Volume 7, Issue 4 ■ Q4 ■ OCT2017

S&T In-Depth

The latest in science and technology research literature

FEATURE TOPIC: BIOINSPIRED DESIGN

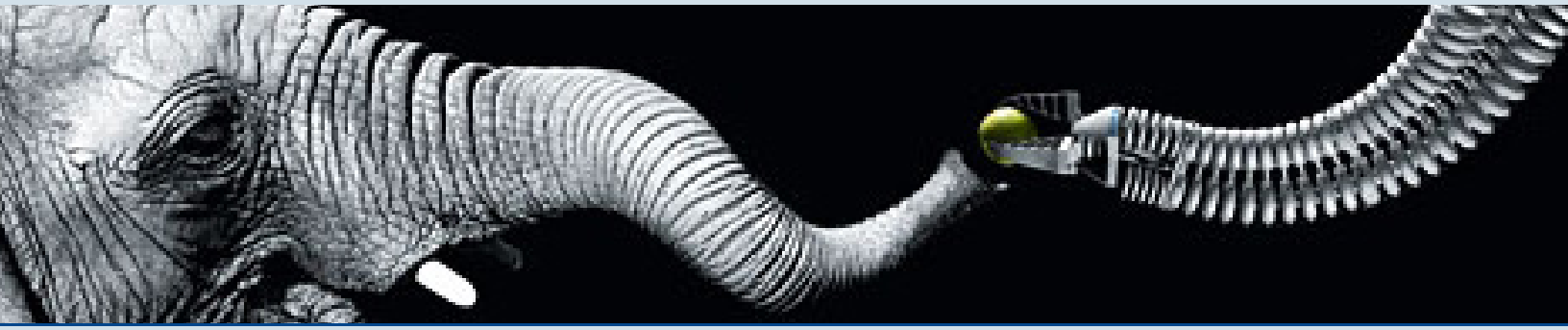


Image credit: Brandeis Bio-Inspired Design Google Site

TABLE OF CONTENTS

continued

- Limbless locomotion on solid surfaces: a case study in soft bio-inspired robotics (Italy) 2015
- An Open-source Bio-inspired Solution to Underwater SLAM (Brazil) 2015
- Petri net modeling and simulation of walking behaviour for design of a bioinspired robot dog (Turkey) 2016
- Salp Swarm Algorithm: A bio-inspired optimizer for engineering design problems (Australia) 2017
- Swimming and crawling motility at microscopic scales: from biological templates to bio-inspired devices (Italy) 2015

APPLICATION - MATERIAL DESIGN

- Application of Bio-Inspired Design to Minimize Material Diversity (USA) 2016
- Bio-inspired design and fabrication of an ultralight and strong nano-carbon gradient composite (China) 2016
- Bio-inspired design: Inner-motile multifunctional ZnO/CdS heterostructures magnetically actuated artificial cilia film for photocatalytic hydrogen evolution (China) 2015
- Bioinspired Design of an Immobilization Interface for Highly Stable, Recyclable Nanosized Catalysts (South Korea) 2015
- Bio-inspired design of SiCf-reinforced multi-layered Ti-intermetallic composite (China) 2016
- Biomimicry, an Approach, for Energy Effecient Building Skin Design (Egypt) 2016
- Development of highly durable and low friction micro-structured PDMS coating based on bio-inspired surface design (South Korea) 2015
- Rational design of bio-inspired high-performance ambipolar organic semiconductor materials based on indigo and its derivatives (China) 2015
- “Toward seashells under stress”: Bioinspired concepts to design tough layered ceramic composites (Austria) 2017

APPLICATION - PRODUCT DESIGN

- 3D Computer Animation of Biomimetic Underwater Vehicle with Magnetic Levitation Technology (India) 2016
- Assessment of a Bio-inspired Artificial Wing for Micro Aerial Vehicle Based on Structural Bio-mimetics (India) 2015
- Bio-inspired hierarchical design of composite T-joints with improved structural properties (Australia) 2015
- A Bioinspired Soft Robotic Gripper for Adaptable and Effective Grasping (Italy) 2015
- Bio-mimicry inspired tall buildings: The response of cactus-like buildings to wind action at Reynolds Number of 104 (USA) 2016
- Design of a bioinspired tunable stiffness robotic foot (China) 2016
- Flexible heat pipes with integrated bioinspired design (China) 2015
- Lessons learned from using some bio-inspired optimizers for real-time controller design for a low-cost electrohydraulic system (India) 2016
- A new biomimicry marine current turbine: Study of hydrodynamic performance and wake using software (Malaysia) 2016
- Stability of hard plates on soft substrates and application to the design of bioinspired segmented armor (Canada) 2016

APPLICATION - SENSORS

- Bio-inspired Design Methodology of Sensor-actuator-structure Integrated System for Artificial Muscle Using SMAO (China) 2017
- Bioinspired design of a polymer-based biohybrid sensor interface (Sweden) 2017
- Biomimetic self-templating optical structures fabricated by genetically engineered M13 bacteriophage (South Korea) 2015
- A biomimetic sensor for the detection of lead in water (China) 2015
- Biomimetic Tactile Sensors and Signal Processing with Spike Trains: A Review (Singapore) 2017
- Computationally modelled receptors for drug monitoring using an optical based biomimetic SPR sensor (UK) 2016
- Electro-leaf, a biomimicry system to estimate in-canopy airflow in fruit crops (USA) 2016
- Mechanoelectrical transduction in the hydrogel-based biomimetic sensors (Russia) 2016

continued

Introduction

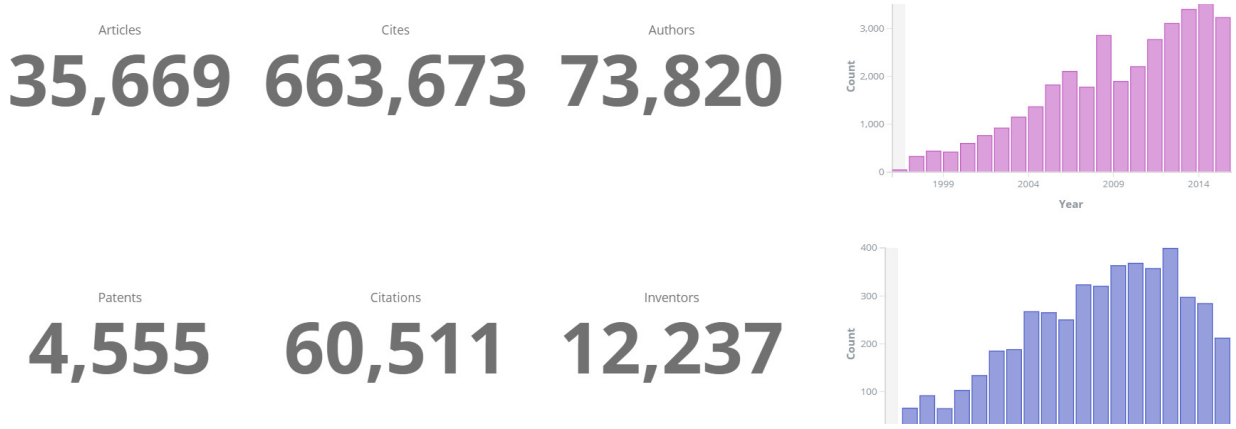
Biologically inspired engineering is an interdisciplinary field encompassing many specialty areas in biology, engineering and the physical sciences. Integrated research programs in this area span many of these disciplines and include biomimicry, as well as analysis of the way that living systems form and function using self-assembling nanomaterials, complex dynamic networks, non-linear dynamical control, self-organizing behavior, evolution, and natural selection.

https://en.wikipedia.org/wiki/Biologically_inspired_engineering

References

Bio-inspired design: An overview investigating open questions from the broader field of design-by analogy (2014)
Katherine Fu, Diana Moreno, Maria Yang, Kristin L. Wood.
Open Access

Biomimicry as an approach for bio-inspired structure with the aid of computation
Moheb SabryAzizAmr Y.El sherif
Alexandria Engineering Journal
Volume 55, Issue 1, March 2016, Pages 707-714, DOI: 10.1016/j.aej.2015.10.015
Open Access



SOURCE: ONTA's TechSight System. Data provided by Web of Science and Derwent Patent Index provided by Clarivate.

Review Articles

Beyond analogy: A model of bioinspiration for creative design (France) 2016

Camila a1, Freitas a2, Salgueiredo a3, Armand Hatchuel a4

Source: AI EDAM, Volume 30, Issue 2 (Design Computing and Cognition (DCC'14)) May 2016 , pp. 159-170; DOI: https://doi.org/10.1017/S0890060416000044

ABSTRACT: In this paper, we model the whole design process in which bioinspiration is only one element. To build this model, we use a general design theory, concept–knowledge theory, because it allows one to capture analogy as well as all other knowledge changes that lead to the design of a bioinspired solution. We ground this model on well-described examples of biologically inspired designs available in the scientific literature. Our modeling disentangles the analogical aspects of the biologically inspired design process, and highlights the expansions occurring in both knowledge bases, scientific (nonbiological) and biological, as well as the impact of these expansions in the generation of new concepts (concept partitioning). This model also shows that bioinspired design requires a special form of collaboration between engineers and biologists.

Author(s) affiliation: a1 Renault, Technocentre Guyancourt, Guyancourt, France; a2 LIVIC-COSYS, IFSTTAR, Versailles, France; a3 Sorbonne Universités, Université Pierre et Marie Curie Paris, Paris, France; a4 MinesParisTech–PSL Research University

Times cited: n/a

Tags: Review article, Bioinspired design

continued

Biomimicry as an approach for bio-inspired structure with the aid of computation (Egypt) 2016

Moheb Sabry Aziz, Amr Y. El sherif

Source: Alexandria Engineering Journal, Volume 55, Issue 1, March 2016, Pages 707-714; DOI: https://doi.org/10.1016/j.aej.2015.10.015

ABSTRACT: The biomimicry emerging field deals with new technologies honed from bio-inspired engineering at the micro and macro scale levels. Architects have been searching for answers from nature to their complex questions about different kinds of structures, and they have mimicked a lot of forms from nature to create better and more efficient structures for different architectural purposes. Without computers these complex ways and forms of structures couldn't been mimicked and thus using computers had risen the way of mimicking and taking inspiration from nature because it is considered a very sophisticated and accurate tool for simulation and computing, as a result designers can imitate different nature's models in spite of its complexity.

Author(s) affiliation: Alexandria University, Faculty of Engineering, Architectural Engineering Department, Egypt

Times cited: 2

Tags: Review article, Bioinspired design

Computer-Aided Biomimetics (UK) 2016

Kruiper, R; Chen-Burger, J; Desmulliez, MPY; Lepora, NF; Mura, A; Mangan, M; Verschure, PFMJ; Desmulliez, M; Prescott, TJ;

Sources: BIOMIMETIC AND BIOHYBRID SYSTEMS, LIVING MACHINES 2016, volume 9793, pages 131 - 143, 2016; DOI: https://doi.org/10.1007/978-3-319-42417-0_13

ABSTRACT: The interdisciplinary character of Bio-Inspired Design (BID) has resulted in a plethora of approaches and methods that propose different types of design processes. Although sustainable, creative and complex system design processes are not mutually incompatible they do focus on different aspects of design. This research defines areas of focus for the development of computational tools to support biomimetics, technical problem solving through abstraction, transfer and application of knowledge from biological models. An overview of analysed literature is provided as well as a qualitative analysis of the main themes found in BID literature. The result is a set of recommendations for further research on Computer-Aided Biomimetics (CAB).

