PREFACE

There has been a time when statistical modeling of observation equations was clear in disciplines like geodesy, geophysics, photogrammetry and practically always based on the conceptual arsenal of least square theory despite the different physical realities and laws involved in their respective observations.

A little number of (very precise) observations and an even smaller number of parameters to model physical and geometrical laws behind experimental reality, have allowed the development of a neat line of thought where "errors" were the only stochastic variables in the model, while parameters were deterministic quantities related only to the averages of the observables. The only difficulty there was to make a global description of the manifold of mean values which could, as a whole, be a very complicated object on which finding the absolute minimum of the quadratic functional[1] could be a difficult task, for a general vector of observations. This point however was mostly theoretical, since the accuracy of observations and the strong belief in the deterministic model were such that only a very small part of the manifold of the means was really interested in the minimization process and typically the non-linearity played a minor part in that.

The enormous increase of available data with the electronic and automatic instrumentation, the possibility of expanding our computations in the number of data and velocity of calculations (a revolution which hasn't yet seen a moment of rest) the need of fully including unknown fields (i.e. objects with infinitely many degrees of freedom) among the "parameters" to be estimated have reversed the previous point of view. First of all any practical problem with an infinite number of degree of freedom is underdetermined; second, the discrepancy between observations and average model is not a simple noise but it is the model itself that becomes random; third, the model is refined to a point that also factors weakly influencing the observables are included, with the result that the inverse mapping is unstable. All these factors have urged scientists in these disciplines to overcome the bounds of least squares theory (namely the idea of "minimizing" the discrepancies between observations and one specific model with a smaller number of parameters) adopting (relatively) new techniques like Tikhonov regularization, Bayesian theory, stochastic optimization and random fields theory to treat their data and analyze their models.

Of course the various approaches have been guided by the nature of the fields analyzed and the physical laws underlying the measurements in different disciplines (e.g. the field of elastic waves in relation to the elastic parameters and their discontinuities in the earth, the gravity field in relation to the earth mass density and the field of gray densities and its discontinuities within digital images of the earth in relation to the earth's surface and its natural or man-made coverage).

So, for instance, in seismology, where 1% or even 10% of relative accuracy is acceptable, the idea of random models/parameters is widely accepted and conjugated with other methods for highly non-linear phenomena, as the physics of elastic wave propa-

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[1] Note that in least squares theory the target function is quadratic in the mean vector, not in the parameter vector.

gation in complex objects like the earth dictates. In geodesy deterministic and stochastic regularization of the gravity field is used since long time while non-linearity is typically dealt with in a very simple way, due to the substantial smoothness of this field; in image analysis, on the contrary, the discontinuities of the field are even more important than the continuous "blobs", however these can be detected with non-convex optimization techniques, some of which are stochastic and lead naturally to a Bayesian interpolation of the field of gray densities as a Markov random field.

The origin of the lecture notes presented here, is the IAG International Summer School on “Data Analysis and the Statistical Foundations of Geomatics”, which took place in Chania, Greece, 25-30 May 1998 and was jointly sponsored by the International Association of Geodesy and the International Society of Photogrammetry and Remote Sensing. According to the responses of the attendees (who were asked to fill a questionnaire) the School has been a great success from both the academic and organizational point of view. In addition to the above mentioned scientific organizations we would also like to thank those who contributed in various ways: The Department of Geodesy and Surveying of The Aristotle University of Thessaloniki, the Department of Mineral Resources Engineering of Technical University of Crete, the Mediterranean Agronomic Institute of Chania, in the premises of which the school took place, the excellent teachers, the organizing committee and especially Prof. Stelios Mertikas who took care of the local organization.

This school represents a first attempt to put problems and methods developed in different areas one in front of the other, so that people working in various disciplines could get acquainted with all these subjects. The scope is to attempt tracking a common logical structure in data analysis, which could serve as a reference theoretical body driving the research in different areas.

This work has not yet been done but before we can come so far we must find people eager to look into other disciplines; so this school is a starting point for this purposes and hopefully others will follow.

In any case we believe that whatever will be the future of this attempt the first stone has been put into the ground and a number of young scientists have already had the opportunity and the interest to receive this widespread information. The seed has been planted and we hope to see the tree sometime in the future.

The editors

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