Preface

Art is a short word; however, since it is based on nature, long words cannot be avoided when talking about science and technology. Some words are new and others are forgotten after the school times had ended. The world may be experienced using the senses, but minuscule, invisible fragments of reality, abstract concepts, or even ideas can be visualized. Nature- or science-derived images may serve an artistic purpose, also when transformed into algorithmic structure. The book's contributors keep an eye on nature and its organic forms, from the tiniest nano particles to cosmos (we are all inhabitants of the cosmos, anyway), and then transform this info into art forms with the use of computing. Individual authors refine their study to particular fragments of nature. Some themes appear in more than one chapter, for example, several authors indicate their interest in flow and examine one concept from various perspectives: Mark Stock discusses in Chapter 2 how flow supports the variety and vitality of life on Earth and describes computational fluid dynamics that involves solving the fluid equations of motion, fluid simulations, and related biological computations, while Hans Dehlinger applies in Chapter 14 the generative drawing to offer metaphorical images of the riverbed and ocean; furthermore, chapters 11 and 12 examine water flow from several viewpoints. More themes, such as fractals, nano structures, or swarm computing are interwoven in the book in a similar way, and so are the people who contribute to the developments in the related domains.

This book comprises a collection of individual approaches to the relationship between nature, science, and art created with the use of computers. Themes of the chapters pertain to a wide spectrum of authors' interests; they involve nature and description of nature including mathematics and scientific disciplines. Thus, themes discussed in the book relate to the use of visual language in communication about biologically-inspired scientific data, visual literacy in science, and application of a practitioner's approach: people can understand things better when they can visualize and picture them theirselves. The notion of computing adopted in this book embraces any kind of activities that require the use or benefit from the use of computer hardware and software.

The topic of this book fits in the world today when the chapters explore connections between nature, science, and art, and discuss how art and design support science understanding by visualizing concepts and processes. Art creation benefits from learning about scientific processes and concepts. Processes and products provide inspiration for creation of meaningful art, while art creation helps understand and memorize data framework and structure. The action of designing materials and data helps understand concepts and processes.

Images enhance connections between biology, engineering, and material sciences resulting in growing partnership among academia, laboratories, and industry. Scientists focus on biology-inspired research to understand how biological systems work, and then create systems and materials that would have efficiency and precision of living structures. According to the National Research Council of the National Academies (National Research, 2008), strategies for creation of new materials and systems may be characterized as bio-mimicry, bio-inspiration, and bio-derivation.

Bio-mimicry refers to learning the principles used by a living system to achieve similar function in synthetic material and also create materials that mimic cells in their response to external stimuli. For example, certain cells such as T-lymphocytes can sense particular external stimuli, and then deal with pathogens. The challenge is to design bio-inspired systems and devices for detecting hazardous biological and chemical agents and strengthen national security systems.

Bio-inspiration means developing a system that performs the same function, even with a different scheme. For example, the adhesive gecko foot, the self-cleaning lotus leaf, and the fracture-resistant mollusk shell are examples of inspiring structures. The cutting-edge optical technology solutions can be found in nature: multilayer reflectors, diffraction gratings, optical fibers, liquid crystals, and structures that scatter light are found in animals as well. For instance, Morpho butterfly has iridescence sparkle and blue color visible from hundreds of meters due to periodic photonic structure in scales on wings, without any dye involved.

Bio-derivation is known as using existing biomaterial to create a hybrid with artificial material, such as incorporation of biologically derived protein into polymeric assemblies for targeted drug delivery. The eyes of higher organisms and the photosynthesis mechanism in plants are examples of biological structures and processes that can support harvesting light and also fuels (by converting cellulose polymer to ethanol). Deciphering force and motions in proteins driven by sub-cellular, molecular motors can advance clinical diagnostics, prosthetics, and drug delivery. Molecular motors convert chemical energy (usually in form of ATP - adenosine triphosphate) into mechanical energy. Contrary to Brownian movements, it is not driven solely by thermal effects. Scientists strive to create self-evolving, self-healing, self-cleaning, and self-replicating super-materials that could mimic the ability to evolve and adapt. The challenge is not easy to meet: for example, the gecko's adhesive works in vacuum and underwater, leaves no residue, and is self-cleaning; adhesion is reversible, so geckoes alternatively stick and unstuck themselves 15 times per second as they run up walls. As for now, "all attempts to mimic their design or to synthesize artificial polymers that are analogous to the bioadhesives in structure or function have been largely unsuccessful … and the magic of a gecko's 'dry' glue with its reversible attachments remains unsolved, unmatched, and more challenging than ever" (National Research, 2008, pp. 63-64).

