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Introduction

The word system, (from the Greek $\sigma\upsilon\sigma\tau\eta\mu\alpha$) is used in a diversified range of contexts and has thus assumed different meanings. The most common definition of system concerns a group of parts linked by some form of interaction. In the context of System Theory a system can be defined as a slice of reality whose evolution in time can be described by a certain number of measurable attributes.

The measuring of system attributes introduces the problem of establishing quantitative relationships between them, i.e. to construct abstract (mathematical) models. The role played by mathematical models in science and technology is today of paramount importance and has attracted increased attention on model construction procedures. Identification is one of these procedures and consists in deducing mathematical models from the observations performed on a system. This approach involves a large variety of choices that lead to many possible schemes; some of these schemes are described in the following with particular reference of their application to multivariable processes.

1.1 SYSTEM MODELS

The etymological roots of model come from the Latin word *modus* and its diminutive *modulus* both meaning measure; its initial use in science and technology can be associated to scale representations used by architects to reproduce the shape of buildings before their actual construction. In this case the models are physical systems that reproduce approximately the aesthetic properties of other physical systems before their realization.

An important advancement was achieved with the introduction of models that were still small scale reproductions of physical systems but were used however to investigate their behavior either before construction or under operating conditions otherwise impossible or too expensive. Well known examples include hydrological models and models of boats that were used to evaluate their hydrodynamical properties. In such cases very complex phenomena are reproduced without any knowledge of the mathematical relations linking the relevant variables (water flows, velocity profiles, boat speed and hydrological resistance). It is also necessary however, to scale properly the variables in order to assure an accurate reproduction of the case to be studied; laminar flows, for example, must not become turbulent flows and *vice–versa*. A further step was taken by reproducing the behavior of a system on another system that could be more easily studied, taking advantage of the different physical laws that can be described by formally equal relations. A typical example is given by analog computers, structured as flexible electrical networks that, properly interconnected (programmed), reproduce the behaviors of other systems (mechanical, hydraulic, economic etc.) less suitable for direct experiments. These models could be defined as analog or, to avoid any confusion with the common use of this term (analog to denote quantities whose measure can be performed with continuity, as opposite to digital used to denote quantizations), models based on analogy laws.

It can be observed that these models offer greater flexibility than previous ones where the only degree of freedom was the scale factor, since the physical nature of the model is also a matter of choice. However, the use of models based on analogy laws requires the knowledge of the laws describing the behavior of the system to be studied, since it is necessary to select, construct or configure another system governed by analog laws by studying its behavior from suitable initial conditions. What is, on the contrary, not required, is the capability of constructing a complete mathematical model and of using it to determine the system behavior.

The last step in the evolution of models is the development of abstract models i.e. mathematical models that describe the links established by the system between its measurable attributes. The important role played currently by mathematical models in science and technology is due to the availability of both the abstract tools offered by System Theory and numerical computers that allow their effective use.

The evolution in use of models fits well the criterion of growth for civilization given by Toynbee. According to this author, this criterion does not consist neither in increasing command in the human environment nor in increasing command over the physical environment, but in "etherialization". This concept, that Toynbee derives from Heard, is rather complex but oversimplifying, involves a transfer of emphasis from some lower sphere of action to a higher sphere; an example could be the media used to record information that from flint and sheepskin have evolved to paper, magnetic and optical media.