JOURNAL OF HUNGARIAN GEOMATHEMATICS

Volume 1

Geophysics and Geomathematics in Hungary

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Abstract

Data processing in the above sense is now an everyday routine in most Hungarian institutions where geophysics is pursued, including university departments, research institutes, industrial laboratories and private geophysical companies. In the following description, the main emphasis will be put on those research groups which have recently contributed to the development of data processing techniques in some theoretical or methodological sense.

Keywords: geophysics, data processing.

Geomathematics, a special application of mathematical statistics to Earth science problems, aims in general at the extraction of geological objectsfrom "noisy" data sets (data including random errors). In a broad sense,this is also the basic goal of field geophysics, and this fact suggests a very close relationship between geophysics and geomathematics.

Geophysicists have long been using various mathematical methods based on probability theory, information theory and mathematical statistics in order to evaluate their field measurements. Traditionally they use the term "geophysical data processing" for this collection of data evaluation methods, but it would not be a big mistake to say "geomathematics" instead.

Notwithstanding, geophysical data processing has its own specialities, and not just because the objects of geophysical prospecting are different from, say, those of mineralogy or petrology. There are some specialities related to the methodological approach. In most geophysical data processing problems, the physical field of the geological object, which is investigated by a particular kind of geophysical measurements, is calculated from a deterministic physical theory, and these deterministically obtained theoretical values are contrasted with the stochastic data obtained in the field measurement. In this way, geophysical data processing mostly aims at an explicit physical model fitting, and the mathematical methods used in this process are selected according to this basic goal.

Data processing in the above sense is now an everyday routine in most Hungarian institutions where geophysics is pursued, including university departments, research institutes, industrial laboratories and private geophysical companies. In the following description, the main emphasis will be put on those research groups, which have recently contributed to the development of data processing techniques in some theoretical or methodological sense.

A basic problem in the theory of model fitting is the probability distribution of the "noise", i.e. the measurement and model errors. The usual "default" assumption is that these errors follow a normal (Gaussian) distribution, but it is easy to find examples where this cannot be true. This question has very important implications for the choice of the criterion function or "norm" of the model fitting. Pioneering work has been carried out in this respect by geophysicists and mathematicians working together at the Geophysical Department of Miskolc University (F. Steiner, L. Csernyák, B. Hajagos, P. Szûcs, M. Dobróka, Á. Gyulai, T. Ormos, G. Petõ, E. Turai). They have published many papers not only on the theory of establishing robust estimators, but also on actual applications of model fitting and parameter estimation for various kinds of geophysical measurements, including the joint usage of different types of measurements ("joint inversion").

Basic theory of statistical parameter estimation and examples of practical applications has long been the subject of researchers at the Geophysical Department of Eötvös University, Budapest (P. Salát, D. Drahos, K. Kis). They have focused on the classical Bayesian estimation principle, with emphasis on the use of prior information and the optimum design of measurement strategy. Important applications of the above-mentioned principles have been established for seismic and electric prospecting
by T. Fancsik, E. Prácser, G. Varga at the Eötvös Loránd Geophysical Institute of Hungary.

A very important data processing tool which, inherited from the theory of general signal processing, has become widespread in geophysics is filtering. Numerical signal filters can be designed for very different purposes of data evaluation. Data transformation by linear filters can be useful in different stages of probabilistic model fitting, and can be used simply for easing data visualization. Seismic signal processing is the largest field of filtering applications in geophysics. A. Meskó, K. Kis (Geophysical Department of Eötvös University, Budapest), F. Steiner, E. Turai (Geophysical Department of Miskolc University), L. Gömböcz, Z. Timár, P. Solt (Eötvös Loránd Geophysical Institute of Hungary), I. Késmárky, G. Göncz, I. Véges (GES Company, Budapest) are just the most important contributors to filter theory and applications.

A third large area of data evaluation which has found applications in geophysics (and in other branches of Earth sciences) is image processing. Aerial and satellite photos can be used in detecting various kinds of geophysical objects at the surface of the Earth. Besides using classical image processing tools, special geophysical applications have also been designed for this purpose. The contribution of the Space Research Group of the Geophysical Department, Eötvös University, Budapest (directed by Cs. Ferencz) and a team at the Eötvös Loránd Geophysical Institute of Hungary (directed by J. Kiss) has been valuable in this field.