BRENDA LAUREL

DESIGNED ANIMISM

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My interest in the relationship between pervasive computing and animism has been brewing for some time – an anthropological bent and an engagement with poetics are old friends. I followed Mark Weiser's work on ubiquitous computing at Xerox PARC and witnessed other early developments in the domain at Interval Research. During my time as chair of the graduate Media Design Program at Art Center, I was drawn to thinking about ambient and pervasive computing from new perspectives within the world of art and design. When I also joined Sun Labs in 2005, I got to see the development of the SunSPOTs up close and personal. Of course, it didn't hurt to be married to one of the principal researchers on the SPOTS team, who continued his work with sensor networks at the NASA Ames Research Center. I'm now heading up a new transdisciplinary grad design program at California College of the Arts, where pervasive computing and sensor networks will play a significant role in many of our studios as well as in collaboration with other institutions. I see pervasive computing as an extremely important phase shift in our capabilities, opening up huge new vistas of possibility for design, discovery, experience and human agency.

What does pervasive computing have to do with animism? Essentially, it can become a tool in manifesting what I call »designed animism«. The goal is fundamentally experiential, but the conequences are profound: designed animism forms the basis of a *poetics for a new world*.

Animism as a spiritual belief system attributes in-dwelling spirits to natural objects like trees and rocks (Bali), places (as in the Greek notion of the *genius loci*), or architectural or made objects. These spirits may be ancestral or local, protective or representative of a kind of agency within the object or the natural world. What's lovely to me about animism is not so much its philosophical or religious dimensions but the *behaviors* and *artifacts* that are created by people in response to animistic beliefs. In Shinto practice, natural objects are worshipped as sacred spirits. One of the four principal affirmations of Shinto practice is the honor given to the Kami – divine spirits that may be found in sacred places such as mountains or springs. You may know them from *Princess Mononoke*. Again, these beliefs order life for the believer in terms of the behaviors and constructions they inspire. In both Balinese and Shinto examples, these include shrines, prayers, and dances.

But animism points at a kind of truth that is consistent with science as well. There are in the natural world many entities within entities – like mitochondria or chloroplasts within cells – each with its own individual perception-representation-action loop. This is a trope to which I will return. All entities that have such a loop may be seen as having purpose – teleology – distinct from the questions of self-awareness or spiritual nature.

In biology, there is a strong trend toward the theory that Earth's enormously diverse and interrelated array of beings, with its numberless feedback loops, functions itself as a kind of organism, where individual entities – including ourselves – are parts of a larger organic whole. This idea can be traced from the Lovelock hypothesis and on through the work of contemporary scientists like Lyn Margulis and Dorian Sagan, but it is also hinted at in several of the works of Aristotle. In a Gaian sense, focusing on the experience of animism in terms of the behaviors it might engender, a healthy dose could do us a lot of good just about now. Designed animism may help us make crucial changes in how we frame the world and how we behave in the face of enormous environmental challenges.

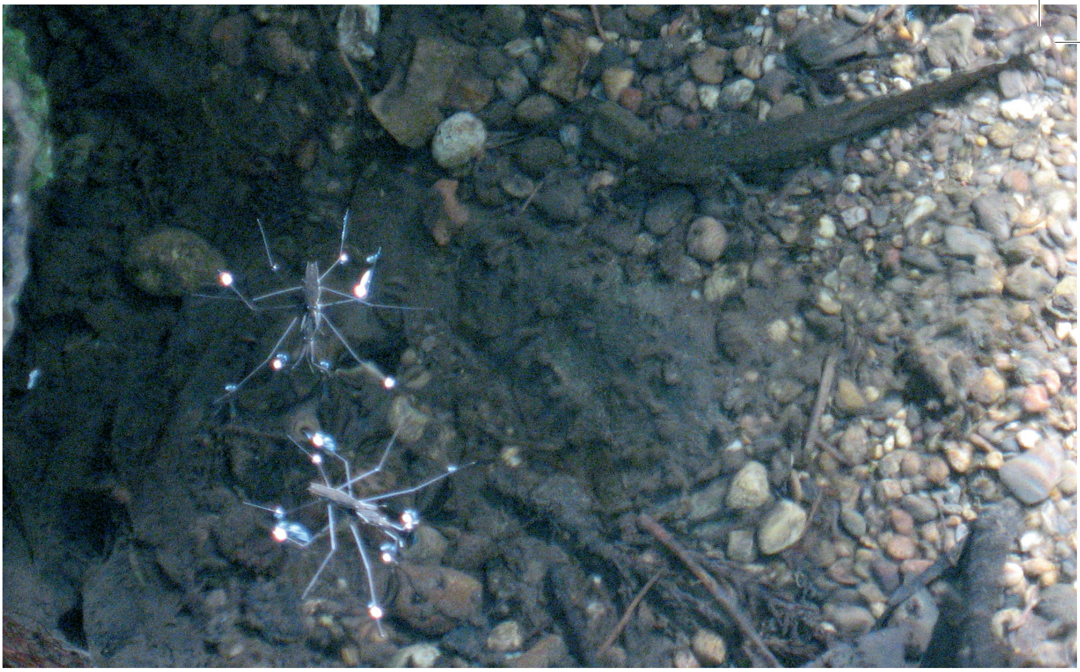
The behaviors and constructions associated with animism are, of course, *designed* (or emerge through cultural evolution) within a context of beliefs, ethical values, and aesthetics. Less formally, animistic beliefs and ritual behaviors act as »co-designers« of everyday life. Because animism is seated in nature, the design of an animistic life encourages the imagination to construct beauty through projection onto the natural world, just as it invites nature in as an active participant. This is also a theme to which I will return.

