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Cuttlefish Algorithm – A Novel Bio-Inspired Optimization Algorithm

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Abstract— In this paper, a new meta-heuristic bio-inspired optimization algorithm, called Cuttlefish Algorithm (CFA) is presented. The algorithm mimics the mechanism of color changing behavior used by the cuttlefish to solve numerical global optimization problems. The patterns and colors seen in cuttlefish are produced by reflected light from different layers of cells including (chromatophores, leucophores and iridophores) stacked together, and it is the combination of certain cells at once that allows cuttlefish to possess such a large array of patterns and colors. The proposed algorithm considers two main processes: reflection and visibility. Reflection process is proposed to simulate the light reflection mechanism used by these three layers, while the visibility is proposed to simulate the visibility of matching pattern used by the cuttlefish. These two processes are used as a search strategy to find the global optimal solution. Efficiency of this algorithm is also tested with some other popular biology inspired optimization algorithms such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO) and Bees Algorithm (BA) that have been previously proposed in the literature. Simulations and obtained results indicate that the proposed CFA is superior to other algorithms.

Index term— Cuttlefish algorithm, Reflection, Visibility, Optimization, Chromatophores, Iridophores, Leucophores, Test functions.

1 Introduction

GLOBAL optimization is a field with applications in many areas of science, engineering, economics, and others, where mathematical modeling is used. Without loss of generality, the optimization maybe defined as the search for a vector x_0 in a possible solution set X minimizing a target function f so that $\forall x \in U \subseteq X: f(x_0) \leq f(x_n)$. For $U = X$, x_0 is called a global optimum, otherwise it is called a local optimum of f in X [29]. Global optimization algorithms are usually broadly divided into deterministic and meta-heuristic [10]. Deterministic algorithms tend to use gradient technique and find greater use in solving unimodal problems. While meta-heuristic models tend to learn as they run, and tend to be more intelligent and adaptive. Meta-heuristic methods are usually faster in locating a global optimum than deterministic ones. The components of any meta-heuristic algorithms are: intensification and diversification, or exploitation and exploration [28]. Diversification means to generate diverse solutions so as to explore the search space on a global scale, while intensification means to focus the search in a local region knowing that a current good solution is found in this region. A good balance between intensification and diversification should be found during the selection of the best solutions to improve the rate of algorithm convergence. The selection of the best ensures that solutions will converge to the optimum, while diversification via randomization allows the search to escape from local optima and, at the same time, increases the diversity of solutions. A good combination of these two major components will usually ensure that global optimality is achievable.

Most of meta-heuristic algorithms are nature-inspired such as Ant Colony Optimization ACO, Particle Swarm Optimization PSO, Bees Algorithm BA, etc. that have previously been proposed by researchers. Some of these studies [1] have been inspired by animal behaviors for developing optimization techniques. For example, ACO algorithm proposed by Dorigo et al. [2], is inspired by the research on the behavior of ant colonies. BA proposed by D.T. Pham et al. [3], is inspired by the food foraging behavior of honey bees. PSO algorithm proposed by Kennedy and Eberhart [4], models the social behavior of bird flocking or fish schooling.

Recently, new meta-heuristic approaches are presented by several researchers. For example, collective animal behavior CAB algorithm proposed by Erik Cuevas et al. [5] is inspired from a group of animals which interact with each other that is based on the biological laws of collective motion. A gravitational search algorithm GSA, proposed by Esmat Rashedi et al. [6] is based on the law of gravity and mass interactions. Bumble bees mating optimization BBMO algorithm presented in Yannis Marinakis et al. [7] simulates the mating behavior of the bumble bees. Parliamentary optimization algorithm POA proposed by Ali Borji [8] is motivated from human social behaviors in political environments. Bat Algorithm BA proposed by Xin-She Yang [9] is based on the echolocation behavior of bats. Firefly algorithm FA proposed by Xin-She Yang [11] is based on flashing characteristics of fireflies.

