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Pursuing Value in Art-Science Collaborations

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Over decades and centuries, the practices of art and science have diverged as separate disciplines and, driven by scrutiny and opinions, have sought to define what makes a great artist or scientist. It is not surprising, therefore, that many scientists remain unfamiliar with the many and varied artistic contributions to scientific advancement. Artists and scientists have refined their practices with discipline-specific norms, leading to ever-unique practices within subspecialties as well. For example, uniformitarianists practiced science during a productive phase in geology whereby slow processes, occurring over eons, were focused on understanding how our planet reached its current geological state.[1] In another example, romanticists practiced art during a productive phase through a body of work that revolted against aristocratic social and political norms and against the scientific rationalization of nature.[2] The success of subspecialization reinforced further specialization.

A joint workshop with the National Science Foundation and National Endowment for the Arts held during September 2010 identified the current state of science and art discipline silos while performing a gap analysis comparing the current state of art and science practices to an ideal future state, where transformative breakthroughs in science and technology would be more likely through creativity and innovation benefitting from art's participation.[3] Workshop attendees identified differences in professional norms regarding values, learning methods, training experiences, and networking approaches as some of the drivers of the gap between art and science today. Follow-on workshops have focused on the benefits of collaborations suggested by participants who share case studies that benefited by art-science collaborations.

Art-science case studies aren't encountered in our everyday work, but they can be highly suggestive of approaches for creative thinking and innovation. Andrew Hanson's article in *CG&A*'s July/August 2014 Visualization Viewpoints department provided a case study in the contribution of artists working with scientists.[4] Alternative visualizations of Fermat surfaces presented in that article vary in terms of attractiveness, faithful representation, understandability, and complexity. Hanson commended various contributions of artists while at the same time admonishing scientists for adopting some expressive features that misrepresent the science involved. Hanson's article serves us well by suggesting that the artist's contribution can be more than a pretty picture—especially when the scientist engages in the feedback loop.

Today you can readily find scientists whose work could be shared with the general public more effectively. By introducing an Art on Graphics department to *CG&A*, we aim to expose the work of teams that draw on the skills of art, science, and technology professions to make rigorous innovative contributions to the domain of computer graphics and applications. By doing so, we can explore how gaps can be overcome as we educate ourselves to better understand and consider artistic process as relevant to our work. The result of our explorations may be unfamiliar as they suggest shifts in perspective, shifts in approach, and shifts in presentation that might contribute to useful work, especially when considered by both artist and scientist.

A Cognitive Tool

In an effort to help us frame an understanding of the diverse and complex nature of art-sci-tech collaborations that we will be presenting in this and future articles, we have put together a basic visual

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cognitive tool on which to facilitate thinking and build a dialogue (see Figure 1). Art-sci-tech collaborations exist on a number of spectrums. Having an understanding of the spectra will help provide a language with which to think about and discuss the field.

The first thing to consider is the intent of the work. Is work being presented as a work of art, a work of science, or some combination of both? The goals and intent of the two fields are very different. An often-suggested adage states that art seeks the relevant questions while science seeks the provable answers. Collaborations rarely produce just art or just science. More commonly, work exists along an intent continuum. Results of collaborative work are more complex. Both artists and scientists report that often what begins as an artistic pursuit often influences or impacts the scientific pursuit and vice versa. It is important to look at work in the light of its intended function and not judge it for what's unintended.

A second spectrum regards the breadth of the subject matter. Just as scientific research can be broad in scope, exploring wide reaching areas of understanding, so often is art. Also like science, art may instead be focused on a specific area of scientific research or revolve around a specific experiment. Collaborative work can fall anywhere along a narrow-broad focus continuum.

As a third example of a continuum on which work can be considered, the physical-virtual continuum addresses the physical properties of the work. Is it a sculpture that has mass and sits on a pedestal, or is it an idea, differing by each person's interpretation? Or is it something in between that resides on a disk, is broadcast via the airwaves, or can be realized physically according to some digital template?