In a process of nature-inspired inquiry about computing for art creation, artists and scientists examine those rules and formulas in science, which define natural processes by abstracting the essentials from specific events or objects, such as elements (e.g., carbon or oxygen) or molecules (e.g., water). One may see organic chemistry as a study of structure, properties, and reactions carbon-based compounds, such as hydrocarbons consisting of hydrogen and carbon, carbohydrates consisting of carbon, hydrogen, and oxygen (for example, with a ratio 2:1 as in water molecule), and other carbon-based compounds. Biological chemistry examines chemical processes in living matter, information transfer, and flow of energy through metabolism, mostly in cellular components such as proteins, carbohydrates, lipids, and nucleic acids, including DNA and RNA. At the atomic level, scientists examine soft condensed materials in states of matter neither liquid nor crystalline solid. Soft matter builds membranes and cytoplasm in human cells, and it is so omnipresent in biological systems that humans may be considered soft matter examples. Scientists apply abstract concepts, for example permeability or electromagnetism, to find rules and patterns that govern these materials. Explorations on structure and functions occurring in living and artificial matter involve intensive use of visualization techniques providing visual representation of information, data, and knowledge through pictures, information graphics, and also artistic display.

All these explorations connect science and art with computing. Art is needed not only in a quest for beauty, but because many times people can apprehend through art the essence of the concepts they attempt to grasp. Art provides the informative qualities of an idea, and thus communicates and explains ideas faster. The process of art creation has its inherent tendency to apply abstract thinking. Artists seek the principles that control the basic elements in art, such as line or color, and then convey the essence of their response to selected slice of reality. People may look at the works of art as if they were not only the aesthetical objects but also as information displays. Scientists and practitioners are showing a growing interest in aesthetics, especially aesthetics of visualization as related to the visual competence in the art, design, and technological solutions in visualization. Analyses of the images, forms, and motions in interactive generative design and art lead to new approaches in defining aesthetic criteria not only in terms of the work beauty. In a growing number of publications, the concept of aesthetics refers to the design effectiveness, efficiency, workability, usability, and easiness to understand (at a low cognitive cost) the visual display, not exclusively the beauty of an image.

In computer based data-, information-, or knowledge-visualization, the use of imaginative thinking leads to discovering new visual metaphors for abstract data, information, or concepts, and consequently to developing several kinds of visualization, for example, tag-cloud visualization of data. In computer science, imaginative approach to natural events and forces resulted in the development of biology-inspired computing, with several branches, such as artificial life, or fractal geometry of nature. Nature serves as a metaphor for developing new computing methods, for example, artificial neuronal networks, evolutionary algorithms, swarm intelligence, and also genetic engineering techniques, and bio-inspired hardware systems. Generative computing resulted in creating art and the developments in biology-inspired design, music, architecture, and other artistic fields.

Attitude towards the environment may influence one's art production, especially in the process of biology-inspired computing for the arts. Many art works obey mathematical order, repeat generative processes already existing in nature, follow randomized processes, rely on information theory, or otherwise support understanding of natural events. People may think about the physical and chemical laws as the essential rules that drive behavior and properties of natural structures and sustain the order in nature. Before examining the new media artists' inspiration with biology or science, people may first explore how the order in nature may apply to art. We may then wonder how physical and chemical laws relate to the elements and principles of art and design. Patterns existing in genetic codes such as the DNA code, or analogies coming from observation of swarm intelligence not only spur the scientists into computing for various technologies, but also inspire the new media artists to create art works built on biological systems. The generative approach makes possible exploring natural phenomena and at the same time allows the creative process. The artists' tools include systems defined by computer algorithms and/or software.

