Preface

Art is the Queen of all sciences communicating knowledge to all the generations of the world. Leonardo da Vinci

Artistic behavior is one of the most valued qualities of the human mind. Although artistic manifestations vary from culture to culture, dedication to artistic tasks is common to all. In other words, artistic behavior is a universal trait of the human species.

The current, Western definition of art is relatively new. However, a dedication to artistic endeavors — such as the embellishment of tools, body ornamentation, or gathering of unusual, arguably aesthetic, objects — can be traced back to the origins of humanity. That is, art is ever-present in human history and prehistory.

Art and science share a long and enduring relationship. The best-known example of the exploration of this relationship is probably the work of Leonardo da Vinci. Somewhere in the 19th century art and science grew apart, but the cross-transfer of concepts between the two domains continued to exist. Currently, albeit the need for specialization, there is a growing interest in the exploration of the connections between art and science.

Focusing on computer science, it is interesting to notice that early pioneers of this discipline such as Ada Byron and Alan Turing showed an interest in using computational devices for art-making purposes. Oddly, in spite of this early interest and the ubiquity of art, it has received relatively little attention from the computer science community in general, and, more surprisingly, from the artificial intelligence community.

In the initial years of artificial intelligence research the main source of inspiration was human intelligence. Recently, this traditional, somewhat anthropocentric, view of intelligence has given rise to the search for other potential sources of inspiration. There is a growing interest in biology-inspired computing techniques, a broad area of research that incorporates techniques such as evolutionary computation, swarm intelligence, ant colony optimization, and artificial life. These techniques offer a wide range of solutions and

opportunities, for scientists, who have always made an effort to understand and model nature, and for artists, who have always used nature as a source of inspiration. The use of a metaphor that is relevant for scientists and artists helps to bridge the gap between the scientific and artistic communities, and fosters the collaboration and transfer of knowledge between the two domains.

In this line of thought, the seminal works of Richard Dawkins, Karl Sims and William Latham led to the emergence of a new research area, usually called *Evolutionary Art and Music*, which is characterized by the use of nature-inspired computation in artistic domains.

The early books edited by Peter Bentley and David Corne gave evolutionary art some important exposure. Over time, the growing interest in the area led to the appearance of dedicated scientific events and special issues, fostering the development of a strong research community and playing an important role in the establishment of evolutionary art and music as a meaningful research field. The current vitality of the area is reflected in the existence of dedicated annual workshops and special tracks at some of the main evolutionary computation conferences (e.g., *Evolved Art and Music* and *Evolutionary Design* at the IEEE Congress on Evolutionary Computation, and EvoMUSART, the Evo* Workshop on Evolutionary Music and Art). This thriving area of research is arguably at the verge of adulthood. Its current stage of development calls for a book that (1) provides a broad and coherent coverage of the field, (2) provides the necessary background information for newcomers, and (3) establishes directions for future research, thus providing a solid basis for its further development. These are the main objectives of the present book.

The book is aimed at a wide audience, including researchers and artists, beginners and experts in the field, and especially those who wish to explore the relationships between nature, science and art. We consider that it is important to shorten the gap between the scientific and artistic communities. Hopefully this book is a step in that direction, and this concern is reflected in the contents and structure of the book.

The book is divided into five parts: *Evolutionary Art*, *Evolutionary Music*, *Real-World Applications*, *Artistic Perspectives*, and *Future Perspectives*.

The first two parts of this book include some of the most interesting works on the application of evolutionary computation techniques in the fields of visual art, video, design (Part 1), sound, music and performance (Part 2). Although these chapters are mainly scientifically oriented, they all make relevant artistic contributions.

The first chapter, by Matthew Lewis, provides a thorough, and much needed, analysis of the state of the art in the fields of evolutionary art and design, introducing key concepts and terminology, reviewing nearly 200 publications, describing the most prominent approaches, and identifying some of the most relevant research topics in the area. In the second chapter John Collomosse describes the use of evolutionary computation techniques in the context of the non-photorealistic, painterly, rendering of images. Starting with an overview of artistic stylization algorithms, he then discusses the use of ge-

netic algorithms to increase control over the level of detail in painting, and to enhance the usability of painterly rendering algorithms. The closing chapter of the first part of the book presents the "Electric Sheep" project, one of the largest and longest ongoing evolutionary art experiments, involving over 40,000 computers and people mediated using a genetic algorithm. Scott Draves offers a description of the representation, genotype–phenotype mapping and genetic operators that allow the evolution of fractal flames movies and still images, and he then focuses on the long-term behavior of the distributed system.

The fourth chapter takes us to the area of evolutionary sound synthesis. James McDermott, Niall J.L. Griffith and Michael O'Neill survey previous work in the area, and then focus on the problem of automatically matching a target sound using a given synthesizer, which involves building fitness functions that take into account timbral, perceptual, and statistical sound attributes. They report and thoroughly analyze the results attained in a comprehensive set of experiments aimed to determine the best combination of algorithm, parameters and fitness functions for this problem, drawing conclusions and indicating future work. Tim Blackwell describes the use of swarm intelligence and granular synthesis techniques for the generation of novel sounds, outlining the theoretical foundations of these techniques and the practical aspects involved in their usage. The explanation is illustrated by the detailed description of two swarm granulation systems, *Swarm Granulator* and *Swarm Techtiles*, and by the analysis of their behavior. In the sixth chapter, which concludes the Evolutionary Music part of the book, Rafael Ramirez, Amaury Hazan, Jordi Mariné and Xavier Serra tackle a challenging problem in computer music, producing an expressive performance of a musical piece. They use a genetic algorithm to build a computational model of expressive performance from a set of examples of jazz saxophone performances. Later, they use this model to automatically create performances of musical pieces.

