

Advances In Physarum Machines Sensing And Computing With Slime Mould Emergence Complexity And Computation

Discover the science of biocomputing with this comprehensive and forward-looking new resource DNA- and RNA-Based Computing Systems delivers an authoritative overview of DNA- and RNA-based biocomputing systems that touches on cutting-edge advancements in computer science, biotechnology, nanotechnology, and materials science. Accomplished researcher, academic, and author Evgeny Katz offers readers an examination of the intersection of computational, chemical, materials, and engineering aspects of biomolecular information processing. A perfect companion to the recently published Enzyme-Based Computing by the same editor, the book is an authoritative reference for those who hope to better understand DNA- and RNA-based logic gates, multi-component logic networks, combinatorial calculators, and related computational systems that have recently been developed for use in biocomputing devices. DNA- and RNA-Based Computing Systems summarizes the latest research efforts in this rapidly evolving field and points to possible future research foci. Along with an examination of potential applications in biosensing and bioactuation, particularly in the field of biomedicine, the book also includes topics like: A thorough introduction to the fields of DNA and RNA computing, including DNA/enzyme circuits A description of DNA logic gates, switches and circuits, and how to program them An introduction to photonic logic using DNA and RNA The development and applications of DNA computing for use in databases and robotics Perfect for biochemists, biotechnologists, materials scientists, and bioengineers, DNA- and RNA-Based Computing Systems also belongs on the bookshelves of computer technologists and electrical engineers who seek to improve their understanding of biomolecular information processing. Senior undergraduate students and graduate students in biochemistry, materials science, and computer science will also benefit from this book.

“Stories that both dazzle and edify... This book is not just about life, but about discovery itself. It is about error and hubris, but also about wonder and the reach of science.” —Siddhartha Mukherjee, New York Times Book Review We all assume we know what life is, but the more scientists learn about the living world—from protocells to brains, from zygotes to pandemic viruses—the harder they find it is to locate life’s edge. Carl Zimmer investigates one of the biggest questions of all: What is life? The answer seems obvious until you try to seriously answer it. Is the apple sitting on your kitchen counter alive, or is only the apple tree it came from deserving of the word? If we can’t answer that question here on earth, how will we know when and if we discover alien life on other worlds? The question hangs over some of society’s most charged conflicts—whether a fertilized egg is a living person, for example, and when we ought to declare a

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person legally dead. Life's Edge is an utterly fascinating investigation that no one but one of the most celebrated science writers of our generation could craft. Zimmer journeys through the strange experiments that have attempted to re-create life. Literally hundreds of definitions of what that should look like now exist, but none has yet emerged as an obvious winner. Lists of what living things have in common do not add up to a theory of life. It's never clear why some items on the list are essential and others not. Coronaviruses have altered the course of history, and yet many scientists maintain they are not alive. Chemists are creating droplets that can swarm, sense their environment, and multiply. Have they made life in the lab? Whether he is handling pythons in Alabama or searching for hibernating bats in the Adirondacks, Zimmer revels in astounding examples of life at its most bizarre. He tries his own hand at evolving life in a test tube with unnerving results. Charting the obsession with Dr. Frankenstein's monster and how Coleridge came to believe the whole universe was alive, Zimmer leads us all the way into the labs and minds of researchers working on engineering life from the ground up.

Hopping, climbing and swimming robots, nano-size neural networks, motorless walkers, slime mould and chemical brains - "Artificial Life Models in Hardware" offers unique designs and prototypes of life-like creatures in conventional hardware and hybrid bio-silicon systems. Ideas and implementations of living phenomena in non-living substrates cast a colourful picture of state-of-art advances in hardware models of artificial life.

his two-volume set LNCS 12689-12690 constitutes the refereed proceedings of the 12th International Conference on Advances in Swarm Intelligence, ICSI 2021, held in Qingdao, China, in July 2021. The 104 full papers presented in this volume were carefully reviewed and selected from 177 submissions. They cover topics such as: Swarm Intelligence and Nature-Inspired Computing; Swarm-based Computing Algorithms for Optimization; Particle Swarm Optimization; Ant Colony Optimization; Differential Evolution; Genetic Algorithm and Evolutionary Computation; Fireworks Algorithms; Brain Storm Optimization Algorithm; Bacterial Foraging Optimization Algorithm; DNA Computing Methods; Multi-Objective Optimization; Swarm Robotics and Multi-Agent System; UAV Cooperation and Control; Machine Learning; Data Mining; and Other Applications.