Biologically inspired art graphics may entail applying two-dimensional and three-dimensional graphics. They often present the processed images that show the steady state conditions (systems at equilibrium) or display dynamic conditions in real-time and/or in interactive way. Many times they may involve other techniques and fields of study, e.g., animation and visualization. Artistic rendering often supports creating models that represent empirical objects and allow making assumptions when it is hard to create experimental conditions. Artistic projects, in combination with simulations, aim at implementation of the model and may support testing, analysis, or training.

Generative art, which often uses digital tools such as mathematical or software algorithms, creates a program that displays certain behavior and reshapes our mental plan in computer terms. Such computer-related process may be seen as a task of abstracting essential codes to produce the efficient and evolvable solution. The final product of writing a computer program is often seen dependent on the choice of programming language (Iverson, 1980) in a similar manner as, according to the Sapir-Whorf hypothesis (Marshall, 1998), language shapes our perceptions of reality, so the way of somebody's thinking may depend on one's spoken language. The choice of digital media, a combination of art, science, and technology, often involving computing and programming, may shape the form and content of the new media art. New media art forms that involve or result from computing are widely used to communicate, interact, involve our senses, describe our social patterns, or socially interact. Creators of generative art often focus on the use of bio-inspired techniques, such as evolutionary computing, artificial life, neural networks, or swarm intelligence. Accordingly, notions about art aesthetics, theory, and classification have to follow the evolvements in art production.

The use of visual language supports communication with the readers. Imagination and creativity are needed in every professional or academic discipline and specialization. It has been often asserted that humans live in more and more visual world because of the ongoing changes in the means of communication (social network with videos and pictures), how concepts are defined (concept maps, visual mining), perceiving the meaning of art, learning (using online interactive visuals, videos), and socializing (exchanging visuals, using for example Skype and Facebook). To become habituated and better prepared for the changes in lifestyle and working habits, we need to expand our visual literacy. We need to be able to work with visual quality in mind.

DESCRIPTION OF THE STRUCTURE OF THE BOOK AND CONTRIBUTING CHAPTERS

The content of this book is divided into five sections.

Section 1 - Visual Data Formation: Biology Inspired Generation of Objects and Processes - comprises five chapters. Rachel Zuanon (Brazil) describes in Chapter 1, "Bio-interfaces: Designing Wearable Devices to Organic Interactions," the process of building interaction governed by the biology of the users. The author presents applications of bio-interfaces as wearable devices in the areas of design, art, and games. Mark Stock (USA) describes in Chapter 2, "Flow Simulation with Vortex Elements," a novel method for creating realistic fluid-like forms and patterns via interacting elements presented on a computer using a particle representation of the rotating portions of the flow. The author illustrates the method's potential with examples from digital flatwork and video art and thus makes both fluid simulations and related biological computations deep, interesting, and ready for exploration. In Chapter 3, "Cooperation of Nature and Physiologically Inspired Mechanisms in Visualisation," Mohammad Majid al-Rifaie, Ahmed Aber, and Mark John Bishop (UK) describe a novel way to integrate two swarm intelligence algorithms; one algorithm simulates the behavior of birds flocking (Particle Swarm Optimisation) and the other algorithm (Stochastic Diffusion Search) mimics the recruitment behaviour of one species of ants. This hybrid algorithm is assisted by a biological mechanism inspired by the behavior of cells in blood vessels, where the concept of high and low blood pressure is utilised. Drawings on the canvas reflect the performance of the swarms and the cells in the hybrid swarm intelligence algorithm. The authors discuss whether or not the art works generated by nature and physiology inspired algorithms can possibly be considered as computationally creative. In Chapter 4: "0h!m1gas: a Biomimetic Stridulation Environment" Kuai Shen Auson (Ecuador and Germany) presents an artistic experiment that explores the bioacoustics involved in the social behavior of ants when they communicate by producing modulatory vibrations. The author investigates the connections between these social organisms and humans, as human-ant relationship plays an important role in the creation of new ecosystems and the construction and mutation of posthuman ecology. In Chapter 5, "Bridging Synthetic and Organic Materiality: Graded Transitions in Material Connections," Hironori Yoshida (USA) introduces gradient material transitions that seamlessly bridge synthetic and organic matter, and applies what he learned about nature to architectural and interior design applications using digital fabrication of hybridized materials. Using digital image processing of organic forms, this fabrication process generates 3D tooling paths, culminating in the concept of bio-customization rather than mass customization, a new prospect of digital fabrication.

