Preface

...it's a Looking-glass book, of course! -Lewis Carroll

This book is a logical continuation and the widening of the editors' *Reflexing Interfaces: The Complex Coevolution of Information Technology Ecosystems* (2008).

Since the first production of tools at the beginning of human presence on earth, human evolution is linked to the invention of new tools, usually combined with new environmental adaptations.

The symbiosis of man with tools and environments represents one of the main factors in human evolutionary processes. It is evident how this coupling is based on the *biophysics* of our bodies and the development of the social memory system called *culture*.

In recent times, computing devices, molecular biology, and new media (all members in different ways of the Information Communication Technology set) are redesigning the human embodiment and its ecological niche.

The studies on interfaces, forming a common boundary between adjacent regions, bodies, substances, or phases, seem located at the core of these new developments (Jonassen & Land, 2000). It is there, at the junction, sometimes originating a projection, or an incorporation, that human new embodied identity evolves. New interfaces are actively reflexive and extend in more and more subtle ways the reflexivity naturally embedded in our bodies.

The cognitive neuroscience of the *reflexive function* can be one of the main keys to understand how the emergence of new interfaces yields new ways of extending and change the human presence and consciousness in the world.

The embodied mind emerges and grows (bottom-up) on the basic reflexive function as an order parameter in biological processes. Some authors use these terms synonymously but, the editors prefer to use the different terminology to stress the conceptual and factual difference. Reflexivity will be direct and non-conceptual: it implies an immediate capacity of awareness without effort, or intellectualization. Reflectivity is a meta-cognitive process of higher order, implying secondary self-observation, denotation and conceptualisation (Gladwell, 2005; Siegel, 2007).

In reflexivity the interface is "under your skin," as we might remind that the embryological origin of skin, brain, and mind is the same. The *ectoderm*, our primary interface, is the outermost of the three primary germ layers of an embryo and the source of the epidermis, the nervous system, the eyes and ears: i.e. interfaces. Reflexions happen at a very pre-cognitive stage, before any higher order metacognition

might be established. Primary reflexivity is based on massive nonlinear dynamics and it is probably the basic property of living matter, whose ultimate extension is consciousness. Modern advancements in complexity theory from Henry Poincare to Walter J. Freeman and Stuart Kauffman point in this direction and beyond. Fractal mathematics has extended the *isomorphism* capabilities in space and time for our techno-cultural niche (Thelen & Smith, 1994; Orsucci, 1998, 2006; Orsucci & Sala, 2005, Sala, 2006).

The current debate on cyborg identity is, by this perspective, relocated to a more familiar (though maybe not less disconcerting) perspective (Marcuse, 1962; Hayles, 1999; Gray, 2001). Our thesis is that man is a cyborg by default as human intelligence and embodied technology are just as in a Möbius strip: you can change perspective, they might look different, but the surface is the same. Ancient Greek and Hindi tales describing strange half-flesh/half-metal creatures, golems, talking heads, homunculi, and modern cyborgs are just expressions of the same effort, for our intellectual Egos, to understand and adapt to this natural evolutionary line.

ORGANIZATION OF THE BOOK

The book is divided in two sections. The first section, organized in seven chapters, explores theoretical perspectives. The second section, including the last seven chapters, presents a series of examples of applications in different fields.

Chapter 1 is titled "Reflexing Interfaces." Franco Orsucci identifies the reflexing interfaces that can redefine different approaches in different disciplines in the new millennium. The chapter sets the scene for discussions presented by various subsequent authors. In particular, it identifies how the cognitive neuroscience of the reflexive function can be a key to understand how the emergence of new interfaces links new ways of projecting human presence and consciousness in the world. In substance, Information Science and Technology are accumulating ground for new possible evolutionary jumps. Computing devices, molecular biology, and new media are redesigning the human embodiment and its environment. An integrated approach, which should include the latest advancements in neuroscience, can draw the map of new possible human evolutions.

Chapter 2 is "Fractal Geometry as a Bridge Between Realms." Terry Marks-Tarlows describes fractal geometry as a bridge between the imaginary and the real, mind and matter, conscious and the unconscious. Fractals are multidimensional objects with self-similar detail across size and/or time scales. Jung conceived of number as the most primitive archetype of order, serving to link observers with the observed. Whereas Jung focused upon natural numbers as the foundation for order that is already conscious in the observer, the author offers up the fractal geometry as the underpinnings for a dynamic unconscious destined never to become fully conscious. Throughout nature, fractals model the complex, recursively branching structures of self-organizing systems. When they serve at the edges of open systems, fractal boundaries articulate a paradoxical zone that simultaneously separates as it connects. When modeled by Spencer-Brown's mathematical notation, full interpenetration between inside and outside edges translates to a distinction that leads to no distinction. By occupying the infinitely deep "space between" dimensions and levels of existence, fractal boundaries contribute to the notion of intersubjectivity, where self and other become most entwined. They also exemplify reentry dynamics of Varela's autonomous systems, plus Hofstadter's ever-elusive "tangled hierarchy" between brain and mind.