In this paper, a new meta-heuristic optimization algorithm that is inspired based on the mechanism of color changing behavior of cuttlefish is presented to find the optimal solution in numerical optimization problems. The patterns and colors seen in cuttlefish are produced by reflected light from different layers of cells stacked together, and it is the combination of certain cells at once that allows cuttlefish to possess such a large array of patterns and colors. The proposed algorithm mimics the light reflection process through the combination of these layers, and the visibility of matching pattern process used by cuttlefish to match its

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International Conference on Innovative Computing and Communications Deepak Gupta,Ashish Khanna,Siddhartha Bhattacharyya,Aboul Ella Hassanien,Sameer Anand,Ajay Jaiswal,2020-08-01 This book includes high quality research papers presented at the Third International Conference on Innovative Computing and Communication ICICC 2020 which is held at the Shaheed Sukhdev College of Business Studies University of Delhi Delhi India on 21 23 February 2020 Introducing the innovative works of scientists professors research scholars students and industrial experts in the field of computing and communication the book promotes the transformation of fundamental research into institutional and industrialized research and the conversion of applied exploration into real time applications **Handbook of Intelligent Computing and Optimization for Sustainable Development** Mukhdeep Singh Manshahia,Valeriy Kharchenko,Elias Munapo,J. Joshua Thomas,Pandian Vasant,2022-03-15 HANDBOOK OF INTELLIGENT COMPUTING AND OPTIMIZATION FOR SUSTAINABLE DEVELOPMENT This book provides a comprehensive overview of the latest breakthroughs and recent progress in sustainable intelligent computing technologies applications and optimization techniques across various industries Optimization has received enormous attention along with the rapidly increasing use of communication technology and the development of user friendly software and artificial intelligence In almost all human activities there is a desire to deliver the highest possible results with the least amount of effort Moreover optimization is a very well known area with a vast number of applications from route finding problems to medical treatment construction finance accounting engineering and maintenance schedules in plants As far as optimization of real world problems is concerned understanding the nature of the problem and grouping it in a proper class may help the designer employ proper techniques which can solve the problem efficiently Many intelligent optimization techniques can find optimal solutions without the use of objective function and are less prone to local conditions The 41 chapters comprising the Handbook of Intelligent Computing and Optimization for Sustainable Development by subject specialists represent diverse disciplines such as mathematics and computer science electrical and electronics engineering neuroscience and cognitive sciences medicine and social sciences and provide the reader with an integrated understanding of the importance that intelligent computing has in the sustainable development of current societies It discusses the emerging research exploring the theoretical and practical aspects of successfully implementing new and innovative intelligent techniques in a variety of sectors including IoT manufacturing optimization and healthcare Audience It is a pivotal reference source for IT specialists industry professionals managers executives researchers scientists and engineers seeking current research in emerging perspectives in the field of artificial intelligence in the areas of Internet of Things renewable energy optimization and smart cities **AI Approaches to Smart and Sustainable Power Systems** Ashok Kumar, L.,Angalaeswari, S.,Mohana Sundaram, K.,Bansal, Ramesh C.,Patil, Arunkumar,2024-03-25 Today the global power demand relies on a delicate balance between conventional and renewable energy systems necessitating both

efficient power generation and the effective utilization of these energy resources through appropriate energy storage solutions Integrating microgrid systems into the utility grid has become a critical facet of modern power systems The intermittent and unpredictable nature of these energy sources poses a formidable challenge for academic scholars and researchers This compels them to explore under investigated areas including energy source estimation storage elements load pattern prediction coordination among distributed sources and the development of energy management algorithms for precise and efficient control AI Approaches to Smart and Sustainable Power Systems tackles these issues using cutting edge AI techniques It examines the most effective methods to optimize voltage frequency power fault diagnosis component health and overall power system quality and reliability AI empowers predictive and preventive maintenance for a sustainable energy future The book focuses on emerging research areas including renewable energy power flow calculations demand scheduling real time performance validation and AI integration into modern power systems accompanied by insightful case studies