Author(s) affiliation: Heriot-Watt UniversityEdinburghScotland, UK

Times cited: 0

Tags: Review article, Bioinspired design

Functional gradients and heterogeneities in biological materials: Design principles, functions, and bioinspired applications (USA) 2017

Zengqian Liu ab, Marc A. Meyers cd, Zhefeng Zhang b, Robert O. Ritchie a

Source: Progress in Materials Science, Volume 88, July 2017, Pages 467-498; DOI: https://doi.org/10.1016/j.pmatsci.2017.04.013

ABSTRACT: Here, we review the basic design forms and principles of naturally-occurring gradients in biological materials and discuss the functions and benefits that they confer to organisms. These gradients are fundamentally associated with the variations in local chemical compositions/constituents and structural characteristics involved in the arrangement, distribution, dimensions and orientations of the building units. The associated interfaces in biological materials invariably demonstrate localized gradients and a variety of gradients are generally integrated over multiple length-scales within the same material. It is expected that in the future bioinspired gradients and heterogeneities will play an increasingly important role in the development of high-performance materials for more challenging applications.

Author(s) affiliation: a Department of Materials Science and Engineering, University of California Berkeley, CA 94720, USA; b Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China; c Department of Nanoengineering, Materials Science and Engineering Program, University of California San Diego, La Jolla, CA 92093, USA; d Department of Mechanical and Aerospace Engineering, Materials Science and Engineering Program, University of California San Diego, La Jolla, CA 92093, USA

Times cited: 1

Tags: Review article, Application - materials design, Bioinspired design

A Protocol for Bioinspired Design: A Ground Sampler Based on Sea Urchin Jaws (USA) 2016

Frank, MB 1; Naleway, SE 1; Wirth, TS 2; Jung, JY 1; Cheung, CL 2; Loera, FB 2; Medina, S 2; Sato, KN 3; Taylor, JRA 4; McKittrick, J 5

JOURNAL OF VISUALIZED EXPERIMENTS, issue 110, 2016; DOI: 10.3791/53554

ABSTRACT: We describe the bioinspiration process as including animal observation, specimen characterization, device fabrication and mechanism bioexploration. The last step of bioexploration allows for a deeper understanding of the initial biology. The design architecture of the Aristotle's lantern is analyzed with micro-computed tomography and individual teeth are examined with scanning electron microscopy to identify the microstructure. Bioinspired designs are fabricated with a 3D printer, assembled and tested to

continued

determine the most efficient lantern opening and closing mechanism. Teeth from the bioinspired lantern design are bioexplored via finite element analysis to explain from a mechanical perspective why keeled tooth structures evolved in the modern sea urchins we observed. This circular approach allows for new conclusions to be drawn from biology and nature.

Author(s) affiliation: 1 Materials Science and Engineering Program, University of California, San Diego; 2 Department of Mechanical and Aerospace Engineering, University of California, San Diego; 3 Integrative Oceanography Division, Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography; 4 Marine Biology Research Division, Scripps Institution of Oceanography; 5 Materials Science and Engineering Program, University of California, San Diego; Department of Mechanical and Aerospace Engineering, University of California, San Diego; jmckittrick@eng.ucsd.edu.

Times Cited: 0

Tags: Review article, Bioinspired design

Review of marine animals and bioinspired robotic vehicles: Classifications and characteristics (USA) 2017

S. Zimmerman, A. Abdelkefi

Source: Progress in Aerospace Sciences, Volume 93, August 2017, Pages 95-119; DOI: https://doi.org/10.1016/j.paerosci.2017.07.005

ABSTRACT: Marine robots are a developing topic for military, scientific, and environmental missions. However, most existing marine robots are either limited to flight or limited to swimming. Therefore, the combination of both provides endless possibilities for tasks, such as espionage, pollution and marine wildlife surveillance, and border protection. Applying bioinspiration and biomimetics not only camouflages the robot, but also increases the efficiency of already perfected designs. This review gathers the characteristics of aerial-aquatic animals useful for such designs. The overview of the current marine bioinspired and non-bioinspired robots that are both aerial and aquatic are also presented, followed by the limitations and recommendations of the bioinspired robots. The main traits these systems are missing are replicating the exact weight, size, muscle movement, and skin texture of the biological animal. In order to have efficient robots, bioinspiration needs to be perfected. Doing so requires not only the basic design to be replicated, but every detail of the system to be imitated.

Author(s) affiliation: Department of Mechanical and Aerospace Engineering, New Mexico State University, Las Cruces, NM, 88003, USA

Times cited: 0

Tags: Review article, Application - product design, Bioinspired design

A study on metadata structure and recommenders of biological systems to support bio-inspired design (South Korea) 2017

Sun-Joong Kim, Ji-Hyun Lee

Source: Engineering Applications of Artificial Intelligence, Volume 57, January 2017, Pages 16-41; DOI: https://doi.org/10.1016/j.engappai.2016.10.003

ABSTRACT: Bio-inspired design was introduced as an alternative method to encourage breakthrough innovations during design projects by stimulating analogical reasoning and thinking of designers. However, the method did not perform as well as researchers expected because most designers, who are novices in the fields of biology and ecology, cannot infer the proper analogue (i.e. biological system) from nature. To resolve this fundamental problem, a causal model based representation framework for 'analogical reasoning' – searching and selecting the biological systems to apply – have been developed. In addition, ontology based repository structures and retrieval systems have been proposed to support 'analogical thinking' of designers. Nevertheless, these systematic approaches still restrict the candidates and inevitably lose potential biological systems relevant to the design project, due to the 'physical relation' biased problem and the ambiguity of the indexing mechanism of both current representation frameworks and retrieval systems. The knowledge-based system we developed allows engineering designers to search and select a particular biological system and extract design strategy without much biological knowledge. This effort provides more opportunities in a bio-inspired design process by adding potential biological systems that might previously not have been considered.

Author(s) affiliation: Graduate School of Culture Technology, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

Times cited: 0

Tags: Review article, Bioinspired design

A synthesis of logic and bio-inspired techniques in the design of dependable systems (UK) 2016

Yiannis Papadopoulos, Martin Walker, David Parker, Septavera Sharvia, Leonardo Bottaci, Sohag Kabir, Luis Azevedo, Ioannis Sorokos

Source: Annual Reviews in Control, Volume 41, 2016, Pages 170-182; DOI: https://doi.org/10.1016/j.arcontrol.2016.04.008

ABSTRACT: Much of the development of model-based design and dependability analysis in the design of dependable systems, including software intensive systems, can be attributed to the application of advances in formal logic and its application to fault

continued

forecasting and verification of systems. In parallel, work on bio-inspired technologies has shown potential for the evolutionary design of engineering systems via automated exploration of potentially large design spaces. We have not yet seen the emergence of a design paradigm that effectively combines these two techniques, schematically founded on the two pillars of formal logic and biology, from the early stages of, and throughout, the design lifecycle. The paper sketches such a model-centric paradigm for the design of dependable systems, presented in the scope of the HiP-HOPS tool and technique, that brings these technologies together to realise their combined potential benefits. The paper begins by identifying current challenges in model-based safety assessment and then overviews the use of meta-heuristics at various stages of the design lifecycle covering topics that span from allocation of dependability requirements, through dependability analysis, to multi-objective optimisation of system architectures and maintenance schedules.

Author(s) affiliation: University of Hull, Hull HU6 7RX, UK

Times cited: 4

Tags: Review article, Bioinspired design

Application - Computing

Analog Computation by DNA Strand Displacement Circuits (USA) 2016

Song, TQ; Garg, S; Mokhtar, R; Bui, H; Reif, J

Source: ACS Synth. Biol., 2016, 5 (8), pp 898-912; DOI: 10.1021/acssynbio.6b00144

ABSTRACT: DNA circuits have been widely used to develop biological computing devices because of their high programmability and versatility. Here, we propose an architecture for the systematic construction of DNA circuits for analog computation based on DNA strand displacement. The elementary gates in our architecture include addition, subtraction, and multiplication gates. The input and output of these gates are analog, which means that they are directly represented by the concentrations of the input and output DNA strands, respectively, without requiring a threshold for converting to Boolean signals. We provide detailed domain designs and kinetic simulations of the gates to demonstrate their expected performance. On the basis of these gates, we describe how DNA circuits to compute polynomial functions of inputs can be built. Using Taylor Series and Newton Iteration methods, functions beyond the scope of polynomials can also be computed by DNA circuits built upon our architecture.

Author(s) affiliation: Department of Computer Science, Duke University, Durham, North Carolina 27708, United States

Times Cited: 2

Tags: Application - computing, Bioinspired design

A bio-inspired multi-camera system for dynamic crowd analysis (Greece) 2014

Dimitrios Chrysostomou c, Georgios Ch. Sirakoulis b, Antonios Gasteratos a.

Source: Pattern Recognition Letters, Volume 44, 15 July 2014, Pages 141-151; DOI: https://doi.org/10.1016/j.patrec.2013.11.020

ABSTRACT: To begin with, the number of guards are replaced by multiple cameras whose number should be minimized. At the same time, the observability of the camera network in the available space should be dynamically maximized, so as to observe the evolving density of the crowded areas adequately. In order to achieve this objective a twofold bio-inspired method is described and implemented, based on the emergent computation of swarms to come up with solutions in complex mathematical problems. More specifically, the observations on bumblebee colonies lead us firstly to the definition of artificial bumblebee agents used to determine the number of cameras needed to maximize the observability of a space given the safety specifications emerged from the crowd analysis. Secondly, the way the spiders wave their webs was used as a source of inspiration to determine the exact positions of the cameras in the given space by artificial spider agents. The feedback of the algorithm is then used to cover the areas with significant crowd density in a dynamic fashion. Experimental results show that the algorithm is capable of producing promising results where the areas with the maximum crowd density are continuously detected and covered in a dynamic way

Author(s) affiliation: a Laboratory of Robotics and Automation, Democritus University of Thrace, Dept. of Production Engineering and Management, Vas. Sophias 12, GR-671 00 Xanthi, Greece;
b Laboratory of Electronics, Democritus University of Thrace, Dept. of Electrical and Computer Engineering, Panepistimioupoli, Kimmeria, GR-671 00 Xanthi, Greece; c Department of Mechanical and Manufacturing Engineering, Aalborg University, Fibigestraede 16, DK-9220 Aalborg East, Denmark

Times cited: 3

Tags: Application - computing, Application - product design, Bioinspired design

Design of bio-inspired computational intelligence technique for solving steady thin film flow of Johnson-Segalman fluid on vertical cylinder for drainage problems (Pakistan) 2016

Muhammad Asif Zahoor Raja a, Fiaz Hussain Shah a, Abdul Ahad Khan a, Najeeb Alam Khan b

Source: Journal of the Taiwan Institute of Chemical Engineers, Volume 60, March 2016, Pages 59-75; DOI: https://doi.org/10.1016/j.jtice.2015.10.020

ABSTRACT: In the present study, bio-inspired computing technique is designed for solving governing mathematical relation for steady thin film flow of Johnson–Segalman fluid on vertical cylinder for drainage problems using Artificial Neural Networks (ANNs),

continued

genetic algorithms (GAs) and active-set algorithm (ASA). The strength of ANN modeling is exploited for the transformed equation of drainage problem which is derived from original partial differential equation using similarity transform. Training of design parameter of ANNs is carried out with evolutionary computing approach based on GAs hybrid with ASA for rapid local convergence. Design scheme is evaluated for number of cases of all four scenarios of drainage problem based on variations in Stokes number, Weissenberg number, ratio of viscosities, and slip parameters. Comparison of the results is made with Adams numerical method for each case in order to validate the accuracy of the proposed scheme. Results of statistical analysis in terms of performance measures based on mean, standard deviation, mean absolute deviation, root mean square error and Nash–Sutcliffe efficiency as well as their global variations further established the worth of the given scheme for each variant of drainage problem.

