

Proceedings

Information: Subjective or Objective?

Ron Cottam ^{1,*}, Willy Ranson ² and Roger Vounckx ¹

¹ The Living Systems Project, Dept. of Electronics and Informatics, Vrije Universiteit Brussel (VUB), Pleinlaan 2, 1050 Brussels, Belgium

² IMEC vzw, Kapeldreef 75, 3001 Leuven, Belgium

E-Mails: ricottam@etrovub.be; wranson@etrovub.be; rvounckx@etrovub.be

* Author to whom correspondence should be addressed; Tel.: +32-2-629-2933

Published: 8 June 2017

Introduction

The target of this paper is to draw a comparison between information in living systems and information in inorganic contexts. The two representative contexts we will refer to are those of an organism and of solid state physics. We have published extensively elsewhere on the properties of a model hierarchy (e.g. Cottam et al, 2003; and most recently Cottam et al, 2016; Cottam et al, 2017), and to reproduce the entire derivation would be inappropriate for this extended abstract. Consequently, we will restrict ourselves to the brief sketch which follows, in the hope that this attenuated version is sufficiently comprehensible.

Natural Model Hierarchy

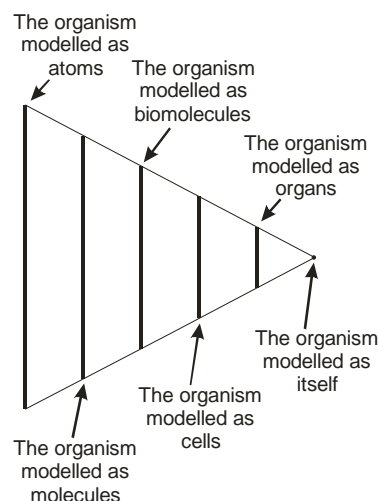


Figure 1: The general form of a model hierarchy as imagined for an organism.

Figure 1 illustrates the general form of a model hierarchy in the example of an organism. The hierarchy is pictured ‘on its side’ to support the view that no one level of organization is ultimately dominant. Each organizational level constitutes a model of an entire organism at a specific structural scale, as indicated, and as opposed to conventional hierarchical representation, for example Salthe’s (2012) compositional hierarchy, where a single constitutional element is presented at each level. The model hierarchy appears to be the parent (Cottam et al, 2013) of both compositional hierarchy and subsumption hierarchy (Salthe, 2012). Although Figure 1 is presented in structural terms, such a hierarchy can also be represented in terms of function, and it automatically includes any required aspects of heterarchy. Regions between adjacent levels are extremely complex in Rosen’s (1991) sense, and these embody the locally scaled internal representations of the organism’s ecosystem. Each organizational level is partially closed and partially open to the rest of the hierarchy, and direct access to individual levels from outside or from other internal levels is limited.

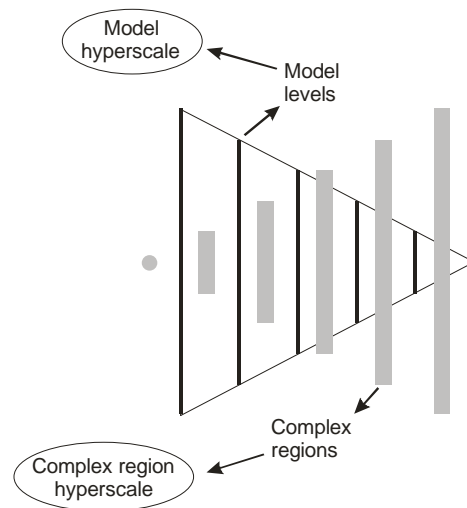


Figure 2: The generation of approximate hyperscalar models of the two partial hierarchies.

The hierarchy automatically creates a pair of approximate models of itself (Cottam et al, 2013), one for the organizational levels, one for the complex regions (see Figure 2), which we refer to as hyperscales (Cottam et al, 2005).

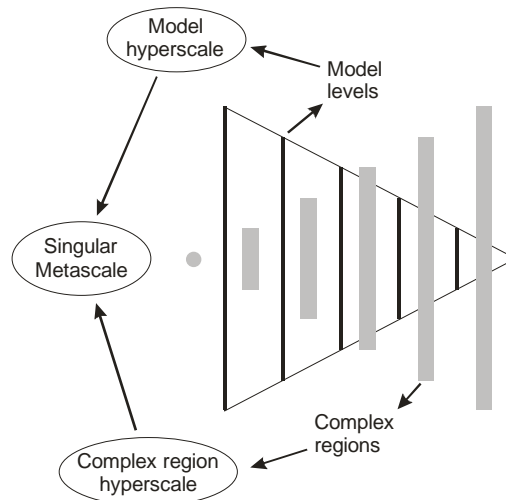


Figure 3: The two hyperscales integrate to a singular metascale, which is the real nature of the organism.

