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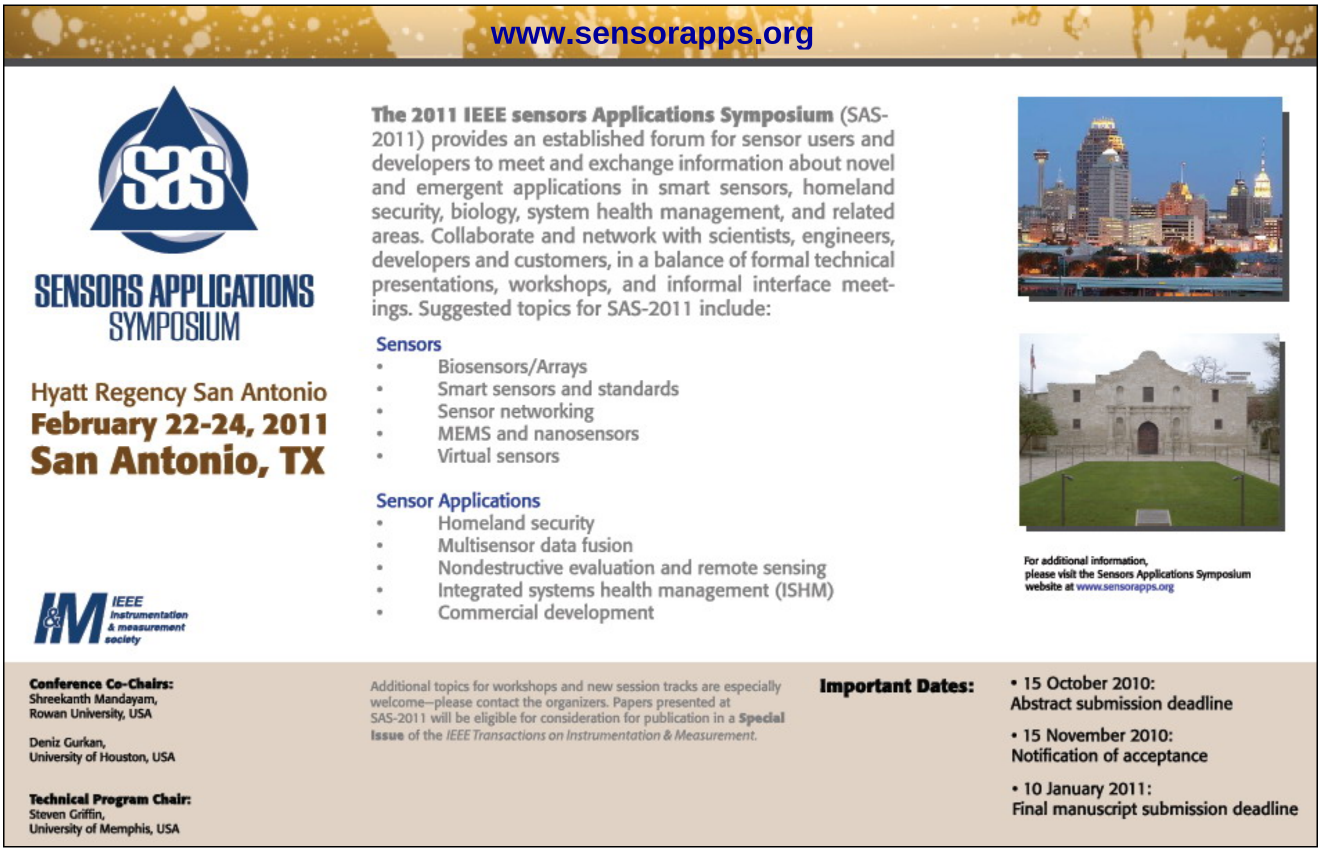

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- 15 November 2010:
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- 10 January 2011:
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Measurement Equation is to be Extensively Used: What One May Expect from Dynamic Measurements

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Abstract: The place assigned to dynamic measurement equations and other necessary equations in the hierarchy of dynamic measurements of dynamically-functioning nonlinear objects in conditions of chaos to obtain the necessary results is shown. *Copyright © 2010 IFSA.*

Keywords: dynamic measurement equation, non-linear structural dynamics, chaos, Dynamic error and uncertainty.

