Leveraging Biological Inspiration in an Information Visualization Class

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ABSTRACT

We reflect on an infovis course with a focus on biomimicry that we taught in Winter 2016. This graduate course looked beyond visualization basics and fundamentals and focused on the idea of making use of a biomimetic approach in visualization. As global interest in visualization expands, exciting new research is emerging in many facets of visualization. One of these new directions draws from the incredible successes in engineering, where improvements in many directions including form and functionality are resulting from leveraging the examples from biology, or biomimicry. The course was set in examples of advanced visualization topics so students with heterogeneous backgrounds could draw from multiple disciplines and implement visualization projects using bio-inspired design.

1 INTRODUCTION

In this paper we reflect on our experience in a recent graduate class when we used biomimicry as the primary source of inspiration for the design of visual representations of data. Biomimicry is *"an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies."*[https://biomimicry.org/what-is-biomimicry/]. Our motivations for this exploration are widespread varying from specific questions about whether biomimicry is an effective classroom innovation approach to broader research questions about whether bio-inspired design can be leveraged to expand possibilites for InfoVis.

An important distinction to make is between visualization of biology (biovis) and biomimicry or using biology as a source of inspiration for representation of data – not necessarily biological data. Visualization of biology is a well established research area with at least two dedicated conferences: BioVis [http://biovis.net/], which is largely organized by visualization researchers, and VizBi [https://vizbi.org/], which is largely organized by biologists. In contrast, biomimicry has received much less attention in the visualization research field. This concept has rarely been applied to information visualization and the few existing examples seem unaware of the larger biomimicry movement. The possible benefits for information visualization still remain under explored.

2 BACKGROUND AND MOTIVATION

Biomimicry comes from the Greek words bios, meaning "life", and mimesis, meaning "to imitate". Biomimicry is an increasingly popular approach to finding sustainable solutions to human problems by taking inspiration from natures patterns [7] to inform form, function or process. This is typically achieved by using biological patterns or principles as the source for design ideas [13], based on the idea that nature and natural selection offer winnowed solutions to human problems. Applications of biomimicry to engineering range from designing the nose of Japanese high-speed trains inspired by the beak of kingfishers [12] to finding optimal trucking routes based on the foraging behavior of individual ants [5] to syringe needles made less painful by copying mosquito proboscis [10].

Because biomimicry is increasingly popular for solving engineering and technology design challenges, we thought that infovis could also benefit from this design approach for creating new visualizations. A few researchers in infovis have already successfully explored this approach. For example, with Visual Sedimentation [9], Huron et al. mimicked the sedimentation in nature to create visualizations using motion and physics. In-Formation Flocking [14] is a visualization in which individuals interact with simple behavioral rules, resulting in a bio-inspired swarm behavior. The emergence and success of the VISAP program [4] at VIS demostrates where bio-inspired visualizations are intensively used at the intersection of art and visualization. For example, Ji and Wakefield [11] document biologically-inspired installations.

3 COURSE ORGANIZATION

Eggermont has been teaching bio-inspired design in engineering for over 10 years and co-founded the Zygote Quarterly bio-inspired design journal (http://zqjournal.org/). Perin and Carpendale have experience teaching infovis. This was a unique opportunity to leverage our combined expertise in both biomimicry and infovis to create this course.

This was a 13 weeks long, three hours a week, graduate course offered if enough students signed up. At the university of Calgary, Computer Science courses are part of the Computer Media Design program which allows for more flexible course offerings due to the multidisciplinary nature of the program. Given the focus of the course, we made the following assumptions:

1. We assumed students were familiar with infovis. We provided an introductory lecture but self-study was expected for those new to the field. This made it possible to focus on leveraging biomimicry instead of on learning basic infovis concepts.

2. We provided an overview of the broad field of bio-inspired design – from product design to bio-inspired computing. We expected students to self-study once they had chosen an area of bio-inspiration for their projects.

3.1 Outline and Assignments

The graded components of the course were as follows:

- 20% in class activities: data sketching activities (weeks 1 and 2) and engagement with discussions during guest lectures.
- 20% in class participation: project proposal (week 3), project update presentations (weeks 6 and 9), final project presentation (week 13), and critiques of other students' projects.
- 60% course project: content of the final presentation (6%), video showcasing the project (10%) and written report (44%).

