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A Statistical Inference Comparison for Measurement Estimation: Application to the Estimation of Groove Dimensions by RFEC

José Ismael de la Rosa, *Member, IEEE*, Gerardo Miramontes, *Member, IEEE*,
Lyle E. McBride, *Fellow, IEEE*,
Signal Processing Laboratory - Engineering Faculty,
Universidad Autónoma de Zacatecas, Av. López Velarde 801, Col. Centro,
98068 Zacatecas, Zac., MEXICO

Gilles Fleury, and Marie-Eve Davoust
École Supérieure d'Électricité - Service des Mesures,
Plateau de Moulon, 3 rue Joliot Curie,
91192 Gif sur Yvette Cedex, FRANCE

Abstract– The purpose of the current paper is to present the comparison of different techniques for making statistical inference about a measurement system model. This comparison presents results when two main assumptions are made. First, the unknowable behavior of the errors probability density function (pdf) }(e), since the real measurement systems are always exposed to continuous perturbations of an unknown nature; second, the assumption that after some experimentation one can obtain suf cient information which can be incorporated into the modelling as prior information. The rst assumption lead us to propose the use of two approaches which permit building hybrid algorithms; such approaches are the non-parametric bootstrap and the kernel methods. The second assumption makes possible the exploration of a Bayesian framework solution and the Monte Carlo Markov Chain (MCMC) auxiliary use to access the a posteriori measurement pdf. For both assumptions over }(e) and the model, different classical criteria can be used; one uses also an extension of a recent criterion of entropy minimization. Finally, a comparison between results obtained with the different schemes proposed in [9] is presented.

Keywords *– Bootstrap, Indirect Measurement, MCMC, Non-parametric PDF Estimation, Nonlinear Regression, Robust Estimation.*

I. INTRODUCTION

The uncertainty characterization of a model is a whole complex problem which depends, among other characteristics, on the degrees of freedom of such a model, its behavior and its structure. The case of nonlinear modelling is a special case treated in the Department of Measurement at the École Supérieure d'Électricité [18] to deal with some problems in an indirect measurement framework (e.g. Instrumentation). Tackling inverse problems according to a statistical point of view, permits the proposed methods to take advantage of the diversity and different characteristics of the collected data and all around information about the collection procedure. According to previous conditions, one will have more or less information about the whole measurement system and then different considerations can be taken about the model structure:

Corresponding autor,e-mail:ismaelrv@ieee.org

Minimum of information: In cases where limited information is available, the most natural proposition is to take a small number of hypotheses and take advantage of all information contained in the data itself using methods like the bootstrap (parametric or non-parametric) [15]–[17], [19]–[22], [31], [32], the kernel methods or non-parametric estimation [6]–[9], and all related methods [1], [11]–[14], [24], [25], [29] (see also some research work of Parzen-Rosenblatt dating of 1968).
Well-known information: In other cases, one may dispose of sufficient, but well-known information, and if the complexity of the modelling problem can be bounded, the modelling problem can be summarized using classical parametric methods which could lead toward analytical models [2]–[4], even if in practical problems the models are more complex than they seem.
Maximum of information: This last case describes ideal conditions which any researcher would like to reach, even if these conditions can be attained only after some experience with the modelling considerations and also with the treated data. In recent years, this way to tackling problems points toward the use of Bayesian methods or even ideas about data fusion. When modelling deals with complex problems but there is a maximum of information, and the problem is studied in a Bayesian framework, then the Monte Carlo procedures known as Monte Carlo Markov Chains (MCMC) provide a set of tools to obtain practical solutions of the proposed models [9], [10].

The purpose when using Monte Carlo simulations like bootstrap or MCMC is to obtain the empirical probability density function (pdf) which in general will lead to establish the different statistics about the treated data, and more specifically about the measurements of interest. The measurement modelling has been considered in various works [2]–[10]. The principal contribution of this work is presented in the following sections, where a comparison of the different schemes for estimation

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