

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

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**Abstract**— In this paper, an oscillatory model is proposed to provide the necessary period of time for the analysis of a system's data in order to reduce its attrition. The actual system was assumed to be a periodic complex dynamical system, since it deals with the human-machine daily routine activity. Typically, in the real life, is the maintenance developed by the employees in the industry. The model presented is suitable for the simulation of the periodicity of the reliability of the studied system, as well as prediction. Then, two types of models are considered: the first one is associated only with the degradation process of the system, while the second one is also associated with the periodic remedying process along the employees production time, from which the lifespan is extended.

**Keywords**-dynamic; systems; attrition; measurements.

## I. INTRODUCTION

The Poisson's distribution together with the reliability definition gives

$$X(\tau) = 1 - e^{-\alpha\tau} = 1 - C(\tau) \quad (1)$$

which is associated with the degeneration of a studied system. This concept is frequently used in both general and specific literature, as in [1]-[2]. The parameter  $\alpha$  is adopted to be the rate of system's faults,  $t$  is the arbitrary time of reliability,  $C(\tau) = e^{-\alpha\tau}$  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 (1). This is due to the fact that it is always necessary 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 its operation. The remedy system starts working again until the new emergent problems appear and affect the operation, see [3]-[5]. This cycle is repeated ad infinitum. Since the attrition is a cumulative process, a new time dependent function  $\alpha = \alpha(t)$  replaces the original parameter  $\alpha$ . Consequently, this is to be done in (1). In this case, the analyst must reset the observation at every period of time, which demands a lot of attention and effort, even when using a computer. This is

due to the fact that the data must be updated at every cycle. The key for this work remains in the assumption that the system has oscillatory motion. This behavior seems a damped mass-spring response, as in [6]. In this context, it is assumed that the system includes humans and machines together. This is also to say that the system stores and loses energy, and also has inertia. Moreover, an appropriate damping implies oscillatory behavior and periodicity. The first objective of this work was to predict the system reliability's evolution through a feedback loop based on the model proposed in [3]-[5], but here the function  $\alpha(t)$  is presented in such a fashion that generates a damped mass-spring periodic model. This dynamical model is likely to that developed in [6], but here it is being necessary only the lineal approximation. The second objective was to save administrative time and resources during the system's operation control by applying the generated dynamical damped mass-spring periodic model in obtaining the period of the system. This paper is organized as follows: In Section I, a brief state of the art and some introductory remarks are presented. In Section II, some developments associated with the process of data processing intervals of self-degenerative systems are described. Finally, in Section III, a set of conclusions is provided.

## II. DATA PROCESSING INTERVALS FOR A SELF-DEGENERATIVE DYNAMICAL SYSTEM

Let us consider systems with inertial, spring and dissipative forces, as in [6]. Note that fewer forces than these three are qualitatively and quantitatively far from representing the real situation, whatever kind of dynamical system is considered. Here, a balance between the machines production and the human counterpart restoration to operate them is proposed. A typical dynamic equation is

$$\ddot{X} + \alpha \dot{X} + W^2 X = 0 \quad (2)$$

, where  $(\dot{\phantom{x}}) = \frac{d}{d\tau}$  is a derivative with respect to  $\tau$ . The fonts  $\alpha$  and  $W$  represent parameters or functions of the system respectively, and  $X$  is the unknown variable. Since

the human contribution to the system may be adopted in order to always follow (2), then  $W$  must be zero. Although an external and actual agent is needed in this oscillatory process to operate the machines, its contribution does not exist in the right member of (2), effectively. So, (2) is derived homogeneous with  $W=0$ . 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 (2). This equation is differential, linear, ordinary, second order and, in general, variable coefficients. Moreover, (2), when used, can model the linear asymmetric interaction due to self-degeneration with a sort of “null natural frequency” ( $W=0$ ). So, we have the equation

$$X'' + \alpha X' = 0 \quad (3)$$

Then, by adding two initial conditions, such as  $X(0)=0$  together with  $\dot{X}(0)=\alpha$ , in order to obtain  $X(\tau)=1-e^{-\alpha\tau}$ , 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 [1]-[2]. The parameter  $\alpha$  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 (3), which is valid for a dynamical system like (2), together with  $W=0$ .
- Then, a periodic behavior is introduced by updating the system's dynamical law from (3) to (2) by including energy storage capability ( $W \neq 0$ ). The negative feedback control-loop (human control or machine control) acts as a spring and generates this behavior.
- Now, by considering  $W \neq 0$ , and  $\alpha = \alpha(\tau)$  in (1), and by using  $C = C(\tau)$  in (1) and (2), and also considering explicitly the “forced” human activity

as  $\frac{\gamma''(\tau)}{C(\tau)}$ , which is proposed or measured, the period associated with the human-machine is

$$T = \frac{2\pi}{\sqrt{\frac{\gamma''(\tau)}{C(\tau)} - \frac{\ddot{C}(\tau)}{C(\tau)} - \frac{2\dot{C}(\tau)\alpha(\tau)}{C(\tau)}}} \quad (4)$$

- Once the time period is generated, the automatic process for resetting the data intervals is implemented:
  - by measuring on site the system's parameters (or functions)  $\alpha$ ,  $W$ ,  $\gamma$  and then by scaling the model and processing the macro-data.
  - by solving  $C'' + 2\alpha C' + W^2 C = \gamma''(t)$  for the reliability  $C(\tau)$ , and then for the attrition  $X(\tau)$ . Then, the response of  $X$  over time is obtained and a superior limit for attrition is adopted.

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 will 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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