Section 2: Visualizing the Invisible: Processes for the Visual Data Formation contains four chapters:

Chapter 6, "Sustainable Cinema: the Moving Image and the Forces of Nature," by Scott Hessels (Hong Kong) discusses the continuing relationship between the forces of nature and the materials of the moving image. The author revisits artworks that considered the natural environment as a co-creator in their realization and then presents his own series of kinetic public sculptures that use natural power sources to create the moving image. In Chapter 7, "Seeing the Unseen," Eve Andrée Laramée, Kalyan Chakravarthy Thokala, Donna Webb, Eunsu Kang, Matthew Kolodziej, Peter Niewiarowski, and Yingcai Xiao (USA) present art works created by the artists associated with the Synapse Group at the University of Akron in collaborations with the scientists in the group and/or inspired by the science of nature. The invisible are made visible by rendering water data with 3D computer graphics or by perceiving interactions between water and other objects. In addition, art works dealing with digital data in the forms of 2D and 3D imagery are also included. Chapter 8, "NanoArt: Nanotechnology and Art," by Cristian Orfescu (USA) introduces nano art. First, it goes back in time to the first uses of nanomaterials and nanotechnologies to create art and continues with the beginnings of nano art. Then, it follows the movement that evolved from recent technological developments in the multidisciplinary area known as nanotechnology. The chapter informs about the NanoArt competitions, displays select art works, and finally presents selected nano artists' thoughts. Chapter 9, "Nature Related Computerkunst," by Wolfgang Schneider (Germany) discusses theoretical background, categorizes examples of nature related computer art, and then presents several examples from artists participating in a series of Computerkunst/Computer Art exhibitions during the years 1986-2010.

Section 3: Visual Communication: Scientific Communication through Visual Language comprises four chapters: Chapter 10, "Biological Translation: Virtual Code, Form, and Interactivity," by Collin Hover (USA) explores the use of code, form, and interactivity in translating biological objects into mathematically generated digital environments. The author's own works: "Clouds & Ichor" and "Stream" demonstrate and ground the concepts being discussed. In both projects, a natural learning experience is at the core of the biological process. Chapter 11, "Looking at Science through Water," by Anna Ursyn (USA) is focused on creating the visual approach to natural concepts and events, rather than on their description. It has been designed as an active, involved, action-based exercise in visual communication. The chapter comprises two projects about water-related themes: States of Matter exemplified by ice, water, and steam, and Water Habitats: lake, river, and swamp. Chapter 12, "Visual Tweet: Nature Inspired Visual Statements," by Anna Ursyn (USA), explores connections between science, computing, and art in a similar way as it is done in a previous chapter, examines concepts and processes that relate to particular fields in science, and pertain to Earth's life and personal, everyday experience. Two projects about science-related themes are: Symmetry and pattern in animal world: geometry and art, and Crystals. Chapter 13, "Visualizing Geometric Problems in Wooden Sangaku Tablets," by Jean Constant (Switzerland/USA) describes visualization of the 19th century scientific representations from a Japanese culture - a set of mathematical problems etched on wooden boards. The author describes the steps in the creation of artistic statements based on geometrical problems. Discussion refers to the dissemination of the project in art galleries and online, its potential instructional use, and examines the audience responses.

