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Foundations of Information Science
Selected papers from FIS 2002

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Abstract: The accompanying papers in the first issue of Entropy, volume 5, 2003 were presented at the electronic conference on Foundations of Information Science FIS 2002 (http://www.mdpi.net/fis2002/). The running title of this FIS e-conference was THE NATURE OF INFORMATION: CONCEPTIONS, MISCONCEPTIONS, AND PARADOXES. It was held on the Internet from 6 to 10 May 2002, and was followed by a series of discussions –structured as focused sessions– which took place in the net from 10 May 2002 until 31 January 2003 (more than 400 messages were exchanged, see: http://fis.iguw.tuwien.ac.at/mailings/). This Introduction will briefly survey the problems around the concept of information, will present the central ideas of the FIS initiative, and will contrast some of the basic differences between information and mechanics (reductionism).

Keywords: Information Science, Reductionism, Mechanics, Bioinformation, Adaptability, Entropy, Symmetry.

The Problem of Information and the FIS Initiative

As the presentation text of the FIS 2002 e-conference stated: “Inconsistencies and paradoxes in the conceptualization of information can be found throughout numerous fields of natural, social and computer sciences. Rather than strictly focusing on the quest for a unifying conceptualization, this FIS (Foundations of Information Science) e-conference will also explore the ‘reverse’ approach: what

information is not. Thus, the conference aims to introduce new categories and unifying theories, as well as to critically analyze conceptual stumbling-blocks that may be acting as inefficient surrogates in strategic areas of information-related disciplines. Given the contemporary social context of booming information technologies and widespread proclamations of the *information society*, reassessing the very status of information within the system of the sciences becomes a timely enterprise." (http://www.mdpi.net/fis2002/, 'Topics').

Participants were invited to present conceptions and misconceptions about information in a variety of fields, such as communication theory, machine intelligence, economic and technological evolution, information society, agency, brain processing, organismic integration, biological evolution, bioinformatics and biosemiotics, molecular recognition, physics of information, self-organization and complexity, entropy, quantum interpretations, symmetry. A total of 24 contributions were presented; some of them have been enlarged into the papers included in this issue.

Actually, this FIS 2002 e-conference was the fourth FIS gathering, after two 'real' meetings, FIS 94 in Madrid and FIS 96 in Vienna, and the FIS 98 Virtual Conference (http://fis.iguw.tuwien.ac.at/). A common idea behind these four conferences, and perhaps the nucleus of the FIS initiative, would be the quest for a unifying approach capable of introducing a new conceptual order into the contemporary mosaic of disparaging acceptations around the term *information*. As Michael Conrad and this author argued in the first FIS venue [1,2], rather than discussing about a unitary meaning for the term, understanding information from the FIS premises appears as the intellectual adventure of developing a 'vertical' science connecting, so to speak, the different scales of informational processes –reminding physics itself, which from a pre-Galilean particularized single term evolved towards a vertical science connecting the previously separated 'celestial', 'sublunar', and 'terrestrial' physical occurrences.

In the prosecution of that goal, each one of the FIS conferences has brought some particular advancements [3]; but perhaps the last conference has represented the highest degree of convergence among the different scientific perspectives involved in the discussion. Actually, the multidisciplinary problems to cohere a unitary perspective about information –to consolidate a genuine information science– are formidable. They cannot be minimized in any way. For instance, we may encapsulate with relative consistency the basic approaches to information in physical sciences, communication engineering, and logic and computer sciences. At least, these are the main scientific avenues which have contemporarily dissected the i-concept within the 'hard' sciences –or as we will argue, insufficiently dissected it. Historically, the *thermodynamic approach* goes first (Maxwell, Boltzmann). Then, *communication engineering* (Shannon, Wiener), which provided the famous formula for measuring the information 'entropy' in sources and transmission channels. Later on, the *algorithmic-computational* approach (Turing, Kolmogorov, Chaitin) and the *logico-linguistic-semantic* approach (Carnap, Nauta, Dreske). But how do these different approaches interrelate? In principle, not too badly.

An immediate consequence is that those schemes, having extended the scope of information from natural patterns up to the computational-digital form, apparently grant the conceptual conversion of the 'material' into 'information': from the *it* to the *bit*, and also conversely (from the *bit* to the *it*). The far-

reaching outcome is that there occurs a conceptual expansion of the mechanical vision up to any information-related realm [4]. Ultimately, the vision of states of matter evolving under the laws of nature, which is common to the *three mechanics* (classical, statistical, and quantum), would be theoretically congruent with the timed flow of states of the algorithmic-computational approach [5]. Philosophically, reductionism becomes the common meta-scientific strategy, the grand vision unifying the different disciplinary strands in a global hierarchy... Roughly, this has been the 'received wisdom' about information in the natural sciences during the last Century.

Reductionism: Life Versus Mechanism

Reductionism, needless to say, does not solve the information conundrum –and perhaps worsens it, becoming the associated notion of mechanism one of the most common and insidious form of information-surrogate. Apart from its theoretical inconsistencies (insurmountable ones in different fields of physics, conspicuously in cosmology, and also in mathematics themselves, or whenever the semantics is seriously considered beyond mere syntax or very shallow pseudo-semantic contexts), one of the biggest paradoxes of reductionism occurs in its application to biology. There, the multidisciplinary scheme of 'fundamental' reductive analysis has barely produced any fertile vision of the integrative architecture of information processes within living beings (just asking what genera or classes of information can be distinguished among the molecular populations of the living cell, largely becomes an unformulated question). Integration does not mean the inverse of analysis; and life's information processes cannot be reduced to an endless accumulation of fractionable molecular mechanisms.