The third part of the book comprises chapters that are characterized by the use of evolutionary art approaches for real-world applications, providing valuable case studies. Christian Jacob and Gerald Hushlak describe the use of evolutionary and swarm design techniques in art, music and design, showing how interactive breeding techniques can facilitate the creative processes, and presenting a wide variety of examples in areas that range from furniture design to swarm choreographies. In the eighth chapter, Martin Hemberg, Una-May O'Reilly, Achim Menges, Katrin Jonas, Michel da Costa Gonçalves and Steven R. Fuchs take us to the domain of architecture, describing *Genr8* — an evolutionary system that allows the evolution of surfaces generated through an organic growth algorithm — and reporting its use on six different architectural projects. Charlie D. Frowd and Peter J.B. Hancock describe *EvoFIT*, a system that allows the evolution of photorealistic human faces, and explore its use for the production of facial composites of criminals. Later, the artistic potential of *EvoFIT* is also analyzed, and other potential application areas discussed. In the tenth chapter, A.E. Eiben describes the modeling of the artistic styles

of the famous Dutch painters Piet Mondriaan and M.C. Escher, giving particular emphasis to the mathematical modeling of Escher's tilings and to the construction of an evolutionary system that allows their generation.

One of the difficulties inherent to evolutionary art and music is the difference between the scientific and artistic perspectives. To lessen this problem the fourth part of this volume gives voice to artists who employ or analyze biology-inspired mechanisms in an artistic context. As such, it consists of chapters where the artistic perspective is the most fundamental. The interest of Nicolas Monmarché, Isabelle Mahnich and Mohamed Slimane in swarm intelligence, ant colony algorithms and self-organization leads them to an exploration of the artistic potential of these concepts for the creation of spatio-temporal structures, which is illustrated by the evolution of musical pieces and paintings. In the twelfth chapter, Günter Bachelier describes the three levels — basic, methodical and superordinate — of his art practice. His unique evolutionary art approach — which relies on a pixel-based representation, on the exchange of regions of interest, and on the application of transformations to these regions — is thoroughly described. Later he presents his novel evolutionary art approach, which also integrates aspects such as multi-sexual reproduction and image templates, and ontogenetic concepts such as spores or fruits. In the thirteenth chapter, Jeffrey J. Ventrella presents *Musical Gene Pool*, an application that allows the evolution of *liquid* music, i.e., nonlinear music whose structure is continually able to flow and rearrange, allowing serendipity. Alan Dorin presents a survey of the use of virtual ecosystem simulation in the context of generative electronic art. Based on a thorough analysis of these systems, he concludes that their major strengths lie in the ability to display multi-scaled complexity and to produce novelty, and that their major weakness lies in their unpredictable response to perturbation; he later describes methods to overcome this weakness. In the concluding chapter of this part, Philip Galanter, following the modernist tradition of the art manifesto, proposes a new art approach, entitled *Complexism*, which relies on the "application of a scientific understanding of complex systems to the subject matter of the arts and humanities". He compares it with modernist and postmodernist movements, arguing that *Complexism* subsumes both, and analyzes the relevance of evolutionary art practices in the context of the *Complexism* movement.

The final part of the book comprises chapters that focus on relatively unexplored areas of evolutionary art and on the identification of future trends and open problems. The sixteenth chapter, by Craig Neufeld, Brian J. Ross and William Ralph, describes the evolution of artistic filters. The use of multi-objective optimization techniques and of a bell curve model of aesthetics, based on the empirical evaluation of artworks, are some of the key contributions of this work, where a correlation between aesthetics and the application of the paint operator is shown. Gary R. Greenfield surveys co-evolutionary approaches to evolutionary art, making a detailed description and analyzing several instances of this type of approach. This analysis is followed by a discussion of the challenges, difficulties and opportunities posed by this type of

approach. In the eighteenth chapter, Penousal Machado, Juan Romero and Bill Manaris describe a novel autonomous evolutionary art approach, where the competition between an artificial critic and an evolutionary creator leads to stylistic variation, presenting and analyzing the results attained across iterations and in validation experiments. In the closing chapter of the book, Jon McCormack looks into the future, examining the challenges and possibilities that lie ahead. He identifies and discusses several of the open problems of the field from a research and artistic perspective, presenting the background and motivation and discussing the theoretical issues involved.

Finally, the DVD of the book comprises demonstration programs, source code and valuable examples of images, music and videos that complement the materials presented throughout the chapters, allowing the reader to fully appreciate some of the evolved works.

As previously stated, evolutionary art and music research is reaching maturity, and part of this process is the growing awareness of the various social, artistic and scientific challenges the area faces.

The biggest social challenge for evolutionary art and music lies in the development of projects or tools that have a relevant social impact. Constructing tools that enhance or promote the creativity of the user is probably the most obvious way to address this goal. However, it is not sufficient — it is equally important to disseminate these tools and to improve the public's awareness of their potential.

From an artistic perspective, the acceptance of the evolutionary approach as a significant art practice is probably the greatest challenge. To meet it, it is particularly relevant to promote the participation of the artistic community in biology-inspired endeavors, disseminate evolutionary projects through the conventional art channels, and ensure their presence in the commercial art circuit. Although some evolutionary art practitioners and musicians have attained all of these objectives, the challenge the area faces is ensuring that these exceptions become the norm. The creation of art spaces devoted to evolutionary art may play an important role in attaining it.

From a scientific standpoint, the development of autonomous fitness assignment schemes that take into account aesthetic criteria, the creation of systems that are able to develop their own aesthetic concepts, the integration and interaction of these systems with the environment, embodiment, and the definition of new forms of human–machine interaction, are some of the most relevant challenges.

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Juan Romero
Penousal Machado