Adaptive Technologies for Sustainable Growth Raja M.,Satya Subrahmanyam,R. Raja Subramanian,J. Karthikeyan,2026-04-07 The International Conference on Adaptive Technologies for Sustainable Growth ICATS 2025 was successfully held on May 28 2025 at Paavai Engineering College Autonomous Namakkal Tamil Nadu India The conference was designed as a vibrant and inclusive platform for researchers academicians industry experts and students to exchange novel ideas present their research findings and foster meaningful collaborations in the fields of science engineering and sustainable development ICATS 2025 aimed to bridge the gap between theoretical knowledge and practical implementation through adaptive technologies that support sustainable growth across smart cities energy systems agriculture and industrial applications The conference with participation from over 21 countries fostered meaningful global collaboration and encouraged rich interdisciplinary research exchange The event featured plenary sessions keynote addresses from renowned international speakers and a series of technical paper presentations ROBOT 2017: Third Iberian Robotics Conference Anibal Ollero,Alberto Sanfeliu,Luis Montano,Nuno Lau,Carlos Cardeira,2017-11-10 These volumes of Advances in Intelligent Systems and Computing highlight papers presented at the Third Iberian Robotics Conference ROBOT 2017 Held from 22 to 24 November 2017 in Seville Spain the conference is a part of a series of conferences co organized by SEIDROB Spanish Society for Research and Development in Robotics and SPR Portuguese Society for Robotics The conference is focused on Robotics scientific and technological activities in the Iberian Peninsula although open to research and delegates from other countries Thus it has more than 500 authors from 21 countries The volumes present scientific advances but also robotic industrial applications looking to promote new collaborations between industry and academia *Bio-Inspired Fault-Tolerant Algorithms for Network-on-Chip* Muhammad Athar Javed Sethi,2020-03-17 Network on Chip NoC addresses the communication requirement of different nodes on System on Chip The bio inspired algorithms improve the bandwidth utilization maximize the throughput and reduce the end to end latency and inter flit arrival time This book exclusively

presents in depth information regarding bio inspired algorithms solving real world problems focussing on fault tolerant algorithms inspired by the biological brain and implemented on NoC It further documents the bio inspired algorithms in general and more specifically in the design of NoC It gives an exhaustive review and analysis of the NoC architectures developed during the last decade according to various parameters Key Features Covers bio inspired solutions pertaining to Network on Chip NoC design solving real world examples Includes bio inspired NoC fault tolerant algorithms with detail coding examples Lists fault tolerant algorithms with detailed examples Reviews basic concepts of NoC Discusses NoC architectures developed to date *Power System Fault Diagnosis* Md Shafiullah,M. A. Abido,A. H. Al-Mohammed,2022-01-14 Power System Fault Diagnosis A Wide Area Measurement Based Intelligent Approach is a comprehensive overview of the growing interests in efficient diagnosis of power system faults to reduce outage duration and revenue losses by expediting the restoration process This book illustrates intelligent fault diagnosis schemes for power system networks at both transmission and distribution levels using data acquired from phasor measurement units It presents the power grid modeling fault modeling feature extraction processes and various fault diagnosis techniques including artificial intelligence techniques in steps The book also incorporates uncertainty associated with line parameters fault information resistance and inception angle load demand renewable energy generation and measurement noises Provides step by step modeling of power system networks distribution and transmission and faults in MATLAB SIMULINK and real time digital simulator RTDS platforms Presents feature extraction processes using advanced signal processing techniques discrete wavelet and Stockwell transforms and an easy to understand optimal feature selection method Illustrates comprehensive results in the graphical and tabular formats that can be easily reproduced by beginners Highlights various utility practices for fault location in transmission networks distribution systems and underground cables *Machine Learning Paradigms* George A. Tsihrintzis,Lakhmi C. Jain,2020-07-23 At the dawn of the 4th Industrial Revolution the field of Deep Learning a sub field of Artificial Intelligence and Machine Learning is growing continuously and rapidly developing both theoretically and towards applications in increasingly many and diverse other disciplines The book at hand aims at exposing its reader to some of the most significant recent advances in deep learning based technological applications and consists of an editorial note and an additional fifteen 15 chapters All chapters in the book were invited from authors who work in the corresponding chapter theme and are recognized for their significant research contributions In more detail the chapters in the book are organized into six parts namely 1 Deep Learning in Sensing 2 Deep Learning in Social Media and IOT 3 Deep Learning in the Medical Field 4 Deep Learning in Systems Control 5 Deep Learning in Feature Vector Processing and 6 Evaluation of Algorithm Performance This research book is directed towards professors researchers scientists engineers and students in computer science related disciplines It is also directed towards readers who come from other disciplines and are interested in becoming versed in some of the most recent deep learning based technological applications An extensive list of

bibliographic references at the end of each chapter guides the readers to probe deeper into their application areas of interest

Bio-Inspired Algorithms for Single and Multi-Objective Optimization Wai-Pong Wilburn Tsang,□□□,2017-01-27