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1. Introduction

The place of dynamic measurements (DM) in the current economy is very important. They (DM) determine the development in practically all of the main fields of applied science and industry. Modern science and techniques, and measurement technologies are aimed in the direction of complicity-functioning structures and the processes tied to them. How it is in order to provide correct results of dynamic measurements for dynamically- functioning objects in many experimental tests and measurements for design, manufacturing, as well as for metrological assurance, and other fields of applications which play a defining role in the economy? It is obvious that unreasonable and incorrect measurements can cause difficulties in acceptance of unique correct decisions. Incorrect measurements are obtained and one may not realize that the measurements are not appropriate. One may understand some of the common problems that are typically encountered. There are several aspects of methodological character included each one of which is tied in deeply to the DM. It must be clearly to be perceived in order to make the best possible overall measurements; it means to build the optimal solutions. Considered problem is growing problem. What is the role of DM in the economy? Incorrect information interpreted by measuring channel, or by multi-channel information-measuring system may lead to economic losses. In fortuitous event of the incorrect DM, economy cannot provide of the correct information to decision makers in any sector which is faced with choices among for example new technologies and policies relating to science, manufacturing, and industrial processes as well as law, and safety. E*ighty percent* of global merchandise trade [1] is influenced by testing and other measurement-related requirements of regulations. Companies in any country and Government structures increasingly depend on dynamic measurement technologies to help ensure access to global markets that create new product and protect its consumer properties. Specialists understand the place occupied by *metrological assurance* in the economy. This is one of the highest levels in the reviewed part of economy, in international relations and trade, in support of productivity enhancement, economic growth, and international competitiveness, with a focus on improving the life-cycle quality to measure the economic impact of new technologies as well as developed performance-measurement methods and has accelerated the adoption of new manufacturing capabilities as well. Therefore, the importance of measurement technologies for the scientific and technical development of society, and of manufacturing industry will only increase as well as all science and technology activities are involved in creating new and unique directions for measurement innovation to transpire. Economic decisions need to have reliable and close access to assess the dynamic measurement place in medium of increasingly higher requirements for complexity in combination with higher dynamic accuracy. This brings with it a need for research and innovation of related dynamic measurement methods.

The special place of dynamic measurement and of metrology is taken away to the *measurement equation* as one of the important elements in the global economy and in the market place of ideas, products, and services. Many publications have been addressed to the considered problem are dedicated to understanding how to adsorb optimal results from the measurements, to optimize the building of metrological assurance in full cycle on the correct measurements, and relative applications. They are based on, at least, “static” measurement equations [2-8]. In most cases, the measurement equation, error, as well as linear and non-linear propagation of uncertainty are mentioned in connection with requirements to accuracy of results of dynamic measurements of the quasi static condition of the object, as the rule, rarely in dynamics. The problem addressed to a dynamic measurement equation requires separate attention. This article is dedicated to the general analysis of methodical features of the DM of dynamically functioning objects with by expressed nonlinear dynamics, or by nonlinear dynamic processes, where the main role is played by the dynamic measurement equation, to give possibilities to obtain the optimal competent results.

2. Motivation and Problem Definition

Most observed real world dynamic processes are non-stationary. No typical & important behaviour of objects is tied with nonlinear structural dynamic, when nonlinearity and other effects are generated by comparatively quickly proceeding processes in structure which may be generated by internal as by external sources of excitements.

So it is, the place of model and it estimate from the point of view of dynamic measurements, this transformation to the non changing measurement equation investigates for everyone concrete stage. However, no smoothing analysis of the information for measurement and information processing and successive application influence of the estimation of the effects of chaotic dynamic in nonlinear dynamic systems behaviour, as well as non stationary processes estimating, and delay dynamic processing are so necessary for extraction of trustworthy information. All of them show that the measurement equation takes the most important place in the world of nonlinear dynamics. It is known [9, 10], the results which conform to wide-spread statistical methods provide by no means all dynamic measurements. Dynamic measurement of dynamic processes or of behaviour of dynamically functioning objects as well as single-valued measurement is relevant for information-measurement systems; they may be normalized by limits of admissible values. This normalization is continuing its life after appearance. Methodical aspects of measuring technologies determine as by a dynamic measurement equation (DME) as by error and uncertainty of measurement channel of measuring system reflected by measurement equation and an equation of measuring processes. What are dominant problems? Let consider the necessary stages for successful measurements.