Author(s) affiliation: a Department of Electrical Engineering, COMSATS Institute of Information Technology, Attock Campus, Attock 43600, Punjab, Pakistan; b Department of Mathematical Sciences, University of Karachi, Karachi 75270, Pakistan

Times cited: 9

Tags: Application - computing, Bioinspired design

Design of bio-inspired heuristic technique integrated with interior-point algorithm to analyze the dynamics of heartbeat model (Pakistan) 2017

Muhammad Asif Zahoor Raja a, Fiaz Hussain Shah a, Eman Salem Alaidarous b, Muhammad Ibrahim Syam c

Source: Applied Soft Computing, Volume 52, March 2017, Pages 605-629; DOI: https://doi.org/10.1016/j.asoc.2016.10.009

ABSTRACT: In this study, bio-inspired computing is presented for finding an approximate solution of governing system represents the dynamics of the HeartBeat Model (HBM) using feed-forward Artificial Neural Networks (ANNs), optimized with Genetic Algorithms (GAs) hybridized with Interiort-Point Algorithm (IPA). The modeling of the system is performed with ANNs by defining an unsupervised error function and optimization of unknown weights are carried out with GA-IPA; in which, GAs is used as an effective global search method and IPA for rapid local convergence. Design scheme is applied to study the dynamics of HBM by taking different values for perturbation factor, tension factor in the muscle fiber and the length of the muscle fiber in the diastolic state. A large number of simulations are performed for the proposed scheme to determine its effectiveness and reliability through different performance indices based on mean absolute deviation, Nash-Sutcliffe efficiency, and Thiel's inequality coefficient.

Author(s) affiliation: a Department of Electrical Engineering, COMSATS Institute of Information Technology, Attock Campus, Attock, Punjab, Pakistan; b Department of Mathematics, King Abdulaziz University, Jeddah 21589, Saudi Arabia; c Department of Mathematical Sciences, UAEU P O Box 15551, Al-Ain, United Arab Emirates

Times cited: 1

Tags: Application - computing, Bioinspired design

Neuromorphic Computing Based on Emerging Memory Technologies (France) 2016

Rajendran, B 1; Alibart, F 2

Source: IEEE JOURNAL ON EMERGING AND SELECTED TOPICS IN CIRCUITS AND SYSTEMS, issue 2, volume 6, pages 198 - 211, 2016; DOI: 10.1109/JETCAS.2016.2533298

ABSTRACT: In this paper, we review some of the novel emerging memory technologies and how they can enable energy-efficient implementation of large neuromorphic computing systems. We will highlight some of the key aspects of biological computation that are being mimicked in these novel nanoscale devices, and discuss various strategies employed to implement them efficiently. Though large scale learning systems have not been implemented using these devices yet, we will discuss the ideal specifications and metrics to be satisfied by these devices based on theoretical estimations and simulations. We also outline the emerging trends and challenges in the path towards successful implementations of large learning systems that could be ubiquitously deployed for a wide variety of cognitive computing tasks.

Author(s) affiliation: Department of Electrical and Computer Engineering, New Jersey Institute of Technology, Newark, NJ, USA; 2 Institut of Electronic, Microelectronic and Nanotechnology, CNRS, Villeneuve d'Ascq, France

Times Cited: 1

Tags: Application - computing, Bioinspired design

On Building Practical Biocomputers for Real-world Applications: Receptacles for Culturing Slime Mould Memristors and Component Standardisation (UK) 2017

Edward Braund, Eduardo Reck Miranda

Source: Journal of Bionic Engineering, Volume 14, Issue 1, January 2017, Pages 151-162; DOI: https://doi.org/10.1016/S1672-6529(16)60386-4

ABSTRACT: Our application of bionic engineering is novel: we are interested in developing hybrid hardware-wetware systems for music. This paper introduces receptacles for culturing Physarum polycephalum-based memristors that are highly accessible to the creative practitioner. The myxomycete Physarum polycephalum is an amorphous unicellular organism that has been found

continued

to exhibit memristive properties. Such a discovery has potential to allow us to move towards engineering electrical systems that encompass Physarum polycephalum components. To realise this potential, it is necessary to address some of the constraints associated with harnessing living biological entities in systems for real-time application. Within the paper, we present 3D printed receptacles designed to standardise both the production of components and memristive observations. Subsequent testing showed a significant decrease in growth time, increased lifespan, and superior similarity in component-to-component responses. The results indicate that our receptacle design may provide means of implementing hybrid electrical systems for music technology.

Author(s) affiliation: Interdisciplinary Centre for Computer Music Research (ICCMR), The House, Plymouth University, Drake Circus, UK, PL4 8AA

Times Cited: 0

Tags: Application - computing, Bioinspired design

Spintronic Nanodevices for Bioinspired Computing (France) 2016

Grollier, J; Querlioz, D; Stiles, MD;

Source: PROCEEDINGS OF THE IEEE, issue 10, volume 104, special issue SI, pages 2024 - 2039, 2016; DOI: 10.1109/JPROC.2016.2597152

ABSTRACT: Bioinspired hardware holds the promise of low-energy, intelligent, and highly adaptable computing systems. Applications span from automatic classification for big data management, through unmanned vehicle control, to control for biomedical prosthesis. However, one of the major challenges of fabricating bioinspired hardware is building ultra-high-density networks out of complex processing units interlinked by tunable connections. Nanometer-scale devices exploiting spin electronics (or spintronics) can be a key technology in this context. In particular, magnetic tunnel junctions (MTJs) are well suited for this purpose because of their multiple tunable functionalities. In this paper, we show how spintronics can be used for bioinspired computing. We review the different approaches that have been proposed, the recent advances in this direction, and the challenges toward fully integrated spintronics complementary metal-oxide-semiconductor (CMOS) bioinspired hardware.

Author(s) affiliation: Univ Paris Saclay, Univ Paris 11, CNRS, Unite Mixte Phys, F-91767 Palaiseau, France; Univ Paris Saclay, CNRS, Ctr Nanosci & Nanotechnol, F-91405 Orsay, France; NIST, Ctr Nanoscale Sci & Technol, Gaithersburg, MD 20899 USA

Times Cited: 6

Tags: Application - computing, Review article, Application - product design, Bioinspired design

Application - Locomotion

BCF swimming locomotion for autonomous underwater robots: a review and a novel solution to improve control and efficiency (Italy) 2017

David Scaradozzi ab, Giacomo Palmieri c, Daniele Costa c, Antonio Pinelli a

Source: Ocean Engineering, Volume 130, 15 January 2017, Pages 437-453; DOI: https://doi.org/10.1016/j.oceaneng.2016.11.055

ABSTRACT: Over millions of years in a vast and often hostile realm, fish have evolved swimming capabilities far superior in many ways to what has been achieved by nautical technology. Looking at nature for inspiration as to how design an Autonomous Underwater Vehicle can significantly improve its flexibility and efficiency. This paper presents an examination of the state of the art on biomimetic robotic fishes, underlining the reasons why bio-inspiration can be a winning move and discussing how fish swimming can be the line of sight of the future locomotion technology. The paper concludes with a novel mechanism proposal, designed to produce optimal oscillatory motion between the flexible parts constituting the hull of the robotic fish.

Author(s) affiliation: a Dipartimento di Ingegneria dell'Informazione, Università Politecnica delle Marche, 60131 Ancona, Italy, b Laboratoire des Sciences de l'Information et des Systèmes - Equipe I&M (ESIL) - umr CNRS 6168, 13288 Marseille cedex 9, France, c Industrial Engineering and Mathematical Science, Università Politecnica delle Marche, 60131 Ancona, Italy

Times cited: 2

Tags: Application - locomotion, Application - product design, Bioinspired design

Bio-inspired approach to learning robot motion trajectories and visual control commands (Serbia) 2016

Marko Mitić, Zoran Miljković

Source: Expert Systems with Applications, Volume 42, Issue 5, 1 April 2015, Pages 2624-2637; DOI: https://doi.org/10.1016/j.eswa.2014.10.053

ABSTRACT: In this paper, a novel bio-inspired learning control approach (BILCA) for mobile robots based on Learning from Demonstration (LfD), Firefly Algorithm (FA), and homography between current and target camera view is developed. BILCA consists of two steps: (i) first step in which the actuator commands are learned using FA and demonstrations of desired behavior, and (ii) second step in which the obtained wheel commands are evaluated through the real world experiment. Two different

continued

problems are considered in this study: trajectory reproduction, and generation of visual control commands for correction of robot orientation. Developed simulations are used to evaluate BILCA in the domain of learning actuator commands for reproduction of different complex trajectories. Results show that the bigger firefly swarms produce better results in terms of accuracy in the final mobile robot pose, and that the desired trajectory is reproduced with minimal error in final control iteration. Likewise, simulations prove that the FA outperforms other metaheuristic techniques. Experiment conducted on a real mobile robot in indoor environment unifies two considered problems within a single transportation task.

Author(s) affiliation: University of Belgrade, Faculty of Mechanical Engineering, Production Engineering Department, Kraljice Marije 16, 11120 Belgrade 35, Serbia

Times cited: 10

Tags: Application - locomotion, Application - product design, Bioinspired design

Bio-inspired Collision-free 4D Trajectory Generation for UAVs Using Tau Strategy (China) 2016

Zuqiang Yang, Zhou Fang, Ping Li

Source: Journal of Bionic Engineering, Volume 13, Issue 1, January 2016, Pages 84-97; DOI: https://doi.org/10.1016/S1672-6529(14)60162-1

ABSTRACT: Inspired by the general tau theory in animal motion planning, a collision-free four-dimensional (4D) trajectory generation method is presented for multiple Unmanned Aerial Vehicles (UAVs). This method can generate a group of optimal or near-optimal collision-free 4D trajectories, the position and velocity of which are synchronously planned in accordance with the arrival time. To enlarge the shape adjustment capability of trajectories with zero initial acceleration, a new strategy named intrinsic tau harmonic guidance strategy is proposed on the basis of general tau theory and harmonic motion. In the case of multiple UAVs, the 4D trajectories generated by the new strategy are optimized by the bionic Particle Swarm Optimization (PSO) algorithm. In order to ensure flight safety, the protected airspace zone is used for collision detection, and two collision resolution approaches are applied to resolve the remaining conflicts after global trajectory optimization. Numerous simulation results of the simultaneous arrival missions demonstrate that the proposed method can effectively provide more flyable and safer 4D trajectories than that of the existing methods.