Chapter 3 is titled "Thinking Animals and Thinking Machines in Psychoanalysis and Beyond." Francesco Scalzone and Gemma Zontini examine some interesting "similarities" between computer science

and psychoanalysis formulating some hypotheses by bringing closer the statute of connectionism to the energetic model of the psychic apparatus as well as the OOP (object-oriented programming) to the object relations theory. They also describe the relation existing between the functioning of mnemic systems and human temporalities as dynamic structures/processes which might be represented as complementary images of each other. The authors make some remarks on the machine and people theme, the way in which men relate to machines, especially "thinking machines," describing the fantasies they arouse. In order to do this the authors use Tausk's classic (1919/1933) "On the Origin of the 'Influencing Machine' in Schizophrenia," as well as some of Freud's writings.

Chapter 4 is "Dynamical Disequilibrium, Transformation, and the Evolution and Development of Integrated Worldviews." Liane Gabora and Maegan Merrifield begin by outlining a promising, new theoretical framework for the process by which human culture evolves inspired by the views of complexity theorists on the problem of how life began. Elements of culture, like species, evolve over time; that is, they exhibit cumulative change that is adaptive in nature. By studying how biological evolution got started, it is possible to gain insight into not just the specifics of biological evolution, but also general insights into the initiation of any evolutionary process that may be applicable to culture. The authors then explore the implications of this new framework for culture on the transformative processes of individuals. Specifically, they address what this emerging perspective on cultural evolution implies for to go about attaining a *sustainable worldview*; that is, a web of habits, understandings, and ways of approaching situations that is conducive to the development of a sustainable world.

Chapter 5 is "Exploring Structural And Dynamical Properties Microtubules By Means Of Artificial Neural Networks." Rita Pizzi, Silvia Fiorentini, Giuliano Strini, and Massimo Pregnolato describe Microtubules (MTs), cylindrical polymers of the tubulin dimer, which are constituents of all eukaryotic cells cytoskeleton and are involved in key cellular functions and are claimed to be involved as sub-cellular information or quantum information communication systems. The authors evaluate some biophysical properties of MTs by means of specific physical measures of resonance and birefringence in presence of electromagnetic field, on the assumption that when tubulin and MTs show different biophysical behaviours, this should be due to their special structural properties. Actually MTs are the closest biological equivalent to the well-known carbon nanotubes (CNTs), whose interesting biophysical and quantum properties are due to their peculiar microscopic structure. The experimental results show a physical behaviour of MTs in comparison with tubulin. The dynamic simulation of MT and tubulin subjected to electromagnetic field was performed via MD tools. Their level of self-organization was evaluated using artificial neural networks, which resulted to be an effective method to gather the dynamical behaviour of cellular and non-cellular structures and to compare their physical properties.

Chapter 6 is titled "Neurofeedback: Refining the Methodology of Brain-Computer Interface Training." David Vernon and Tammy Dempster explore the use of neurofeedback training as a mechanism for altering human brain functioning and in turn influencing behaviour. The chapter outlines the notion that such training provides a plausible mechanism by which an individual may be able to learn to alter and control specific aspects of his electro-cortical activity. The chapter highlights some of the findings from research, including clinical, peak performance and functional validation studies. In addition, it delineates some important methodological issues that remain to be addressed. It is hoped that outlining these issues will serve a dual purpose. First, it will assist in the understanding of some of the theoretical and methodological limitations that may be holding the field back. Second, it is hoped that such information will stimulate researchers to work towards designing more efficient and effective research protocols and neurofeedback training paradigms.