3. The Dynamic Measurement Equations in the Medium of Nonlinear Dynamics of Markov's Object or Processes and General Problems of Dynamic Measurements

The solution of a measuring problem begins with the construction of a priori physic- mathematical or conceptual model directed at the specific aim of the investigation. The models of the concrete object cannot be exhaustive [11]. In the real world, the adopted model unavoidably differs to some extent from the physic model of the object and, in view of that, the results of the measurements contain dynamic error and dynamic uncertainty. The depth of knowledge based on the dynamic model has to give possibilities to minimize functional uncertainty and error. In order to complete the considering stage of the measurement theory, one has to use not only physic and mathematical instruments but also the results of special experiments to construct an a priori mathematical model of the objects, one has to solve specific problems of the characteristic estimating of the metering error caused by the missing information what is the result of the model uncertainty.

In most cases, the physic- mathematical model describing of a structure bases on geometrical, material, inertial, and boundary nonlinearity [11]. To solve such class of problems, different perspective approaches are being used, where the nonlinear structural equation modelling (SEM) methodology consists of three parts [12]: (i) a measurement model to specify the relationships of the latent constructs to the observed variables; (ii) a computational model to both map the response to input variables and to quantify the relationships of the latent variables to the predicted variables, and (iii) a structural model to identify the relationships among the unobserved latent variables, thus relating the computational model output to the high-level data, and relating the lower-level data to the high-level data. Hierarchical Bayesian inference network is associated with Markov Chain Monte Carlo simulation and Gibbs sampler is employed to represent the nonlinear SEM and to estimate the model parameters [13]. Therefore, the nonlinear structural equation modeling approach provides more accurate modeling of the hierarchical validation problem. The nonlinear relationships in structural equation modeling method can effectively represent the nonlinearities which exist in physics model of a dynamical system in light of the validation data.

3.1. A Physic-mathematical Model and a Dynamic Measurement Equation on the Example of Mechanical Measurements

In most cases the physic- mathematical model describing an object and based on geometrical, material, inertial, and boundary as well as nonlinearity distributed non-linearity in the structure [14] classified by a second-order differential equation having the form [15]

$$\ddot{y}\ (t) = F\ (t,\ y\ (t),\ \dot{y}\ (t)), \tag{1}$$

where F is a function. Let consider nonlinear equation. For an example, this may be the state equation from [16]

$$[M]\{\ddot{\delta}(t)\} + [C]\ \{\dot{\delta}(t)\} + [K]\ \{\delta(t)\} + \{F_{nl}\ (\delta(t);\ \dot{\delta}(t))\} = \{F(t)\}, \tag{2}$$

where [M] and [K] are mass and stiffness matrixes respectively, [C] = α [M] + β [K]; α and β are external and internal damping coefficients, respectively; $\{\delta(t)\}$ is the column vector of nodal of displacements; top dots denote derivations with respect to time t, and {F(t)} is the nodal external load vector, and $\{F_{nl}\,(\delta(t);\,\dot{\delta}(t))\}$ is a non-linear function of the displacement and velocity, respectively.

It is the known example from general representation, {F(t)} may be presented as g (t) $\{F_s(t)\}$; $\{F_s(t)\}$ is stationary stochastic load force vector; g(t) reflects of the non-stationary characteristic of the stochastic load force $\{F_s(t)\}$. So, g(t)$\{F_s(t)\}$ may be as a special nonstationary excitation whose non-stationary property only depends on time and is independent of frequency.

The value of changing nonlinearity determines as by amplitudes of excitations as and by load rates. Let assume that an object describes by a state equation

$$Y\ (t) = [B\ (t) + n\ (t)]\ X\ (t), \tag{3}$$

where Y (t) is the output results, B (t) is the transformation operator, n (t) is the operator for total dynamic error and uncertainty, and X (t) is the input impact, respectively, as consequence, a measurement equation is

$$y_t = C_t\ X_t + \varepsilon_t\,, \tag{4}$$

where y_t is results of measurements, C_t is the certain many-component function, X_t is input impact, and ε_t is total dynamic error and uncertainty, respectively.

