Ecological Modelling 328 (2016) 85–94

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

Semantics of language for ecosystems modelling: A model case

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ARTICLE INFO

Article history:
Received 18 September 2015
Received in revised form 26 January 2016
Accepted 19 February 2016
Available online 14 March 2016

Keywords:
Complex systems
Ecological model
Metasystem
Semantic
Syntax
Systems general theory

ABSTRACT

In this paper, the authors continue developing a Linguistic Theory of the Complex Systems models, but in terms of Semantics. Each symbol (transformed function) is syntactically a lexeme, carrying an associated sememe or atomic semantic unit. Each sememe can be decomposed into semes or quantic semantic unities. They may be studied as semantic systems, associated with syntactic systems that serve them as superstructure, with two levels: the quantic and the atomic. Also, it is demonstrated that for all models of complex reality, there exists a complex model from the syntactic and semantic point of view.

1. Introduction

The concept of a model has been frequently used on an intuitive and reduced scale; however, no model has all the characteristics of the reality that it represents. A model only concerns certain properties and relationships. A model should be called "authentic" when it represents a defined, determined system. Any defined model is the isomorphic and homomorphic image of a system that exists in reality. On the other hand, the idea of model itself comes from common language, re-thought by philosophical tradition. The Platonic School is somehow evoked though the double function through which reasoning is exercised: "*concept*" and "*image*" is internal and dialectically models of one another. Until now modelling has been considered as based on the technical perspectives (use) of the branches of reasoning in which they are applied, but for Semantics, which is a general theory of human language and representation, presents itself as a problem with undefined limits. Language, in this way, acquires a new dimension: it makes a scheme from a graph of our action, establishes rules for our operations over our representations of beings and our exchanges with the others. According to the project, diverse references are picked up from the world and the direct categories of senses are chosen in an appropriate way.

Complex systems as a whole possesses certain characteristics that clear up the original and proper form of these functions, even though its methodology is not separated from other models. On the other hand, they must be separated from models based on physical, mechanical causes. The existence of feedback expresses the conditions of adaptation, regulation or structured response from equally structured signals that have been constructed on the scientific literature belonging to the theories of Biology, Ecology, Sociology and other related areas. The possibility of establishing models in Complex Systems is low if the elements and relationships cannot be characterised unequivocally. The structure of a set of Complex Systems can never be limited totally to a model. Such models are only approximations. No matter what the model, a representation of a natural being can at best only be a homomorphous model. Modelling is homorphic mapping, which is, constructing on image (a model) of reality by abstracting a particular aspect (Higashi and Burns, 1991). The model itself (semiotic system) will always be homorphic in relation to reality or the Ontological System (Nescolarde-Selva and Usó-Doménech, 2013a,b; Morowitz, 2012; Villacampa and Usó-Domènech, 1999). However, at the same time there can be cases of homomorphism and isomorphism even in models which describe the same part of reality. In mathematics it can be easily determined if isomorphism or homomorphism exists. On the other hand, it is not always easy to establish if two given physical systems are isomorphic or homomorphic. Up to what point is an ecological system of the physical world a model of the other? And the same question can be asked about the relationship which exists between the said physical system and a

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http://dx.doi.org/10.1016/j.ecolmodel.2016.02.012
0304-3800/

formal mathematical system. As Frey (1972) says, to answer this question, first all of the elements between the correspondences must be established and have to be characterised unequivocally in both systems as they are presented and the existing relationships must be definable unequivocally in all their properties.

A specific effort to overcome the ambiguity and facility of intuition has to be made. With the use of a mathematical expression a plane of objectivity can be reached or at least the aim is to get as close to it as possible. However, a mathematical expression is a formality. All formality is an object language (Bach, 1964). The functions of any object language are objectivity, systemisation and communication (Klüver, 2011) of our knowledge. It is not designed to deal with propositions, signs and various calculations characteristic of the object language (Mathematics), and that means that the metalanguage (natural language) dominates. The linguistic structuring of reality is not a perceptual structuring, but a semantic restructuring which reorganises the elements schematically on another level of meaning, having perceived the first level of meaning. Language or any system of concepts does not reflect reality, but creates a reality over which we can use to communicate. Looking at this process of reasoning of knowledge, and paraphrasing Morin (1977), we use a second class cybernetics in which we use language to know language, that is to say where resourcefulness is the norm where there is no possible linearity and where there are only feedback processes.

Random-text models have been proposed as an explanation for the power law relationship between word frequency and rank, the so-called Zipf's law (Tsonis et al., 1997). They are generally regarded as null hypotheses rather than models in the strict sense, recent theories of language emergence and evolution assume this law as *a priori* information with no need of explanation. Ferrer i Cancho and Solé (2002), compared random texts and real texts through the lexical spectrum and the distribution of words having the same length.

