed by Klimeš (2004), Bucha (2009) (see also references therein).

In this paper we address main steps of the migration strategy for 2D common-shot gathers as described by Bucha (2009): (1) data decomposition into Gaussian wave packets; (2) flow -out of wave-packets into subsurface; (3) imaging condition (cross-correlation of wave packets).

1. We will address the problem of data decomposition in great detail while proposing iterative non-linear algorithm based on l1-optimization ideas. So far we have implemented a 2D decomposition that can be used for getting sparse representation of 2D seismic data sets with as few Gaussian wave packets as possible.

Sparse data representation is important for reducing computational cost for the whole migration procedure, i.e. reducing a number of rays to be traced and a cost of applying an imaging condition. In addition we essentially get a high quality analysis of data directionality that can be used in many different ways apart from migration: detecting slopes, data regularization, as a part of event picking etc.

2. Gaussian wave-packet flow-out is the most restrictive step of the migration strategy. It was noticed by many authors that a smooth migration velocity model should be used for propagation (flow-out) of Gaussian wave packets. Even using a smooth model one gets in trouble trying to propagate Gaussian packets for a long distance. For now we restrict ourselves to a so called rigid flow: each Gaussian wave packet is moved along a ray and stretched in the ray direction according to a velocity at the packet central point. Although not ideal, this choice allows for fast flow-out implementation.

3. We note that after rigid flow of Gaussian wave packets their form remains unchanged. Thus, after propagation their form is still described by analytic formulas. Then it is possible to write out analytic formulas for applying imaging condition: cross-correlation of two moving Gaussian wave-packets is still a Gaussian wave packet (assuming locally homogeneous medium). As a result we get fast implementation of imaging condition.

In conclusion we want to stress again that imaging based on flowing out Gaussian packets can be used only in smooth velocity models. Thus it is crucial to aim for fast implementation in order to make it attractive compared to other methods and use for preliminary or iterative migration.

References

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