Data Processing Intervals through Dynamical Models Applied to the Analysis of Self-Degenerative Systems

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***Abstract*— A dynamical model was applied to analyze the data from an actual complex dynamical system. Data are processed at computed intervals of time, which were obtained from the analytical model. This process was developed to evaluate the methods of resolving some industrial operative problems in the presence of a self-degeneration from the same system. The model presented is suitable for the simulation as well as prediction of the studied system. Two types of models are presented: the first ones associated with the degradation process and the others were obtained after remedying the dynamic of the system along its production time. The process of resetting new intervals for remedying the system was developed in order to extend its lifespan.**

Keywords-dynamic;systems;attrition;measurements.

I. Introduction

The Poisson's distribution together with the reliability definition allows people obtaining

$$X(\tau) = 1 - e^{-A\tau} \tag{1}$$

, which is associated with the degeneration of a studied system. This concept is frequently used in both general and specific literature, as in [1-4]. The parameter A is adopted to be the rate of system's faults, t is the arbitrary time of reliability, $e^{-A\tau}$ is the reliability, while $X(\tau)$ is the attrition as a function of time. However, in addition to these results of the applications, a slaving procedure is implied by Eq. (1). This is due to the fact that it is always necessary to to process the whole system's data (system or complex system) before emergent real time problems and attrition's values affect the system's operation. Consequently, it was necessary to fix the system's faults to continue the operation at least one more time, but in a more recent state. Then, the counter for the new system's parameters is reset to quantify the attrition together with its cumulative effects for the next time period, and then this cycle is repeated ad infinitum. This behavior seems a damped mass-spring response, as in [5-9]. The objectives of this work were to develop a tool to avoid the data's macro-lecture at each time period, to save administrative time and resources during the system's operation control, and to predict the system evolution through a feedback loop using the actual system's parameters and the complex system's measurements.

II. Data Processing Intervals for a Self-Degenerative Dynamical System

Let us consider systems with only inertial, spring and dissipative forces, as in [5-9]. Note that less forces than these three are qualitatively and quantitatively far from representing the real situation, whatever kind of dynamical system is present. Here, we propose a typical dynamic equation related to this kind of problems

$$\overset{**}{X} + A\overset{*}{X} + W^2 X = 0 \tag{2}$$

, where $\left(\overset{*}{\ }\right) = \dfrac{d}{d\tau}$ is a derivative with respect to τ. The fonts A and W represent parameters of the system, and X is the unknown variable. In this context, the most relevant fact to point out is the assumption that X is a global, non-deterministic, and abstract property of the system. For instance, this property could be the degeneration, or the attrition, $X = X(\tau)$, of the system, and obeys Eq. (2). This equation is differential, linear, ordinary, second order, constant coefficients. Moreover, Eq. (2) , when used, can model the linear asymmetric interaction due to self-degeneration. For example, by assuming a null natural frequency ($W = 0$) we have the equation

$$\overset{**}{X} + A\overset{*}{X} = 0 \tag{3}$$

Then, by adding two initial conditions, such as $X(0) = 0$ together with $\overset{*}{X}(0) = A$, in order to obtain $X(\tau) = 1 - e^{-A\tau}$, agrees with the degeneration of

the system obtained from the field of statistical analysis by applying the Poisson distribution as frequently reported in the literature, see Eq. (1). The parameter A was adopted to be the rate of faults per unit of time, while $X(\tau)$ was the attrition as a function of time.
The following sequence of steps to define a new procedure was developed:

- The system's model suffers a change from stochastic to deterministic after it has been proof that the stochastic model also obeys Eq. (3), which is valid for a dynamical system.
- Then, a periodic behavior is introduced by updating the system's dynamical law from Eq. (3) to Eq. (2) by including energy storage capability. The negative feedback control-loop (human control or machine control) acts as a spring and generates this behavior.
- Once the time period is generated, the automatic process for resetting the data intervals is implemented:
    - by measuring on site the system's parameters A, W, and then by processing the macro-data.
    - by solving $\overset{**}{X} + A\overset{*}{X} + W^2 X = 0$ for the attrition X, the response of X over time is obtained.

Finally, it is also useful to apply both the Poisson distribution and the reliability definition repetitively at each time period, in order to allow the response to be obtained over time for a statistical tool. Therefore, a comparison should be made to calibrate both responses (dynamical and statistical).

III. Conclusions

A procedure for setting the Data Processing Intervals for analysis of Self-Degenerative Systems was given as an external support. A new tool is proposed:

- by avoiding the data lecture at each time period.
- by connecting theoretically and experimentally the Poisson distribution with the parameters and response of a dynamical system.

The tool developed was based on physical laws and can be applied to the fields of health care, economy and politics, as well as to other social sciences. This tool advises the operator which parameters should be changed in the actual dynamical system in order to obtain the desired response over time.

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