Author(s) affiliation: School of Aeronautics and Astronautics, Zhejiang University, Hangzhou 310027, China

Times cited: 2

Tags: Application - locomotion, Bioinspired design

Bio-Inspired Design: Aerodynamics of Boxfish (Australia) 2015

Andrei Kozlov, Harun Chowdhury, Israt Mustary, Bavin Loganathan, Firoz Alam

Source: Procedia Engineering, Volume 105, 2015, Pages 323-328; DOI: https://doi.org/10.1016/j.proeng.2015.05.007

ABSTRACT: This paper investigates the aerodynamic behavior of a boxfish using both experimental and computational methods. A scaled up model boxfish was manufactured and tested in RMIT Industrial Wind Tunnel under a range of Reynolds numbers and yaw angles. The drag, lift and side forces and their corresponding moments were measured simultaneously. A CAD model of the boxfish was used in CFX FLUENT Computational Fluid Dynamics (CFD) modeling. The CFD modeling data were validated using the experimental findings. The results indicate that the drag coefficient of a boxfish is around 0.10 which is significantly lower than current drag coefficient of a passenger car. Hence, a boxfish shape can be adapted for achieving low drag and energy efficient motor vehicle design.

Author(s) affiliation: School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, Melbourne, 3083, Australia

Times cited: n/a

Tags: Application - locomotion, Application - product design, Bioinspired design

Bio-inspired Flow Sensing and Prediction for Fish-like Undulating Locomotion: A CFD-aided Approach (China) 2015

Han Zhou a, Tianjiang Hu ab, Kin Huat Low c, Lincheng Shen a, Zhaowei Ma a, Guangming Wang a, Haijun Xu a

Source: Journal of Bionic Engineering, Volume 12, Issue 3, July 2015, Pages 406-417; DOI: https://doi.org/10.1016/S1672-6529(14)60132-3

ABSTRACT: Inspired from fish sensing their external flow via near-body pressure, a computational scheme is proposed and developed in this paper. In conjunction with the scheme, Computational Fluid Dynamics (CFD) is employed to study the bio-inspired fish swimming hydrodynamics. The spatial distribution and temporal variation of the near-body pressure of fish are studied over the whole computational domain. Furthermore, a filtering algorithm is designed and implemented to fuse near-body pressure of one or multiple points for the estimation on the external flow. The simulation results demonstrate that the proposed computational scheme and its corresponding algorithm are both effective to predict the inlet flow velocity by using near-body pressure at distributed spatial points.

continued

Author(s) affiliation: a College of Mechatronics and Automation, National University of Defense Technology, Changsha 410073, China, b State Key Laboratory of High Performance Computing, National University of Defense Technology, Changsha 410073, China, c School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore 639798
Times cited: 6
Tags: Application - locomotion, Bioinspired design

Bio-inspired self-organising multi-robot pattern formation: A review (South Korea) 2017

Hyondong Oh a, Ataollah Ramezan Shirazi b, Chaoli Sun b, Yaochu Jin b
Source: Robotics and Autonomous Systems, Volume 91, May 2017, Pages 83-100; DOI: https://doi.org/10.1016/j.robot.2016.12.006

ABSTRACT: Self-organised emergent patterns can be widely seen in natural and man-made complex systems generated by interactions among local components without external or global control. This paper presents a survey of recent research advances in self-organising pattern formation in mobile multi-robot (or swarm robotic) systems. Relevant pattern formation methods are reviewed with a special focus on biologically-inspired self-organising approaches inspired from macroscopic collective behaviours or microscopic multicellular developing mechanisms. As the ultimate goal of this review is to provide insight into pattern formation using real robots, limitations and considerations on dealing with a large number of robots are discussed. In addition, guided self-organisation is also discussed as a design strategy where the swarm robotic system may be endowed with local rules for generating desired global patterns.

Author(s) affiliation: a Department of Mechanical and Nuclear Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan, 44919, Republic of Korea, b Department of Computer Science, University of Surrey, Guildford, Surrey, GU2 7XH, UK
Times cited: 1
Tags: Application - locomotion, Review article

Bird-mimetic Wing System of Flapping-wing Micro Air Vehicle with Autonomous Flight Control Capability (South Korea) 2016

Sriyulianti Widhiarini a, Ji Hwan Park a, Bum SooYoon a, Kwang JoonYoon a, Il-Hyun Paik b, Jong Heon Kim c, Chan Yik Park c, Seung Moon Jun c, Changho Nam d
Source: Journal of Bionic Engineering, Volume 13, Issue 3, July 2016, Pages 458-467; DOI: https://doi.org/10.1016/S1672-6529(16)60319-0

ABSTRACT: A micro air vehicle with a bird-mimetic up-down and twisting wing drive system was developed in this study. The Flapping-wing Micro Air Vehicle (FMAV), with a 50 cm wingspan and a double-crank drive system, performed successful flights of up to 23 min. The performance and capabilities of the FMAV were enhanced by adapting a number of unique features, such as a bird-mimetic wing shape with a span-wise camber and an up-down and twisting wing drive mechanism with double-crank linkages. This lift-enhancing design by mimicking the flapping mechanism of a bird's wing enabled the 210 g FMAV to fly autonomously in an outdoor field under wind speeds of less than 5 m·s−1. Autonomous flight was enabled by installing a flight control computer with a micro-electro-mechanical gyroscope and accelerometers, along with a micro video camera and an ultralight wireless communication system inside the fuselage.

Author(s) affiliation: a Department of Aerospace Engineering, Konkuk University, Gwangjin-gu, Seoul, South Korea; b Deptartment of PGM Technology, Hanwha Corp. R&D Center, Daejeon, South Korea; c Agency for Defense Development, Daejeon, South Korea; d Department of Engineering Technology, Arizona State University, Mesa, Arizona
Times cited: 1
Tags: Application - locomotion, Bioinspired design

A Brief Survey on Bio-inspired Algorithms for Autonomous Landing (India) 2016

Amritesh Maitra a, Sri Ram Prasath ab, Radhakant Padhi abc
Source: IFAC-PapersOnLine, Volume 49, Issue 1, 2016, pp. 407-412; DOI: https://doi.org/10.1016/j.ifacol.2016.03.088

ABSTRACT: The paper briefly introduces a few bio-inspired algorithms which can be applied to autonomous landing for Unmanned Aerial Vehicles (UAVs). A number of vision based data acquisition methodologies used for UAV navigation and guidance are described. Monocular camera based vision data can be used to extract plethora of information about the dynamics of a target plane in landing problems and also about the pose of the camera itself. Some recent developments in the areas of autonomous landing and perching based on vision data from monocular camera are introduced. Some possible relevant extensions are also provided.

Author(s) affiliation: a Aerospace Engineering Department, Indian Institute of Science, ab Aerospace Engineering Department, Indian Institute of Science, abc Aerospace Engineering Department, Indian Institute of Science, Bangalore
Times cited: 0
Tags: Application - locomotion, Bioinspired design

continued

Design, swimming motion planning and implementation of a legged underwater robot (CALEB10: D.BeeBot) by biomimetic approach (South Korea) 2017

Heejoong Kim a, Jihong Lee b

Source: Ocean Engineering, Volume 130, 15 January 2017, Pages 310-327; DOI: https://doi.org/10.1016/j.oceaneng.2016.11.006

ABSTRACT: In this paper, we propose swimming pattern generator (SPG) which is mimicking locomotion of diving beetles with a view point of bimomimetics for legged underwater robots. Firstly, the locomotion of the diving beetle has been observed and classified through experiments with a motion capture system consist of a high-speed camera and imaging processing software Image. Subsequently, we analyzed coordinated patterns of rhythmic movements of the diving beetle's leg and formulated equations by employing Fourier least mean square fitting method corresponding to the obtained raw data from the motion capture system. Based on this, control parameters have been determined by understating their characteristics through the procedure of comparing produced swimming trajectories according to varying their values to observed motions of the diving beetle. Consequently the number of parameters has been successfully reduced for effective real time application of SPG. Furthermore, a six legged underwater robot has been developed by considering structural advantages that diving beetles have for their effective swimming. Underwater experiments have been conducted to confirm the feasibility of the proposed idea.

Author(s) affiliation: a Agency for Defense Development, P.O.Box 35, Yuseong-gu, Daejeon 305-600, Republic of Korea, b Chungnam National University, 79 Daegang-ro, Yuseong-gu, Daejeon 305-764, Republic of Korea

Times cited: 1

Tags: Application - locomotion, Bioinspired design

Design of biomimetic robofish system (China) 2017

Liu L., Sun Z., Wang J., Shi Y., Gao M., Chen J.

Source: Revista de la Facultad de Ingenieria, Volume 32, 2017

ABSTRACT: In this paper, the mechanism of fish movement propelled by carangiform and lunular tailfins was analyzed. A one-dimensional steady-state swimming model was established according to the three turning forms and five up-and-down locomotion patterns of robot fishes. Through the analysis of the drag forces and thrusts acted on oscillating fishes, we constructed a kinetic equation of robofishes, and determined itsbasic kinematic parameters. With a steering engine as the component of driving units, we designed a three-joint biomimetic robofish (consisting of the head, the body and the fin sections) to simulate its internal structure. The microcontroller system was employed to build up an infrared-obstacle-avoidance-sensor-based control system, in which CPG control model was used wirelessly to perform remote control on the robot fish.

Author(s) affiliation: College of Mechanical and Electronic Engineering, Northwest AandF University, Yangling, China

Times cited: n/a

Tags: Application - locomotion, Application - product design

Energy-efficient Bio-inspired Gait Planning and Control for Biped Robot Based on Human Locomotion Analysis (China) 2016

Hongbo Zhu ab, Minzhou Luo b, Tao Mebi b, Jianghai Zhao b, Tao Li b, Fayong Guo b

Source: Journal of Bionic Engineering, Volume 13, Issue 2, April 2016, Pages 271-282; DOI: https://doi.org/10.1016/S1672-6529(16)60300-1

ABSTRACT: In this paper an experiment of human locomotion was carried out using a motion capture system to extract the human gait features. The modifiable key gait parameters affecting the dominant performance of biped robot walking were obtained from the extracted human gait features. Based on the modifiable key gait parameters and the Allowable Zero Moment Point (ZMP) Variation Region (AZR), we proposed an effective Bio-inspired Gait Planning (BGP) and control scheme for biped robot towards a given travel distance D. First, we construct an on-line Bio-inspired Gait Synthesis algorithm (BGSN) to generate a complete walking gait motion using the modifiable key gait parameters. Second, a Bio-inspired Gait Parameters Optimization algorithm (BGPO) is established to minimize the energy consumption of all actuators and guarantee biped robot walking with certain walking stability margin. Third, the necessary controllers for biped robot were introduced in briefly. Simulation and experiment results demonstrated the effectiveness of the proposed method, and the gait control system was implemented on DRC-XT humanoid robot.

Author(s) affiliation: a Department of Automation, School of Information Science and Technology, University of Science and Technology of China, Hefei 230022, China, b Institute of Advanced Manufacturing Technology, Hefei Institutes of Physical Science, Chinese Academy of Sciences, Changzhou 213164, China

Times cited: 1

Tags: Application - locomotion, Bioinspired design

continued

Limbless locomotion on solid surfaces: a case study in soft bio-inspired robotics (Italy) 2015

Giancarlo Cicconofri a, Antonio DeSimone ab

Source: IFAC-PapersOnLine, Volume 48, Issue 1, 2015, Pages 827-828, DOI: https://doi.org/10.1016/j.ifacol.2015.05.178

ABSTRACT: We examine the problem of snake-like locomotion by studying a model system consisting of a planar inextensible elastic rod that is able to control its spontaneous curvature. Using Cosserat theory we derive the equations of motion for two special cases: one in which the system is confined inside a channel with frictionless walls, and one in which the system is placed on an anisotropic frictional environment with an infinite contrast between longitudinal and transversal friction, so that the rod can slide longitudinally along its axis, but cannot slip laterally (i.e., in the transversal direction). The results obtained by solving these equations of motion are reminiscent of classical experimental results in the biological literature, and provide a scheme to rationalise the observed behaviour.

