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A genetic algorithm based focal parameter and seismic velocity estimation procedure

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The reliability of the determination of earthquake focal parameters (i.e. the coordinates of hypocentre and the origin time) depends strongly on the quality of the applied velocity model. Therefore, the methods based on the so called joint hypocentre-velocity inversion, which computes the location of hypocentres and the velocity model at the same time from the arrival time data, are highly popular.

The problem posed by the joint hypocentre-velocity inversion is strongly nonlinear, consequently the appropriate selection of the initial models is of high importance. It must be provided that the models cover the wide range of physically plausible velocity structures in order to avoid to be trapped in one of the local minima. However, the preparation and processing of this initial model set is usually a tedious manual task.

Genetic algorithms are global optimization procedures which model the evolution of the biosphere. They are particularly adept for solving non-linear, multiparametered problems. These methods provide us a convenient tool to circumvent the difficulties outlined above.

After careful, a priori information based setting of model parameter ranges, genetic algorithms are able to generate a wide set of initial models which can be used as the input of the iteration of joint hypocentre-velocity inversion.

The authors developed a procedure based on genetic algorithm which is able to provide reliable focal parameter and velocity structure estimation with minimal manual intervention. This accelerates significantly the process of the velocity model and focal parameter determination, while reduces the unavoidable subjectivity of manual initial model generation.

It follows from the nature of the problem that there is numerous velocity models for which computed travel times yield almost equally good, low residual values relative to the measured data. The velocity model influences the focal parameters as well, what allows to choose one of these models which gives the best approximation of the real structure. The selection e.g. can be carried out with the use of the data of controlled explosions.

As an application of the procedure the authors relocated the earthquakes occurred in Hungary between 1994 and 2007. The control data for the model selection were coming from the CELEBRATION-2000 seismic experiment.

Using the method presented here, the refinement of the velocity structure and focal parameters based on the increasing quantity of seismological data can be performed quickly and the resulting velocity model can be integrated into the seismological observatory practice.