Zygote Quarterly: A Free Online Journal About Biomimicry, Bio-inspired Design, and Engineering

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■ **ABSTRACT**

Zygote Quarterly (http://zqjournal.org/) is an open-source, award-winning journal that reports on recent developments in bio-inspired design (BID). Via in-depth case studies, interviews, portfolios, and product, tool, and methodology discussions, the journal is making BID information readily available to a cross-disciplinary audience of engineering and design practitioners, biologists, researchers, and others. This paper introduces the journal and gives examples of the types of articles that we publish. All of the articles in the journal can help the systems engineering community and others learn about biomimicry.

MOTIVATION

As engineers, architects, industrial designers, and educators, we all live in the 'Age of Biology.' We can benefit by knowing something about how *the science and engineering of Nature* can enrich our lives and our work. However, between peer-reviewed journals and the popular press there was a vacuum, devoid of information about *designing* things based on Nature. Traditional magazines, newspapers, and websites titillate readers with fantastical stories about the wonders of Nature and how the miracle of spider silk can save us from ourselves. *Zygote Quarterly* seeks to provide additional details and facts for practical use in real engineering and design contexts: How was it done? How can we use it? Why is it important? How can we improve current design and application? How can we abstract forms, processes, and systems from biology into viable innovative methodologies and technologies?

Our interest is the *whole story* from inspiration, to concept generation, to development, to testing, to redesigning, to marketing, to commercialization—and in many cases to 'failure:' why does a seemingly great idea not become commercially viable?

Zygote Quarterly (*ZQ*) showcases many angles of exploration and innovation—with the goal of enriching the field of bio-inspired design (BID). Scientists, engineers, and researchers, for their part, want to know how their benchtop work can benefit from the larger cultural trends of innovation, design, and production. *Zygote Quarterly* includes comprehensive case studies that are being used in classrooms and design studios. These case studies are structured to allow students and designers to abstract research concepts for practical use in designing products and systems.

THE BEGINNING AND THE PRINCIPALS

Three of us (Norbert Hoeller, Tom McKeag, and Marjan Eggermont) observed that while there were many inspiring stories, very few went beyond brief mention of the inspiration concept. In 2011, we decided to take action. After deciding to establish an on-line journal, agreeing on an approach, and working the logistics, we published our inaugural issue in March 2012. Our lead story was by Steven Vogel: "When Success Fails" (Vogel 2012). The three of us bring different skill sets to the *ZQ* publication task. Hoeller is the section manager for tools and methodologies, conducts interviews, and is one of our main editors. McKeag provides our case studies and finds recent innovations and interesting people and research. Eggermont designs the journal, finds the visuals, and discovers product and portfolio candidates.

As stated above, *ZQ* seeks to document BID stories and examples in sufficient detail to be useful to a wide range of practitioners. We welcome contributions as well as suggestions for interviews, articles, and case studies.

FOUR ARTICLE EXAMPLES

We describe four diverse example articles briefly below. Each full article is accessible via the *ZQ* archive (http://zqjournal.org/?page_id=90).

Example 1: Developing Cross-Domain Analogies using Natural-Language Resources (Hoeller 2012)

This *tools-related article* draws from a review of selected literature authored by Professor Li Shu and her team at the Biomimetic for Innovation and Design Laboratory (BIDLab), University of Toronto (http://www.mie.utoronto.ca/labs/bidlab/). BIDLab is developing tools and methods that help designers access and effectively use biological information relevant to engineering problems—using natural-language online sources such as textbooks and journals.

Example 2: Things Multiply Up (McKeag 2014)

This *case study article* reviews the discoveries occurring at the Aizenberg and Buehler labs that have broad implications for material and structure development for everything from biomedical devices to buildings. The research team mode of investigating these phenomena also has implications for how we think about design. Understanding the structure of various biological systems, for example, keratin (Figure 1), and being able to predict their performance capabilities cannot happen by an examination of the isolated constituent parts. An integrated assessment is needed to test processes, structures, and properties across scales. Complex problems sometimes require complex solutions and understanding those problems sometimes requires complex models. The use of lessons learned from labs like those of Buehler and Aizenberg represents a significant shift in the concept of structural design for buildings. The multi-layered structure of keratin can teach us how to create materials that can adapt and respond to a variety of conditions. Keratin solves functional challenges across length scales and uses structure for strength rather than material bulk.