Creation of a high- accuracy dynamically functioning object requires scrupulous synthesis and analysis. The C_t may be the vector, the scalar, or presented in view of components. It is obviously that the member of measurement equation always do not always determine by direct measurements. Being components of the main DME, they often can determine a result of indirect measurements by a local dynamic measurement equation. As an accessible example, this is indirect measurements of dynamic temperature, dynamic pressure, and parameters of motion (acceleration, vibration, and shock). There has to be a compromise-based extrapolation throughout the function (or the functional) which joins all elements in order to extract useful and necessary information from the DME to predict the behaviour of an object in extreme conditions, too.

Let note that extracted information addressed to the object or the process may be essentially different in dependence on: measurement methodology used in the basis, dynamics of the nonlinear object, generated by damping-inflicted nonlinearity, damaged- structure nonlinearity, small degradation of joints [14], and others, as well as the ‘instantaneous’ complete dynamic characteristics of the object [17] that is not always obvious. *The nature of nonlinear dynamics is highly individualistic.* Certainly, the behaviour of nonlinear objects or processes is subordinated to multifactor influences [18, 19]. There has to be considered and transformed to physical, mathematical, and numerical nonlinear, no stationary models of objects. Investigators studying realistic simulation, no stationary nonlinear chaotic model response, if it is necessary, model verification, model validation, the model error and uncertainty estimation, as well as model credibility. Naturally, model improvement for different input conditions, model diagnosis, experimental uncertainty, model metrological certification, fidelity-testing for prediction, as well as sensitivity to variability, uncertainty, as well as to lack-of-knowledge is by the necessary and important integral parts of the complex works.

Let consider the novel parameter estimation method, termed as the SFMI-method [20], which is suggested to be by effective instrument for creation of the DME. Yes, it fully embraces both the nonlinearity and nonstationarity of strongly nonlinear systems dynamical structures or systems. Moreover, multiscaled identification is performed, because the method identifies the dominant characteristic time scales of the system response and establishes the dimensionality of the dominant dynamics. The SFMI method is a 'linear-in-the-parameters' method and does not rely on nonlinear optimization techniques, which greatly facilitates parameter estimation and it yields quite accurate results and offers an effective tool for parameter estimation of MDOF nonlinear dynamical structures. No typical and important direction has to consider the DME tied with nonlinear structural dynamic, when nonlinearity and others effects are generated by comparatively quickly proceeding processes in structure which may be generated by as internal as external sources of excitements. Considered method differs by high resolution, it concerns to the instantaneous frequencies, in first line. As one example, the complexity of the DME reflects the dynamic behaviour of the dynamically- functioning object. For better obviousness, a sample nonlinear Duffing oscillator without damping and with harmonic excitation is considered. The Duffing equation is given as

$$\ddot{y} + D\, y = \beta \cos \omega t \tag{5}$$

where $D = 1 + \alpha\, y^2$, α is the parameter, β is the magnitude of the driving excitation, and ω is the frequency, respectively. The D may change with position, as a result, the frequency of the object also changes with position within even one oscillation period. There is the frequency "modulation" as the special reflection of the considered object. Yes, it requires a priori information, however, one does not have it. The effect is to find enough harmonic components to fit "the harmonic distortions". Nevertheless, using incorrect a priori analysis, one may obtain a collection of the harmonic of one or other form; thus the problem of any analysis cannot give the correct results. If a measurement channel does not give possibility of distinguishing behaviour of the object in different conditions, the dynamic behaviour of the object is perceived as the widely dim process which does not yield intelligible approximation. However, investigators do not know about it without of detailed analysis of the DME. Fuzziness considers as dynamic uncertainty. Results of approximated measurements are carried to uncertainty. In the real world, it is not so. It is known that the linear approximation of the DME loses sense if it is used for the chaotic processes. One has to understand what kind of variations of the measuring information, generated by behaviour of a Markov's object, lead to a variation of the dynamic measurement equation (DME) during measuring procedures, correctly built measurements based on the DME, as well as analyzed effects tied with behaviour of nonlinear and chaotic dynamic system, and their influence on total measurement uncertainty and metering error. The DME considers non smoothing analysis in measuring processing; integral analysis distorts the reality. Responses of measurement equations have to be analyzed theoretically with needed accuracy.

