Space and Time in Eco-Ontologies

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Abstract

In this paper we are interested in identifying the ecologically relevant points of an ontology. What is it that makes an ontology more or less ecological? Specifically, it is a question whether or not the integration of two or more ecological ontologies furthers ecological analysis by showing how a function described by one of the ontologies is carried out. We discuss the importance of recursion, roles, space, and time for the differentiation of eco-ontologies from other non-ecological ontologies.

Introduction

In light of the fact that we are concerned to describe the integration and differentiation of ecological ontologies, we suggest that analysis of ecological systems from this point of view may be helpful in identifying the ecologically relevant points of connection and discrimination among alternative ontologies. Specifically, it is a question whether or not the integration of two or more ecological ontologies furthers ecological analysis by showing how a function described by one of the ontologies is carried out.

Moreover, there is the important possibility that an ontology resulting from the integration of two or more prior ecological ontologies might possess emergent ecological characteristics (recursions not found in any of the source ontologies). On the other hand, an integration of two or more non-ecological ontologies might (because it possesses emergent recursions) be ecological. These kinds of complementarities – in which the whole is greater than the sum of its parts – would be of particular interest in light of the subject matter of the ontologies we propose to investigate.

Briefly, some of the possibilities we wish to explore in light of the foregoing considerations are as follows:

1. Development of a metric for distinguishing the degree to which an ontology is ecological (characterized by recursion and time). This might be significant in discriminating perspectives in terms of their grasp of ecological issues. We are interested also in the development of a metric in terms of which we can examine the similarities and differences among ecological ontologies in terms of geometrical patterns of recursion. Recognition of similarities and differences would be important for guiding the integration and disintegration of ontologies.
2. One of the most interesting characteristics of an ecological system is that it is neither entirely open, nor entirely closed. It retains what coherence and continuity it possesses by virtue of its recursive character. That characteristic enables it to assimilate new components into its structure and to accommodate its structure to novelty without being destroyed by it. An analysis of the capacity of ecological systems to assimilate and accommodate to a constantly perturbing environment would be crucial for the representation of an ecological ontology.
3. Development of an account of meaning of nodes in an ecological ontological network in terms of the relations (roles) that specify the nodes in question.

It is clear that an exploration of the geometry of ecological ontologies and their combinations would be both interesting and important for the computational representation of information about ecological systems. Further, the essentially temporal nature of ecological ontologies may complement the already existing work dealing with spatial ontologies, and, as such, constitute an important step in the development of a theory of ontologies.

Recursion in Eco-Ontologies

A key to the specification of eco-ontologies is the notion of teleological organization grounded in a notion of recursion. The recursively based teleological organization of ecosystems embodies a fundamental distinction between eco and non-ecological ontologies. Working out what teleological organization of eco-ontologies entails will reveal essential characteristics of eco-ontologies and their differences from other types of ontologies.

One initial assumption when creating a framework for the development of eco-ontologies is that living systems are auto-poetic – self-organizing (Maturana and Varela 1980; Kauffman 1995). Kant (2000) was the first to introduce this hypothesis. He viewed biological systems as having components that are, recursively, both means and ends in relation to one another. In this way, a living system, whether the organs of an individual organism or individuals comprising a whole, symbiotic, eco-system, is interpretable in terms of teleological categories. We may ask, "What function does this organ or organism serve?" Kant's point in this regard concerns what might be called 'levels of analysis.' If one is interested in biology, as opposed to physics, the questions one wants to ask have to do with the function of an organ or organism in the larger whole of which it is a part.

Space and Time in Ecological Borders

We can consider space and time as two important dimensions to explain the interactions between an ecological environment and its surroundings.

Regarding where the disturbance occurs we can have:

- the disturbance is external to the system. It interacts with the system but without penetrating it, at least in a permanent character.
- the disturbance penetrates the system. The new element crossed the system boundary and it now in the system in a definite way.

Regarding the duration of the disturbance we can have:

- some disturbances can be of an ephemeral character;
- some disturbances have a permanent character or a recursive one.

When the disturbance is ephemeral and internal the tendency of an ecological system is to absorb locally the disturbance without propagating the instability to the whole system. When the disturbance occurs externally to the system and it is ephemeral we can consider it only a distraction without any consequences.