By subjectively considering work as existing in a 3D space, each reader can map each artist's work within a space of possibility, providing a creative tool to help imagine what it might look like for the work to move toward another location in that space. Figure 1 demonstrates the concept (see an interactive version on the Web at http://bdcampbell.net/ieee/cga/). Other characteristic spectrums could be used instead—historical-current and static-dynamic, for example. If a shared goal of art and science is to communicate about the world around us, a visual mapping space provides a cognitive tool for suggesting possible ways of doing so.

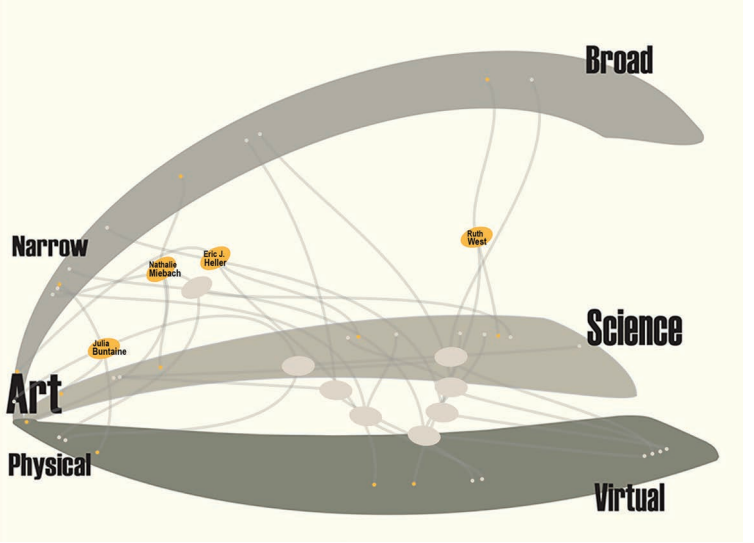


Figure 1. Creative tool for categorizing each artist's work in a 3D space. An interactive version is available on the Web at http://bdcampbell.net/ieee/cga/.

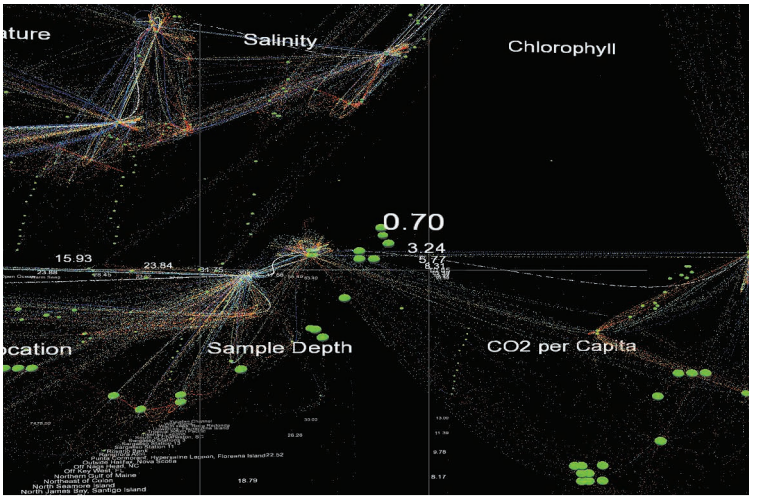
Representative Artists

Ruth West is an artist with background as a molecular genetics researcher. As a result, she's been able to participate in art-science collaborations with training and experiences from both art and science professions. She conceived and led the team to create *ATLAS in silico*, a large-scale installation, with significant impact as part of a "vibrant collaboration between artists and scientists spanning new media, computer science, metagenomics, biology, and engineering" (see Figure 2). As West explains,

> ATLAS in silico is a physically interactive virtual reality installation. It fuses art and emerging technologies with pioneering science. The installation offers an ethereal and dreamlike immersive 3D environment wherein you can explore life-size rendering of the Global Ocean Survey—a recent pioneering voyage of discovery circumnavigating the Earth's oceans, the results of which give us a new picture of life on Earth.

Unlike other art explored in this article, *ATLAS in silico* affords individuals or groups dynamic interaction with the presentation. One of several themes explored in the work is the role of pattern in creating meaning and knowledge in both science and culture. Participants experience an environment constructed as an abstract visual and auditory pattern that is at once dynamic and coherently structured, yet which only reveals its underlying characteristics as the participant disturbs the pattern through their exploration.

