Measurement Problems of Structural Identification of Mathematical Models of Physical Objects

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The author presents a methodology for structural identification of mathematical models of physical objects, based upon the following principles:

1. Principle of relativity of a true value. The true value of a physical quantity is a calculable one in the fully consistent physical theory whose constants have been determined from the data of measurements carried out by reference standards of hierarchical calibration schemes.
2. Principle of uniformity of results of reproduction, measurement and calculation of values of physical quantities. An uncertainty of scales of physical quantities depends upon the fact of how much would the conditions of metrization be completely and exactly observed. A conventional true value of a physical quantity is the result of a measurement carried out by the standard which is at such a level of a hierarchical calibration scheme that its variation of the true value in the given measurement problem can be neglected.
3. Principle of simultaneous measurements of all the variables of a model carried out by means of standards. An error introduced due to inadequacy of the mathematical model of a measurement object is defined as a difference between the calculated value of an output variable of the model of an object obtained from the data of simultaneous measurements of input variables and the results of its measurement under conditions that correspond to calculations. It consists of components being dimensionally, structurally and parametrically uncertain.
4. Principle of structural identification. The component of an error, being structurally uncertain, which is caused by inadequacy, becomes observable in extrapolation of the model. The errors of extrapolation are defined as the errors of inadequacy of a mathematical model.
5. Principle of linearity of a correctness criterion. If the probability distribution function $F_{\mathrm{E}}(\varepsilon)$ of the error due to inadequacy $\mathrm{E} = \mathrm{Y} - \theta(\mathbf{X}) = \varepsilon(\mathbf{X})$ of the model of an object of

measurements $\theta(\mathbf{X})$ by output variable Y is such that $\lim\limits_{\varepsilon \to -\infty} \varepsilon \cdot F_E(\varepsilon) = 0$, then,

$$\mathbf{M}|Y - \theta| \equiv \mathbf{M}(Y - \theta) + 2\int_{-\infty}^{\theta} F_Y(\varepsilon)\, d\varepsilon$$

6. Principle of maximum of reproducibility. From amongst the versions being considered, a maximum of the reproducibility index corresponds to the most likely versions of probability density $f(x)$ of the variable X, i.e. :

$$K_{S2} \equiv \int_{-\infty}^{\infty} \inf_{f} \{f_{\Pi}(x), f_K(x)\}\, dx \text{ ,}$$

where $f_P(x)$ and $f_K(x)$ – the estimates of the density $f(x)$ for different parts of the data.

The author considered different algorithms for structural identification of mathematical models of physical objects, among them – MMC+ the method of parametric identification, MMC+ the method of least squares, MMC+ the method of least modules, MMC+ the method of maximum probability. He also presents the examples of systems of metrological assurance of measurement problems: “MMC-stat”, “MMC-spectrum” and “MMC-dynam”.