Advances in Physarum Machines Sensing and Computing with Slime Mould Springer

This book is a tribute to Julian Francis Miller's ideas and achievements in computer science, evolutionary algorithms and genetic programming, electronics, unconventional computing, artificial chemistry and theoretical biology. Leading international experts in computing inspired by nature offer their insights into the principles of information processing and optimisation in simulated and experimental living, physical and chemical substrates. Miller invented Cartesian Genetic Programming (CGP) in 1999, from a representation of electronic circuits

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he devised with Thomson a few years earlier. The book presents a number of CGP's wide applications, including multi-step ahead forecasting, solving artificial neural networks dogma, approximate computing, medical informatics, control engineering, evolvable hardware, and multi-objective evolutionary optimisations. The book addresses in depth the technique of 'Evolution in Materio', a term coined by Miller and Downing, using a range of examples of experimental prototypes of computing in disordered ensembles of graphene nanotubes, slime mould, plants, and reaction diffusion chemical systems. Advances in sub-symbolic artificial chemistries, artificial bio-inspired development, code evolution with genetic programming, and using Reed-Muller expansions in the synthesis of Boolean quantum circuits add a unique flavour to the content. The book is a pleasure to explore for readers from all walks of life, from undergraduate students to university professors, from mathematicians, computer scientists and engineers to chemists and biologists.

Myxomycetes: Biology, Systematics, Biogeography and Ecology, Second Edition provides a complete collection of general and technical information on myxomycetes microorganisms. Its broad scope takes an integrated approach, considering a number of important aspects surrounding their genetics and molecular phylogeny. The book treats myxomycetes as a distinct group from fungi and includes molecular information that discusses systematics and evolutionary pathways. Written and developed by an international team of specialists, this second edition contains updated information on all aspects of myxomycetes. It incorporates relevant and new material on current barcoding developments, plasmodial network experimentation, and non-STEM disciplinary assimilation of myxomycete information. This book is a unique and authoritative resource for researchers in organismal biology and ecology disciplines, as well as students and academics in biology, ecology, microbiology, and similar subject areas. Written in a simple, concise and relatively non-technical style, allowing for a broad readership within biological, environmental and life science programs at academic and research institutions Contains the comprehensive body of information available on myxomycetes under one cover, with contributions from the leading authorities in their respective areas of expertise Provides straightforward, compiled information about myxomycetes and the potential of this group for basic and applied research Offers completely updated material in every chapter, including new material on barcoding and Physarum polycephalum biological factors

This systematic and comprehensive overview of enzyme-based biocomputing is an excellent resource for scientists and engineers working on the design, study and applications of enzyme-logic systems.

An introduction to the interdisciplinary subject of molecular electronics, revised and updated The revised second edition of Organic and Molecular Electronics offers a guide to the fabrication and application of a wide range of electronic devices based around organic materials and low-cost technologies. Since the

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publication of the first edition, organic electronics has greatly progressed, as evidenced by the myriad companies that have been established to explore the new possibilities. The text contains an introduction into the physics and chemistry of organic materials, and includes a discussion of the means to process the materials into a form (in most cases, a thin film) where they can be exploited in electronic and optoelectronic devices. The text covers the areas of application and potential application that range from chemical and biochemical sensors to plastic light emitting displays. The updated second edition reflects the recent progress in both organic and molecular electronics and: Offers an accessible resource for a wide range of readers Contains a comprehensive text that covers topics including electrical conductivity, optical phenomena, electroactive organic compounds, tools for molecular electronics and much more Includes illustrative examples based on the most recent research Presents problems at the end of each chapter to help reinforce key points Written mainly for engineering students, Organic and Molecular Electronics: From Principles to Practice provides an updated introduction to the interdisciplinary subjects of organic electronics and molecular electronics with detailed examples of applications.