As patterns dynamically reform and are broken by participants' interaction with the luminous and colorful 3D graphics and a responsive data-driven sonic microworld, participants explore relationships



(a)

(b)

(c)

Figure 2. ***ATLAS in silico*** **by Ruth West. (a) Virtual environment with Global Ocean Survey (GOS) dataset in overview mode. (b) Interaction modes with Global Ocean Sampling Expedition data. (c) Participant interacting with** ***ATLAS in silico*** **on the Varrier TM 100-million pixel autostereographic display at UCSD Calit2. (Images courtesy of Ruth West.)**

within data that spans from the molecular to the global. The project also yielded a novel approach for visualizing the results of the Basic Local Alignment Search Tool (Blast), a foundational comparative genomics analysis utilized worldwide.[5] In this way, the art provides a context for science, and the science for art. Although often playful and highly immersive to the point of providing an overwhelming number of variables, a feedback loop on the effectiveness of graphics can be explored through observation and discussion.

Nathalie Miebach has created sculptures from local data observations near her home in Cape Cod, Massachusetts. For the piece *Warm Winter* made of reed, wood, and data, Nathalie uses a base of 24 hours and converts locally collected data (at Herring Cove) with data from regional buoys (from the Gulf of Maine Observation System) and historical data (from the National Oceanic and Atmospheric Administration [NOAA] and US Naval Observatory, www.wunderground.com). The data converted includes temperature (air, water, and soil), wind speed and direction, tides, and moon phases for the timeframe between December 2006 to January 2007. Nathalie's analysis process of integrating her personal data with historical and global trends in weather led to a series of sculptures (see Figure 3).

Trained and experienced as an artist, Nathalie performs skills within the scientist's trained skill set and performs numerical analysis tasks that have grown in magnitude for scientists as the natural world has been embedded with sensors and observation platforms. Her focus on weather, among other domains, seems timely, as climate change analyses have again become an emergent focus of science. She represents potential contributions to science collaborations by developing the observation skills of a citizen scientist, providing data for a crowdsourced input to weather and climate models, and providing a differently trained mind for performing analysis into what all the data might be suggesting about change. Her representation of an expressive interest in her local beach adds an emotional connection science might consider a source of potential bias, but numerical methods are evolving that can ferret bias out. The emotional aspect might engage others to care enough to develop the citizen scientist skills she's been building.

Julia Buntaine creates art that attempts to arouse specific subcomponent experiences of consciousness. She also creates art to communicate the cumulative knowledge being acquired by neuroscientists. Because contemplative studies have become a popular term for a field that investigates the gap between experience of consciousness and physical structure of elements involved in producing consciousness, Julia's art brings awareness to the field and opportunity to discuss the ramifications of scientific findings.

Her installation *Raw Feels* creates a visual and aural experience of the color red, providing us the ability to access the *quale*, or subjective experience of the color red as the eye adjusts to overwhelming color while integrating sound (see Figure 4). Her piece *Neighborhoods* shows a cross-section of

Figure 3. Nathalie Miebach sculptures. Using local data observations, the artist integrates personal data with historical and global weather trends in a series of sculptures. (Images courtesy of Nathalie Miebach.)

the East Village in Manhattan with a cross-section of a digitally reconstructed brain, suggesting that we consider parallels in structure and interacting complexity of the two environments, a theme she returns to continually in her work.

Having majored in both neuroscience and sculpture during college, Julia went on to earn her MFA and keep up with current neuroscience on her own. Her perspective on process is represented by her founding of "a virtual platform and pop-up events organization dedicated to bringing scientists and artists together for a common cause, showcasing artists and scientists work, and promoting a transdiciplinary cultural partnership between the arts and sciences at large."

Eric J. Heller was trained and gained experience as a scientist first. He worked as a theoretical chemist during a time when quantum theory shed light on many aspects of science. His interest in art became a natural byproduct of being successful as a scientist in a field that benefited from creative visualization. He described art's influence on his work in this September 2014 artist statement:

> Art has a unique capacity convey insights, intuitively and emotionally, about complex subject matter. If there is a short circuit to wisdom, it is through art. I try to exploit the powers of art to relate secrets of Nature only recently uncovered. A key element in my work is exploitation of Nature's almost narcissistic self-similarity, her repetition of pattern on vastly different scales and in radically different contexts. Consider, the motion of the planets around the sun and electrons orbiting a nucleus, or waves on water and electron waves in a semiconductor. With such repetition, Nature provides her own windows into otherwise secret worlds.