Designed animism calls for a marriage of the notion of animism with a sense of poetics. Poetics, although most often associated with Aristotle, refers in general to literary theory that deals with the nature, forms and laws of poetry. Aristotle's *Poetics* looked at the various forms of poetry and their attributes, at the ways in which each kind of poetry might produce pleasurable experience, and how the form of poetry – a drama, for example – has value or serves its purpose; that is, the notion of virtue.

Nearly twenty years ago, in a book called *Computers as Theatre* (which is, strangely enough, still in print), I explored principles from Aristotle's works, primarily the *Poetics*, to discover whether and how they might apply to interactive drama or what you and I might now call a computer game. I revisited some of that work to think about how we might design systems that incorporate sensor networks and other distributed computational devices. How might we design new sources of pleasurable experience with the new affordances of ubiquitous or ambient computing? The Stoics and the Epicureans had some thoughts on the use of pleasure that can be revisited in light of modern affordances – and in the context of new conversations with mitochondria, rain forests, and our own selves.

The goal of pleasure seems somewhat at odds with the prevailing ethos of ubiquitous computing, which is still most often seen as having an essentially utilitarian or productive purpose. The discourse of ubiquitous computing emphasizes its value as a kind of human-computer interface coupled with software technologies that can make accurate inferences about the human need or desire to create an automagically convenient world. It also looks at the complementary problem of how a human can make needs or desires explicit. In terms of efficiency, a centralized computing model is often envisioned as the machine behind the curtain. Of course, this is the idea of Central Services that Terry Gilliam maligned in his classic film, *Brazil*. But in fantasy as well as in the reality of research labs – from smart houses to well-monitored cities – the tidy, efficient notion of ubiquitous computing is suspect. Over all hangs a cloud of social concerns: trust, privacy, erosion of human agency, reification of classism, and so on.

I don't mean to diminish the importance of the ideas and concerns I just sampled. I am simply exercising a particular design tactic, which is to look for the less populated area of the landscape, or what a designer might call the »opportunity space.« I'm hung up on pleasure because it seems a bit underserved in the discourse, because, well, I *like* it, because pleasure is good for getting people to notice things that they might not otherwise care about and because technology continues to offers new capabilities for creating it.



Water striders position themselves on the basis of wave patterns created by their fellows' movements.

In several domains we can observe something that my husband, Rob Tow, and I have been chewing on for a while: that is, the difference between a model of unitary central control versus a model that invites emergence from the summed actions of many actors, each with its own perception-representation-action loop. Rob characterizes this contrast variously: »clockwork and windmills«, or »Apollo and the rain forest«. The contrast might be delineated as a closed versus open system design, point versus field, or indeed »Central Services« versus a rain-forest *ecology of relationships*. In a rain forest ecology you can knock out any one species and the system still functions, other species slide into vacant niches. Central Services just doesn't work like that.

This contrast is apparent in many realms, and it can obviously inform our design practice. Let me give you an example. In 1976 in his book *Computer Lib*, Ted Nelson envisioned a system that would make all of the world's knowledge available and traversable through hyperlinks. He called his system »Xanadu.« The idea was glorious and massively inspirational, but the system concept was »closed« and proprietary – even quite secretive. Central Services again. As a closed world, this vision was too big to get one's arms around. And then along comes a noisy, crowded *field* of individual agencies and cockeyed affordances that ended up making Ted's dream a reality: the Web. You see what I mean.

Here's another example from the world of computer games. Back in the 1980s, about the time that Chris Crawford, myself and several others founded the Game Developers' Conference, the central issue in the game design community was the design of non-player characters and the kinds of »artificial intelligence« that could be used to animate them well enough to entertain, challenge and surprise human players. I took a similar tack in *Computer as Theatre*, attempting to figure out what aspects of Aristotelean poetics might be useful in designing interactive fantasy worlds – worlds that would provide robust, dramatic experiences for players or participants by incorporating some Aristotelean intelligence into the ways a computational system might generate actions of non-player characters and situational variables in a fantasy world.

Near the end of the 1980s, most likely inspired by Vernor Vinge's canonical tale, *True Names*, guys like Chip Morningstar started fooling around with the idea of graphical MUDs (standing for Multi-User Dungeons, in honor of the D&D community). Chip and his colleagues developed a system at Lucasfilm called *Habitat*. Although online multiplayer games had existed since the days of *Spacewar* and later in the domain of MUDs and MOOs, I think it was primarily the avatar-based graphical UI of Habitat that pushed multiplayer games over the »tipping point«. The change in design was profound, based upon the simple observation that, in contrast to AI-driven non-player characters, the source of the most interesting and lifelike actions might actually be *other human beings*. What a concept!

With the advent of this sort of space (and it progeny, such as *Everquest*, *Ultima Online*, and today's panoply of massively multiplayer online games and social spaces like *Second Life* and *Myspace*), designers had to *give up some authorial control*. In these cases, they give it up to other human beings. As you might imagine, many of the old lone-wolf designers just couldn't cope, where designers like Will Wright, who always seemed to understand that his players were his co-authors, jumped in with both feet. Computer game designers had to step back from *formal* control of the *shape* of a game and focus instead on the manipulation of *material causality* – that is, designing materials and environments that would predispose players to take actions that would yield dramatically satisfying outcomes.