Chapter 7 is "The Biotic Logic of Quantum Processes and Quantum Computation." Hector Sabelli and Louis H. Kauffman explore how the logic of physical and biological processes may be employed in the design and programming of computers. Quantum processes do not follow Boolean logic; the development of quantum computers requires the formulation of an appropriate logic. While in Boolean logic entities are static, opposites exclude each other, and change is not creative, natural processes involve action, opposition, and creativity. Creativity is detected by changes in pattern, diversification, and novelty. Causally-generated creative patterns (Bios) are found in numerous processes at all levels of organization: recordings of presumed gravitational waves, the distribution of galaxies and quasars, population dynamics, cardiac rhythms, economic data, and music. Quantum processes show biotic patterns. Bios is generated by mathematical equations that involve action, bipolar opposition, and continuous transformation. These features are present in physical and human processes. They are abstracted by lattice, algebras, and topology, the three mother structures of mathematics, which may then be considered as dynamic logic. Quantum processes as described by the Schrödinger's equation involve action, coexisting and interacting opposites, and the causal creation of novelty, diversity, complexity, and low entropy. In addition to 'economic' (not entropy producing) reversible gates (the current goal in the design of quantum gates), irreversible, entropy generating, gates may contribute to quantum computation because quantum measurements as well as creation and decay, are irreversible processes. quantum gates and circuits may provide an opportunity to incorporate the pattern of quantum processes into the logical structure of the computer, and thereby employ rules for reasoning that take into account the pattern of quantum processes as well as that of many other natural processes.

The second section is organized in seven chapters.

Chapter 8 is titled "Networks: A Sketchy Portrait of an Emergent Paradigm." Alessandro Giuliani presents the notion of 'network,' which is more and more widespread in all the fields of human investigation, from physics to sociology. Network based approaches gave very brilliant results in fields like biochemistry where the consideration of the whole set of metabolic reactions of an organism allowed us to understand some very important properties of the organisms that cannot be appreciated by the simple enumeration of the single biochemical reactions. Nevertheless, appreciation networks are modelling tools and not real entities, which could be detrimental to the exploitation of the full potential of this paradigm. Some applications of network based modelling are presented so to introduce the basic terminology of the emergent 'network paradigm,' to highlight strengths and limitations of the method, and to put sketch the strong relation linking network based approach to other modelling tools.

Chapter 9 is "Complexity, Emergence, and Molecular Diversity via Information Theory." Francisco Torrens and Gloria Castellano present the *complexity* and its definition. The definition here is related to *Kolmogorov complexity* and *Shannon entropy* measures. However, the price is to introduce context dependence into the definition of complexity. Such context dependence is an inherent property of complexity. Scientists are uncomfortable with such context dependence that smacks of subjectivity, which is the reason why little agreement is found on the meaning of the terms. In an article published in *Molecules*, Lin presented a novel approach for assessing molecular diversity based on Shannon information theory. A set of compounds is viewed as a static collection of microstates that can register information about their environment. The method is characterized by a strong tendency to oversample remote areas of the feature space and produce unbalanced designs. This report demonstrates the limitation with some simple examples and provides a rationale for the failure to produce results that are consistent.

Chapter 10 is titled "Recurrence Indicators for the Estimation of Characteristic Size and Frequency of Spatial Patterns." Chiara Mocenni and Angelo Facchini propose a method for the estimation of the

characteristic size and frequency of the typical structure in systems showing two dimensional spatial patterns. In particular, the authors use several indicators caught from the nonlinear framework for identifying the small and large scales of the systems. The indicators are applied to the images corresponding to the instantaneous realization of the system. The method assumes that it is possible to capture the main system's properties from the distribution of the recurring patterns in the image and does not require the knowledge of the dynamical system generating the patterns neither the application of any image segmentation method

Chapter 11 is: "The Residence Time of the Water in Lake MAGGIORE: Through an Eulerian-Lagrangian Approach." Leonardo Castellano, Nicoletta Sala, Angelo Rolla, and Walter Ambrosetti describe a study designed to evaluate the spectrum of the residence time of the water at different depths of a deep lake, examining the mechanisms governing the seasonal cycle of thermal stratification and destratification, with the ultimate aim of assessing the actual exchange time of the lake water. The study was performed on Lake Maggiore (depth 370m) using a multidimensional mathematical model and computer codes for the heat and mass transfer in very large natural water bodies. A 3D Eulerian time-dependent CFD (Computational Fluid Dynamics) code was applied under real conditions, taking into account the effects of the monthly mean values of the mass flow rates and temperatures of all the tributaries, mass flow rate of the Ticino effluent, and meteorological, hydrological, and limnological parameters available from the rich data-base of the CNR-ISE (Verbania Pallanza, Italy).