His piece *Transport III* is one of many he's created with this point of view that suggests possibilities in art-science collaboration (see www.ericjhellergallery.com/index.pl?page=aboutartist).

About the Department Editors

Realizing that new tools and approaches were being applied to science at a phenomenal rate, Bruce Campbell's research began in a virtual reality laboratory at the University of Washington, where scientist, artist, and newly minted VR researcher professions collided. There, Bruce had 10 years to contemplate how artists and scientist could work together with new technologies to augment human

Figure 4. ***Raw Feels*** **by Julia Buntaine. The installation creates a visual and aural experience of the color red. (Images courtesy of Julia Buntaine.)**

cognition for the betterment of society. The lab's published papers and technologies demonstrated that suggested collaborators could work together to overcome technical hurdles to the lab's overall vision. The harder work often came when confronting the many identified cultural issues that likely would be hard to manage given the rates of human physical and intellectual development on an evolutionary scale.

After 10 years of experimenting, Bruce turned his attention to tool building and tool use at the Center for Environmental Visualization, also at the University of Washington. He continues to work as part of CEV while performing an adjunct faculty role at the Rhode Island School of Design, performing activities that benefit from a better understanding of how to blend technology and artistic methods. Most of his students have had formal training and highly regarded professional experiences as artists.

Francesca Samsel has a 20-year history of art/science collaboration. She first consulted scientists while working on a series of sculptures, a 15-foot tall photo-plankton that drifted down the Niagara River. A local aquatic biologist gave her access to his specimen samples and microscope. Since then, it has been a circuitous route, oft interweaving her art with science, leading to her current position at the Los Alamos National Laboratory (LANL) as an artist-in-residence with the Data at Science Scale project. There she uses her artistic training to enable scientists to gain greater understanding of the underlying scientific phenomena through innovative use of design principles in visualizing their data.

Merging contemporary research, scientific data, and visualization with a visual metaphor of poetry, Francesca's work provides an interactive framework for the public to explore scientific issues through an intuitive language. Her work is a means for viewers to contemplate the environmental issues of our time and draw conclusions about options and actions that impact the future. Her recent collaborators include working with the COSIM Climate, Ocean, and Sea-Ice Modeling team at LANL; the Next-Generation Eco-System Experiments, Arctic team, at LANL; Craig Tweedie and the System Ecology Laboratory at the University of Texas at El Paso, researching extreme environments such as the Arctic, the Chihuahuan desert, and the Bornea rainforest; and visualizations of flu pandemic transmission with Lauren Meyers and Kelly Gaither of Texas Advanced Computing Center (TACC) at the University of Texas at Austin (see Figure 5).

All scientists can pursue collaborations with artists, like those introduced here, in an attempt to be more innovative through exposing a successful scientific process to potential beneficial disruptions. There need not be a feeling of jumping off a cliff while some leap of faith is explored. By looking at the overall objectives of an activity's enterprise, the artists' training and point of view can be injected to move the work in a new direction. By getting to know the artists, we at least begin to trust an artist's intent and commitment to science as they pore over the results of scientific work to enlighten their own work. This is the most basic reasoning behind introducing an Art on Graphics department in *CG&A*.

We hope to become your trusted editors when you feel the desire to share your useful experiences with art-science collaborations. We feel confident such art-science collaborations are useful for each participant's growth and for the emergence of new work that comes out of cooperation. In an effort to promote art-science opportunity as a spectrum of subopportunities, this article provides but one cognitive tool to explore potential configurations