Because computer games bear a striking resemblance to theatrical representations, with the addition of interactivity, it makes sense to look at dramatic form and experience and how interactivity changes it, not only for the interactor, but also for the author or designer. From there we may begin to look at how experience and design morph again when we introduce distributed sensing and computing devices and begin to incorporate their inputs into designed platforms for experience. This analytical exercise brings us back to Aristotle.

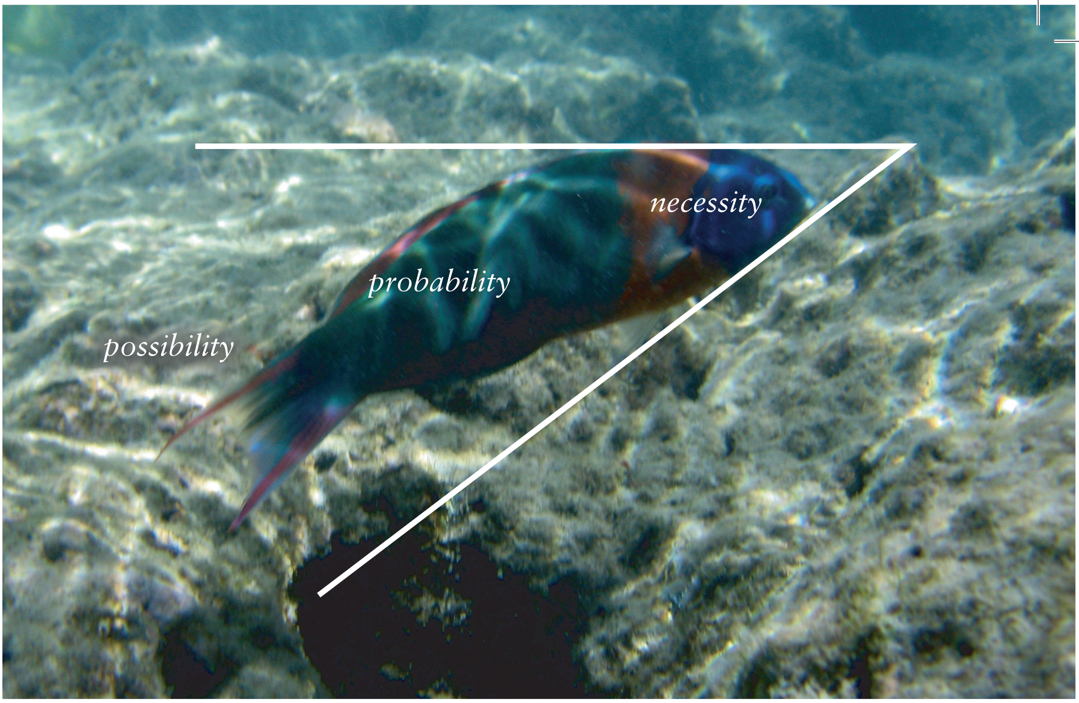
In the *Poetics*, Aristotle wrote about three different kinds of poetry. The *Epic* is a story or chain of stories describing events that may unfold over long periods of time, meant to be recited (or read), in the first or third person. It relies upon *extensification* – stretching time, as James Joyce did so well, so that a second can take minutes or hours to unfold. *Drama* is an imitation of an action with a beginning, middle, and end, and of a certain magnitude that can be taken in during the course of a day, enacted by players. Dramatic form relies upon *intensification*. So while the stand-alone computer game tends to take a more or less dramatic form (intensification), persistent multiplayer online games or worlds are more epic in nature (extensification).The *Lyric* form was more mysterious to Aristotle – he referred to »flute-playing and lyre-playing« as forms that incorporated music and rhythm. He also included in this category a form which, with the addition of language, still had »no name« in his day – this would be what we now think of as lyric poetry, spoken word, or even narrative music – that is, songs that tell stories.

Aristotle believed that any instance of poetry – a play, for example – was the result of four distinct but interrelated causes:
END – what a thing is intended to do
FORMAL – how the thing is influenced by a notion of form
EFFICIENT – how it is influenced by its maker(s)
MATERIAL – how it is shaped by what it is made of.