The permanent disturbance causes structural changes in the system. When they are internal to the systems, the two system learn how to live with each other and the relationship is beneficial to both of them. This process is called symbiosis.

The second type of permanent disturbance is between a system and an external agent. Since its character is permanent or at least of a recurrent character the system needs to learn how to live with it. What happens then is what Maturana and Varela (1987) call *structural coupling*.

Structural coupling is the resulting change in the structure of each of the two interacting living systems. The structures in each system change as a result of the presence of the other system. As Maturana and Varela stress the change is not made by the other system being instead started by it.

Roles

It is very interesting that this sort of analysis introduces, in a natural way, a teleological dimension into the description of an ecological system. Under its guidance, one begins to see an ecological sense in which it is appropriate to ask what something is for, or what its function (or, role) might be in the ecological system. Of course, if one ignores the reciprocal means-end analysis Kant pointed to, one might describe the causal antecedents of any number of events but fail to see the ecological system. Such an investigator would fail to identify the ecologically relevant events or relations, or to distinguish them from the indefinitely large set of events and relations that are of mi-nor importance in understanding the ecological system. For example, in examining the mammalian body there are many relatively subsidiary questions one might ask about the heart – such as what color it is when viewed on the laboratory dissection table. On the other hand, if one knows that the function, or role, of the heart is to move the blood, and that it is through that function that the heart enables the continued existence of the other organs of the body, and thus its own continued existence as well, then one is directed to ask questions concerning the heart that are relevant to the function of the whole body of which it is a part. Specifically, one is led to ask how the heart moves the blood. The investigator will be led to question of the role of a structure or relation in the function of an ecological system as a whole.

The Essentially Temporal Character of Eco-Ontologies

Ecological ontologies, then, must be represented in terms that allow us to capture their genuinely self-organizing, ecological nature (i.e., the ecological level of analysis). More formally, such self-organizing systems have the characteristic of recursion in the sense that A=>B=>C=>A=>B=>, etc. This description reveals the essentially temporal character of eco-ontologies. In contrast with the essentially spatial character of geo-ontologies, eco-ontologies are fundamentally temporal in character. The spatial character of geo-ontologies, ontologies for the geographic world, contributes to the hierarchical organization of geo-systems. The temporal character of eco-ontologies on the other hand is a function of the recursive process that is essential to their definition. There is, of course, a possibility of hierarchical relations in eco-ontologies. However, in this case the hierarchies are functional and dynamic in nature. For example, at one level of analysis, the heart may be seen as moving the blood. At a subordinate level of analysis, moving the blood may be seen as pumping the blood, etc.

The special importance of time eco-ontologies derives from the fact that the life course for living beings is structured in terms of time. Today, for a living being, is different from yesterday because he/she is older. Moreover, many living beings learn from their experiences, which makes today even more different from yesterday from their point of view. Organisms in an ecological system have a short span of life com-pared to regular geographic features that can last millions of years. Thus, while for some purposes it may by possible to ignore the temporal dimension in constructing geo-ontologies, the circular causal chains that make for ecological self-causation re-quire that eco-ontologies represent the temporal character of ecological systems.

Conclusions

In this paper we have elaborated some of the fundamental characteristics of ecological ontologies and drew attention to the formal differences between ecological and non-ecological ontologies. The presence of recursion, time, and of nodes representing a function are the three main characteristics of an ecological ontology.

We think that focusing the study of how to represent formally these main components of an ecological ontology we will be able to build metrics to examine similarities and differences between (1) different eco-ontologies and (2) eco-ontologies and non-ecological ontologies.

References

Kant, I. (2000) The Critique of Judgment. Prometheus Books, Amherst, N.Y.

Kauffman, S. A. (1995) At home in the universe : the search for laws of self-organization and complexity. Oxford University Press, New York.

Maturana, H. R. and Varela, F. J. (1980) Autopoiesis and Cognition: the Realization of the Living. D. Reidel Pub. Co., Dordrecht, Holland ; Boston.

Maturana, H. R. and Varela, F. J. (1987) The Tree of Knowledge: the Biological Roots of Human Understanding. New Science Library: Distributed in the United State by Random House, Boston.