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Need for Expert Knowledge (and Soft Computing) in Geosciences

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Abstract: Civilization greatly depends on the things we extract from the Earth: oil, gas, water, etc. The need is growing, so we must find new resources. The problem is that most easy-to-access mineral resources have been discovered. For example, new oil fields are at large depths, under water, in remote areas – so drilling is very expensive. It is therefore necessary to predict resources before we invest in drilling. How can we do that? We know what structures are promising. For example, oil and gas concentrate near the top of (natural) underground domal structures. So, to find mineral resources, we must determine the structure at different depths and locations.

In other words, we need to reconstruct the values of the quantities of interest -- such as density at different depths and different locations -- from the measurement results. From the mathematical viewpoint, the corresponding problems are often "ill-posed", meaning that usually, several drastically different density distributions are consistent with the same observations. Out of all these distributions, we need to select the physically meaningful one(s) -- and this is where expert knowledge is needed, to describe what "physically meaningful" means. On the example of the above geophysical problem, we show how this expert knowledge can be taken into account.

Somewhat surprisingly, the need for such expert knowledge emerges even in situations when we simply want to "fuse" data from different sources. In such situations, seemingly natural statistical approaches (such as Maximum Likelihood methods), sometimes lead to physically meaningless results. To get physically meaningful results, we must supplement the data itself (and the corresponding statistical information) with expert knowledge describing which fusion results are physically meaningful and which are not. In the talk, we show how this expert knowledge can help.

Finally, expert knowledge is needed to estimate how accurate are the results of geophysical data processing.

Vladik Kreinovich received his M.Sc. in Mathematics and Computer Science from St. Petersburg University, Russia, in 1974, and Ph.D. from the Institute of Mathematics, Soviet Academy of Sciences, Novosibirsk, in 1979. In 1975-80, he worked with the Soviet Academy of Sciences, in particular, in 1978-80, with the Special Astrophysical Observatory (representation and processing of uncertainty in radioastronomy). In 1982-89, he worked on error estimation and intelligent information processing for the National Institute for Electrical Measuring Instruments, Russia. In 1989, he was a Visiting Scholar at Stanford University. Since 1990, he is with the Department of Computer Science, University of Texas at El Paso. Also, served as an invited professor in Paris (University of Paris VI), Hong Kong, St. Petersburg, Russia, and Brazil.

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Honors: President, North American Fuzzy Information Processing Society; Foreign Member of the Russian Academy of Metrological Sciences; recipient of the 2003 El Paso Energy Foundation Faculty Achievement Award for Research awarded by the University of Texas at El Paso, and a co-recipient of the 2005 Star Award from the University of Texas System.