Figure 1: The multi-layered structure of the keratin: "False coloured scanning electron micrograph of the keratin of a dog claw" (Image Credit: Anne Weston, LRI, CRUK, Wellcome Images, 2012 Flickr cc by-nc-nd 2.0 UK: England & Wales)

Example 3: Festo's Bionic Learning Network (Frontzek 2014)

An *interview* with Festo discusses how his research group, The Bionic Learning Network, explores Nature to influence the design of technical products and factory operations. The Network goals are to focus on and learn from specific characteristics of Nature, to try to understand the underlying principles, and to transfer and apply these into developing innovations for factory and process automation of the future.

In the course of evolution, Nature developed a wide variety of optimization strategies for adapting to the environment. Energy efficiency through lightweight construction, function integration, energy recovery, and the ability to learn and communicate, are a few of the strategies optimized over millions of years. Within the Bionic Learning Network, Festo focuses on exactly those strategies — and seeks to facilitate their transfers to the technical world of engineering and design. An example is shown in Figure 2: the NanoForceGripper takes inspiration from the setae of a Gecko foot and is able to adhere to and move cell phones without scratching their surface.

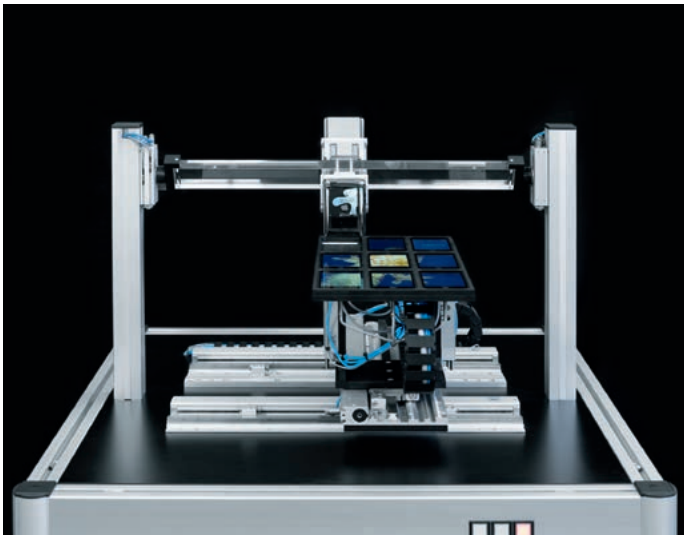

Figure 2: Energy-efficient grasping based on the model of the gecko foot setae: NanoForceGripper (Photo: Festo AG & Co. KG) [*See more at:* https://www.festo.com/cms/en_corp/12756.htm]

Example 4: Engineered Biomimicry (Ellison 2015)

This *book review article* of a text addresses primarily, but not exclusively, engineers working in development of new materials and in devising novel systems as solutions to pressing societal problems (such as sustainability). Many of the current solutions themselves are problematic and thus require new approaches to materials development.

RECOGNITION

The journal was as a Digital Magazine Awards finalist in 2012 for Magazine Launch of the Year (New Title) and for Science and Nature magazine of the Year alongside *Scientific American* and *New Scientist* among others. In 2013, 2014, and 2015, it was again a finalist in the Science and Nature category in the company of *National Geographic Magazine* and *First Light Magazine*.

OUR ASPIRATIONS

Zygote Quarterly is working to provide a credible platform displaying the nexus of science, technology, and creativity in the field of biologically inspired design. We strive to use case studies, news, and articles that are exemplary in their impact on the field, rigorous in their methodology, and relevant to the readership of today. All of our issues are freely and easily accessible in our archive: http://zqjournal.org/?page_id=90.

We aim to be:

- *An intelligence source*—that is useful for both the informed nonprofessional and the practicing professional
- *A model*—for presentation that mirrors and frames the content of a multi-disciplinary and rapidly changing field
- *A periodical*—that appeals to the senses as well as the intellect
- *A venue*—that is between the popular press and peer-reviewed journals, for a wide diversity of practicing professionals who are working at the crossroads of design and biology and would like to tell their stories.