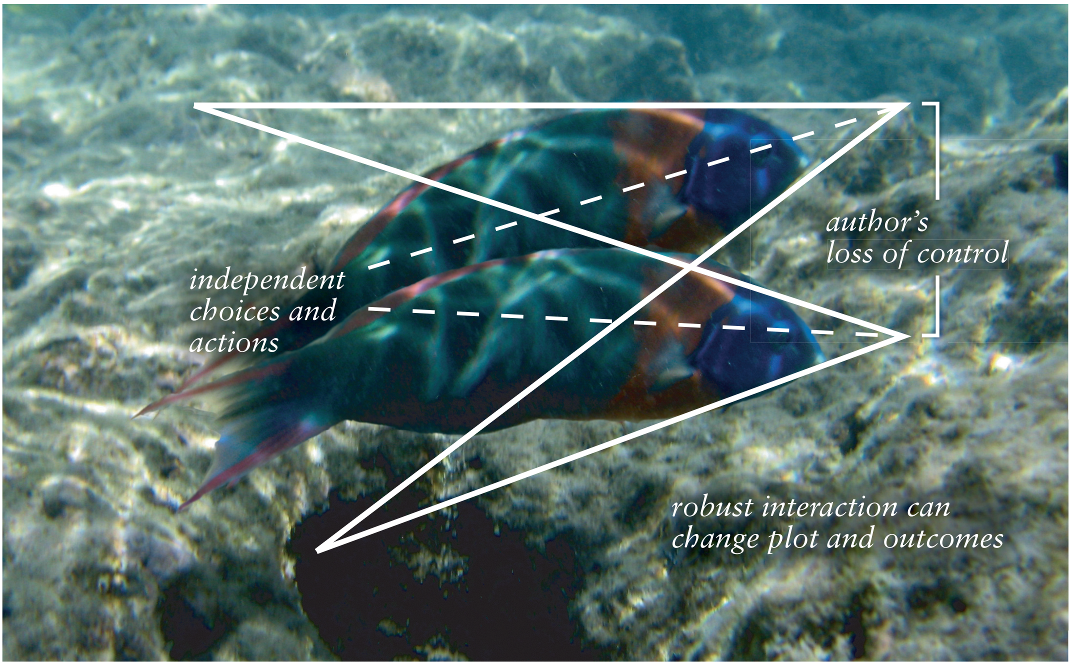
Moreover, Aristotle saw that a drama had six fundamental structural elements: plot, character, thought, diction, music, and spectacle. A nifty thing here is that each element could be seen to exist in causal relation to those above and below it, so in terms of material causality, sensation in the material from which pattern is constructed, thought is the material for character, etc. while character is the formal shaper of thought, thought of meaning, and so on.

Designing from the direction of the material cause is like reasoning or creating inductively. Formal causality begins with a notion of form and works more or less deductively to fill it out. In reality, most artists and designers work both ways at once.

Aristotle saw the action of a play as a progression from a wide range of possibilities, narrowed down through the choices and actions of characters and changes in situation to a smaller set of probabilities, which eventuate in a necessary end. Because the playwright controlled all of these choices and actions, he could also control the *shape* of the overall plot by *structural* means.



Left: Aristotle's elements of dramatic structure.
Action of play progresses from wide possibilities to narrow necessity (above), but what if the author loses control (below)?



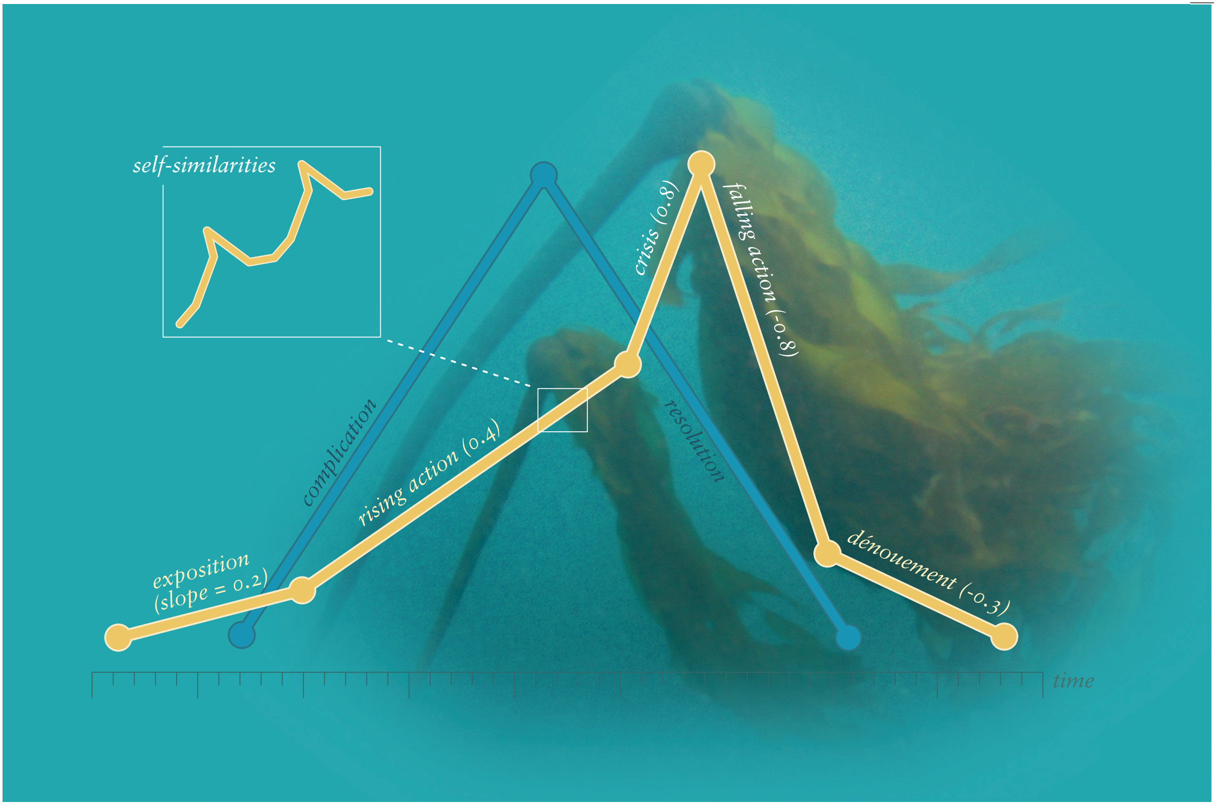
But what if the playwright is not the only fish in the sea? What if there is another agent – a character with free will, so to speak – making choices and performing actions that the playwright might not have foreseen? Then the trajectory of the plot will likely have a different end point – a different ending to the story. The interactor joins the playwright as the efficient cause of the whole action. What's an author to do with this loss of control?