The absence of an integrative vision is acutely felt in the recently framed bioinformatic field, which is conceptually struggling to make sense of an increasing avalanche of biomolecular data. The tentative conceptualizations in that field on 'systems biology', 'computational biology', 'functional modules' or 'modular networks' represent experimentalist attempts to approach biological information –the multilevel networking of causality instances in living beings– in a new, non-reductionist way [6]. Indeed a *bioinformation* or an *informational biology* looms.

Stating clearly the problematic relationship between life and mechanics, with information right in the middle, appears as a central theme of the FIS enterprise. Paying attention to the papers presented in this Issue, to the contributions of the FIS 2002 e-conference, and to the abundant post-conference discussions (http://fis.iguw.tuwien.ac.at/mailings/), it is easy to realize that the theme represents both a crucial problem and a crucial divide. Besides, its retinue of accompanying problems grows as one ascends along further levels of biological, neuronal or social complexity. The study of nervous systems and human behavior, for instance, has historically witnessed some of the greatest blunders of mechanistic reductionism (the whole behaviorist attempt, most of cognitive psychology, and substantial parts of artificial intelligence and artificial life research programs) which have provoked strong idealistic and anti-science reactions against them. In the social sciences proper and in the humanities, the lack of interdisciplinary visions harmoniously integrating with the natural sciences has

severely crippled the contemplation and understanding of the 'natural' information processes that historically support social life –depriving complex societies of their characteristic varieties of circulating information, simply, collapses them at all. Again, there has not been much effort by theoreticians of the 'information society' about the nature of such informational processes and about the misunderstandings and paradoxes of the i-term within the natural and social sciences. A 'tunnel vision' on information has prevailed [7, 8].

Proposing reductionism as the only thought avenue capable of coping with the social and scientific problems of our times is a cul-de-sac strategy [9]. Perhaps it is not too farfetched thinking that the FIS discussions on life, information, and reductionism could be meaningfully connected with the poorly understood interdisciplinary dynamics of our system of the sciences, and also with the role to be played by the sciences in front of the great problems of our times (sustainable development, civilization crisis).

Advancing the New Information Synthesis

In the papers presented in this issue of **Entropy**, as well as in the post-conference discussions (http://fis.iguw.tuwien.ac.at/mailings/), one can find a number of conceptual elements that will be forming part, quite probably, of future solutions of the information puzzle. Trying to organize a 'conceptual itinerary' across those relevant elements is beyond the scope of this brief report; however, that type of itinerary might be cursorily drafted just thinking on what a new information synthesis could attempt in a near future.

For instance, an informal narrative about those partial conceptual elements could start with the general theme of the nature of the observer and the interrelationship with the observed, and then the subsequent problems of communication, meaning, and knowledge validation; thus, it could be followed by the philosophical framework to work out consistently the ontological, epistemic, and metaphysical consequences (pragmatism, phenomenology, hermeneutics, semiotics, empiricism, perspectivism... –or a brand new approach?); then, the informational interpretation of quantum problems and principles, including the fundamental interrelationship information-symmetry and the problem of consciousness; the choice of theoretical tool to explore an alternative, unifying information theory (set theory, group theory, category theory, partitions, or some new system-logics); the paradoxes related to information and symmetry in the molecular realm, e.g., disagreements on the entropy of mixing and the treatment of disorder, entropy, and information in open systems; the generalization of the molecular recognition theme in biochemical interactions; the categorization of the information genera and information architectures in the living cell; the emergent cellular dynamics of abduction (following Bateson); the formal characteristics of cellular communication through signaling systems; the fundamental role of protein degradation and apoptosis in biological self-production (the paradoxical 'evanescent permanence' quality of all biological structures); the biological management of 'constraints' as tools of organismic order; the resulting biological capability of evolutionary adaptation to the environment (from sequences and molecules to the environmental measurement of

fitness); the towering dynamics of optimization in living beings... and finally, the uncanny complexity of neuronal and social realms (for space reasons, not addressed in this brief sketch; see http://fis.iguw.tuwien.ac.at/mailings/ for the whole discussion of these subjects).

In the extent to which an optimized conceptual itinerary could be prepared among the previous areas, and new bridges could be built in strategic points, the result might be a brave new view on living matter and, probably, the beginning of a new science about complex 'open systems' –information science. Besides, there is the serious possibility that the most sensible part of that view could work properly for further existentialities based also on informational and adaptability games within neuronal processing contexts or within 'abstract' sociosystems. It would mean establishing the informational triad: *cells, brains, (enterprises) societies*. The crucial input for precipitating the new information synthesis might come from any of the previous conceptual areas or perhaps, not quite unexpectedly, from those situated in the most complex territories, or from new ways of thinking completely outside of current speculations yet.

Just thinking in terms of natural science alone, a promising thin axis to concentrate explorations looms: symmetry, entropy, molecular recognition, cellular abduction, biological self-production & self-degradation, adaptability. This sequence could establish a fundamental direction for the advancement of the new science.

To conclude, the FIS 2002 e-conference has advanced several steps in the redefinition of the information problem, and has opened exciting new perspectives for further explorations. Indeed an elegant and mature synthesis of the information 'Encyclopedia' looks closer. However, for the success of the FIS enterprise much interdisciplinary blending is still necessary: of theoretical speculation with empirical science, of science with philosophy, of observation of nature and society with the art.

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