Author(s) affiliation: a SISSA-International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy, ab SISSA-International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy.

Times cited: 0

Tags: Application - locomotion, Bioinspired design

An Open-source Bio-inspired Solution to Underwater SLAM (Brazil) 2015

Luan Silveira, Felipe Guth, Paulo Drews-Jr, Pedro Ballester, Matheus Machado, Felipe Codevilla, Nelson Duarte-Filho, Silvia Botelho

Source: IFAC-PapersOnLine, Volume 48, Issue 2, 2015, Pages 212-217; DOI: https://doi.org/10.1016/j.ifacol.2015.06.035

ABSTRACT: We present a bio-inspired approach to deal with the localization and spatial mapping problem, extending the successful previous RatSLAM approach from 2D ground vehicles to the 3D underwater environments. Our approach, called DolphinSLAM, is a SLAM system based on mammals navigation. Experiments in simulation and real environments were conducted involving long-term navigation tasks with different robots and sensors. Our proposal is open- source, being integrated with the Robot Operating System (ROS).

Author(s) affiliation: Universidade Federal do Rio Grande - FURG NAUTEC - Centro de Ciencias Computacionais Rio Grande, RS, Brazil

Times cited: 7

Tags: Application - locomotion, Bioinspired design

Petri net modeling and simulation of walking behaviour for design of a bioinspired robot dog (Turkey) 2016

Zuhal Erden a, Macit Araz b

Source: 2016 6th International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH), 29-31 July 2016, Lisbon, Portugal

ABSTRACT: This paper reports a research that focuses on the development of a Petri Net model to represent a biological system's behavior. The model is based on real time data collected from an experiment in which a dog is walking on a treadmill with a speed of 1km/h. The model has the ability of simulating the real time rhythm of dog's walking behavior utilizing colors and numbers as well as the step-by-step simulation. The aim is to observe the behavior of a walking dog in time domain as an early stage of conceptual design of a bioinspired robot dog. Main challenge is to develop a methodology to guide designer towards more creative designs based on bioinspired design ideas. The presented work is an early attempt to initiate a systematic approach towards the stated goal.

Author(s) affiliation: a Department of Mechatronics Engineering, ATILIM University, Kizilcasar Mah., Incek, Ankara, Turkey; b Micro-Electro-Mechanical Systems Research and Application Center, Middle East Technical University, Ankara, Turkey

Times cited: n/a

Tags: Application - locomotion, Bioinspired design, Application - product design

Salp Swarm Algorithm: A bio-inspired optimizer for engineering design problems (Australia) 2017

Seyedali Mirjalili a, Amir H. Gandomi bf, Seyedeh Zahra Mirjalili c, Shahrzad Saremi a, Hossam Faris d, Seyed Mohammad Mirjalili e

Source: Advances in Engineering Software, In Press, Corrected Proof, Available online 24 July 2017; DOI: https://doi.org/10.1016/j.advengsoft.2017.07.002

ABSTRACT: This work proposes two novel optimization algorithms called Salp Swarm Algorithm (SSA) and Multi-objective Salp Swarm Algorithm (MSSA) for solving optimization problems with single and multiple objectives. The main inspiration of SSA and MSSA is the swarming behaviour of salps when navigating and foraging in oceans. These two algorithms are tested on several mathematical optimization functions to observe and confirm their effective behaviours in finding the optimal solutions for optimization problems. The results of MSSA show that this algorithm can approximate Pareto optimal solutions with high

continued

convergence and coverage. The paper also considers solving several challenging and computationally expensive engineering design problems (e.g. airfoil design and marine propeller design) using SSA and MSSA. The results of the real case studies demonstrate the merits of the algorithms proposed in solving real-world problems with difficult and unknown search spaces.

Author(s) affiliation: a Institute for Integrated and Intelligent Systems, Griffith University, Nathan, QLD 4111, Australia; b School of Business, Stevens Institute of Technology, Hoboken, NJ 07030, USA; c School of Electrical Engineering and Computing, University of Newcastle, Callaghan, NSW 2308, Australia; d Business Information Technology Department, King Abdullah II School for Information Technology, The University of Jordan, Amman, Jordan; e Department of Electrical and Computer Engineering, Concordia University, Montreal, Quebec, H3G1M8, Canada; f BEACON Center for the Study of Evolution in Action, Michigan State University, East Lansing, MI 488241, USA

Times cited: 0

Tags: Application - locomotion, Bioinspired design

Swimming and crawling motility at microscopic scales: from biological templates to bio-inspired devices (Italy) 2015

Antonio DeSimone a, Giancarlo Cicconofri ab

Source: IFAC-PapersOnLine, Volume 48, Issue 1, 2015, Pages 825-826; DOI: https://doi.org/10.1016/j.ifacol.2015.05.179

ABSTRACT: We discuss the mechanical bases of cellular motility by swimming and crawling. Special emphasis is placed on the connections between low Reynolds number swimming and Geometric Control Theory, and on the geometric structure of the underlying equations of motion. We examine some concrete examples, taken from the case studies that have been recently considered by our group. These include reverse engineering of the euglenoid movement, self-propelled droplets of active fluids, and one-dimensional models of slender crawlers.

Author(s) affiliation: a SISSA-International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy, ab SISSA-International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy.

Times cited: 0

Tags: Application - locomotion, Bioinspired design

Application - Material Design

Application of Bio-Inspired Design to Minimize Material Diversity (USA) 2016

Katie S. McCullar1, Preston C. Rhodes2, S. Austin Underhill3, Jacquelyn K.S. Nagel, Ph.D.4

Source: Proceedings of the ASME 2015 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2016

August 21-24, 2016, Charlotte, North Carolina, USA

ABSTRACT: In this project we take inspiration from biological morphologies to develop new forms for semi-recyclable products. Biological systems exhibit multi-functionality from form, not necessarily material, which offers inspiration for product life-cycle management. The goal is to better understand the connection between form and function as found in nature to enable ustainable product design and enhance additive manufacturing processes. Through the application of bio-inspired design product recyclability is increased through minimization of material diversity while still achieving desired functions.

Author(s) affiliation: 1Department of Biology, James Madison University, Harrisonburg, VA, USA; 2 Department of Integrated Science and Technology, James Madison University, Harrisonburg, VA, USA; 3Department of Engineering, James Madison University, Harrisonburg, VA, USA; 4Department of Engineering, James Madison University, Harrisonburg, VA, USA

Times cited: n/a

Tags: Application - material design, Bioinspired design

Bio-inspired design and fabrication of an ultralight and strong nano-carbon gradient composite (China) 2016

Yanjie Wang a, Min Li a, Weibang Lu b, Yizhuo Gu a, Shaokai Wang a, Rui Sun b, Xuetong Zhang b, Qingwen Li b, Zuoguang Zhang a

Source: Materials & Design, Volume 107, 5 October 2016, Pages 198-204; DOI: https://doi.org/10.1016/j.matdes.2016.06.042

ABSTRACT: A nano-carbon composite, consisting of a graphene aerogel-carbon nanotube (CNT) film, is constructed by coating a strong and flexible CNT film onto the surface of a porous graphene aerogel core. The prepared gradient composite, ultralight and strong, can carry objects more than 15,000 times its own weight, exhibiting impressive compression resistance. Compared to the original graphene aerogel, the composite exhibits 8–9-fold increased values in its elastic modulus and compressive strength at a strain of 20% and an approximately 10-fold increase in electrical conductivities in the axial direction. In addition, the elastic recovery ability after compressive deformation and the ability to preserve liquid are also improved.

continued

Author(s) affiliation: a Key Laboratory of Aerospace Advanced Materials and Performance, Ministry of Education, School of Materials Science and Engineering, Beihang University, No. 37 Xueyuan Road, Haidian District, Beijing 100191, China; b Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, No. 398 Ruoshui Road, Suzhou 215123, China;
Times cited: 1
Tags: Application - material design, Bioinspired design

Bio-inspired design: Inner-motile multifunctional ZnO/CdS heterostructures magnetically actuated artificial cilia film for photocatalytic hydrogen evolution (China) 2015

Fengping Peng a, Qiang Zhou a, Dunpu Zhang a, Chunhua Lu a, Yaru Ni ab, Jiahui Kou a, Jian Wang a, Zhongzi Xu a
Source: Applied Catalysis B: Environmental, Volume 165, April 2015, Pages 419-427; DOI: https://doi.org/10.1016/j.apcatb.2014.09.050

ABSTRACT: A novel inner-motile film for photocatalytic water splitting has been designed for the first time. The inner-motile photocatalyst film is a highly elaborate machinery and mainly integrates three functional modules – magnetically actuated artificial cilia, ZnO nanowires arrays and CdS quantum dots, which can work synergistically to enhance the photocatalytic hydrogen evolution activity. Through citing magnetically actuated artificial cilia, the inner-motile film can mimic ciliary motion like nature beating cilia under a rotational magnetic field. Hence it exhibits a singular ability of microfluidic manipulation, which is helpful to solve the stubborn problem of desorption of hydrogen and promotes release of active sites. Furthermore, the photocatalytic modules – coupled ZnO/CdS heterostructures based on the Z-scheme mechanism has been devised to enhance electron–hole separation and interfacial charge transfer, in which ZnO and CdS serve as PS II and PS I, respectively. Consequently, the H2 evolution rates of ZnO nanowires arrays/CdS heterostructures are about 2.7 times, 2.0 times of CdS substance and ZnO nanoparticles/CdS heterostructures, respectively. The design of the inner-motile system film is based on both nature cilia and photosynthesis, which would broaden the horizon for constructing artificial photocatalyst system and provide a new working prototype for photochemical hydrogen production.

Author(s) affiliation: a State Key Laboratory of Materials-Orient Chemical Engineering, College of Materials Science and Engineering, Nanjing Tech University, Nanjing 210009, PR China; b Southeast University, Nanjing 210096, PR China
Times cited: 20
Tags: Application - material design, Bioinspired design

Bioinspired Design of an Immobilization Interface for Highly Stable, Recyclable Nanosized Catalysts (South Korea) 2015

Insu Kim a, Ho Yeon Son a, Moon Young Yang b, Yoon Sung Nam b
Source: ACS Appl. Mater. Interfaces, 2015, 7 (26), pp 14415–14422; DOI: 10.1021/acsami.5b03249

ABSTRACT: To maintain a high activity of immobilized nanocatalysts, it is critically important to design an interface that minimizes the contact area and favors reaction chemistry. Here we report on the application of mussel-inspired adhesion chemistry to the formation of catalytic metal nanocrystal-polydopamine hybrid materials that exhibit a high catalytic efficiency during recycled uses. Electrospun polymer nanofibers are used as a template for in situ formation and immobilization of gold nanoparticles via polydopamine-induced reduction of ionic precursors. The prepared hybrid nanostructures exhibit a recyclable catalytic activity for the reduction of 4-nitrophenol with a turnover frequency of 3.2-5.1 μmol g(-1) min(-1). Repeated uses of the hybrid nanostructures do not significantly alter their morphology, indicating the excellent structural stability of the hybrid nanostructures. We expect that the polydopamine chemistry combined with the on-surface synthesis of catalytic nanocrystals is a promising route to the immobilization of various colloidal nanosized catalysts on supporting substrates for long-term catalysis without the physical instability problem.

