Description

Field of the Invention

[0001] The present invention generally relates to generating models of Linear Time-Invariant (LTI) systems and more in particular to generating models of multivariate systems, i.e. systems that are responsive to variations in two or more parameters. The practice of the present invention can be used for instance to model responses of electronic circuits to variations in plural parameters such as for instance the typically highly dynamic frequency dependent behaviour, systems for signal processing, control theory mechanical systems, etc. The present invention further can advantageously be used for macro-modelling for the design, study and optimization of microwave structures.

Background of the Invention

[0002] Modelling systems in various fields of technology allow designers and researchers to study input and outputs or action and reaction based on a theoretical representation of the system. For instance, a model of a system with multiple inputs and multiple outputs enables a designer or researcher to understand and determine how outputs respond to particular input signals over a wide range of frequencies. Such system that is modelled with a single parameter such as frequency is called a univariate system. The problem of modelling a system obviously becomes more complex when multiple parameters are to be taken into consideration. For instance a model taking geometrical specifications, characteristics of the materials and the frequency as parameters would constitute a multivariate system.

[0003] A paper titled "Adaptive Multivariate Rational Data Fitting With Applications in Electromagnetics" by Annie Cuyt et. al. which was published on May 5th 2006 in the IEEE transactions on microwave theory and techniques, Volume 54, no. 5 discloses a mathematical approach to modelling multivariate systems.

[0004] The paper teaches a method for modelling multivariate systems based on interpolating data samples which are scattered in the multivariate space. This prior art requires that optimally located positions of the data samples are used, preferably grid-structured data samples. Although the paper notes that the use of non-grid structured data samples is possible, this is left for further study. A first drawback of the method known from Annie Cuyt et. al. is that optimally located data samples may be hard to achieve because they require a technique to determine the optimal location of data samples. Such a technique makes the overall method more complex and may increase overall computation time. In addition, it may be difficult or even impossible to obtain such optimally located data samples from a system by testing.

[0005] A second problem of the method described in the above mentioned paper results from the fact that the method is based on interpolation. Interpolation requires that the data samples are accurate. If the data samples are not accurate, the model obtained through Annie Cuyt's method will be incorrect and cannot be used reliably for its purpose. Thus, any data samples which are noisy generate an incorrect model of a system. Summarizing, the method disclosed in the paper needs optimally located data samples which are not noisy. As a consequence, the method is rather complex and may be very time consuming even before any modelling has occurred.

[0006] A third problem with the method described in Annie Cuyt's paper is that it is mainly designed to use real data samples and handles complex data samples by using the real parts and the imaginary parts independently. This works fine in a pure mathematical sense, but is less useful when applied in system theory, control techniques, etc. These fields typically rely on complex data to satisfy the causality of a system.

[0007] Yet another drawback is that the method as described in the paper is limited in complexity of the systems that can be modelled. High order systems may become too difficult to model using this method as is for instance illustrated in Fig. 2 (a) and (b) and Fig. 3 (a), (b), (c) and (d) of the paper. These figures show smooth surfaces as models, which illustrates that more complex or dynamic models are very hard if not impossible to model.

[0008] It is an objective of the present invention to provide a method for modelling multivariate systems that overcomes the drawbacks of the above cited prior art solution, more specifically, it is an objective of the present invention to provide a method for modelling multivariate systems which is less computational intensive and therefore faster in execution. It is another objective of the present invention to provide a method for modelling multivariate systems which does not rely on specifically chosen data samples. It is a further objective of the present invention to provide a method for modelling systems which can deal with noisy and eventually complex data samples.

Summary of the Invention

[0009] The objectives of the present invention are realized by a method for generating a multivariate system model of a multivariate system, the multivariate system having a plurality of parameters and the multivariate system model being representative for the system response to changes in the parameters, the method comprising the steps of:

- performing a plurality of measurements and/or simulations on the multivariate system to obtain reference data;