Everyone dreams of having the stable object to disturbances, to the internal and external sources of nonlinearity as well as to transient dynamics. Naturally, an unchanged measurement equation is the desired purpose to reach the necessary level of accuracy. Use of the "static" equation of measurements for cases with high level of the latent dynamic error often deforms of the real picture of processes or of behaviour of a dynamically- functioning object that does the further processing of the measuring information senseless. For one channel or for an information- measuring system, it is suitable to take into consideration the transition from the *dynamic measurement equation* to the *equation of measurement processes* (EOMP) representing all the main operations of detailed procedures. The EOMP establishes interaction between the quantities in measuring processes, gives the possibility to choose, or to create not only information- signal processing techniques [21]. Let consider the problems of dynamic measurements of dynamically- functioning objects in conditions, when a dynamic measurement equation, incorporating aim for established accuracy (error and uncertainty), changes during measuring procedures (for instance, there are high-speed dynamics and quickly proceeding processes which can be in the considering object). For it, evaluation of the dynamic uncertainty and error established by the "instantaneous" *dynamic measurement equation* for the measurements of the concrete referred processes; they have not received by integral methods.

3.2. The Local DME and Interaction a Measuring Transducer- an Object

The aim of a dynamic measurement equation also is to estimate and predict the characteristics of errors and uncertainties which are introduced into the results of a measurement by a measuring channel. This is a function of an equation of measurement process, too. Let pay attention to errors and uncertainties tied with a measuring transducer- an object interaction. It explicitly follows to mark several determining influences of common error of measurements. It is impossible to extract proper information from an object without *direct interaction between the object and the sensitive element of a measuring transducer* (SEOMT); interaction a SEOMT- an object may extend changes in an object, where a measurement transducer is placed and an object in turn influence the properties of a measurement transducer, for instance [11, 22]. Such interaction can influence the final results a varying extent. As next example, the known effect of the attached mass for quasi static approximation is refreshed in [23].

Producers of measuring transducers may provide minimum effects which have a place as a result of interaction of a measuring transducer with an object and vice versa. This requires the usage and fundamental development not only of fundamental methods for predicting and estimating error characteristics of measurements but also of experimental investigations from the accompanying applied and fundamental science. Of course, measuring transducers and their interaction with an object introduce distortions in the results of measurements that are due to a partial loss of the measuring information. In order to achieve the aim i.e. to decrease named errors and uncertainties, it is also necessary theoretically to solve problems of prediction of the measurement transducer response without direct or indirect interaction between by the MT and by the object in which the MT is mounted. Let note separately, when manufactures calibrate the accelerometers intending for those or other purposes they aspire to carry out of calibration in conditions when reproduced impact is close to unbeatable. However, measurement often realizes in different conditions in comparison with calibration.

3.3. The Local DME and Measurand Recovering

Let consider the errors and uncertainties tied with the input recovering. It is necessary to note for everyone from measuring channels of an information- measuring system that indirect measurements of members (component) from the main DME include in themselves measurand recovering (an input recovering), for instance, acceleration, pressure, temperature, and others, to means of measurements are known topic in theory and practice of dynamic measurements. Sometimes, some procedures of *measurand recovering* in a measuring channel require use of comparatively difficult local DME. Nevertheless, it must be. The most common methods of recovering of the measurand to means of measurements based on integral equation containing convolutions together with processing methods of dynamic measurements. The aim of *recovering of an input is ill-posed one* and regularization methods have to be used for that. Let underline special mathematical apparatus to obtain a sensible solution of ill-posed problems is developed, for instance [24]. Non smooth analysis provides the necessary condition for a minimum in error functional.

Let consider some measuring channel including the process source- the transferring environment-the MT. The transferring environment may garble a process from disturbance zone, for instance [25]. Nevertheless, a process may be reconstructed with adequate accuracy [26].