Author(s) affiliation: a Department of Materials Science and Engineering; b KAIST Institute for NanoCentury (KINC CNiT), Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea
Times cited: n/a
Tags: Application - material design, Bioinspired design

Bio-inspired design of SiCf-reinforced multi-layered Ti-intermetallic composite (China) 2016

Wenbo Yu a, Kai Zhu a, Yann Aman b, Zhipeng Guo a, Shoumei Xiong a
Source: Materials & Design, Volume 101, 5 July 2016, Pages 102-108; DOI: https://doi.org/10.1016/j.matdes.2016.03.138

ABSTRACT: In reference to the well-evolved keratin layer of turtle shell, which has a collagen fiber-reinforced multi-layered structure, bio-mimicking SiCf-reinforced Ti-intermetallic multi-layers were successfully fabricated. The initial Ti and Al foils were firmly bonded to each other through the formed intermetallic layers. Additionally, SiCf and Ti were connected by the compound TiC0.75 formed through the reaction between the Ti matrix and the deposited C coating on SiC fibers. Along the longitudinal direction of SiCf, the ultimate tensile, flexural strengths and fracture toughness of the hybrid composite have been respectively enhanced of 53%, 74% and 75%, while the elongation remained almost similar to the Ti-intermetallic multi-layers composite. In-situ observations indicated that cracks were always initiated in the intermetallic region. The crack propagating paths were significantly changed and the cracks length

continued

was visibly prolonged through crack deflection and crack blunting. Due to the strong interfacial connection between the SiC fibers and the Ti matrix, the broken SiCf pieces could strengthen the Ti matrix. Herein, the hybrid composite could support higher external loads than the corresponding Ti–Al intermetallic multilayers without SiCf.

Author(s) affiliation: a School of Materials Science and Engineering, Tsinghua University, Beijing, 100084, China; b Laboratory of Chemical Physics, Université Félix Houphouet Boigny, Abidjan, 22 BP 582 Abidjan 22, Côte d'Ivoire

Times cited: 5

Tags: Application - material design, Bioinspired design

Biomimicry, an Approach, for Energy Effecient Building Skin Design (Egypt) 2016

Gehan.A.N. Radwan, Nouran Osama

Source: Procedia Environmental Sciences, Volume 34, 2016, Pages 178-189; DOI: https://doi.org/10.1016/j.proenv.2016.04.017

ABSTRACT: Proper management of the building skin can significantly reduce the building's energy demand. The main objective of this paper is to investigate the ability of reducing energy consumption by applying the biomimicry approach on buildings skin design. In order To achieve this aim, a research methodology has been designed to accomplish four objectives. First, it will carry out an in depth research on biomimicry, skin, and biomimicry in building skin through the study of existing literature. Second, international case studies will be presented and analyzed in terms of usage of biomimicry, in addition to, the impact it had on reducing the buildings energy consumption. Finally it will conclude with guidelines for building skin biomimicry design for more efficient energy consumption in buildings.

Author(s) affiliation: British Unoversity in Egypt,Sherouk city, Egypt

Times cited: 0

Tags: Application - material design, Bioinspired design

Development of highly durable and low friction micro-structured PDMS coating based on bio-inspired surface design (South Korea) 2015

Byung-Hoon Ryu, Dae-Eun Kim

Source: CIRP Annals, Volume 64, Issue 1, 2015, Pages 519-522; DOI: https://doi.org/10.1016/j.cirp.2015.03.004

ABSTRACT: A novel micro-structured PDMS coating with high durability and relatively low friction was successfully replicated from a lotus leaf. Unlike the bio-inspired coatings developed previously, the micro-structured PDMS specimen could be fabricated in the form of a coating which could be successfully deposited on a solid surface. Results showed that friction and wear of the micro-structured PDMS specimens were significantly lower than those of the smooth specimens. It was also found that the wear resistance of micro-structured PDMS coating with 200 μm thickness was much higher than that of the micro-structured PDMS bulk specimen. The drastically high durability of the PDMS coating specimen was attributed to frictional energy dissipation through elastic deformation of the micro-structures.

Author(s) affiliation: School of Mechanical Engineering, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, South Korea

Times cited: 3

Tags: Application - material design, Bioinspired design

Rational design of bio-inspired high-performance ambipolar organic semiconductor materials based on indigo and its derivatives (China) 2015

Shou-Feng Zhang, Xian-Kai Chen, Jian-Xun Fan, Ai-Min Ren

Source: Organic Electronics, Volume 24, September 2015, Pages 12-25; DOI: https://doi.org/10.1016/j.orgel.2015.05.021

ABSTRACT: Indigoids have received much attention as the candidates of sustainable ambipolar organic semiconductor. However, the low charge carrier mobilities extremely limit their practical applications. Therefore, in-depth understanding of their electronic-structure properties and rational molecular modifications are urgently required. Here, we propose a promising strategy to design ambipolar organic semiconductors based on indigo fragments. Moreover, we predicted the organic crystal structures by evolutionary algorithm combined with DFT-D method. Charge transport properties have been significantly improved for the designed molecules, such as narrower energy gaps, higher electron affinity, larger transfer integrals as well as much smaller reorganization energies for hole and electron. Thusly, remarkable ambipolar charge transport behavior has been predicted, for example, the charge carrier mobilities are up to μh/μe = 7.71/5.42 cm2 V−1 s−1 for NN-indigo-6,6′-2CN and μh/μe = 5.15/2.13 cm2 V−1 s−1 for C9-NN-indigo-6,6′-2CN respectively.

Author(s) affiliation: International Joint Research Laboratory of Nano-Micro Architecture Chemistry, Institute of Theoretical Chemistry, Jilin University, Changchun, China

Times cited: 5

Tags: Application - material design, Bioinspired design

continued

"Toward seashells under stress": Bioinspired concepts to design tough layered ceramic composites (Austria) 2017

Raúl Bermejo

Source: Journal of the European Ceramic Society, Volume 37, Issue 13, 2017, Pages 3823-3839, ISSN 0955-2219, https://doi.org/10.1016/j.jeurceramsoc.2017.04.041

ABSTRACT: In this manuscript the potential of building tough, layered ceramic composites with embedded "protective" features has been explored. Novel concepts have been pursued to design ceramics using a non-conventional disposition of "embedded" compressive layers to significantly increase toughness and reduce the scatter in strength. A combination of experiments and modelling has shown the potential of layered architectures in the design of ceramic components with spatially resolved strength and toughness. In addition, texturing of the microstructure in the protective layers has been demonstrated to provide preferential paths for conducting propagating cracks in graceful manner. Recent work has shown that the "flaw tolerance" behaviour of such systems can be enhanced by embedding textured layers holding compressive stresses. Crack arrest and delamination have been observed acting together during the fracture process, which resembles the fracture of nacre. This approach might be further exploited to reduce strength variability and increase toughness in advanced ceramics.

Author(s) affiliation: Institute for Structural and Functional Ceramics, Montanuniversitaet Leoben, Franz Josef Strasse 18, 8700 Leoben, Austria

Times cited: n/a

Tags: Application - materials, Bioinspired design

Application - Product Design

3D Computer Animation of Biomimetic Underwater Vehicle with Magnetic Levitation Technology (India) 2016

Acharya, K; Ghoshal, D

Source: 2016 INTERNATIONAL CONFERENCE ON ELECTRICAL, ELECTRONICS, AND OPTIMIZATION TECHNIQUES (ICEEOT), pages 2644 - 2647, 2016; DOI: 10.1109/ICEEOT.2016.7755173

ABSTRACT: The concept of Biomimicry and magnetic levitation have opened new area and possibility in the field of research. In the present study, biological behavior based design structure with magnetic levitation technology has been applied in the proposed underwater vehicle design. The bio-propelled balance plan on the vehicles has been made and animated based on the idea of magnetic levitation. The fish shaped vehicle design is proposed to produce the optimal movements in different modes and to provide smooth, balanced and high speed traveling facility to the passengers. Some animations of the underwater vehicle have been shown here. This paper is expected to provide a good basis for the understanding of magnetic levitation based optimized design of underwater vehicle using the concepts of Biomimicry.

Author(s) affiliation: NIT Agartala, Dept Comp Sci & Engn, Agartala, India

Tags: Application - product design, Bioinspired design

Assessment of a Bio-inspired Artificial Wing for Micro Aerial Vehicle Based on Structural Bio-mimetics (India) 2015

Sachin Mishra a, Ajay Kumar a, Ojasvi Singh a, Anurag Upadhyay a, Roshan Antony b

Source: Materials Today: Proceedings, Volume 2, Issues 4–5, 2015, Pages 2407-2413; DOI: https://doi.org/10.1016/j.matpr.2015.07.179

ABSTRACT: This paper presents the structural design assessment of a bio-inspired artificial wing for flapping wing micro air vehicle based on pigeon bird. Bio-inspired ornithopters are unable to implement themselves in surveillance environment due to lack of basic bio-mimetics during conceptual and design phase. The idea of this research is to bridge this gap through assessment of structural parameters including weight, moment of inertia and feather placement leading to development of an artificial wing using actual feathers of pigeon bird and glass fiber-epoxy composite. The camber and wing structure is assessed through the fabrication of mold which is further utilized to define the shape of artificial wing. Future work includes the performance assessment of the developed wing for lift and thrust generation in an actual prototype of flapping type micro air vehicle.

Author(s) affiliation: a School of Engineering, Gautam Buddha University, Greater Noida -201312, Uttar Pradesh, India; b National Aerospace Laboratories,Bangalore -560 017, Karnataka, India

Times cited: 1

Tags: Application - product design, Bioinspired design

continued

Bio-inspired hierarchical design of composite T-joints with improved structural properties (Australia) 2015

L. Burns a, A.P. Mouritz b, D. Pook ab, S. Feih ac

Source: Composites Part B: Engineering, Volume 69, February 2015, Pages 222-231; DOI: https://doi.org/10.1016/j.compositesb.2014.09.041

ABSTRACT: The biological principle of hierarchical (multi-scale level) design was used at the structural and laminate levels to design a novel carbon/epoxy T-joint with improved structural properties for potential use in light-weight aircraft structures. The bio-inspired structural modification mimics tree branch–trunk joints by embedding the stiffener flange into skin plies. This design concept results in increased fracture toughness due to crack branching and deflection. Simultaneously, bio-inspired ply angle optimisation was used to mimic the tailored arrangement of cellulose micro-fibrils observed in the wood cells contained within tree branch joints. The optimisation procedure minimises the interlaminar stress concentration in the T-joint radius bend and increases strength while maintaining similar global laminate stiffness properties. The hierarchical joint resulted in a significantly improved tensile strength compared to a conventionally designed T-joint. The new design additionally exhibited higher absorbed strain energy to failure load for bending and tension loading. Additionally, the hierarchical T-joint had a significantly reduced critical joint cross-sectional area (weight) due to the embedded design.