Ultimately these integrate, giving a singular metascalar representation (as illustrated in Figure 3) which is the real identity of the organism (Cottam et al, 2013). This corresponds with the identification

of information with the integration of data (the model level hyperscale) and context (the complex region hyperscale) (Cottam et al, 2016).

Solid State Physics

Our next task is to describe formulation of the electronic properties of solid state physics. We start with a single atom, which exhibits a sequence of electron energetic levels spreading outward from the nucleus, as indicated in Figure 4.

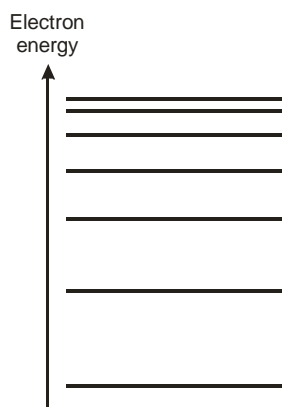


Figure 4: Electron energy levels around the atomic nucleus.

In a crystal consisting of a myriad of closely packed atoms these energy levels broaden, following the Pauli exclusion principle (Azàroff and Brophy, 1963), to a set of energetic bands, as illustrated in Figure 5. Adjacent bands are separated by ‘forbidden regions’ as indicated.

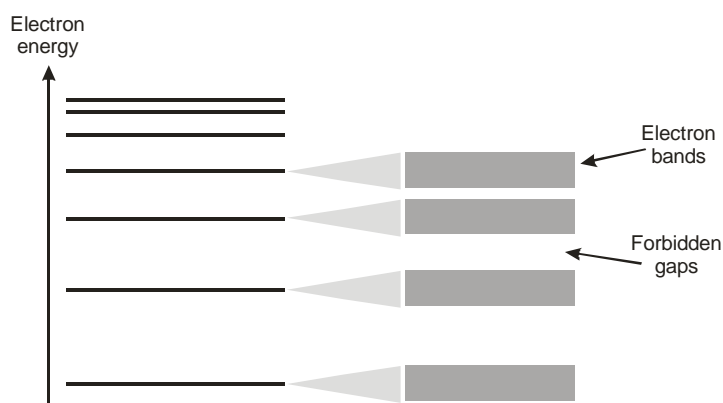


Figure 5: Spreading of the atomic electron energy levels into bands separated by ‘forbidden regions’.

A parallel mathematical derivation of this context following the Kronig-Penney model (Azàroff and Brophy, 1963) yields the equivalent arrangement of bands shown in Figure 6.

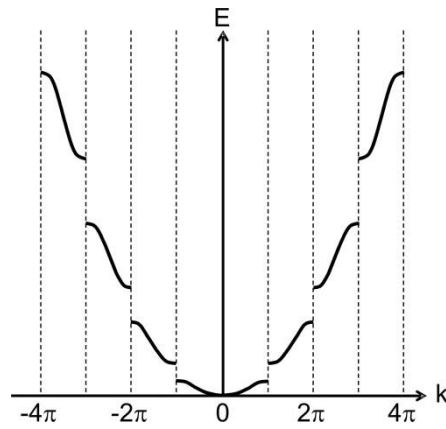


Figure 6: The electronic band structure derived from the Kronig-Penney model. E is electron energy; k is electron momentum.

Similarity between the electronic band structure and the organism model hierarchy is already apparent. The horizontally extended regions of Figure 6 – called Brillouin zones – fold in to the central region to give Figure 7 – an apparent equivalence to the generation of the model-level hyperscale in an organism.

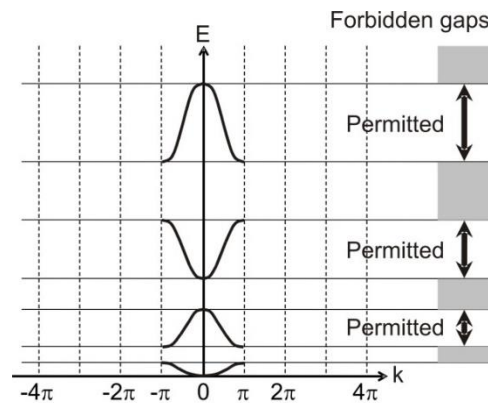


Figure 7. Folding-in of the Brillouin zones into the central region.

The second ecosystemic hyperscale is here relatively simple, as in the inorganic case it collapses down to a simple set of parameters of temperature, pressure, magnetic field, ... At the highest level of organization, electronic conduction is controlled by two aspects. Firstly, the electrons themselves, secondly, the regions from which they may be absent, called ‘holes’. The holes’ properties are those of the electrons’ ecosystems. Consequently, conductivity in a crystal is derived from the properties of both electrons and their ecosystems – an apparent mirroring of metascale in an organism.