Bio-inspired Algorithms for Global Optimization Utsav Poudel,2019 There are many algorithms developed that use evolutionary concepts and biotic components of nature These algorithms use stochastic methods rather than deterministic methods to reach an optimal solution In this report three of the bio inspired algorithms are studied Ant Colony Optimization is inspired by the food searching process of ants that has been widely used in mathematical and engineering applications Similarly Artificial Bee Colony is another algorithm that is based on the procedure that honey bees carry out to find a food source Firefly Algorithm is based on the flashing behavior of fireflies These three algorithms are described in detail in the report These algorithms are used to solve benchmark mathematical optimization problems The algorithms are also used to synthesize an antenna pattern for the radiometer application Finally these algorithms are used to design Finite Impulse Response Digital Filters **Bio-Inspired Computational Algorithms and Their Applications** Shangce Gao,2012-03-07 Bio inspired computational algorithms are always hot research topics in artificial intelligence communities Biology is a bewildering source of inspiration for the design of intelligent artifacts that are capable of efficient and autonomous operation in unknown and changing environments It is difficult to resist the fascination of creating artifacts that display elements of lifelike intelligence thus needing techniques for control optimization prediction security design and so on Bio Inspired Computational Algorithms and Their Applications is a compendium that addresses this need It integrates contrasting techniques of genetic algorithms artificial immune systems particle swarm optimization and hybrid models to solve many real world problems The works presented in this book give insights into the creation of innovative improvements over algorithm performance potential applications on various practical tasks and combination of different techniques The book provides a reference to researchers practitioners and students in both artificial intelligence and engineering communities forming a foundation for the development of the field **Bio-inspired Optimization Techniques for High Performance Computing** Gianluigi Folino,2011 **Bio-inspired Algorithms in Machine Learning and Deep Learning for Disease Detection** Balasubramaniam S,Seifedine Kadry,Manoj Kumar TK,K. Satheesh Kumar,2025-03-13 Currently computational intelligence approaches are utilised in various science and engineering applications to analyse information make decisions and achieve optimisation goals Over the past few decades various techniques and algorithms have been created in disciplines such as genetic algorithms artificial neural networks evolutionary algorithms and fuzzy algorithms In the coming years intelligent optimisation algorithms are anticipated to become more efficient in addressing various issues in engineering scientific medical space and artificial satellite fields particularly in early disease diagnosis A metaheuristic in computer science is designed to discover optimisation algorithms capable of solving intricate issues Metaheuristics are optimisation algorithms that mimic biological behaviours of animals or birds and are utilised to discover the best solution for a certain

problem A meta heuristic is an advanced approach used by heuristics to tackle intricate optimisation problems A metaheuristic in mathematical programming is a method that seeks a solution to an optimisation problem Metaheuristics utilise a heuristic function to assist in the search process Heuristic search can be categorised as blind search or informed search Meta heuristic optimisation algorithms are gaining popularity in various applications due to their simplicity independence from data trends ability to find optimal solutions and versatility across different fields Recently many nature inspired computation algorithms have been utilised to diagnose people with different diseases Nature inspired methodologies are now widely utilised across several fields for tasks such as data analysis decision making and optimisation Techniques inspired by nature are categorised as either biology based or natural phenomena based Bioinspired computing encompasses various topics in computer science mathematics and biology in recent years Bio inspired computer optimisation algorithms are a developing method that utilises concepts and inspiration from biological development to create new and resilient competitive strategies Bio inspired optimisation algorithms have gained recognition in machine learning and deep learning for solving complicated issues in science and engineering Utilising BIAs learning methods with machine learning and deep learning shows great promise for accurately classifying medical conditions This book explores the historical development of bio inspired algorithms and their application in machine learning and deep learning models for disease diagnosis including COVID 19 heart diseases cancer diabetes and some other diseases It discusses the advantages of using bio inspired algorithms in disease diagnosis and concludes with research directions and future prospects in this field *Bio-inspired Optimization Techniques for High Performance Computing* ,2011 *Bio-Inspired Computational Algorithms and Their Applications* Shangce Gao,2012-03-07 Bio inspired computational algorithms are always hot research topics in artificial intelligence communities Biology is a bewildering source of inspiration for the design of intelligent artifacts that are capable of efficient and autonomous operation in unknown and changing environments It is difficult to resist the fascination of creating artifacts that display elements of lifelike intelligence thus needing techniques for control optimization prediction security design and so on Bio Inspired Computational Algorithms and Their Applications is a compendium that addresses this need It integrates contrasting techniques of genetic algorithms artificial immune systems particle swarm optimization and hybrid models to solve many real world problems The works presented in this book give insights into the creation of innovative improvements over algorithm performance potential applications on various practical tasks and combination of different techniques The book provides a reference to researchers practitioners and students in both artificial intelligence and engineering communities forming a foundation for the development of the field **Bio-inspired Algorithms for Single and Multi-objective Optimization** Wai-pong Tsang (Wilburn),University of Hong Kong,2009 **Optimistic Perspective on Bio-Inspired Algorithms** Samrudhi Rajendra,2020-10-26 **Bio-inspired Algorithms for Data Streaming and Visualization, Big Data Management, and Fog Computing** Simon James Fong,Richard C.