Author(s) affiliation: a Sir Lawrence Wackett Aerospace Research Centre, School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, GPO Box 2476, Melbourne, Victoria 3001, Australia; b Boeing Research and Technology Australia, 226 Lorimer St (Private Bag 4), Port Melbourne, Victoria 3207, Australia; c Singapore Institute of Manufacturing Technology (SIMTech), Joining Technology Group, 71 Nanyang Drive, Singapore 638075, Singapore

Times cited: 9

Tags: Application - product design, Bioinspired design

A Bioinspired Soft Robotic Gripper for Adaptable and Effective Grasping (Italy) 2015

Manti M Hassan T Passetti G D'Elia N Laschi C Cianchetti M

Source: Soft Robotics. September 2015, 2(3): 107-116; DOI: https://doi.org/10.1089/soro.2015.0009

ABSTRACT: The present article shows the development of a gripper for general purposes with grasping and holding capabilities enabled by a simple control scheme.This objective has been reached exploiting the combination of soft materials, underactuated mechanisms, and a bioinspired design. The devices are here presented in their main components , underlining the anthropomorphic approach used in the design of the fingers. The used actuation mechanism is based on the control of a single cable tension , which guarantees a grasping adaptable to objects of different shape. Manipulation capability and grasping force have been tested in order to extract a quantitative comparative analysis between the three proposed devices.

Author(s) affiliation: The BioRobotics Institute, Pontedera, Pisa, Italy.

Times cited: 20

Tags: Application - product design, Bioinspired design

Bio-mimicry inspired tall buildings: The response of cactus-like buildings to wind action at Reynolds Number of 104 (USA) 2016

C.W. Letchford a, D.C. Lander a, P. Case b, A. Dyson c, M. Amitay d

Source: Journal of Wind Engineering and Industrial Aerodynamics, Volume 150, March 2016, Pages 22-30; DOI: https://doi.org/10.1016/j.jweia.2016.01.001

ABSTRACT: To this end, the alongwind and crosswind responses of high aspect ratio (15:1) cylinders, (smooth, roughened and grooved) were obtained from wind tunnel tests in simulated smooth and rough atmospheric boundary layer flows. The influence of top, flat or domed was also studied. The Saguaro cactus-inspired cylinder with 24 circumferential grooves was seen to have large reductions (~20%) for mean and fluctuating alongwind base shear (drag) and overturning moments in comparison with smooth cylinders and is in agreement with 2D studies in uniform low turbulence flow. Domed tops also led to reduced drag over flat tops. Differences in fluctuating crosswind base shear (lift) and overturning moment were much less marked. In spectral terms the amplitudes of response near the pronounced vortex shedding frequency were almost unchanged, however the cactus-shape had a higher Strouhal Number indicating a shift to a higher frequency as might be attributed to a narrowing of the wake.

Author(s) affiliation: a Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute, Troy, NY, USA; b The Alan G. Davenport Wind Engineering Group, University of Western Ontario, London, ON, Canada; c Center for Architecture, Science and Ecology, Rensselaer Polytechnic Institute, Troy, NY, USA; d Center for Flow Physics and Control, Department of Mechanical, Nuclear and Aerospace Engineering, Rensselaer Polytechnic Institute, Troy, NY, USA

Times cited: n/a

Tags: Application - product design, Bioinspired design

continued

Design of a bioinspired tunable stiffness robotic foot (China) 2016

Zeeshan Qaiser a, Liping Kang a, Shane Johnson ab

Source: Mechanism and Machine Theory, Volume 110, April 2017, Pages 1-15; DOI: https://doi.org/10.1016/j.mechmachtheory.2016.12.003

ABSTRACT: The human foot is capable of adapting to various diverse terrains, and this function is due, in part, to the foot's capacity of varying its stiffness in different anatomical regions. The purpose of this study is to develop an adaptable robotic foot by emulating the human foot's arch, horizontal tie (the plantar aponeurosis, midfoot ligaments, etc.), and its ability of varying its stiffness. The robotic foot is designed, analyzed, optimized and fabricated as a semi-circular arch with a horizontal tie consisting of a Tunable Stiffness Mechanism (TSM). Analytical and finite element modeling results closely match the experimental validation of both the tunable axial stiffness behavior of the TSM and tunable bending stiffness of the robotic foot assembly. The results also show that the TSM is capable of varying the potential energy storage at midstance depending on the load or displacement applied.

Author(s) affiliation: a Center of Advanced Mechanics, Material and Structures (CAMMS), University of Michigan and Shanghai Jiao Tong University Joint Institute, Shanghai Jiao Tong University, 800 Dongchuan Rd, Shanghai 200240, China; b State Key Laboratory of Mechanical Systems and Vibrations, Shanghai Jiao Tong University, Shanghai 200240, China

Times cited: 0

Tags: Application - product design, Bioinspired design

Flexible heat pipes with integrated bioinspired design (China) 2015

Chao Yang, Chengyi Song, Wen Shang, Peng Tao, Tao Deng

Source: Progress in Natural Science: Materials International, Volume 25, Issue 1, February 2015, Pages 51-57; DOI: https://doi.org/10.1016/j.pnsc.2015.01.011

ABSTRACT: In this work we report the facile fabrication and performance evaluation of flexible heat pipes that have integrated bioinspired wick structures and flexible polyurethane polymer connector design between the copper condenser and evaporator. Inside the heat pipe, a bioinspired superhydrophilic strong-base-oxidized copper mesh with multi-scale micro/nano-structures was used as the wicking material and deionized water was selected as working fluid. Thermal resistances of the fabricated flexible heat pipes charged with different filling ratios were measured under thermal power inputs ranging from 2 W to 12 W while the device was bent at different angles. Furthermore, repeated heating tests indicated that the fabricated flexible heat pipes have consistent and reliable heat-transfer performance, thus would have important applications for advanced thermal management in three dimensional and flexible electronic devices.

Author(s) affiliation: State Key Laboratory of Metal Matrix Composites, School of Materials Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

Times cited: 5

Tags: Application - product design, Bioinspired design

Lessons learned from using some bio-inspired optimizers for real-time controller design for a low-cost electrohydraulic system (India) 2016

Pranibesh Mandal a, Rana Saha a, Saikat Mookherjee a, Amitava Chatterjee b, Dipankar Sanyal a

Source: Applied Soft Computing, Volume 48, November 2016, Pages 638-649; DOI: https://doi.org/10.1016/j.asoc.2016.07.056

ABSTRACT: Well-designed searching procedures following natural processes have been developed for finding optimized solutions of complex systems. Here, a comparison of performances of some optimizers, namely differential evolution, genetic algorithm, bacterial foraging and artificial bee colony technique, have been carried out for designing a fuzzy-feedforward real-time controller of an electrohydraulic motion actuation system. The first two optimizers execute dominatingly exploratory search, while the latter two execute a combination of exploratory search with intensified exploitive search in prospective regions, thus providing faster convergence. The optimized controller has been designed by minimizing a response error integral for some standard displacement demands of the highly nonlinear system. The convergences to the minimum of zero for a number of nonlinear functions have also been demonstrated for all the optimization processes. These optimizers with faster convergence rate have been shown to be robust against arbitrary demands like variable frequency sinusoidal demands and sinusoidal demands with superimposed log concave-convex variations.

Author(s) affiliation: a Mechanical Engineering Department, Jadavpur University, 700 032, India; b Electrical Engineering Department, Jadavpur University, 700 032, India

Times cited: 0

Tags: Application - product design, Bioinspired design

continued

A new biomimicry marine current turbine: Study of hydrodynamic performance and wake using software (Malaysia) 2016

Yung-Jeh CHU

Source: Journal of Hydrodynamics, Ser. B, Volume 28, Issue 1, February 2016, Pages 125-141; DOI: https://doi.org/10.1016/S1001-6058(16)60614-5

ABSTRACT: Inspired by Dryobalanops aromatica seed, a new biomimicry marine current turbine is proposed. Hydrodynamic performance and wake properties are two key factors determining whether a new marine current turbine design is practical or not. Thus, a study of hydrodynamic performance and wake of the proposed biomimicry turbine is conducted. The computational fluid dynamics (CFD) software, OpenFOAM is used to generate the required results for the mentioned study. The simulation results showed that the proposed biomimicry marine current turbine gives optimum power output with its power coefficient, Cp ≈ 0.376 at the tip speed ratio (TSR) of 1.5. Under the same boundary conditions, the maximum torque pro- duced by the proposed biomimicry turbine at zero rotational speed is 38.71 Nm which is 1110% greater than the torque generated by the turbine of Bahaj et al.. The recovery distance for the wake of the biomimicry turbine is predicted to be 10.6% shorter than that of IFREMER-LOMC turbine. The above-mentioned results confirm the potential application of the proposed biomimicry marine curre- nt turbine in the renewable energy industry.

Author(s) affiliation: Department of Civil Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia

Times cited: 0

Tags: Application - product design, Bioinspired design

Stability of hard plates on soft substrates and application to the design of bioinspired segmented armor (Canada) 2016

R. Martini, F. Barthelat

Source: Journal of the Mechanics and Physics of Solids, Volume 92, July 2016, Pages 195-209; DOI: https://doi.org/10.1016/j.jmps.2016.04.009

ABSTRACT: Despite a growing interest in bio-inspired flexible protection, there is little guidelines as to the choice of materials, optimum thickness, size, shape and arrangement for the protective plates. In this work, we focus on a failure mode we recently observed on natural and bio-inspired scaled armors: the unstable tilting of individual scales subjected to off-centered point forces. We first present a series of experiments on this system, followed by a model based on contact mechanics and friction. We condense the result into a single stability diagram which capture the key parameters that govern the onset of plate tilting from a localized force. We finally discuss how some of these parameters can be optimized at the design stage to produce bio-inspired protective systems with desired combination of surface hardness, stability and flexural compliance.

Author(s) affiliation: Department of Mechanical Engineering, McGill University, 817 Sherbrooke Street West, Montreal, QC, Canada H3A 2K6

Times cited: 7

Tags: Application - product design, Application - material design

Application - Sensors

Bio-inspired Design Methodology of Sensor-actuator-structure Integrated System for Artificial Muscle Using SMAO (China) 2017

Cheng Peng, Yue H. Yin, Hai B. Hong, Jian J. Zhang, Xing Chen

Source: Procedia CIRP, Volume 65, 2017, Pages 299-303; DOI: https://doi.org/10.1016/j.procir.2017.04.016

ABSTRACT: Addressing the two bottlenecks of present robotic design, low force-to-weight ratio and low integration level, this paper presents a general bio-inspired design methodology supported using a sensor-actuator-structure integrated system fully inspired by natural muscle. The system design is centred on the reproduction of natural muscle's contraction mechanism unveiled by multi-scale researches, and the versatility and morphology of muscle are approximated concurrently through multi-objective and coupled iterative optimizations. The effectiveness of the proposed bio-inspired design methodology is verified by the experiments demonstrating the muscle-like FW ratio and mechanical behaviour of the integrated system.