This book constitutes the proceedings of the 17th International Conference on Unconventional Computation and Natural Computation, UCNC 2018, held in Fontainebleau, France, in June 2018. The 15 full papers presented were carefully reviewed and selected from 22 submissions. The paper cover topics such as hypercomputation; chaos and dynamical systems based computing; granular, fuzzy and rough computing; mechanical computing; cellular, evolutionary, molecular, neural, and quantum computing; membrane computing; amorphous computing, swarm intelligence; artificial immune systems; physics of computation; chemical computation; evolving hardware; the computational nature of self-assembly, developmental processes, bacterial communication, and brain processes.

This edited volume is about how unprejudiced approaches to real human cognition can improve the design of AI. It covers many aspects of human cognition and across 12 chapters the reader can explore multiple approaches about the complexities of human cognitive skills and reasoning, always guided by experts from different but complimentary academic fields. A central concept is explained: blended cognition, the natural skill of human beings for combining constantly different heuristics during their several task-solving activities.

Something that was sometimes observed like a problem as “bad reasoning”, is now the central key for the understanding of the richness, adaptability and creativity of human cognition. The topic of this book connects in a significant way with the disciplines of psychology, neurology, anthropology, philosophy, logics, engineering, logics, and AI. In a nutshell: understanding better humans for designing better machines. Any person with interests on natural and artificial reasoning should read this book as a primary source of inspiration and a way to achieve a critical thinking on these topics.

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Machines can be divided into two entities-biomimetic systems, those that harness the principles discovered in nature and embody them in new artifacts, and biohybrid systems, which couple biological entities with synthetic ones. *Living Machines: A handbook of research in biomimetic and biohybrid systems* surveys this flourishing area of research. It captures the current state of play and points to the opportunities ahead, addressing such fields as self-organization and cooperativity, biologically-inspired active materials, self-assembly and self-repair, learning, memory, control architectures and self-regulation, locomotion in air, on land or in water, perception, cognition, control, and communication. In all of these areas, the potential of biomimetics is shown through the construction of a wide range of different biomimetic devices and animal-like robots. Biohybrid systems is a relatively new field, with exciting and largely unknown potential, but one that is likely to shape the future of humanity. Chapters outline current research in areas including brain-machine interfaces-where neurons are connected to microscopic sensors and actuators-and various forms of intelligent prostheses from sensory devices like artificial retinas, to life-like artificial limbs, brain implants, and virtual reality-based rehabilitation approaches. The handbook concludes by exploring the impact living machine technology will have on both society and the individual, by forcing human beings to question how we see and understand ourselves. With contributions from leading researchers drawing on ideas from science, engineering, and the humanities, this handbook will appeal to both undergraduate and postgraduate students of biomimetic and biohybrid technologies. Researchers in the areas of computational modeling and engineering, including artificial intelligence, machine learning, artificial life, biorobotics, neurorobotics, and human-machine interfaces, will find *Living Machines* an invaluable resource.

This book constitutes the proceedings of the 13th International Conference on Cellular Automata for Research and Industry, ACRI 2018, held in Como, Italy, in September 2018. The 47 full papers presented in this volume were carefully reviewed and selected from 64 submissions. This volume contains invited contributions and accepted papers from the main track and from the three organized workshops. The volume is organized in the following topics: biological systems modeling; simulation and other applications of CA; multi-agent systems; pedestrian and traffic dynamics; synchronization and control; theory and cryptography; asynchronous cellular automata; and crowds, traffic and cellular automata.

Why you are more than just a brain, more than just a brain-and-body, and more than all your assumptions about who you are. Who are you? Are you just a brain? A brain and a body? All the things you have done and the friends you have made? Many of us assume that who we really are is something deep inside us, an inner sanctuary that contains our true selves. In *Who You Are*, Michael Spivey argues that the opposite is true: that you are more than a brain, more than a brain-and-body, and more than all your assumptions about who you are. Rather

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than peeling layers away to reveal the inner you, Spivey traces who you are outward. You may already feel in your heart that something outside your body is actually part of you—a child, a place, a favorite book. Spivey confirms this intuition with scientific findings. With each chapter, Spivey incrementally expands a common definition of the self. After (gently) helping you to discard your assumptions about who you are, he draws on research in cognitive science and neuroscience to explain the back-and-forth among all the regions of the brain and the interaction between the brain and body. He then makes the case for understanding objects and locations in your environment as additional parts of who we are. Going even further, he shows that, just as interaction links brain, body, and environment, ever-expanding systems of interaction link humans to other humans, to nonhuman animals, and to nonliving matter. This may seem an interaction or two too far. But you don't have to take his word for it—just consider the evidence he presents.

