Spatial Thinking

April 1, 2008

What do DNA, Black Studies, and "anywhere augmentation" have in common.

With roots in geography and a reach into subjects ranging from music and psychology to black studies, spatial thinking is big at UC Santa Barbara. It all comes together at the UCSB Center for Spatial Studies, known as spatial@ucsb.
UCSB Geography Professor Michael Goodchild is making the case for space. The problem with much of modern science, he says, is that it’s neither here nor there. Physicists, psychologists, sociologists and other students of the human and natural worlds look for the rules that, like the laws of quantum mechanics, apply without respect to where things are. “It has become customary to strip away context,” he says. As the director of UCSB’s new Center for Spatial Studies? known as spatial@ucsb?Goodchild is now working to put that context back.

Known worldwide as a leader in the theory and development of geographic information systems (GIS), Goodchild is not alone in his zeal for spatial thinking. Not just in the sciences, but also in the arts and humanities, UCSB already has a strong spatial emphasis, exemplified in a wide array of research efforts and creative initiatives that involve spatial analysis, technology and presentation. spatial@ucsb now acts as a nerve center and help desk for all this activity.

One goal of spatial@ucsb is to promote spatial thinking in academia and beyond. That includes explaining what spatial thinking is and why it’s so important. Another aim is to raise UCSB’s profile and influence, as spatial thinking and spatial technologies assume greater importance in science, technology, business, and everyday life.

At a basic cognitive level, spatial thinking is three-dimensional perception and recall. Strong spatial thinkers can easily recognize the same assembly of blocks in different positions (in so-called “mental rotation” tests). They always turn in the right direction when leaving buildings and never have trouble locating their cars in parking lots. Well-developed spatial thinking leads to spatial literacy—the capacity to learn about, analyze and explain the natural and social worlds through spatial visualization, technologies such as GIS, and spatial displays such as maps.
Spatial thinking has long played a crucial role in physical and social science. It has led to breakthroughs as varied as the discovery of the structure of DNA by James Watson and Francis Crick in 1953, a tour de force of three-dimensional visualization, and the curbing of deadly diseases. In the 1850s, surgeon John Snow helped end a cholera epidemic by drawing a simple map that showed how new cases of the disease in one London neighborhood clustered around a water pump, which authorities then closed. A century later, researchers discovered the link between asbestos and cancer by noting the high incidence of the disease near locations where "liberty ship" freighters were built during World War II.
The Near and Far of It All

What these examples have in common is a concern for how things and people exist in space—their height, depth, width, shape, and relation in space, typically expressed in terms of x, y, and z axes. How near and far they are to other things (or people) is crucial. So are all the data tied to the same location. Where two or more things happen at the same place—like cancer cases clustered around shipyards—spatial analysis may uncover cause-and-effect links that otherwise could remain buried in statistics.

Spatial thinking is at the core of several important physical sciences, including geography, epidemiology, geology, meteorology, and environmental sciences in general. It also plays an increasingly important role in social sciences?UCSB?s Center for Spatially Integrated Social Science (CSISS) is devoted specifically to that role.

Don Janelle, spatial@ucsb program director, says, "One of the benefits of the spatial perspective is that it?s an incubator for interdisciplinary work? (Janelle, a research professor of Geography and the Institute for Social, Behavioral and Economic Research, also directs the program SPACE ?Spatial Perspectives for Analysis and Curriculum Enhancement?at CesisS). "The block where you live has its own politics, health patterns, demographics and culture. It?s all there; the spatial perspective gives you a way to integrate it," he says.

At UCSB alone, says Janelle, spatial analysis has attracted the interest of faculty in the Departments of Mathematics, Anthropology, Religious Studies, Psychology, Music and Black Studies, to name just a few. UCSB?s new Allosphere—a spherical enclosure three stories high, used for creating and studying 3-D phenomena in light and sound—is a nexus for spatial research in the arts as well as engineering, quantum physics and nanoscience.

Why a Spatial Center?

spatial@ucsb has its roots in geography and in Goodchild?s work with GIS, the computing technology that processes and analyzes location-linked data. In 1988, he won a $10 million grant from the National Science Foundation to set up the lead site of the National Center for Geographic Information and Analysis. The mission of this research consortium was to "interact as widely as possible with scientists worldwide, he says, rather than focusing on building resources at Santa Barbara. This was one reason why he began thinking about a new kind of program, designed to foster a community of spatial thinkers at UCSB, including arts and humanities as well as sciences.

His idea became reality in 2007, when spatial@ucsb started up, with a three-year commitment from the office of UCSB Chancellor Henry Yang. Goodchild?s goal is to put spatial@ucsb on a solid, long-term foundation of funding from private donors and research grants.
Images will be projected in real time—from an MRI, for instance—so that people can stand inside the cortex of a colleague’s brain,” says JoAnn Kuchera-Morin.