3.4. Measuring Transducer Inertia, Measurement Duration, and the Changing DME

In dynamic measurements, a form of signal is distorted on account of the *measuring transducer inertia* which is determined by the full dynamic characteristics of the MT, too, as well as a form of signal changes in a process of converting of the signal to measured quantity. All together in practice, this means that even the slightest error in measuring information or in calculations, right up to the rounding-off error in modern computers can result in complete loss of physical sense in the result. Yes, such result may be. This type of errors and uncertainties also is a function of the EOMP which can predict named dynamic error and uncertainty. Unfortunately, inertia of each measurement transducer- of the member of the information-measuring system- may be different if one uses different types of the MT with the different full dynamic characteristics.

As it follows, we consider the dynamic measurements where measurement transducers with the different full dynamic characteristics are used. Let pay attention to problems of dynamic measurements in conditions, when a DME changes not only during measuring procedures. When one measures the parameters (members) from the DME, one has to pay attention to the transition from the stationary or quasi-stationary state of an object to the non-stationary state.

For simple exemplification, we may use the Duffing equation for some model with concentrated parameters. The transient state requires of usage of the “instantaneous” DME. For instance, this occurs because the parameters of an object deviate from boundary of permissible values.

For non stationary process, any *increase in the measurement duration* may arise in additional dynamic error. Here the question is about optimization of the measurement duration to minimize of errors. It requires of evaluating accuracy of a measuring system as a function of the time basing on the EOMP. As it has to be, one may need to make intermediate experiments. One has deal with by an instantaneous DME and time-dependence of dynamic uncertainty.

3.5. Nonlinear and Chaotic Dynamics of an Object and a DME

There are considered some effects of chaotic dynamics and of their influence on an object behaviour and measurement uncertainty. Different physical and mathematical models have to be used in analysis and evaluation of potential dynamic measurements; they describe not only an object itself but also require of the analysis of the measuring parameters. In accordance with writing approach, any measurable quantity characterizing the object can be presented by the transient process and expressed by law addressed to changes in the object parameters. The uniqueness of dynamic measurements is in it, too. All investigators look to describe spread in measurement as the proximate process, for instance, as the ergodic random process due to that that it can be far from of reality. Such convergence is straightforward- the theoretical basis of any method of evaluation is “statistical” treatment. There is the equivalent result from the averaging single time realization of the random process and the result of averaging over an ensemble of all possible states with observation time. Ergodic behaviour of an object in random variations is most satisfactory. Methods of information processing for of that are sometimes effectively feasible and standardized.

What may one say about the version when a physic-mathematical model is nonlinear and nonlinearity changes in depending from of the level and of time-parameters of load? We extend of a considering problem on the example of nonlinear objects which may be in stable states, too. It is obviously the dynamic measurement equation have to be oriented to possible chaotic changes in characteristics of the nonlinear object in the values due to of deterministic dynamic chaos. How is it to investigate effects of dynamic chaos and their influence on dynamic uncertainty and error? In order to examine the conditions, under which the behaviour of a nonlinear dynamic object influences random spread in the measurements, one selects behaviour of an object so that it may be described by the equation [27]

$$\partial \mathbf{x} / \partial t = f(\mathbf{x}, \alpha), \tag{6}$$

where **x** is a dynamic measurement equation characterizing of the state characteristic as output measurement quantity for indirect measurements; α is measured input quantity, and $f(\mathbf{x}, \alpha)$ is the function determined by the object physical properties, respectively. If the object is in the stable and stationary state, or one does so that the state was by stable and stationary it means that $\partial x / \partial t = 0$ (the condition of chaos disappearing is).

Consequently,

$$f(x, \alpha) = 0, \tag{7}$$

If $x = f_0(\alpha)$, where $f_0(\alpha)$ is nonlinear function [28], one extracts the following equation

$$x_{n+1} = \alpha x_n (1 - x_n). \tag{8}$$

The object stable stationary state describes by the equation (7), from which follows that if chaotic states come about from dynamics of the object it means that uncertainty in the measurements in the chaotic state relates to the dynamic random spread in the measurement quantity and which exceeds uncertainty in the parameter measurements.