This book introduces art projects that resulted from unconventional explorations, curious experiments and their creative translations into sensorial experiences. Using electronic and digital art, bioart, sculpture and installations, sound and performance, the authors are removing boundaries between natural and artificial, real and imaginary, science and culture. The invited artists and researchers come from cutting-edge fields of art production that focuses on creating aesthetic experiences and performative situations. Their artworks create a spatial aesthetic experience for visitors by manifesting themselves in physical space. Experiencing the Unconventional is a unique selection of works by artists not based on formal similarities, but on investigative practices. It offers in-depth insights and first-hand working experiences into current production of art works at the edge of art, science and technology.

Contents: Epistemological Machines and Protocomputing (Mitchell Whitelaw and Ralf Baecker) The Crystal World (Jonathan Kemp) Nigredo: Configuring Human and Technological Bodies (Marco Donnarumma) Sensing Spatial Experiences. The Essential Nature of Things (Sonia Cillari) Perfect Paul: On Freedom of Facial Expression (Arthur Elsenaar) Hacking the Universe (Frederik De Wilde) Mesoscopic Ripples in the Neural Sea (Evelina Domnitch and Dmitry Gelfand) Vanitas Machine (Verena Friedrich) Interview with Verena Friedrich Connections Continuum: A Life (Saša Spa?al) A New State of the Living (Dmitry Bulatov) That Which Lives in Me (Dmitry Bulatov and Alexey Chebykin) Robotics and Design: Towards a New Symbiosis in Gilberto Esparza's Artwork (Reynaldo Thompson and Tirtha P Mukhopadhyay) Pancreas. All Flesh (Candyman) Demons of Art (Interview with Thomas Feuerstein by Hartmut Böhme) Metabodies — Exploring Social Networks on Our Body (Sonja Bäumel and Manuel Selg) Re-Imagining the Biological Membrane (Juan M Castro) Bodymetrics. Mapping the Human Body Through Amorphous Intelligence (Theresa Schubert, Michael Markert, Moritz Dre?ler, Andrew Adamatzky) The Engineer's Report: "Swarm Cities" and Other Synthetic Companions (Francisco Gallardo and Álvaro Castro-Castilla) Der Zermesser (Leo Peschta) Interview with Leo Peschta Readership: Artists and scientists interested in removing boundaries between their work. Key Features: Brings together established and emerging artists from Europe, the Americas and Asia Provides in-depth insight and first hand working experiences into art works at the edge of art, science and technology Keywords: Media Art; Electronic Art; Bioart; Unconventional Computing; Science; Technology; Robotics; Body Sensors

This book provides high-quality research results and proposes future priorities for more sustainable development and energy security. It covers a broad range of topics on atmospheric changes, climate change impacts, climate change modeling and simulations, energy and

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environment policies, energy resources and conversion technologies, renewables, emission reduction and abatement, waste management, ecosystems and biodiversity, and sustainable development. Gathering selected papers from the 7th Global Conference on Global Warming (GCGW2018), held in Izmir, Turkey on June 24–28, 2018, it: Offers comprehensive coverage of the development of systems taking into account climate change, renewables, waste management, chemical aspects, energy and environmental issues, along with recent developments and cutting-edge information Highlights recent advances in the area of energy and environment, and the debate on and shaping of future directions and priorities for a better environment, sustainable development and energy security Provides a number of practical applications and case studies Is written in an easy-to-follow style, moving from the basics to advanced systems. Given its scope, the book offers a valuable resource for readers in academia and industry alike, and can be used at the graduate level or as a reference text for professors, researchers and engineers.