Millham,2020-08-26 This book aims to provide some insights into recently developed bio inspired algorithms within recent emerging trends of fog computing sentiment analysis and data streaming as well as to provide a more comprehensive approach to the big data management from pre processing to analytics to visualization phases The subject area of this book is within the realm of computer science notably algorithms meta heuristic and more particularly bio inspired algorithms Although application domains of these new algorithms may be mentioned the scope of this book is not on the application of algorithms to specific or general domains but to provide an update on recent research trends for bio inspired algorithms within a specific application domain or emerging area These areas include data streaming fog computing and phases of big data management One of the reasons for writing this book is that the bio inspired approach does not receive much attention but shows considerable promise and diversity in terms of approach of many issues in big data and streaming Some novel approaches of this book are the use of these algorithms to all phases of data management not just a particular phase such as data mining or business intelligence as many books focus on effective demonstration of the effectiveness of a selected algorithm within a chapter against comparative algorithms using the experimental method Another novel approach is a brief overview and evaluation of traditional algorithms both sequential and parallel for use in data mining in order to provide an overview of existing algorithms in use This overview complements a further chapter on bio inspired algorithms for data mining to enable readers to make a more suitable choice of algorithm for data mining within a particular context In all chapters references for further reading are provided and in selected chapters the author also include ideas for future research *Handbook of Bioinspired Algorithms and Applications* Stephan Olariu,Albert Y. Zomaya,2006 The mystique of biologically inspired or bioinspired paradigms is their ability to describe and solve complex relationships from intrinsically very simple initial conditions and with little or no knowledge of the search space Edited by two prominent well respected researchers the Handbook of Bioinspired Algorithms and Applications reveals the connections between bioinspired techniques and the development of solutions to problems that arise in diverse problem domains A repository of the theory and fundamentals as well as a manual for practical implementation this authoritative handbook provides broad coverage in a single source along with numerous references to the available literature for more in depth information The book s two sections serve to balance coverage of theory and practical applications The first section explains the fundamentals of techniques such as evolutionary algorithms swarm intelligence cellular automata and others Detailed examples and case studies in the second section illustrate how to apply the theory in actually developing solutions to a particular problem based on a bioinspired technique Emphasizing the importance of understanding and harnessing the robust capabilities of bioinspired techniques for solving computationally intractable optimizations and decision making applications the Handbook of Bioinspired Algorithms and Applications is an absolute must read for anyone who is serious about advancing the next generation of computing **Development, Evaluation and Practical Application of Bio-inspired Algorithms** Matthias

Becker,2014

Unveiling the Power of Verbal Artistry: An Psychological Sojourn through **Cuttlefish Algorithm A Novel Bio Inspired Optimization**

In a world inundated with monitors and the cacophony of fast communication, the profound power and emotional resonance of verbal beauty usually fade in to obscurity, eclipsed by the constant onslaught of noise and distractions. Yet, located within the lyrical pages of **Cuttlefish Algorithm A Novel Bio Inspired Optimization**, a fascinating function of literary brilliance that impulses with natural feelings, lies an memorable trip waiting to be embarked upon. Penned by way of a virtuoso wordsmith, that exciting opus manuals viewers on a mental odyssey, gently exposing the latent possible and profound influence embedded within the complicated internet of language. Within the heart-wrenching expanse with this evocative analysis, we will embark upon an introspective exploration of the book is main themes, dissect its fascinating writing style, and immerse ourselves in the indelible impact it leaves upon the depths of readers souls.

Table of Contents Cuttlefish Algorithm A Novel Bio Inspired Optimization

Cuttlefish Algorithm A Novel Bio Inspired Optimization Introduction

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