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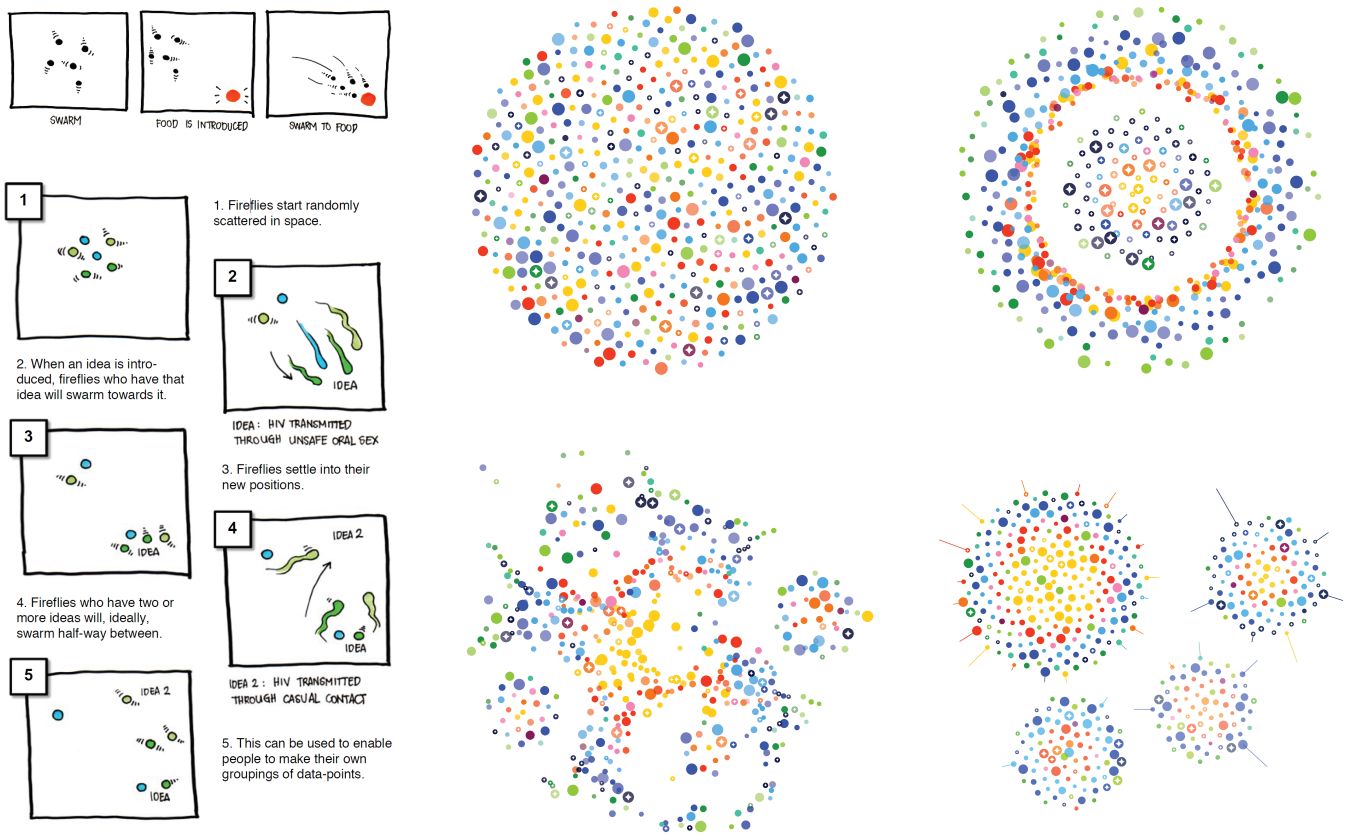

Figure 1: Attitude towards HIV explored with Fireflies [6] by Bon Adriel Aseniero. On the left hand-drawn sketches explaining the swarm behaviour of graphical marks. On the right snapshots of the web-based application for exploring attitude towards HIV.

We integrated infovis and biomimicry through graphic design process methodology. In the first 3 hours class we gave a brief overview of information visualization basics (primarily based on J. Bertin [8]), and in the second 3 hours class an overview of biomimicry. Then, to give a broad perspective of the variety of approaches currently being applied to visualization, each class featured lectures from established researchers who publish visualization in their own fields including: kinesiology, neurology, reservoir geoscience, and biology. Classes were then split into two parts: the first half was dedicated to projects and student presentations; the second half was dedicated to guest lectures.

The graphic design approach included dedicating three hours of class time to design process for every six hours of lecture and seminar time. In the design process sessions, we used a mixture of student presentation, critique, discussions, and brainstorming techniques including basic design charrettes (`https://en.wikipedia.org/wiki/Charrette`). Through this process students chose a dataset near the beginning of the class and worked through several possible sources of bio-inspiration during the class.

4 Student Projects

Students had to think about their projects from the first class. Week 1, they were asked to think about what data they would use, how they would collect the data, and why this data is important to them.

Week 2, they were asked to look more deeply into their data and characterize data dimensions, types and scales, and to explain what they found interesting in this data. Then they were then asked to create ten independent sketches during a data sketching in class activity to map the variables spatially. They were further asked to pick the best sketch and to create ten variations on a theme.

Weeks 1 and 2, students were asked to explore where bio-inspiration can be introduced in their design process. They were asked to find interesting functions on `www.asknature.org` and to present their bio-inspirations to the class.

From week 3 and until the end of the course, they were asked to code their visualization or to create their physical visualization.