Modern computing relies on future and emergent technologies which have been conceived via interaction between computer science, engineering, chemistry, physics and biology. This highly interdisciplinary book presents advances in the fields of parallel, distributed and emergent information processing and computation. The book represents major breakthroughs in parallel quantum protocols, elastic cloud servers, structural properties of interconnection networks, internet of things, morphogenetic collective systems, swarm intelligence and cellular automata, unconventionality in parallel computation, algorithmic information dynamics, localized DNA computation, graph-based cryptography, slime mold inspired nano-electronics and cytoskeleton computers. Features Truly interdisciplinary, spanning computer science, electronics, mathematics and biology Covers widely popular topics of future and emergent computing technologies, cloud computing, parallel computing, DNA computation, security and network analysis, cryptography, and theoretical computer science Provides unique chapters written by top experts in theoretical and applied computer science, information processing and engineering From Parallel to Emergent Computing provides a visionary statement on how computing will advance in the next 25 years and what new fields of science will be involved in computing engineering. This book is a valuable resource for computer scientists working today, and in years to come.

This book is a printed edition of the Special Issue "Advances in Multi-Sensor Information Fusion: Theory and Applications 2017" that was published in Sensors

This book is devoted to Slime mould *Physarum polycephalum*, which is a large single cell capable for distributed sensing, concurrent information processing, parallel computation and decentralized actuation. The ease of culturing and experimenting with *Physarum* makes this slime mould an ideal substrate for real-world implementations of unconventional sensing and computing devices The book is a treatise of theoretical and experimental laboratory studies on sensing and computing properties of slime mould, and on the development of mathematical and logical theories of *Physarum* behavior. It is shown how to make logical gates and circuits, electronic devices (memristors, diodes, transistors, wires, chemical and tactile sensors) with the slime mould. The book demonstrates how to modify properties of *Physarum* computing circuits with functional nano-particles and polymers, to interface the slime mould with field-programmable arrays, and to use *Physarum* as a controller of microbial fuel cells. A unique multi-agent model of slime is shown to serve well as a software slime mould capable for solving problems of computational geometry and graph optimization. The multiagent model is complemented by cellular automata models with parallel accelerations. Presented mathematical models inspired by *Physarum* include non-quantum implementation of Shor's factorization, structural learning, computation of shortest path tree on dynamic graphs, supply chain network design, p-adic computing and syllogistic reasoning. The book is a unique composition of vibrant and lavishly illustrated essays which will inspire scientists, engineers

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and artists to exploit natural phenomena in designs of future and emergent computing and sensing devices. It is a 'bible' of experimental computing with spatially extended living substrates, it spans topics from biology of slime mould, to bio-sensing, to unconventional computing devices and robotics, non-classical logics and music and arts.

This book constitutes the refereed conference proceedings of the First International Conference on Emerging Technologies in Computing, iCEtiC 2018, held in London, UK, in August 2018. The 26 revised full papers were reviewed and selected from more than 59 submissions and are organized in topical sections covering Cloud, IoT and distributed computing, software engineering, communications engineering and vehicular technology, AI, expert systems and big data analytics, Web information systems and applications, security, database system, economics and business engineering, mLearning and eLearning.

This book constitutes the refereed proceedings of the 6th European Conference on Artificial Life, ECAL 2001, held in Prague, Czech Republic, in September 2001. The 54 revised papers and 25 posters presented together with five invited papers were carefully reviewed and selected from numerous submissions. The book reflects the state of the art in ALife. It is divided into topical sections on agents in environments; artificial chemistry; cellular and neural systems; collaborative systems; evolution; robotics; vision, visualization, language, and communication; and miscellaneous.

This book constitutes the refereed proceedings of the 25th Australasian Joint Conference on Artificial Intelligence, AI 2012, held in Sydney, Australia, in December 2012. The 76 revised full papers presented were carefully reviewed and selected from 196 submissions. The papers address a wide range of agents, applications, computer vision, constraints and search, game playing, information retrieval, knowledge representation, machine learning, planning and scheduling, robotics and uncertainty in AI.

This book offers advanced parallel and distributed algorithms and experimental laboratory prototypes of unconventional shortest path solvers. In addition, it presents novel and unique algorithms of solving shortest problems in massively parallel cellular automaton machines. The shortest path problem is a fundamental and classical problem in graph theory and computer science and is frequently applied in the contexts of transport and logistics, telecommunication networks, virtual reality and gaming, geometry, and social networks analysis. Software implementations include distance-vector algorithms for distributed path computation in dynamics networks, parallel solutions of the constrained shortest path problem, and application of the shortest path solutions in gathering robotic swarms. Massively parallel algorithms utilise cellular automata, where a shortest path is computed either via matrix multiplication in automaton arrays, or via the representation of data graphs in automaton lattices and using the propagation of wave-like patterns. Unconventional shortest path solvers are presented in computer models of foraging behaviour and protoplasmic network optimisation by the slime mould *Physarum polycephalum* and fluidic devices, while experimental laboratory prototypes of path solvers using chemical media, flows and droplets, and electrical current are also highlighted. The book will be a pleasure to explore for readers from all walks of life, from undergraduate students to university professors, from mathematicians, computers scientists and engineers to chemists and biologists.