Making a drama interactive means that the author has less and less influence from the direction of *formal* causality (that is, direct manipulation of plot, character, and thought). As we discovered in the days when interactive plays were in vogue, a way to compensate is to work more strongly from the direction of *material* causality, manipulating the environment and the materials out of which a »free agent« will construct thoughts, choices, and actions. The playwright's influence on the shape of the plot becomes indirect; he must *predispose* the interactor to make choices and take actions so that the interactor's *experience* has a pleasing shape.

How do we judge whether the action of a play has a pleasing shape? Aristotle described the metrics in terms of kinds of actions and emotions, as well as other structural elements. A big leap in our understanding of a pleasing shape for a plot came in 1863 from a fellow named Gustav Freytag, who created a visualization of dramatic action that was essentially a simple triangle labeled with Aristotle's anatomical terms, showing complication and resolution over time.

The triangle was refined by succeeding critics to show the relative duration and slope of these anatomical parts, giving us a more finely articulated vision of dramatic »shape.« The slope of each segment shows the relative level of complication, tension, stress, or suspense for that part of the play.

If you think of complication as asking a question and resolution as answering a question, you can see the shape as a kind of information analysis. Suddenly you're not looking at a picture of dramatic structure or even a picture of an



Basic Freytag graph of dramatic action (blue) and elaborated (yellow).

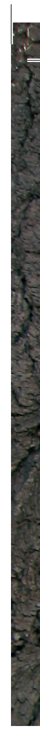
emotional progression, but simply a picture of information dynamics. But this a pretty grainy picture.

If you were to do a scene-by-scene or even line-by-line analysis of the play, you would find roughly self-similar curves at a smaller scale. Thanks, in part, to the invention of soap operas, episodic drama shows that sub-plots within episodes exhibit similar shapes, as well as overarching plot developments that arc across several episodes, encouraging the viewer to tune in again and again.

You are probably wondering what this analysis is good for in the context of this topic. What I've tried to show here is that there is a characteristic shape of dramatic experience that exists at various scales of time and granularities of information. I find this provocative. I suspect that, beyond the canonical shape itself, the self-similarity at scale is part of what makes drama beautiful or pleasurable. Kind of *fractal*.

This shape of experience might apply to forms besides drama as well; for example, rituals. Dramas were in fact rituals in early Greek culture, performed by priests of Dionysus for the greater emotional health of the polis. But that's another story. An animistic ritual can have an experiential shape similar to the shape of a plot.

This particular ritual has emerged among people of the Midwestern diaspora in Northern California. Yeah, tree-hugging.



This analysis is all well and good for the arc one person's experience, or the dramatic arc proposed by a play presented on a stage. But what does it have to do with distributed computing? Well, we can begin by thinking of how to make a distribution of dramatic arcs.

We move from a point source to a field.

A play is a kind of point source. Thinking along the trajectory of material causality, we can turn this point into a field by creating an environment that predisposes people to have different, but dramatically satisfying, experiences within a shared »field« of materials, patterns and so on. Here's an example from my own experience: the Renaissance Faire.

Trolls, royals, lepers, washer-women and the obligatory Spaniards vie for participants' attention. From the enormous spectacle of the joust to in-your-face excoriations of Protestants and whores, the participants' experiences seem to be somewhat »self-similar at scale«. Participants dress as wenches, pirates, faeries, trolls – even Samurai out here on the Pacific Rim. The Renaissance Faire is a field of materials for myriad dramatic experiences. The environment – the material causality of the Faire – predisposes those experiences to be pleasurable in similar ways. The miracle of the fishes.

Master storyteller David Ponkey (»Jack«) pictured above at the Northern California Renaissance Faire.

So there are two central, related ideas that I hope I've communicated by this look at drama: that there's *pleasure in the pattern of action* (which may exhibit self-similarity at different scales), and that *moving toward material causality* in authorship or making is a good strategy for collaborating gracefully with free agents to achieve experiences with pleasurable shapes.

Here's a bonus. Just as *Habitat* and multiplayer games demonstrated that a designer or author might have to do less rather than more to accommodate shared authorship, so the designer may have to do less rather than more by inviting nature into the collaboration. *Materials derived from the natural world usually come with »pleasing shapes« already embedded in them – shapes that please in ways that are different from the pleasure of a dramatic arc*. This is the third movement in our allegory: from the point source of drama, to the field of interactive media (which, although greatly more complex and inviting of emergence is still essentially *human-centric*), to the notion of inviting the *natural world* into our work as a collaborator.

Take the example of a windchime. It works on several relevant levels. It is what most would describe as a pleasing pattern of sounds. This pattern brings the invisible (wind) into the realm of the senses. The qualities of both the wind and the chimes exhibit chaotic patterns of a fractal nature, and these patterns may be rendered to address various sensory modalities. The windchime maker invites nature into collaboration. The maker crafts the materials and structures of the chimes and then lets the wind have it.