At the end of the class, students were asked to include in their project report: i) changes that they made to their initial proposal and how they used biomimicry; ii) inspirations from related work; iii) data description; iv) representation components of the project (how to read the visualization); v) interaction components of the project (how to interact with the visualization and explore the data); and vi) lessons learned, including what worked and what did not work.

Next we present two student bio-inspired projects that illustrate how bio-inspired design encourages original visualization projects.

4.1 Fireflies: Bon Adriel Aseniero

The Fireflies project is an exploration that uses swarming behaviours and plant phyllotaxis to create a bio-inspired visualization of a Canadian attitudinal survey on HIV/AIDS (see poster [6] at the VIS 2016 conference). The data [1] contains participants' answers to a series of health-related questions, which concentrate on public opinion and knowledge about HIV/AIDS. Along with demographic information such as age range and location in Canada, it includes self-reported knowledge of HIV/AIDS, and other factors such as their ideas about how the virus spreads, their opinions about the disease, and their degree of comfort/discomfort with HIV/AIDS.

The chief sources of bio-inspiration for this project are firefly swarming behavior and plant phyllotaxis. In nature, fireflies swarm towards food. In this visualization, particles representing participants swarm towards ideas they agree with. The phyllotatic patterns are used to layout dense swarms. The motion of the fireflies is

Figure 2: Chameleon skin, music and mood by Roxane Fallah. The images on the left show bio-inspirations, with the skin of a chameleon changing colour according to its mood. The image on the right is the physical, ambient, dynamic installation that represents the mood conveyed by a song when played.

used to depict comfort levels concerning HIV/AIDS, with particles representing participants less comfortable with HIV/AIDS appearing agitated and nervous. The visual properties of fireflies led to an expressive representation of a sensitive dataset (see Figure 1).

4.2 Chameleon skin, music and mood: Roxane Fallah

Fallah says: *"In this project biomimicry not only is used to improve aesthetic aspects of data visualization, but is used as a conceptual inspiration in order to bridge between science, nature, and art."* The data are the moods based on tags in social media of music gathered from Harvard Dataverse [3]. This dataset studies the relationships between music content and mood. For more than 600 popular music tracks, several moods are included and given a value.

Bio-inspirations are the skin color variation and skin cell geometry of chameleons. The aesthetics of the project are inspired by chameleon skin. Each of the active cells exhibit one of the moods of the dataset. Every cell has a color chosen based on the chameleon mood skin color variation. The dynamics make use of servo motors that rotate according to the value of their related mood. This performative piece is still a work in progress (see Figure 2).

5 Reflection and Thoughts for the Future

Generally students were positive about the course, though they were also quick to point out this was challenging. Students gave us feedback such as *"I learned a lot about the process and execution of information visualization using the biomimicry methodology"* and also talked to us about *"the difficulty of abstracting and not simply cloning a biology-inspired thing"*. While some students were simply enthusiastic *"Biomimicry is a great way for finding solutions to problems and the Infovis community can benefit by taking guidelines from it and applying them to the design of new visualization techniques"*, it was clear that this was a challenging approach.

All students entered enthusiastically into the process and attendance was close to 100%, with people – both other professors and other graduate students – partaking at times with permission. This was clearly both an exciting and innovative process as well as a challenging one. All students shifted the sources of bio-inspiration several times during the process. Students with even a small amount of art or creative background (artists, architects, etc.) performed very well and designed incredible bio-inspired visualizations (as seen in the examples above). Other students struggled with this and many had not arrived at a good fit between biology inspiration and the data they were working with. While they did manage to complete their projects they were clearly still searching, and as a result their project were less satisfying.

The complexity of the process, particularly for some students, would probably not make this a suitable approach for undergraduate students (although a more thorough intro to infovis and biomimcry replacing the guest lectures could be more appropriate to an undergraduate class). However, it is promising as an innovation process and definitely led to original and unique visualizations. It is also a way of integrating interdisciplinary work and of leveraging design, art, and computer science.

Finally, while our goal was to explore biomimicry, in reality our class more closely reflected bio-inspiration. In the larger technological world, including engineering and architecture, the advantages and potential of biomimicry are increasingly evident. Biomimicry was a term coined in 1997 in Benyus's book of the same name [7]. Benyus, a biologist, tied the term directly to sustainability. Other terms, such as bioinspiration, biomimetics, and bionics, are closely related, but do not necessarily lead to a sustainable outcome. For example, engineers have looked at nature for inspiration for many centuries. Planes, engines, and the built environment are all inspired by nature, but not necessarily sustainable. Using benign manufacturing and sustainable life cycles is where biomimicry tries to separate itself from other areas of bio-inspired design. Within our class hours we did not have the time to explore the sustainability questions posed by the idea of biomimicry. Exactly what sustainability means in terms of visualization and whether biomimicry can help us achieve this remains an open challenge.

Acknowledgements

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