CONTROLLED INITIAL–VALUE RAY TRACING AND TWO–POINT RAY TRACING IN 3-D

Petr Bulant & **Luděk Klimeš**
Department of Geophysics, Charles University, Ke Karlovu 3, 121 16 Praha 2, Czech Republic.

The *controlled initial–value ray tracing* is a promising tool of fast calculation of most energetic ray–theory *elementary travel times* at gridpoints of dense rectangular 3-D grids of points. The aim of controlled initial–value ray tracing is to cover the target zone in a seismic model with a sufficiently dense system of rays, and to interpolate travel times and other quantities at gridponts of the target grid. The method is basically equivalent to *wavefront tracing method* (Vinje, Iversen & Gjøystdal, 1993).

The presented version of the controlled initial–value ray tracing algorithm is closely related to *two–point ray tracing* algorithm (Bulant & Klimeš, 1996 ; Bulant, 1996), as the dense coverage of the target zone by seismic rays of all possible *ray histories* (see below) play the principal role in both cases.

The two–point ray tracing by means of shooting is based on iterative application of an *initial–value ray tracing* algorithm. In each computation, only the rays of a single *elementary wave*, i.e. the rays whose behaviour at structural interfaces is prescribed by a priori information called the *ray code*, are considered. The rays are thus specified uniquely by the *ray take–off parameters*. For each given ray code, the principal problem of two–point ray tracing consists in a sufficiently accurate determination of boundaries between rays with different ray histories, i.e. passing through different geological blocks, across different structural interfaces, terminated in different areas for different reasons, or passing through a different number of caustics. The demarcation belts between the different ray histories, corresponding to numerical uncertainty of the boundaries between the ray histories, have to be kept reasonably narrow.

As soon as the 2-D *domain of ray take–off parameters* is decomposed, with given accuracy, into *homogeneous subdomains* corresponding to rays of equal ray histories, the individual homogeneous subdomains with rays passing through the target area are selected, and the sufficiently dense coverage of the target zone by rays of the subdomains is checked. Then the two–point rays can be found (using, e.g., the paraxial ray approximation) within individual homogeneous subdomains, and the travel times to the gridpoints can be interpolated within individual *ray cells*, similarly as in the wavefront tracing method.

The corresponding Fortran 77 computer code for 3-D controlled initial–value ray tracing is being developed on the basis of package `MODEL` to specify *smooth block models* of geological structures, and package `CRT` for initial–value ray tracing in such models (Červený, Klimeš & Pšenčík, 1988). The model specification has been proposed in the way enabling the application of a broadest variety of travel–time and full–wavefield modelling techniques. A smooth block model is composed of blocks of arbitrary shapes, separated by structural interfaces covered by a finite number of smooth surfaces. Inside each block, the material parameters, like P and S wave velocities, are smooth functions of spatial coordinates.

References

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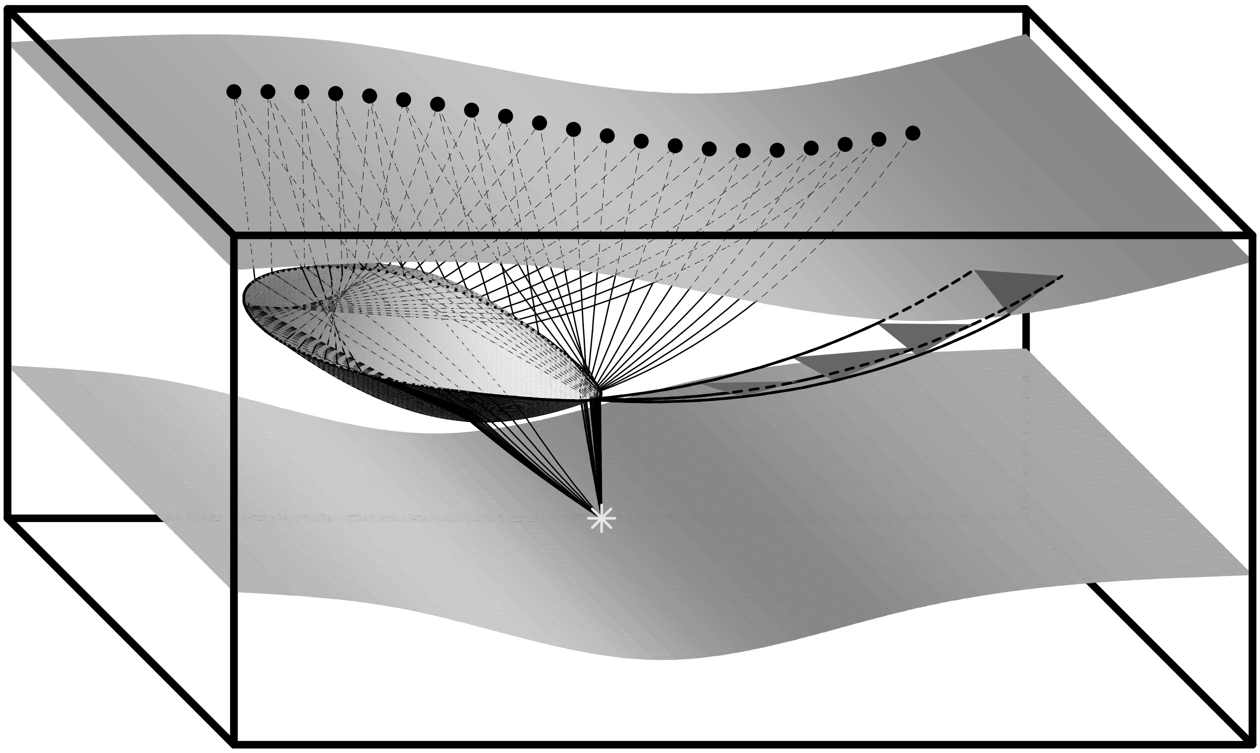