There is one of the ways how to investigate whereby *the object chaotic behaviour* influences on measurement results. Nonlinearity and chaos are very egoistic, therefore, in order to be assured of the contribution of chaotic processes which are responsible for random irregular behaviour in the parameters of an object one requires of scrupulous methodical analysis and of measurement evaluations in real- time adsorbing the chaotic behaviour [29]. Modern technology allows real-time data collection in the variety of measurement technology. Consequently, there is growing need for algorithms capable of performing inferential tasks in the on-line manner, continuously revising their estimates to reflect the current status of the considered processes.

3.6. Delayed Measurements in Medium of a DME and an EOMP

Not less important place occupies *delayed measurements* which can create difficulties for of discrete time information processing [30]. In real-world applications, information processing procedures are often the subject to data corruption mechanisms. These mechanisms can manifest as non-negligible delays in transmission or receipt of the measuring information. Some information about procedure of measurement arrives significantly later than their time stamp, that is, they are delayed. Considered discrete time system is subordinated to of a state equation of the object and of the DME, as well as of an EOMP. A common feature of known methods proposed to handle of the delay problem is delay measurements always are incorporated when they finally arrive. Fundamental distraction of dividing measuring information on constant delays, fusing delays, and random delays is determined by the delay mechanisms. Techniques of fusion delay measurements in discrete time are the important problem [31]. The relationship of the useful information-to noise ratio can have significant impact on of the considered measurements manifesting that fusion delayed measurements can be worthless leading to non-uniform sampling. Usage of the *thresholding technique* gives possibility to incorporate of these delay measurements which can improve of the complex characteristics of a measurement channel. In practice, this is very individualistically in frames of general approach.

3.7. Software and a DME and an EOMP

One of the main places in the considered hierarchy is taken away to *software;* it unites all that we consider. The reprocessing of measuring information is performed by the methods of computing mathematics and of other mathematical directions (statistics is included if it is expedient). Radically, new methods for information and signal processing have recently received widespread understanding and using. It is to include not only of interval calculation, of apparatus of actions with fuzzy variables, of frequency-time transformation, and of transformation based on compressive sampling but of neuron, of genetic algorithms, of algorithms from theory of catastrophes and fractals, and others. As an important part, there is necessary to use a part of measurement theory for preservation of measuring information during computing reprocessing, as well as methods and algorithms for determining and monitoring of the characteristics of errors and of uncertainties introduced by computer hardware and techniques. A study stated that software errors are by so financially capacious that they cost at the US economy was estimated $59.5 billion annually [32].

Measurement software is an intrinsic part of metrology. Metrological estimation of components of uncertainty provided by software includes the input data uncertainty, the uncertainty associated with information processing algorithms, as well as the uncertainty and error due to software implementation plays the determining role for the algorithms [33].

Measurement result processing software includes programs for processing of the data built into means of measurements, computational components of data-acquisition systems, software that automates data selection, the storage, the transmission, and also processing of measurements in accordance with not only a DME and an EOMP but by computer or microprocessor possibilities. Programs and suites of programs for computers and microprocessors are objects of design, of development, of testing, and of quality evaluation. There is obviously to use standards [34] in the aria of estimation software quality parameters in order to determine it functional correctness, availability of software providing compatibility, interactions, upgrading, and development as well as software risk estimation and safety, for instance [35].

It is necessary to distinguish *metrological assurance* of measuring processing software. How does software influences on uncertainty and error? What does software influence on error components? Powerful factors determining of software errors are the input data error, the processing algorithm error, the final result estimating error algorithm as well as the transformed error. As important error, error is stipulated by any transformation of the data before staring of calculation. There are rounding of intermediate results, the use of finite number of interactions, impossibility of correct scaling, interpretation, normalization as well as use of unstable parameterization, impossibility of correct organization of the computations, and difference between by mathematical equivalent of an EOMP and it by numerical equivalent [33]. Nonetheless, it is not full items of error sources. The methods of error components estimating are important instrument to extract finishing results with minimal error and uncertainty. Error is tied with by a DME as a function of time, software effects and their influences on error, and transformed error have to be considered. Integral value of error is not such instrument which gives possibility effectually to use of information and of signal processing. Error asked on a DME may be estimated analytically in accordance with the law about an upper bound.

If one has the DME and the EOMP, it means, one implies that the specifications for measurement result error, practical condition of execution has to be given. It is determined how completely one incorporates all influencing factors in measurements and what it is to need of correction. Errors in the input data are incorporated to receive of estimation.