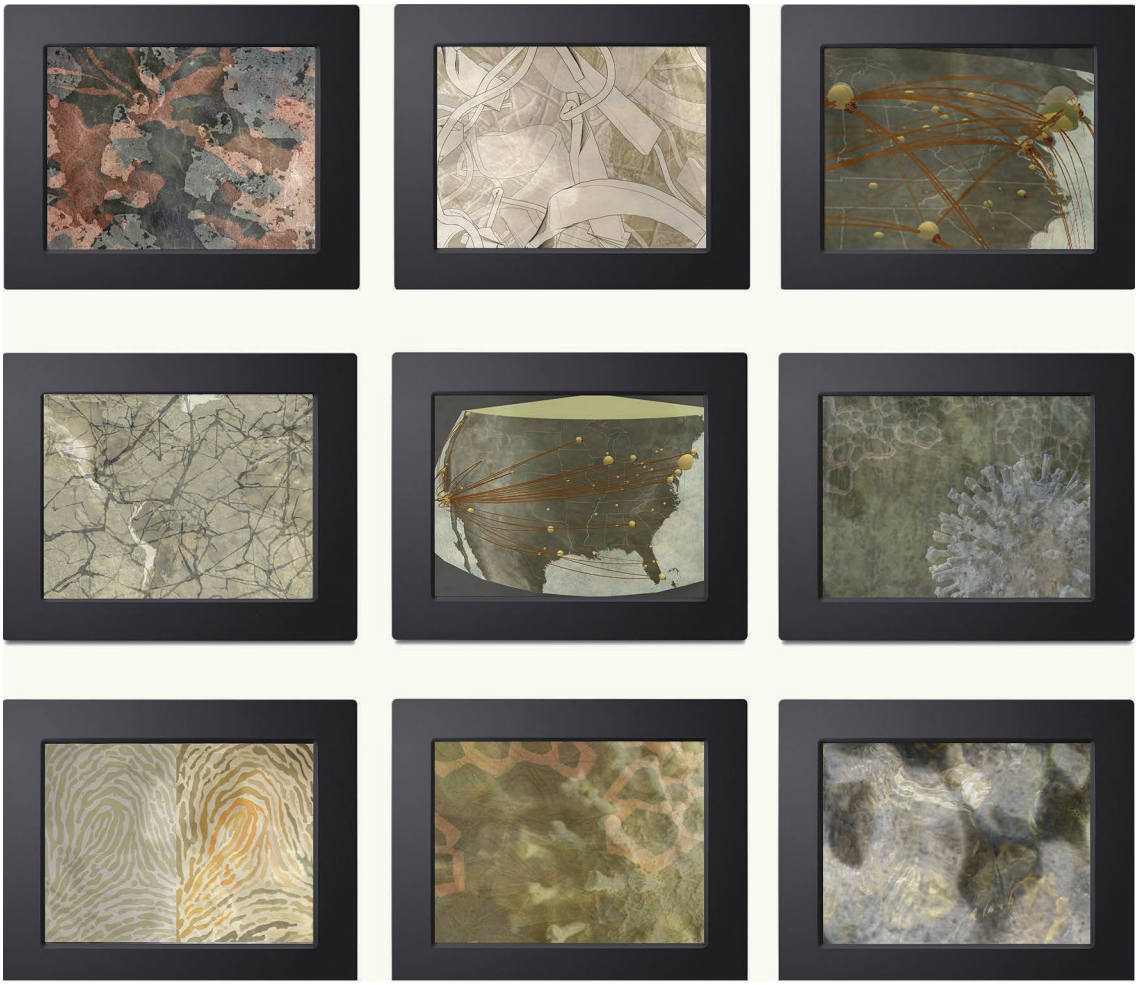


Figure 5. *Transmission* by Francesca Samsel. Collaboration between Francesca Samsel (artist), Kelly Gaither (visualization), and Lauren Meyers (pandemic flu transmission research). Still from a nine panel video installation.

of art-science work. We have certainly appreciated the lessons learned and thoughts explored through projects in the art-science realm—projects that had us working with teams of people who span formal education, training, and experiences from along the art-science continuum.

Additional contributions on projects come from areas beyond art or science. When that is the case, explorations may be complex and beyond any definite quantification of what contribution provided what tangible benefit to an activity. The use of the scientific method to pursue quantification in art-science activities has frustrated many good scientists. That's when the artist's instinct is likely to be a more expedient place to look for truth. Without the art-science collaboration exposure, the scientist is more likely to continue to dismiss the artist's perspective. We hope you will read the Art on Graphics articles in an attempt to consider artists in areas of scientific pursuit.

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