Chapter 11
Advanced Model of Complex Information System

Miroslav Svitek
Czech Technical University in Prague, Czech Republic

ABSTRACT

This chapter presents an original approach to information representation, transmission, and processing together with their features that yield into basic principles of informatics. Models of complex systems are based on knowledge from information science that has been gathered over the years in classical physics, a specialized part of which is called information physics. At present, this discipline is still in its infancy, but many discoveries have already been and some scientists have realized that without basic theories in this area, the further development of human knowledge will not be possible.

INTRODUCTION

The proposed methodology represents the new ideas that come from defined mathematical assumptions like information-electrical or information-mechanical analogies. From these simple assumptions a lot of information physical principles can be derived like for example information flow, information content, information power, etc.

Analogies among electrical, mechanical and information circuits seem to be efficient attempts for problems solving within *systems engineering* by Vlček (1999). Concepts of *information power* and significant proximity of the measure of information and knowledge could enable upgrading these analogies for solving even wider class of tasks.

BACKGROUND

Data mean a change of state, for example from 0 to 1 or from 1 to 0, where the state vector is not necessarily only digital or one-dimensional. Every such change can be described with the use of a quantity of *information* in bits.

DOI: 10.4018/978-1-5225-7659-4.ch011

Information theory was founded by Shannon (1948) and his colleagues in the 1940s and was associated with coding and data transmission, especially in the newly emerging field of radar systems, which became a component of defensive systems during the Second World War.

Syntactic (Shannon) information has been defined as the degree of probability of a given event and has replied to the question: how often a message appears? For example, by telling you that the solar system would cease to exist tomorrow, I would be giving you the maximum information possible, because the probability of this phenomenon occurring is nearly equal to zero. The probability model of information so defined has been used for the designing of self-repairing codes, digital modulations and other technical applications. Telecommunications specialists and radio engineers were concentrating on a probabilistic description of encoded data and on the minimizing of probability errors during data transmission.

The model-theoretical work of *semantic information* was done by Carnap and Bar-Hiller (1953). On the other hand, semantic information asks: how often a message is true? Zadeh (1965) introduced the theory of *fuzzy sets* as functions that map a value, which might be a member of a set, to a number between zero and one, indicating its actual degree of membership.

Currently, a number of interesting results have been discovered in the field of *quantum information science*, taking as their basis the foundations of quantum physics and using for modeling of complex systems those principles that do not arise in classical physics, such as *entanglement* and *quantization*. In the technical literature, we read that the behavior of entangled states is very odd. Firstly, it spreads rapidly among various phenomena, where for this spreading it makes use of a property known as *entanglement swapping*. The quantum information quantity in bits can be measured e.g. by *von Neumann entropy* in Vedral (2006) which measures the amount of uncertainty contained within the density operator taking into account also wave probabilistic features like entanglement, quantization or bosonic / fermionic quantum behavior by Svítek (2012).

On the basis of the information theories, a number of methods and algorithms have emerged that attempt to eliminate or minimize indefiniteness and to do a better job of extracting the real, useful information from data. An excellent example is the *Bayes method* by Peterka (1981), which interprets the density of probability not as a description of a random quantity, but rather as a description of the indefiniteness of the system, i.e. how much information we have available about the monitored system. The system itself might be completely deterministic (describable without probability theory), but we may have very little available information about the system. When performing continuous measurement, we obtain more and more data, and therefore more information as well about our system, and our system begins to appear to us to be more definite. The elimination of indefiniteness therefore increases the quantity of information we have about the monitored system.

When eliminating indefiniteness, we also have to bear in mind the possibility of a change to the context of the event or phenomenon. There is plenty of testimony available to us from live witnesses, but there is none from dead ones, and this gives us an asymmetrical set of observations by Taleb (2010). It brings to mind the well-known saying that history is not written by the losers.

Once indefiniteness has been eliminated, one may proceed to the *interpretation of information,* or in other words, to the determination of how to reconstruct the described system, or how to build a more or less perfect model of it using the information. This task already belongs to the theory of systems, where it is necessary to identify the state vector, individual processes of the system etc. There emerges from this a knowledge system, which is able to describe the given object appropriately.

Related Content