The slime mould *Physarum polycephalum* was a source of explosive growth of bioengineered hybrid sensing and computing devices in the past decade. Being in its vegetative state, the plasmodium, the slime mould configures its protoplasmic network to optimize its geometry with relation to patterns of attractants and repellents. The slime

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mould's adaptability, polymorphism and aestheticism inspired artists and architects. The slime mould has been seen as a self-conscious liquid form continuously changing its shape in response to external stimulation and due to interactions of thousands of micro-oscillators in its body. Elusiveness is a magic feature of the slime mould. One moment the slime mould gives you a solution to a mathematical problem by a shape of its body, next moment it changes its shape and the solution, disappears. *Slime Mould in Arts and Architecture* presents a set of unique chapters written by leading artists, architects and scientists, which resulted from creative translations of the slime mould behaviour into forms and sounds, unconventional investigations and sensorial experiences and the slime mould ability to remove boundaries between living and artificial, solid and fluid, science and arts. The book gives readers unique tools for designing architectural forms and creative works using the slime mould, understanding how pro-cognitive living substrates can be used in everyday life, it sparks new ideas and initiates further progress in many fields or arts, architecture, science and engineering. Key features: - Vibrant concepts of biology, arts, non-linear sciences and architecture are inter-reacting in the book towards the formation of an unorthodox vision of future and an emergent concepts of the physical state, where science and are becoming a singly unity; - Striking polymorphism of contributions, which reflects the vibrant development of the field of bio-inspired and bio-integrated arts and architecture. This makes the publication stand out from the standard art, science or architecture book; - The book provides an in-depth insight and first hand working experiences into current production of art works at the edge of art, science and technology. It provides a unique compendium of works made by a new type of artists and architects who is not only concerned with the visual level of their work but also with scientific conceptualization and theoretical reflection on contextualization of their studies and work in interdisciplinary fields; - Contributions from main stream scientists demonstrate unusual artistic and architectural developments; - All contributors of in the book are from leading artists, architects or scientists, with an impressive track record of exhibitions, installations, and scientific and engineering discoveries. They provide in-depth insights and first-hand working experiences into current developments of art and architectural works at the edge of art, science and technology.

This book presents comprehensive coverage of the latest advances in research into enabling machines to listen to and compose new music. It includes chapters introducing what we know about human musical intelligence and on how this knowledge can be simulated with AI. The development of interactive musical robots and emerging new approaches to AI-based musical creativity are also introduced, including brain-computer music interfaces, bio-processors and quantum computing. Artificial Intelligence (AI) technology permeates the music industry, from management systems for recording studios to recommendation systems for online commercialization of music through the Internet. Yet whereas AI for online music distribution is well advanced, this book focuses on a largely unexplored application: AI for creating the actual musical content.

This book shows that the plasmodium of *Physarum polycephalum* can be considered a natural labelled transition system, and based on this, it proposes high-level programming models for controlling the plasmodium behaviour. The presented programming is a form of pure behaviourism: the authors consider the possibility of

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simulating all basic stimulus–reaction relations. As plasmodium is a good experimental medium for behaviouristic models, the book applies the programming tools for modelling plasmodia as unconventional computers in different behavioural sciences based on studying the stimulus–reaction relations. The authors examine these relations within the framework of a bio-inspired game theory on plasmodia they have developed i.e. within an experimental game theory, where, on the one hand, all basic definitions are verified in experiments with *Physarum polycephalum* and *Badhamia utricularis* and, on the other hand, all basic algorithms are implemented in the object-oriented language for simulations of plasmodia. The results allow the authors to propose that the plasmodium can be a model for concurrent games and context-based games.