We solicit and welcome your contributions, questions, suggestions, and feedback (*via* info@zqjournal.org) to help us make the journal increasingly useful to the systems engineering community. ■ >

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ABOUT THE AUTHORS

Marjan Eggermont is the Associate Dean of Student Affairs at University of Calgary, Canada. She is a Senior Instructor in the Mechanical and Manufacturing Department of the Schulich School of Engineering (https://schulich.ucalgary.ca/departments/mechanical-and-manufacturing-engineering). Marjan teaches visualization, drawing, design history, biomimicry, and green engineering topics. She is interested in biomimicry as a teaching tool because it allows for a great deal of creativity and "bridging" of subjects: science, engineering, design, art, biology, chemistry, and others. She is a Biomimicry Institute Fellow and was a member of their Biomimicry Educational Advisory Board. With co-editors Tom McKeag (San Francisco) and Norbert Hoeller (Toronto) she co-founded, designs, and publishes *Zygote Quarterly*. In addition to a background in Fine Arts and Military History, she is a PhD Candidate in Computational Media Design, specializing in Biomimetic Data Visualization.

Tom McKeag is the program director of the University of California Berkeley Center for Green Chemistry (http://bcgc.berkeley.edu) where he co-teaches the Greener Solutions graduate course. He is also an adjunct professor in the Industrial Design department of the California College of the Arts, San Francisco, where he holds the BioWerks studio course. Tom is one of the founding editors of Zygote Quarterly magazine, writes the monthly Biomimicry Column at Greenbiz.com (http://www.greenbiz.com/blogs/featured/biomimicry-column), and is the founder and president of BioDreamMachine, a California public interest corporation dedicated to teaching K-12 science through bio-inspired design techniques. He was a 2013-2014 Fulbright Nehru senior scholar, posted at the Centre for Product Design and Manufacturing, Indian Institute of Science, Bangalore, India, where he instructed graduate engineering students.

Springer Natural Computing Series

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ABSTRACT

The Springer Natural Computing Series was established in 2000, and now includes 49 published book titles—including monographs, textbooks, and state-of-the-art collections ranging from theory to applications. This paper addresses five titles from the series—titles thought likely to be of special interest to the INCOSE community. After summarizing the motivation for the series, the paper introduces the selected titles as an annotated reference list. Additional details on all of titles in the series are available at http://www.springer.com/series/4190.

MOTIVATION FOR THE SERIES

Natural Computing is the field of research that investigates human-designed models and computational techniques *inspired by Nature* as well as information processing phenomena *taking place in Nature*.

Research in natural computing is genuinely interdisciplinary and forms a bridge between the natural sciences and computer science. This bridge connects both at the level of information technology and at the level of fundamental research. Because of its interdisciplinary character, research in natural computing covers a spectrum of research methodologies ranging from pure theoretical research, algorithms, and software applications to experimental laboratory research in biology, chemistry, and physics.

This book series includes monographs that communicate new or established research results in consolidated form, and textbooks of value to advanced undergraduate and graduate students, or to practitioners engaged with the design of biologically inspired systems.

REFERENCES

- Brabazon, A., M. O'Neill, and S. McGarraghy. 2015. *Natural Computing Algorithms*. New York, US-NY: Springer. http://www.springer.com/us/book/9783662436301.

Natural computing algorithms use metaphorical inspiration from systems and phenomena that occur in the natural world and that have proven to be successful problem-solvers across domains as diverse as management science, bio-informatics, finance, marketing, engineering, architecture, and design. This comprehensive 574-page textbook explains the key paradigms of the field. The book is suitable for academic and industrial researchers and for undergraduate and graduate courses.

- Di Marzo Serugendo, G., M-P. Gleizes, and A. Karageorgos, Eds. 2011. *Self-organising Software—From Nature to Artificial Adaptation*. New York, US-NY: Springer. http://www.springer.com/us/book/9783642173479.

This 480-page book is the first book to offer an integrated view of self-organizing software technologies. Self-organization, self-regulation, self-repair, and self-maintenance are promising conceptual approaches for dealing with complex distributed interactive software and information-handling >