Comparing Natural Hierarchy and Solid State Physics

The coupling feature between these two systems appears to be the relationship between process and structure, where both are intimately connected in an organism, and where process is virtually absent from a crystal. This gives us a way of characterizing system properties, including information, in the two situations. We believe that the higher level characteristic of complementarity can best represent this coupling, and that objectivity or subjectivity in a given context can be referred to the degree of its presence in a context, or of its absence.

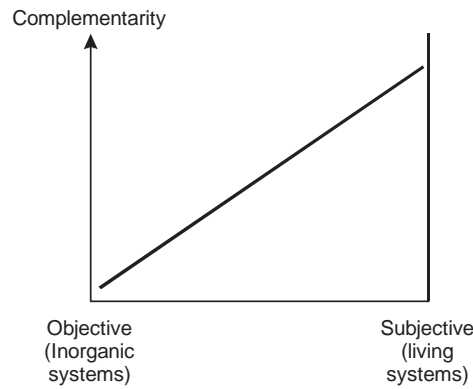


Figure 8: A suggested relationship between complementarity and subjectivity and objectivity, linked to organisms and inorganic systems.

Figure 8 attempts to picture this relationship. It should be noted that we do not suggest that the implied coupling is linear: this is shown in the Figure merely to establish the sense of the relationship between complementarity and objectivity/subjectivity. Interestingly, this relationship resembles one that we have published earlier (Cottam et al, 2013) between complementarity and the excluded or exclusive middle in bilateral contexts, such as in Brenner’s (2008) Logic in Reality (see Figure 9). Increase in system complementarity corresponds to a decrease in the accessibility of the bilateral ‘end-points’ of the system, and a focusing of system properties on the mid-region.

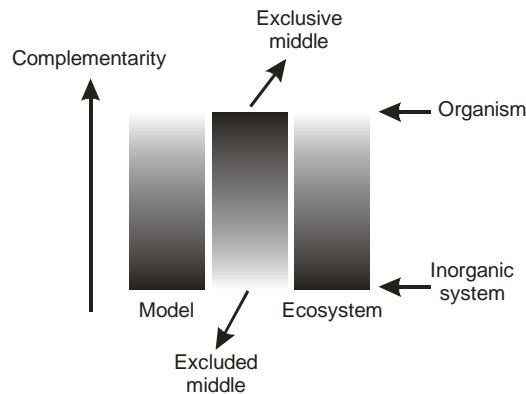


Figure 9: Change from the excluded middle to the exclusive middle with increase in system complementarity.

We have earlier published an investigation of information in living systems (Cottam et al, 2016) which concluded, following Havel’s (1996) propositions of the natures of subjectivity and objectivity, that information in organisms is fundamentally *subjective*, and *exclusive* in character. This corresponds to the preponderance of complementarity in living systems, as we indicated in Figure 8. On the other hand, complementarity in inorganic systems is lacking, and measures of information derived in these systems are fundamentally *objective*, in Havel’s (1996) sense.

References

Azàroff, L.V.;Brophy, J.J. *Electronic Processes in Materials*; Publisher: McGraw Hill, Tokyo, 1963.
 Brenner, J.E. *Logic in Reality*; Publisher: Springer, Berlin, 2008.
 Cottam, R., Ranson, W. and Vounckx, R. Autocreative hierarchy II: dynamics - self-organization, emergence and level-changing. In *International Conference on Integration of Knowledge Intensive Multi-Agent Systems*; Hexmoor, H., Ed.; Publisher: IEEE, Piscataway, NJ, 2003; pp. 766-773.

- Cottam, R.; Ranson, W.; Vounckx, R. Life and simple systems. *Systems Research and Behavioral Science* **2005**, *22*, 413-430.
- Cottam, R., Ranson, W. and Vounckx, R. (2013). A framework for computing like Nature. In *Computing Nature*; Dodig-Crnkovic, G., Giovagnoli, R., Eds.; Publisher: Springer SAPERE series, Heidelberg, 2013; pp. 23-60.
- Cottam, R.; Ranson, W.; Vounckx, R. Hierarchy and the nature of information. *Information* **2016**, *7*, 1-10.
- Cottam, R.; Ranson, W.; Vounckx, R. Scaled ecosystemic Rosennean complexity. In publication: invited paper for the journal *Ecological Complexity* **2017**.
- Havel, I.M. Scale dimensions in Nature. *International Journal of General Systems* **1996**, *24*, 295-324.
- Rosen, R. *Life Itself: A Comprehensive Inquiry into the Nature, Origin and Fabrication of Life*; Publisher: Columbia U.P., New York, 1991.
- Salthe, S.N. Hierarchical structures. *Axiomathes* 2012, *22*, 355–383.

© 2015 by the authors; licensee MDPI and ISIS. This abstract is distributed under the terms and conditions of the Creative Commons Attribution license.