That experimental check on the entire system indirectly enables to judge the correctness of the software used. To estimate accuracy, one recommends the approaches described in metrological legislation, for instance [34], where it has to be suggested that each computational component in the information- measuring system should be supplied with the subroutine for calculating the uncertainty and error by standardized methods. If such an approach has been used then it produces not only measurement results but also estimates of the accuracy in full agreement with the current definition of the measurement results as numerical estimate of related uncertainty.

Unfortunately, in this field of knowledge, software accuracy still contains several of unsolved problems [36].

3.8. Time-dependence of Dynamic Uncertainty- one of the Examples

An example from [37], the results presented in Fig.1 are illustrated for the model of the object with concentrated parameters which transforms by wave processes in the object with distributed parameters during it function. The results determine what one may do in order to increase fidelity of adsorbed information by used information and signal processing.

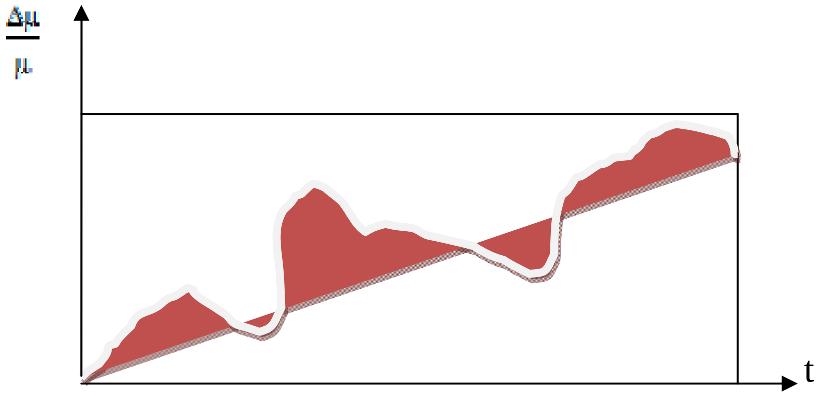

Fig. 1. Dependence of fractional uncertainty Δμ to average of uncertainty value μ as of the function of time t.

Uncertainty based on a *measurement equation* may be estimated analytically in accordance with the law about an upper bound.

However, it cannot be for the even when one follows to the changing of a measurement equation in a time which is created by models of difficultly- functioning objects with nonlinear and chaotic dynamics when parameters of an object every time change.

As it has to be, one may need to make experiments. There one has deal with by the instantaneous measurement equation and time-dependence of uncertainty. If one has the measurement equation and the equation of measurement processes it means one implies that the specifications for measurement result accuracy, practical condition of execution are given. It is determined how completely one incorporates all influencing factors in measurement results. They may need in correction. Models are wrong nevertheless one uses thereof to improve knowledge.

4. Summary

Yes, it is the hard work which requires of considerable efforts, read, of expenses. If one does not do all complex described investigations one cannot reach of significant results. Nevertheless, the expenses will grow. Affections of majority of investigators to see the results of dynamic measurements as the results of direct measurements often are unjustified.

It is shown what the place is assigned by a dynamical measurement equation, by an equation of measurement processes, by a local dynamic measurement equation as well as by a state equation in the hierarchy of dynamic measurements of dynamically- functioning nonlinear objects in the chaotic medium to receive necessary results.

The analysis has showed that the dynamic characteristics of a measurement channel during dynamic measurements may be distorted on account by the inertia of members of a dynamic measurement equation. In practice, one generates the slightest dynamic measuring error in measuring information or in calculations, righting up to the rounding-off error in modern computers those results in complete loss of the physical sense.

Correct results only can be received when the scrupulous analysis is carried out by interactions the measurement transducer- the object and the object- the measurement transducer. There are dynamic characteristics of measurement channels and their influence on the equation of measurement processes, as well as non-smooth analysis, measurement duration in time-delay measurements for correct information and signal processing analysis. The place of software influence on measurement and information processing results are considered.

Chaos and nonlinearity reflection in the dynamic measurement equation require of simulation and the scrupulous analysis of all components which bear responsibility for reliability of measurement results which conversely determine of the subsequent critical solutions.

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