

Article

Mathematical and Statistical Aspects of Estimating Small Oscillations Parameters in a Conservative Mechanical System Using Inaccurate Observations

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Abstract: This paper selects a set of reference points in the form of an arithmetic progression for planning an experiment to evaluate the parameters of systems of differential equations. This choice makes it possible to construct estimates of the parameters of a system of first-order differential equations based on the reversibility of the observation matrix, as well as estimates of the parameters of a system of second-order differential equations describing vibrations in a mechanical system by switching to a system of first-order differential equations. In turn, the reversibility of the observation matrix used in parameter estimation is established using the Vandermonde formula. A volumetric computational experiment has been carried out showing how, with an increase in the number of observations in the vicinity of reference points and with a decrease in the step of arithmetic progression, the accuracy of estimates of the parameters of the analyzed system increases. Among the estimated parameters, the most important are the oscillation frequencies of a conservative mechanical system, which establish its proximity to resonance, and therefore, determine the stability and reliability of the system.

Keywords: reference points; experiment planning; Vandermonde determinant; matrix exponents; diagonal matrices

MSC: 60J28

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1. Introduction

In [1], an algorithm was constructed for estimating the parameters of a system of first-order ordinary differential equations by a large number of inaccurate observations in the vicinity of one selected point. We will further call such points reference points. Estimates of the solution of the system and its derivative at the reference point are constructed by the method of linear regression analysis. According to them, estimates of the system parameters are determined by the method of moments, and their consistency is proved. However, the development of this topic requires the selection of several reference points for estimating the parameters of a linear system of ordinary differential equations. Such a problem arises, for example, if the number of unknown parameters is greater than the number of equations in the system and if the order of the system is higher than the first.

The estimation of the parameters of a system of linear differential equations with constant coefficients based on inaccurate observations of its solution is of particular interest. The choice of reference points forming a finite arithmetic progression allows us, in this case, to construct ratios for evaluating the elements of the coefficient matrix, including the inverse matrix, the square root of the matrix, etc. [2–4]. At the same time, it turns out that the Vandermonde determinant plays the main role in the circulation of the matrices

Statistical And Mathematical Aspects Of Pollution Problems

A Gutmann



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