The center has a large menu of activities, including academic presentations (the ?ThinkSpatial? public lectures and ?brown bag? lunch-hour events), regular meetings of graduate students from different disciplines to share research interests involving spatial perspectives, workshops on spatial tools and their applications, and the UCSB Spatial Review, a Web portal to examples of spatial perspectives from across the university. Expanding the use of GIS is another important part of the spatial@ucsb agenda. The center offers a course in GIS for graduate students, and it offers drop-in consultation to help UCSB faculty and students design GIS programs for their research or creative projects.

spatial@ucsb acts as a GIS resource for UCSB researchers who are trained to use numbers and words, says Black Studies Professor George Lipsitz. The existence of spatial@ucsb is essential for us to get knowledge that, as a small department, we wouldn’t otherwise have. For instance, Janelle introduced Black Studies researchers to Social Explorer, an online site that produces detailed maps from Census data going back to 1940. Lipsitz says Social Explorer is especially useful for [tracking] migration and neighborhood change.

A researcher in the Allosphere interacts with the three-dimensional display through the touch-sensitive handrail.

Spatial analysis is an important tool for Lipsitz (who focuses on topics such as housing discrimination and the impact of transportation on access to jobs) and for several other Black Studies researchers. One is Clyde Woods, who, says Lipsitz, works at the intersection of race and space by analyzing black migration patterns. Another is Gaye
Johnson, who uses geographic analysis in her studies of black and Mexican relations in Los Angeles. Lipsitz says GIS is a “wonder” in the detail of economic and social data that can be processed and displayed geographically. “You can do readings of banks vs. payday lenders, and grocery stores vs. liquor stores.”

**Interfacing with Computer Science**

spatial@ucsb also helps continue the interaction of geography and computer science that created modern GIS technology. It has close ties with the Four Eyes Lab (the name stands for Imaging, Interaction and Innovative Interfaces), where UCSB computer scientists work on improving human-computer interaction and creating display systems that mimic 3-D reality. Four Eyes co-director Tobias Höllerer recently gave a spatial@ucsb brown-bag talk on the lab’s work with “anywhere augmentation,” a merging of GIS, global positioning and mobile computing in portable systems that enable users to “annotate any physical object wherever they go.” By simply pointing to an object, such as a building, one could mark it for others who are using the same database? The other co-director, Matthew Turk, says spatial@ucsb gives computer scientists access to data and spatial computation problems that we wouldn’t otherwise know about, giving rise to new opportunities for collaboration.

The mission of spatial@ucsb goes well beyond the promotion of geographic ideas and tools, important as these are. Janelle says it is “not trying to impose a geographic discipline” on other fields of study. The center treats spatial thinking as essential to disciplines that never get near a map.

The center’s research network reaches into cognitive science and education, for instance. Professor of Psychology Mary Hegarty, a member of spatial@ucsb’s executive committee, researches spatial thinking from two angles. One is to study how people read visual displays such as maps and diagrams. Her other focus is on spatial thinking ability and the question of whether it can be taught.

The jury is out on the teachability of spatial thinking, Hegarty says, but she points out that it is a crucial skill in a number of fields. Chemists need it to visualize molecular structure. Radiologists must be able to visualize tissue in three dimensions using layers of two-dimensional images, and surgeons need to navigate through the body in three dimensions. Not everyone is blessed with the same level or type of spatial intelligence. Hegarty says men are better than women at mental rotation tests, while women are better at others, such as remembering an array of objects and spotting the ones that have moved. But she says it’s important to make everyone as good a spatial thinker as he or she can be, just as schools try to increase everyone’s verbal skills even though we know there are differences in verbal ability.

**Arts and the Allosphere**

Spatial thinking plays an important role in the arts and is central to some, such as sculpture. Art and spatial science come together at the Allosphere, housed at the California NanoSystems Institute (CNSI). The structure was completed in 2007 and is now being equipped with speakers and projectors. When all the audio and video elements (including 500 speakers) are in place, the Allosphere will be able to simulate 3-D environments and structures at all scales, from the atomic to the cosmic.
The Allosphere’s director, JoAnn Kuchera-Morin, says images will be projected in real
time—from an MRI, for instance—so that people can stand inside the cortex of a
colleague’s brain. Kuchera-Morin, a Media Arts and Technology professor who also
has collaborated on research with Goodchild since the mid-1990s, says the Allosphere
offers the possibility of presenting data in new and exciting ways—such as turning it into sound. The facility also will serve as a lab for 3-D movie technology and
a venue for visualizing structures as minute as quantum dots. In these ways, the
Allosphere represents a new technological leap for spatial thinking, though the objective
is not fundamentally different from what Watson and Crick were doing 55 years ago.
Now, as then, scientists are trying to think about things as they really are—in space, in
context—and artists are trying to create works as close as possible to real life.

www.spatial.ucsb.edu
csiss.ncgia.ucsb.edu
www.spatial.ucsb.edu/reviews
ilab.cs.ucsb.edu
www.mat.ucsb.edu/allosphere

Latest Issues

Tag Cloud
stem cells Erkki Ruoslahti brain science science cells neurogenesis Eucalyptus CytomX

ceramics electrical engineering Galen Stucky licensing Computer Engineering
high-energy physics Dennis Clegg spintronics PREM QuickClot nanofabrication biosensors fl

distributed systems nuclear spin memories bioengineering polymers nanotechnology macular degeneration materials greenhouse gases woman

in mechanical engineering DARPA semiconductors biodiversity cleanroom

environment disease global warming quantum computer inventions solar cells Alan
Heeger SpectraFluidics tech transfer fabrication diagnostics proteins energy efficiency

bio