Sensors that gather information about wind, or solar flares, or neutrino showers, or bird migrations, or tides, or processes inside a living being, or dynamics of an ecosystem are means by which designers can invite nature into collaboration, and the invisible patterns they capture can be brought into the realm of the senses in myriad new ways.

As you undoubtedly know, Pythagoras, Copernicus and Kepler explored music as a representation of some of nature's deepest principles. Some musical compositions, like Holst's *Planets*, take the narratives of astrology as their core rather than any actual natural object or process.

Kepler's work in mathematics and astronomy is better known than his influence on musical theory of the time. »The Music of the Spheres« was to him much more than a metaphor. In his book on the history of music and science, Jamie James reports that »Kepler's most marvelous revelation came when he began to make ratios by pairing off the planets.« Kepler said, »…in the extreme movements of two planets compared with one another, the radiant sun of celestial harmony immediately breaks in all its clarity through the clouds.« James continues, »Using these extreme values, Kepler was able to construe the entire musical scale. Furthermore he discovered that each of the planets had its own scale, which is also determined by its speed at perihelion and aphelion.« For example, Saturn, the deepest, and Mercury, the highest pitched were notated this way.

That is not to gloss over mathematics and science. The twin inventions of the telescope and microscope changed fundamentally how we could see and think; real entities from the natural world that *were* invisible became visible. Kepler can be seen as a transitional figure between the solid geometry that reigned from Ptolemy and Euclid through Galileo – a span of over 20 centuries – and the new world of Newton's calculus. There was a pause of another 150 years, give or take, before mature chaotic dynamics, fractal math and emergent phenomena showed up as breathtaking new ways of understanding the world in the later twentieth century. It's worth noting here that these three domains were enabled by a new affordance: the computer.

Contemporary composers use information from the natural world by different means in their work. The controversial composer John Cage used probability and chance in some of his compositions, embedding chance events correlated to the I Ching or to computer-generated random numbers. Physics PH.D. Fiorella Terenzi used optical and radio data from galaxy UGC 6697 as the basis for a composition she called *Music from the Galaxies*. Composers like Stravinsky, Debussy, and Ravel attempted to express natural processes as music based upon a fusion of phenomenological observation and musical style. Debussy's *Voile* – French for »sail« – attempts to capture complex layers and dynamic shapes of wind and water, and the motion of a boat as the wind rises and falls. This piece of music is almost like a movie. In it, Debussy has approximated in a non- or pre-scientific way a kind of beauty that will later be amenable to exacting mathematical description.

Beginning with Turner, many painters in and around the impressionist period worked from an explicit desire to find artistic styles that more accurately represented human vision. Monet is an intriguing example: from his paintings, scientists were later able to derive his astigmatism, functioning as a kind of proof of the accuracy of his phenomenological observation. From his paintings of the Rouen cathedral, later scientists could also derive information about air pollution, something that Monet probably didn't think he was looking at.

A truly stunning example of the pre-scientific expression of a kind of pattern in nature that was not well understood by science at the time is the work of painter Jackson Pollock. In an article entitled »Fractal Expressionism« published in *Physics World* in 1999, Richard Taylor, Adam Micloich and David Jonas were able to demonstrate that Pollock's painting accurately represented fractal patterns. The authors observe that »experimental observations of the paintings of Jackson Pollock reveal that the artist was exploring ideas in fractals and chaos before these topics entered the scientific mainstream.« Pollock's motion around the canvas and his application of paint by dripping are natural causes for the fractal nature of the work. He literally invited physics in as a collaborator. Pollock saw beauty in forms that could not even be named when he painted them.

Mandelbrot brought the work of the centuries-long explorations in the realm of chaos theory to mathematical fruition. Fractal geometry, created principally by Mandelbrot, has been dubbed »the true Geometry of Nature.« The impact of fractal geometry and new tools for generating fractals on art and popular culture has been huge, from feature film effects to computer games.

The purpose of this part of my rant is to observe that in areas such as music and visual arts, artists have captured patterns in nature based purely on phenomenological evidence that were later reified by mathematics. Computational tools have allowed contemporary artists to collaborate directly with the natural world in novel ways through the use of mathematical and computational representations of nature. Surely there is more to come.

Here's another discovery that just blows my socks off. In 1976, Richard Voss and John Clarke identified the temporal manifestation of fractals in the mathematical expression of 1 over f noise, commonly called »pink noise.« Mandelbrot and Frame tell the story of this discovery in the course notes for »A Panorama of Fractals and Their Uses« taught in the Mathematics department at Yale:

> As a graduate student at Berkeley, Richard Voss was studying this problem, using signal-processing equipment and computers to produce the power spectrum of the signal from a semiconductor sample. When one sample had burned out and another was being prepared, Voss plugged his signal-analyzing equipment into a radio and computed the power spectrum. Amazingly, a 1/f spectrum appeared. Voss changed radio stations and repeated the experiment – another 1/f distribution. Classical, jazz, blues, and rock all exhibited 1/f distributions. Even radio news and talk shows gave (approximate) 1/f distributions.

Mandelbrot and Frame have documented 1/f noise in Western music as well as African, Japanese, Indian, and Russian, and through a range of times, from the Medieval period through the Beatles. They conclude that:

> Voss uses these observations eloquently to bring closure to one of the classical Greek theories of art. The Greeks believed art imitates nature, and how this happens is relatively clear for painting, sculpture, and drama. Music, though, was a puzzle. Except for rare phenomena such as aeolian harps, few processes in Nature seem musical. Voss uses the ubiquity of 1/f noise to assert [that] music mimics *the way the world changes with time*.