Section 4: Tools for Metaphors: Nature Described with the use of Mathematics and Computing contains three chapters. Chapter 14, "Drawings from Small Beginnings," by Hans Dehlinger (Germany) experimentally addresses the formulation of a few concepts inspired by nature, aimed at generating line drawings executed on pen-plotters. Generative drawings are produced through a structured process including a sequence of discrete procedural steps. Chapter 15, "On the Designing and Prototyping of Kinetic Objects," by Scottie Chih-Chieh Huang and Shen-Guan Shih (Taiwan) explores kinetic interactions with a biomimetic perspective and demonstrates three kinetic interactive artworks through a modular design approach. "MSOrgm" is developed as a robot plant to interact with the viewer in a soothing way, "SSOrgan" is designed as an organic skin to interact with the viewer's touch of the top of it, and "LBSkeleton" is a robotic instrument that produces pneumatic sound and emits soothing light into space and can make the whole body transformation. In a Chapter 16, "A New Leaf," Liz Lee (USA) discusses her latest digital image series, "A New Leaf Series", within the context of early photographic imaging and its connection to science and biology. The author discusses how contemporary electronic imaging has returned to its photographic origins through nature-related subject matter.

Section 5: Analytical Discourse: Philosophy and Aesthetics of Nature Inspired Creations contains chapters: Chapter 17, "Science with the Art: Aesthetics Based on the Fractal and Holographic Structure of Nature," by Doug Craft (USA) discusses how both art and science proceed from an appreciation for and application of the natural proportions and forms associated with nature: the Golden Ratio, fractals, and the holographic metaphor. An outline of a personal theory of aesthetics and a collage series entitled The Elements in Golden Ratio illustrate application of the author's aesthetic theory. In Chapter 18, "Getting Closer to Nature: Artists in the Lab," James Faure Walker (UK) discusses works of artists who work alongside biologists to produce visual works of extraordinary quality, in both their decorative and intellectual aspects. The author describes his own use of scientific sources, arguing that, there is also a place for art that evokes the wonders of nature without being tied to the visible facts. Chapter 19: "drawing//digital//data: A Phenomenological Approach to the Experience of Water" by Deborah Harty (UK) discusses the translation (the finding of equivalences) of a phenomenological experience of water during the activity of swimming into drawing with both traditional drawing media and a tablet computer - an Apple iPad. The author discusses the premise that drawing is phenomenology, considering whether this premise is compromised when drawing with an Apple iPad rather than traditional drawing media. In Chapter 20, "From Zero to Infinity: A Story of Everything," Clayton S. Spada and Victor Raphael (USA), a practicing artist and a practicing artist/scientist present examples of art works entitled From Zero to Infinity, to illustrate the commonalities that art and science share with respect to pragmatic and creative processes, while not equating art with science as similar cognitive domains. This chapter examines how a generalist perspective may counterbalance deconstruction of perceived elemental units, so as to avoid becoming bound by paradigm. Art and science are addressed as related observational methods to explore hypotheses and represent the varied aspects of existence.

In conclusion, discussion of the role of creativity in artistic process becomes even more complicated with the advent of many new types of art. Working on visual projects based on natural processes is one of possible ways to strengthen one's visual literacy, especially when related to scientific concepts. The resulting artistic projects may be seen as analogy for the way nature works. Many agree the increase in visual literacy and visual imagination supports man's creativity, problem solving, and problem finding abilities. The developments in computing and information science seem to alter the ways of perceiving the notions of creativity, imagination, problem solving, problem finding, and knowledge acquisition and retention. More active approach is observable, and it could happen due to the online interactive learning possibilities and the evolvement of social networks. Changes in the ways of perceiving art may run parallel and be seen comparable to the evolvements in technologies. First of all, art creating is now more often a collaborative process. Many times artists create generative art constructing their works in an algorithmic way, often in multidisciplinary, collaborative manner. The ways of seeking inspiration seem to evolve from non-participative observation of nature and people toward pursuing, researching, and understanding the principles how both the nature and humans work or act. Many artists connect with physical sources of inspiration. Developments in technology achieved in particular domains of knowledge catch an interest and inspire people from other disciplines. Recently developed tools open new possibilities for research, and thus the ascent of computing inspired study of nature through art and data graphics may be observed.

Anna Ursyn
University of Northern Colorado, USA

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