Slime mould *Physarum polycephalum* is a monstrous single cell well known for its task-solving abilities solves computational geometry and logical problems, navigates robots and generates music. The slime mould could also build motorways, highways and expressways. It is used to analyse transport networks of Africa, Australia, Belgium, Brazil, Canada, China, Germany, Iberia, Italy, Malaysia, Mexico, The Netherlands, UK and USA. The largest cities are represented by oat flakes and the slime mould is inoculated in a capital. When all oat flakes are covered by the slime mould, the structure of the protoplasmic networks formed are analyzed. In the laboratory experiments and theoretical analyses, intriguing country-specific properties of the motorway networks are uncovered and compared with the man-made and slime mould networks. They are studied as proximity graphs, leading to hierarchies of complexity and bio-rationality of the motorways. The book will inspire novel and original thoughts, paradigms and approaches for re-evaluation of historical findings on the emergence of ancient roads and will help to design future transcontinental pathways. The book is self-contained and does not require any special training or knowledge. This lavishly illustrated text will be appreciated by readers from all walks of life.

This book presents fundamental theoretical results for designing object-oriented programming languages for controlling swarms. It studies the logics of swarm behaviours. According to behaviourism, all behaviours can be controlled or even managed by stimuli in the environment: attractants (motivational reinforcement) and repellents (motivational punishment). At the same time, there are two main stages in reactions to stimuli: sensing (perceiving signals) and motoring (appropriate direct reactions to signals). This book examines the strict limits of behaviourism from the point of view of symbolic logic and algebraic mathematics: how far can animal behaviours be controlled by the topology of stimuli? On the one hand, we can try to design reversible logic gates in which the number of inputs is the same as the number of outputs. In this case, the behaviouristic stimuli are inputs in swarm computing and appropriate reactions at the motoring stage are its outputs. On the other hand, the problem is that even at the sensing stage each unicellular organism can be regarded as a logic gate in which the number of outputs (means of perceiving signals) greatly exceeds the number of inputs (signals).

This book presents the latest trends in and approaches to computational intelligence research and its application to intelligent systems. It covers a long list of interconnected research areas, such as fuzzy systems, neural networks, evolutionary computation, clustering and classification, machine learning, data mining, cognition and robotics, and deep learning. The individual chapters are based on peer-reviewed contributions

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presented at the 18th Annual UK Workshop on Computational Intelligence (UKCI-2018), held in Nottingham, UK on September 5-7, 2018. The book puts a special emphasis on novel methods and reports on their use in a wide range of applications areas, thus providing both academics and professionals with a comprehensive and timely overview of new trends in computational intelligence.

Biología teórica, explicación y complejidad .

The refereed proceedings of the Second International Workshop on Biologically Inspired Approaches to Advanced Information Technology, BioADIT 2006. The contributions range from basic research in biology and in information technology, to more application-oriented developments in software and in hardware. The papers are organized in topical sections on robotics, networking, biological systems, self-organization, evolutionary computation, and modeling and imaging.

The unconventional computing is a niche for interdisciplinary science, cross-bred of computer science, physics, mathematics, chemistry, electronic engineering, biology, material science and nanotechnology. The aims of this book are to uncover and exploit principles and mechanisms of information processing in and functional properties of physical, chemical and living systems to develop efficient algorithms, design optimal architectures and manufacture working prototypes of future and emergent computing devices. This second volume presents experimental laboratory prototypes and applied computing implementations. Emergent molecular computing is presented by enzymatic logical gates and circuits, and DNA nano-devices. Reaction-diffusion chemical computing is exemplified by logical circuits in Belousov-Zhabotinsky medium and geometrical computation in precipitating chemical reactions. Logical circuits realised with solitons and impulses in polymer chains show advances in collision-based computing. Photo-chemical and memristive devices give us a glimpse on hot topics of a novel hardware. Practical computing is represented by algorithms of collective and immune-computing and nature-inspired optimisation. Living computing devices are implemented in real and simulated cells, regenerating organisms, plant roots and slime mould. The book is the encyclopedia, the first ever complete authoritative account, of the theoretical and experimental findings in the unconventional computing written by the world leaders in the field. All chapters are self-contained, no specialist background is required to appreciate ideas, findings, constructs and designs presented. This treatise in unconventional computing appeals to readers from all walks of life, from high-school pupils to university professors, from mathematicians, computer scientists and engineers to chemists and biologists.