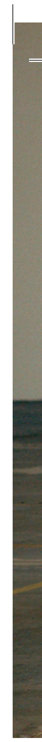
I'm hearing windchimes again. Here may also be the definition of Aristotle's elusive Lyric form. We live in a time in which many new forms of »windchimes« reveal previously invisible patterns and forces in the natural world.

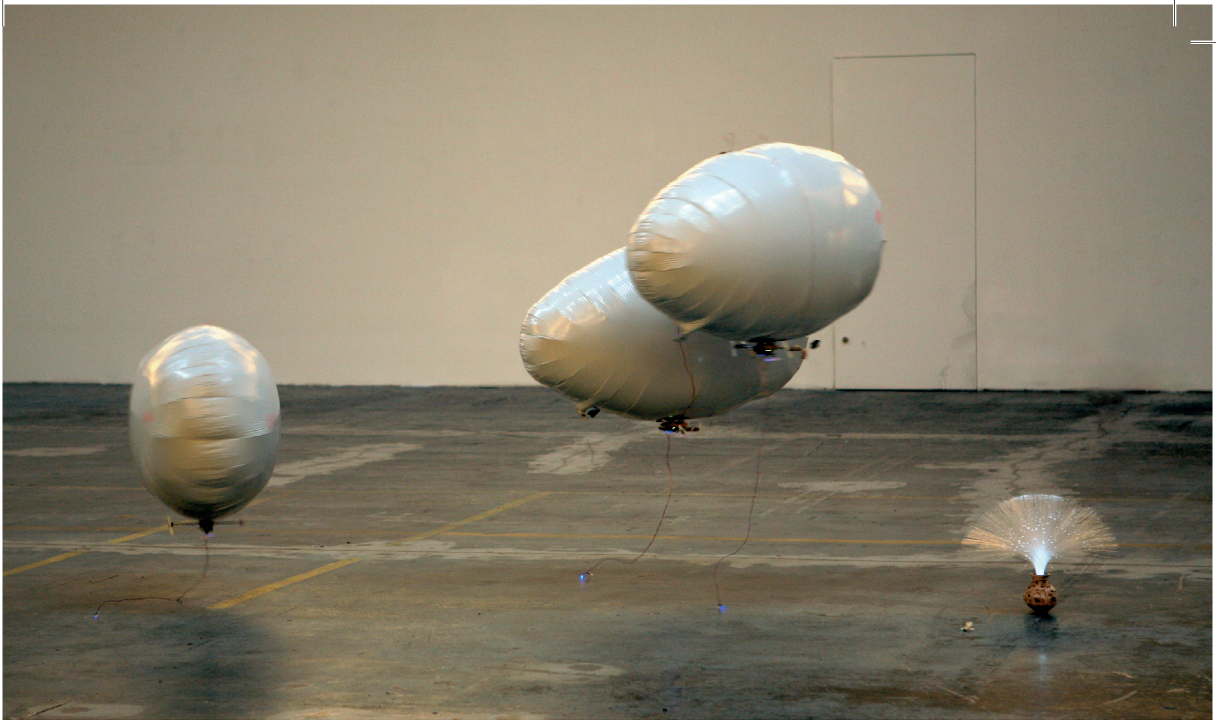
1/f noise is not just a characteristic of music. Mandelbrot and others have explored in depth how chaos works in economic systems – 1/f noise is present there as well. For me, this is a clue that human behavior – even in a pinstripe suit – is much more closely related to the natural world than we generally acknowledge.

I want to turn to a different kind of pattern: the pattern of emergence based upon the interaction of entities with perception-representation-action loops. Water striders are a gorgeous example of emergence in the natural world (see the picture on p. 255). Rob calls them little state machines. They have fairly simple rule sets that respond to characteristics of water, light and proximity to other mass-y things. By operating independently, they dynamically arrange themselves evenly over the surface of a pool to optimize each individual's feeding area. There is no Water-Strider Central trying to manage this distribution. It is emergent from the local rules of each individual in interaction with its environment.

I won't attempt to catalog all of the wonderful examples of emergence in natural, social, and computational systems. I want to simply call your attention to emergence as a design resource that can be tapped by networks of sensor-enabled devices working on local rules to create both beauty and knowledge.

So here's a funny thing. In 2005, Sun Labs sponsored a transdisciplinary studio hosted by the Media Design Program at Art Center. Bruce Sterling, who was in residence in our studio that year, co-taught the course, along with Nik Hafermas and Phil Van Allen. The idea was to lob a bunch of SunSPOTs – networked devices that are capable of producing emergent behavior – at a bunch of design students and let them have it. Jed Berk and Nikhil Mittner, both Media Design students, designed a flock of blimps that they called ALAVs – »autonomous lighter-than-air vehicles«. The blimps could be »fed« through an array of fiberoptic tubes. When they were »hungry« they descended, and when they were nourished, they lifted off. When they were close to one another, they flocked and cooed. I have to say, it was totally trippy. When I last spoke with Jed, he was attaching video cameras to them and let them create a kind of ambient video BLOG. Cool.





ALAVs 1.0. Wind Tunnel, Art Center College of Design. Project by Jed Berk and Nikhil Mittner. Photo courtesy of Theo Alexopolous.