Author(s) affiliation: Robotics Institute, State key Lab of MSV, Shanghai Jiao Tong University, Shanghai, China

Times cited: 0

Tags: Application - sensors, Application - product design, Bioinspired design

Bioinspired design of a polymer-based biohybrid sensor interface (Sweden) 2017

ErdoğanÖzgürab, OnurParlakb, ValerioBenibc, Anthony P.F.Turnerb, LokmanUzunab

Source: Sensors and Actuators B: Chemical, Volume 251, November 2017, Pages 674-682; DOI https://doi.org/10.1016/j.snb.2017.05.030

ABSTRACT: Given the basic role of functional amino acids in biorecognition, we focused on the synthesis of polymerizable amino acid derivatives and their incorporation into a polymer-based biohybrid interface to construct generic bioinspired analytical tools. We also utilized polyvinyl alcohol (PVA) as a sacrificial polymer to adjust the porosity of these biohybrid interfaces. The surface morphologies of the interfaces on gold electrodes were characterized by using scanning electron (SEM) and atomic force (AFM) microscopies. The electrochemical behavior of the polymeric films was systematically investigated using differential pulse voltammetry (DPV) to demonstrate the high affinity of the biohybrid interfaces for Cu(II) ions. The presence of macropores also significantly improved the recognition performance of the interfaces while enhancing interactions between the target [Cu(II) ions] and the functional groups. As a final step, we showed the applicability of the proposed analytical platform to create a Cu(II) ion-mediated supramolecular self-assembly on a quartz crystal microbalance (QCM) electrode surface in real time.

Author(s) affiliation: a Hacettepe University, Department of Chemistry, Ankara, Turkey, b Linköping University, Biosensors and Bioelectronics Centre, IFM, Linköping, Sweden, c RISE Acreo, Research Institute of Sweden, Norrköping, Sweden

Times cited: 0

Tags: Application - sensors, Bioinspired design

Biomimetic self-templating optical structures fabricated by genetically engineered M13 bacteriophage (South Korea) 2015

Won-Geun Kim ac, Hyerin Song b, Chuntae Kim ac, Jong-Sik Moon c, Kyujung Kim b, Seung-Wuk Lee d, Jin-Woo Oh acde

Source: Biosensors and Bioelectronics, Volume 85, 15 November 2016, Pages 853-859, DOI: https://doi.org/10.1016/j.bios.2016.05.099

ABSTRACT: Here, we describe a highly sensitive and selective surface plasmon resonance sensor system by utilizing self-assembly of genetically engineered M13 bacteriophage. About 2700 copies of genetically expressed peptide copies give superior selectivity and sensitivity to M13 phage-based SPR sensor. Our M13 phage-based SPR sensor takes advantage of simplicity of self-assembly compared with relatively complex photolithography techniques or chemical conjugations. Additionally, designed structure which is composed of functionalized M13 bacteriophage can simultaneously improve the sensitivity and selectivity of SPR sensor evidently.

Author(s) affiliation: a Department of Nano Fusion Technology, Pusan National University, Busan 609-735, South Korea, b Department of Cogno-Mechatronics Engineering, Pusan National University, Busan 609-735, South Korea, c BK21 PLUS Nanoconvergence Technology Division, Pusan National University (PNU), Busan 46241, Republic of Korea, d Department of Bioengineering, University of California, Berkeley, Biological Systems and Engineering, Lawrence Berkeley National Laboratory, Berkeley Nanoscience and Nanoengineering Institute, Berkeley, CA 94720, USA, e Department of Nanoenergy Engineering, Pusan National University, Busan 609-735, South Korea

Times cited: n/a

Tags: Application - sensors, Bioinspired design

A biomimetic sensor for the detection of lead in water (China) 2015

Wendy Chu a, Yuanchao Zhang ab , Da Li a, Colin J. Barrow a, Hongbin Wang c, Wenrong Yang ac

Source: Biosensors and Bioelectronics, Volume 67, 15 May 2015, Pages 621-624, DOI: https://doi.org/10.1016/j.bios.2014.09.077

ABSTRACT: Herein, a simple yet innovative biosensor for Pb2+ detection is presented. The sensor is developed by the self-assembly of gold nanoparticles (GNPs) core–satellite structure using naturally occurring tripeptide glutathione (GSH) as linker. The addition of Pb2+ caused a red-to-blue color change and the localized surface plasmon resonance (LSPR) band was shifted to ca. 650 nm. The limit of detection (LOD) is found to be 47.6 nM (9.9 ppb) by UV–vis spectroscopy with high selectivity against other heavy metals. This method offers a new strategy for heavy metal detection using functionalized GNPs.

Author(s) affiliation: a School of Life and Environmental Sciences, Deakin University, Vic. 3217, Australia, b College of Chemistry and Chemical Engineering, Ocean University of China, Qingdao 266100, China, c School of Chemistry and Biotechnology, Yunnan Minzu University, Kunming 650031, China

Times cited: 13

Tags: Application - sensors, Bioinspired design

continued

Biomimetic Tactile Sensors and Signal Processing with Spike Trains: A Review (Singapore) 2017

Zhengkun Yi ab, Yilei Zhang a, Jan Peters bc

Source: Sensors and Actuators A: Physical, Available online 22 September 2017; DOI: https://doi.org/10.1016/j.sna.2017.09.035

ABSTRACT: In the past decade, tremendous effort and progress have been made to mimic the sense of touch in human beings on robotic systems. Particularly, biomimetic tactile sensors and signal processing with spike trains have gained a growing interest. In this paper, we firstly review human sense of touch as it serves as a reference point in the case of biomimetic tactile sensing. Then, we focus on biomimetic tactile sensing technologies, which are primarily presented in two aspects: emulating the properties of mechanoreceptors using artificial tactile sensors, and biomimetic tactile signal processing with spike trains. Finally, we discuss the problems in current biomimetic tactile sensing techniques and deduce the future directions.

Author(s) affiliation: a School of Mechanical and Aerospace Engineering, Nanyang Technological University, 639798, Singapore, b Intelligent Autonomous Systems Lab, Department of Computer Science, Technische Universitaet Darmstadt, 64289, Germany, c Max Planck Institute for Intelligent Systems, Tuebingen,72076, Germany

Times cited: n/a

Tags: Application - sensors, Bioinspired design

Computationally modelled receptors for drug monitoring using an optical based biomimetic SPR sensor (UK) 2016

Zeynep Altintas, Benoit France, Jose O. Ortiz, Ibtisam E. Tothill

Source: Sensors and Actuators B: Chemical, Volume 224, 1 March 2016, Pages 726-737, DOI: https://doi.org/10.1016/j.snb.2015.10.075

ABSTRACT: Molecularly imprinted polymers (MIPs) were designed using computational simulation for the synthesis of high affinity synthetic receptors to be used for drug recognition and detection in combination with optical based biosensors. A regeneration method was developed for the sensor reuse and cross-reactivity studies were conducted using the control drugs. The receptor affinity and capacity towards metoprolol were also confirmed by solid phase extraction (SPE) method coupled with LC–MS. The achieved results highlight the success of computationally modelled receptor with SPR biosensor for pharmaceuticals detection and monitoring. The application of this work can be extended to the separation and detection of drugs from water samples, providing useful information and separation techniques for ecotoxicity studies.

Author(s) affiliation: Cranfield University, Bedford MK43 0AL, Bedfordshire, England, UK

Times cited: 9

Tags: Application - sensors, Bioinspired design

Electro-leaf, a biomimicry system to estimate in-canopy airflow in fruit crops (USA) 2016

Tomas Palleja, Andrew J. Landers

Source: Computers and Electronics in Agriculture, Volume 127, September 2016, Pages 606-614, DOI: https://doi.org/10.1016/j.compag.2016.07.025

ABSTRACT: This paper proposes a method, based on an array of sensors, to estimate in-canopy airflow in fruit orchards and vineyards. These sensors, called electro-leaves, mimic a real leaf which oscillates randomly under the air turbulence coming from an air-assisted sprayer. These oscillations are sampled at 700 Hz and processed in order to detect peaks of movement. The value of these peaks could be used as a reference to make adjustments to the operating parameters of the sprayer, with the aim of improving spray deposition and reducing drift. Results show that the electro-leaves estimate different airflows as a function of the air volume, the tractor forward speed and the canopy sizes. Also, the detected airflow is highly correlated with the wind speed measured by an ultrasonic and a vane anemometer.

Author(s) affiliation: Cornell University, Barton Laboratory, Geneva, NY 14456, USA

Times cited: 0

Tags: Application - sensors, Bioinspired design

Mechanoelectrical transduction in the hydrogel-based biomimetic sensors (Russia) 2016

F.A. Blyakhman ab, A.P. Safronov c, A.Yu. Zubarev d, T.F. Shklyar ab, O.A. Dinislamova a , M.T. Lopez-Lopez e

Source: Sensors and Actuators A: Physical, Volume 248, 1 September 2016, Pages 54-61, DOI: https://doi.org/10.1016/j.sna.2016.06.020

ABSTRACT: The study addresses the phenomenon of mechanoelectrical transduction in polyelectrolyte hydrogels and, in particular, the search of the driving force for the change of the electrical potential of a gel under the applied mechanical stretch. Polyelectrolyte gels of calcium and magnesium salts of polymethacrylic acid were synthesized by the radical polymerization in water solution. Sensor elongation resulted in the overall increase of gel volume, and it was always accompanied by the gel potential change toward the depolarization (diminishing of the negative values). Theoretical model based on the assumption of the total electrical charge

continued

conservation in the course of the dynamic deformation of a filament was proposed to describe the dependence of the electrical potential of a gel on its volume. The proposed mechanism of mechanoelectrical transduction based on the stretch-dependant volume changes in polyelectrolyte hydrogels might be useful to understand the nature of mechanical sensing in much more complex biological gels like the cell cytoskeleton

Author(s) affiliation: a Department of Biomedical Physics and Engineering, Ural State Medical University, 3 Repin Str., Yekaterinburg 620028, Russian Federation, b Department of Physics, Ural Federal University Named After the First President of Russia B.N.Yeltsyn, Yekaterinburg 620083, Russian Federation, c Department of Chemistry, Ural Federal University Named After the First President of Russia B.N.Yeltsyn, Yekaterinburg 620083, Russian Federation, d Department of Mathematics, Ural Federal University Named After the First President of Russia B.N.Yeltsyn, Yekaterinburg 620083, Russian Federation, e Departamento de Fısica Aplicada, Universidad de Granada, 18071 Granada, Spain

Times cited: 0

Tags: Application - sensors, Bioinspired design ■

ABOUT THIS PUBLICATION

The S&T In-Depth Bulletin is a compilation of selected recent technical articles on emerging fields in science and technology which may have long or short term implication for national security. Articles are selected from peer-reviewed journals and focus on providing a more detailed insight to the R&E community. Each quarter we will feature a topic and provide abstracts from the most timely and relevant review articles. Providing a comprehensive bibliography is beyond the scope of this publication but full articles may be requested via the Pentagon library or via your local Command's library. Personnel assigned to the Pentagon may request articles from John Mills at john.mills@whs.mil.

We welcome your feedback to improve the publication and make it more relevant to your work. To subscribe (or unsubscribe), visit https://tin-ly.sainc.com/ASDRE. To provide feedback or ask questions, contact us at asdre-st-bulletin-reply@sainc.com.

This publication is authored and distributed by:

Ryan Zelnio, Ph.D., Associate Director - Tech Watch / Horizon Scans,
Office of Net Technical Assessments, OSD AT&L/OASD(R&E)

Ms. Hema Viswanath, TW/HS, ONTA Corporate Librarian

continued