Building on Handbook of Machine Learning - Volume 1: Foundation of Artificial Intelligence, this volume on Optimization and Decision Making covers a range of algorithms and their applications. Like the first volume, it provides a starting point for machine learning enthusiasts as a comprehensive guide on classical optimization methods. It also provides an in-depth overview on how artificial intelligence can be used to define, disprove or validate economic modeling and decision making concepts.

This book comprehensively introduces non-destructive methods for food quality (i.e. external, internal, sensory, components, and microbiological indicators) detection, through optics, acoustics, chemistry, imaging, and bionic sensing. It highlights in-situ detection of food quality and safety, including principles, signal processing, and analysis of data, non-destructive detection system, and application in the food industry

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for each method. First, this book introduces the principles and characteristics of various food non-destructive methods. As non-destructive measurements always involve obtaining big data for each testing, this book also describes in detail the signal and big data processing for each non-destructive method. The chapters also introduce the rapid portable detection equipment for food and agricultural products developed in recent years, as well as the intelligent monitoring equipment in the process of food processing. Relevant application cases are provided to help readers better understanding how to apply non-destructive technology for food quality detection. In the noninvasive measurement of food quality, this book has a systematic introduction of the detection principle, data processing, and rapid detection system, in-field detection case studies. This book is novel and practical and can be used as a professional textbook for undergraduates majoring in food science and engineering. It can also be used as a reference book for scientific research and technical personnel engaged in the field of food quality and safety detection.

A Physarum machine is a programmable amorphous biological computer experimentally implemented in the vegetative state of true slime mould *Physarum polycephalum*. It comprises an amorphous yellowish mass with networks of protoplasmic veins, programmed by spatial configurations of attracting and repelling gradients. This book demonstrates how to create experimental Physarum machines for computational geometry and optimization, distributed manipulation and transportation, and general-purpose computation. Being very cheap to make and easy to maintain, the machine also functions on a wide range of substrates and in a broad scope of environmental conditions. As such a Physarum machine is a 'green' and environmentally friendly unconventional computer. The book is readily accessible to a nonprofessional reader, and is a priceless source of experimental tips and inventive theoretical ideas for anyone who is inspired by novel and emerging non-silicon computers and robots. An account on Physarum Machines can be viewed at <http://www.youtube.com/user/PhysarumMachines>.

This pioneering text/reference explores how innovative new modes of computation may provide exciting new directions for future developments in the music industry, guiding the reader through the latest research in this emerging, interdisciplinary field. This work includes coverage of electronic music compositions and performances that incorporate unconventional interfacing, hacking and circuit bending. Features: presents an introduction to unconventional computing in music; discusses initiatives involving biophysical electronic music, the work of self-styled silicon luthiers, and the intersection of music and quantum computing; introduces the memristor, a new electronic component with the potential to revolutionize how computers are built; reviews experiments and practical applications of biological memristors in music; describes IMUSIC, an unconventional tone-based programming language, which enables the programming of computers using musical phrases; includes review questions at the end of each chapter.

Single processing units have now reached a point where further major improvements in their performance are restricted by their physical limitations. This is causing a slowing down in advances at the same time as new scientific challenges are demanding exascale speed. This has meant that parallel processing has become key to High Performance Computing (HPC). This book contains the proceedings of the 14th

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biennial ParCo conference, ParCo2011, held in Ghent, Belgium. The ParCo conferences have traditionally concentrated on three main themes: Algorithms, Architectures and Applications. Nowadays though, the focus has shifted from traditional multiprocessor topologies to heterogeneous and manycores, incorporating standard CPUs, GPUs (Graphics Processing Units) and FPGAs (Field Programmable Gate Arrays). These platforms are, at a higher abstraction level, integrated in clusters, grids and clouds. The papers presented here reflect this change of focus. New architectures, programming tools and techniques are also explored, and the need for exascale hardware and software was also discussed in the industrial session of the conference. This book will be of interest to all those interested in parallel computing today, and progress towards the exascale computing of tomorrow.

In a world that is changing faster and with more complexity than at any other time in history, Tom Goodell explores how to make sense of it all, and how individuals and organizations can thrive in a world this complex. He taps into hot business management trends of mindfulness, simplicity science, and agile leadership along the way.

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