Cool. So what? This chapter was about pleasure, poetics and designed animism. I guess I'd better give you some examples of what I mean by designed animism in a technological context before I conclude. As I said earlier, with animism I am not so concerned with the attribution of spiritual powers to beings and processes in the natural world as I am concerned with what those attributions induce in us. When we see the world as deeply alive and beautiful, how does it change us? How does it change what we decide and do in the world?

My good friend Sean White has been working on a system called an Electronic Field Guide. The vision for the project is to explore new forms of field guides that enhance cognition and memory. The project's explicit purpose is to serve botanists and other scientists in identifying plants and observing or visualizing some of the relationships at work in their ecosystems. The project is a large-scale collaboration between Columbia, the Smithsonian and the University of Maryland. A prototype system has been deployed on Plummers Island and will soon be mounted again at a science station on Barro Colorado Island in Panama. Sean says:

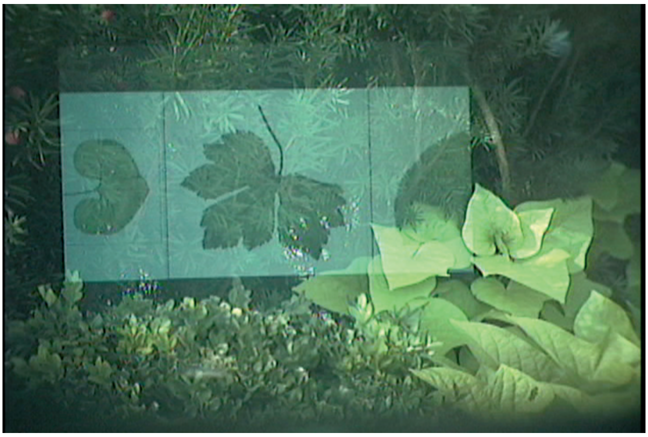
> Biologists of all stripes go down there for research and most of them have their own specialty. We are exploring the possibility of providing the EFG to aid researchers in quick identification of flora relevant to their own ecosystem research. If a botanist is studying a caterpillar, they may not be able to identify the species of plants that it eats. The system will help them create an ecological web of relationships and perhaps even help build a semantic web in the field for further eco-informatic study.

Sean has experimented with multiple cameras and sensors as inputs and with hardened tablets, augmented reality displays and mobile phones as UI devices. He believes that a distributed system without centralized control will eventually be an optimal form. He describes his goals this way: »We do this to support being *in* the world and *part* of the world.« He reports that when people experience these realtime streams of data in combination, a holistic sense of delight often emerges. In other words, emergence happens *inside the person*, and this is true even when one brain could not possibly sort the specific information content of each of the streams of information that are available to them. He's had botanists tell him that they have felt the boundaries of their bodies dissolve. But, he cautions, this transcendental awareness is fragile and must be approached with a spirit of lightness.

As Sean's system demonstrates, the process that I described in the context of pre-scientific representations in art and music is has its inverse. In the first case, the creation of a representation that delights the artist reveals a deeper intuition of some of the unseen shapes of nature. In the inverse case, the fusion of inputs from distributed sensors delivered in delightful ways creates the same sort of joyous intuition.

When discussing this phenomenon at the 2006 Ubicomp conference, Bruce Sterling asserted in his usual acerbic way that »there is no magic.« Sean's project combines sensor data with machine learning techniques to look at covariance in an n-dimensional space and find the eigenvectors or most meaningful axes in that space. Those reveal interesting patterns that a person can experience in sensory ways. They look at frequency patterns with Fourier transforms and the

Augmented reality image of matching virtual leaves overlaid on physical scene as viewed through Sony LDI-D100B color, optical see-through, head-worn display. The image of the user's view was captured directly from inside the head-worn display, using a Toshiba remote lipstick camera and digitized at 720 x 480 resolution. Courtesy of Sean White.



texture of irises with gabor jets. With semantic zooming they are able to move in and out of the pattern space. Now *that's* magic!

In my garden, there are faeries.

One of my faeries watches the lavender. This one has a history of the flowers and knowledge of how sun and shade move over the garden as the day passes. The lavender faerie brings the scent of warm flowers into my room just at the sunniest hour. It also whispers with the bee faerie, who knows that when the lavender is just so, the bees will come. The water faeries taste the soil around my plants and drip when they are too dry. The lizard faeries dance around the top of my desk when they see the lizards scurry from the Oregon grapes to the woodpile.

We see faeries, or make them up, but now we can also *make* them. We have, for the first time, the capacity to create entities that can sense and act autonomously, or with one another, or with living beings. They can learn and evolve. They can reveal new patterns, extend our senses, enhance our agency and change our minds.

My fairies watch the sun set with me. They dance the changes in light and temperature, in the closing of certain flowers, in the quieting of songbirds and the wakening of owls. And I have this perfectly joyful sense that my body is my home, my garden, my canyon, my trees. If I had more sensors, my body could be the earth. With matching effectors, I become a »Gaian Gardener«, responsible for and enacting the health of the living planet.

Scientists and artists know that patterns drawn from nature tickle our nervous systems at a deep, preconscious level. Designed animism is a healing system for our disconnect with our planet. But as our history so vividly shows, we are not likely to come to new awareness though fear, or even through information. We may, however, come to it through delight.

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