Chapter 12 is titled "Possibility of Fractal Aesthetics." Ljubiša M. Kocić considers the fast development of computer networking contributes to the global spreading and popularizing of the notion of fractals and complex patterns in their use in computer-aided design and computer art. He looks for answers to the following questions: "How do we perceive fractals?" "Are fractals predominantly man-made or natural objects?" "How do fractals relate to the overall visual art experience of mankind?" "What are the main problems in using fractals in arts?" "What are the experiences from the visual art-history?" "Do Nature and artists use the same algorithm?" "What fractal experts can do to help artists?"

Chapter 13 is "Parametric Generator for Architectural and Urban 3D Objects." Renato Saleri Lunazzi presents a research project, developed by Map-Aria research team, which consists in applying automatic generative methods in design processes. The Map-Aria research team of the School of Architecture of Lyon develops modeling assistants within the process of architectural conception. They run specific heuristics dramatically reducing time-consuming tasks of wide scale architectural and urban modeling by the implementation of bio-mimetic and/or parametric generative processes. Prior experiments implemented rule-based generative grammars with interesting results. The author describes a specific tool able to model the global structure of architectural objects through a morphological and semantic description of its finite elements. This discrete conceptual model - still in study - was refined during the geometric modeling of the "Vieux Lyon" district, containing a high level of morpho-stylistic disparity. Future developments should allow for increasing the genericity of its descriptive efficiency, permitting even more sparse morphological and\or stylistic varieties. Its general purpose doesn't consist in creating a "universal modeler," but to offer a simple tool able to quickly describe a majority of standard architectural objects compliant with some standard parametric definition rules.

Chapter 14 is "Fractals, Computer Science, and Beyond." Nicoletta Sala describes the fractal geometry as a recent "tool," which can help us to understand the Nature and its shapes (e.g., clouds, trees, shells, river basins, mountains), exceeding the limits imposed by Euclidean geometry. The author presents some applications of fractals and their properties in computer science, e.g. for image compression, in landscape modelling, in computer networks and in the creation of virtual worlds based on the Web technologies.

The chapter highlights that the self-similarity property that characterizes some fractal objects is a unifying concept. In fact, it is an attribute of many laws of nature and it is present in different fields of computer science, for example in Fractional Brownian motion, which has been observed for controlling traffic in computer networks (LANs, MANs, WANs, and the Internet), and in the creation of virtual worlds using procedures based iterative fractal algorithms.

CONCLUSION

In the Kubrick's movie *2001: A Space Odyssey* (1968), a savannah-dwelling ape has a eureka-like flash of inspiration in realizing the awesome power of the bone tool in his hands. He tosses it skyward, where it morphs into a space station at the dawn of this millennium (Ambrose, 2001).

This book, logical continuation and the widening of *Reflexing Interfaces: The Complex Coevolution of Information Technology Ecosystems* (2008), is a multifaceted mirror on how human evolution has had a constant psychobiological link with the development of new tools and environmental changes. Discoveries and technological innovations in Information & Communication Science and Technology (ICST) are paving the ground for new evolutionary steps. Computer devices could play a central role in this evolution, as Giovanni Degli Antoni (1988) affirms: "Computers become mirrors in which the real lives his new reality beyond space and the time."

In the book: *Through the Looking-Glass* (1872), sequel of *Alice's Adventures in Wonderland* (1871), Lewis Carroll described many mirror experiences lived by Alice. Alice's adventures beyond the mirror could be considered a metaphor for ICST realities. If Alice was a modern child, certainly her mirror could be a computer screen. She would be used to experience how actions in a real world are transformed in other actions in the virtual world, and vice versa. These transformations follow interesting mathematical and physical processes which Lewis Carroll would certainly be interested into: Degli Antoni named these new processes as *bi-causality* (Pizzi, 1989).

The isomorphism between bio-cognitive structures and the ICST niche we inhabit is progressively blurring boundaries between *res cogitans* and *res extensa*. Our new insights in neuro-cognition and the multiple reflexions implied in our sensory-perceptive processes are leading to new interfaces and new media. Reflexing interfaces are extensions of human embodiment just as the bone tool tossed skyward by a savannah-dwelling ape. Time flows, always different yet similar.

As Francisco Varela distilled aphoristically: "Readiness-for-action is a micro-identity and its corresponding level a micro-world: we embody streams of recurrent micro-world transitions" (1991).

We are flowing in and we are the flow of micro and macro worlds, nested and intermingled. The stream of time flows here and there, generating multiple cascades, reflexing in billions of infinitesimal mirrors, radiating in what we use to call consciousness.

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