Written language is a complex communication signal capable of conveying information (Gershenson and Fernández, 2012) encoded in the form of ordered sequences of words. Beyond the local order ruled by grammar, semantic and thematic structures affect long-range patterns in word usage. Montemurro and Zanette (2010), shows that a direct application of information theory quantifies the relationship between the statistical distribution of words and the semantic content of the text. Levels of a complex system are characterised by the fact that they admit a closed functional description in terms of concepts and quantities intrinsic to that level. Recently, Pfante et al. (2014) presented four of these approaches, restricted to the case of discrete dynamical systems, and investigated their mutual relationships.

We assume that the dynamics of the system can be modeled starting off with a set of ordinary differential equations as follows:

$$\frac{\mathrm{d}y_i}{\mathrm{d}t} = F(x), \quad \bar{x} = x(t) \quad , t \geq 0; \quad \bar{x}(0) = x_0, \forall j$$

$$x[0, +\infty] \to R^n; \quad y(t) = F(x(t)); \quad F : R^n \to R$$

where, R^n is the phase space, t the time and y is the state variable.

Hence we start off with a system of non-linear differential equations.

$$\frac{\mathrm{d}y_i}{\mathrm{d}t} = \sum_{i=1}^{n} x_{ij}, \quad \forall j = 1, 2, \ldots, n$$

where, x_{ij} are the flow variables which produce the state variable y_j. The flow variables determine the variations of the system states and characterise the actions that are taken in it, which are accumulated in the corresponding levels or states. The flow variables determine how the available information is converted into an action. Equations that define the behaviour of the system are associated with a flow variable. These equations associated with a flow variable receive the name of *flow equations* or *decision equations* (Fig. 1). These equations represent the biological, chemical and physical processes in the ecosystems. They are the relationship between the external variables (forcing functions) and state variables.

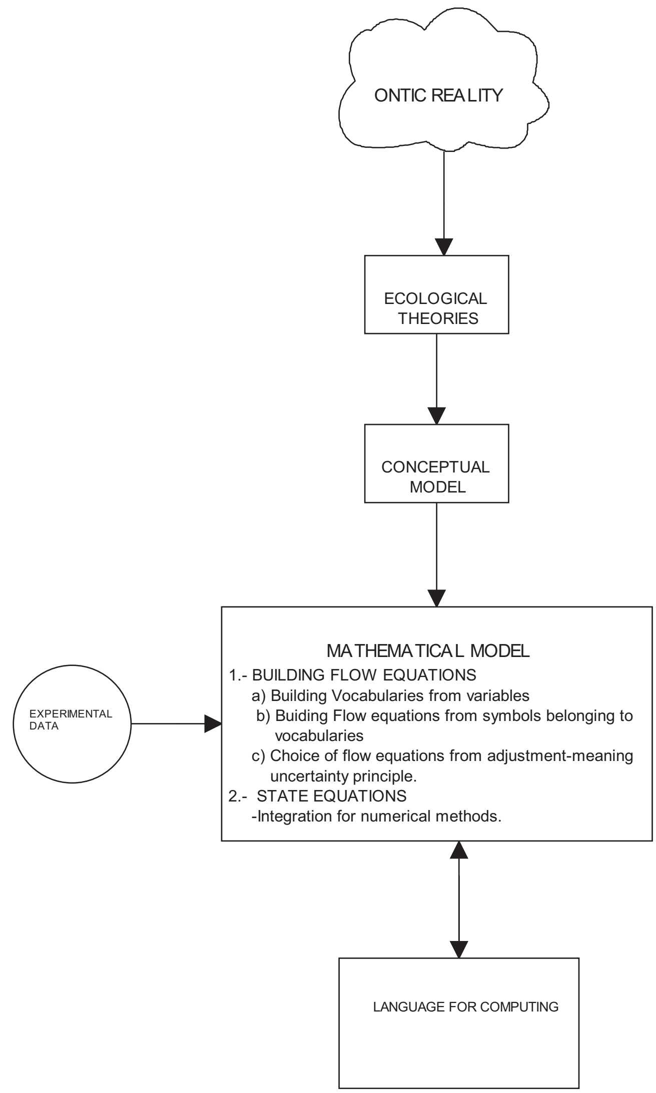

Fig. 1. Flow equations and mathematical model.

Each one of the flow variables can depend either on the input variables or on state variables. We will call z the set formed by the state and input variables and we will identify it as an open subset of R^n. it is possible to write it as follows:

$$\forall x_{ij}, \quad x_{ij} = f_{ij}(z_1(t), \quad z_2(t), \ldots, z_n(t))$$

$$z_i : [0, +\infty] \to z \in R^n, \quad \left(f_{ij} : R^{n^2} \to R^n\right)$$

Our goal is to express every x_{ij} as a linear combination of transformed functions, so that they adjust to the model studied through linear regression.

For convenience, the transformed functions of order 0 are expressed by $T^1(z_r)$. The transformed function of order 1 by T^2