Figure 1. Edge-diffracted rays in a simple artificial model with a homogeneous lenticular inclusion embedded in a layer of a constant velocity gradient. The receivers are specified along the curved Earth surface, and found two–point rays are plotted as thiner lines.

Surface of the model is covered by diffracted rays with prescribed density, which enables interpolation of, e.g., travel times anywhere near the model surface using the controlled initial–value ray tracing. One ray tube, formed by three rays (thicker lines), and its ray cells are plotted for illustration.

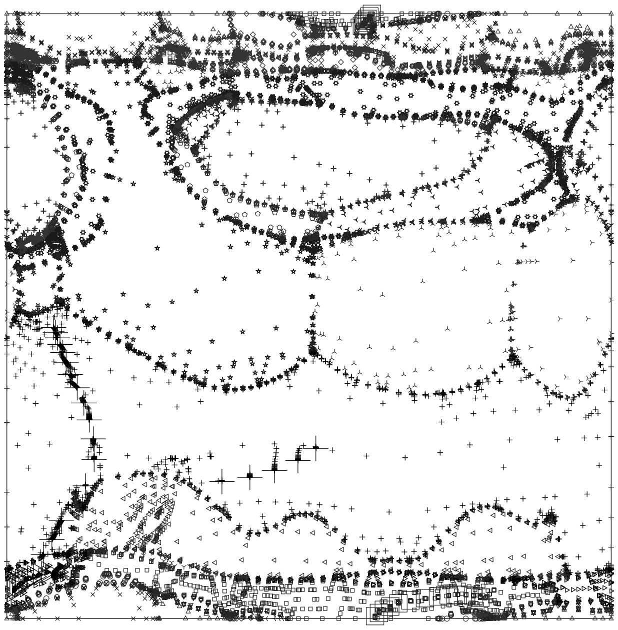

Figure 2. Take-off parameters of the rays diffracted at the edge of a lenticular inclusion. The horizontal axe is a length along the edge, the vertical one is proportional to a take-off angle. Rays of different ray histories are denoted by different marks. The two–point rays are emphasized by considerably enlarged marks.

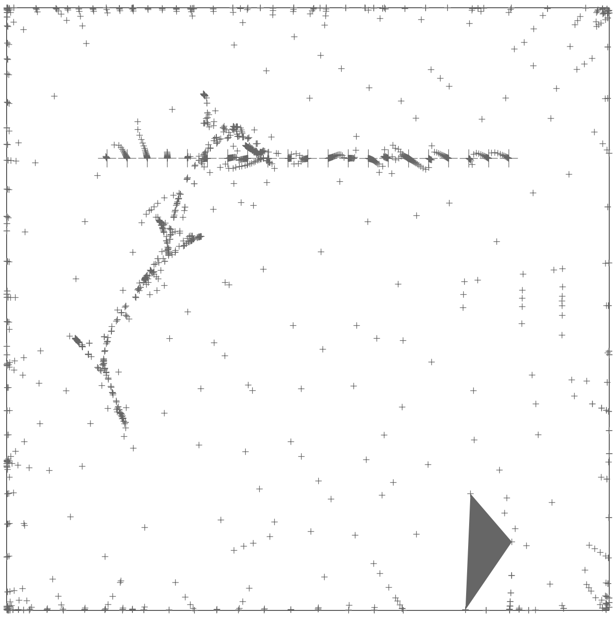

Figure 3. Endpoints of the rays on the surface of the model. Only the rays of the history marked by crosses on figure 2 are plotted. The triangle selected for visualization of the ray tube on figure 1 is here emphasized by shading. The two–point rays are denoted by large crosses.