WoW – Tangled Food Webs Organisms Weave

by Stephanie Soloman

To understand the ecology of a habitat, ecologists need to know who is eating whom.

"Having an accurate model of food webs gives us a valuable tool for predicting the impact of biodiversity loss on ecosystems as different as oceans and deserts,"

That's easier said than done. Collecting and analyzing data on just a few species is a job for a specialized biologist. But the ecosystem of a lake may contain over a hundred species, which are connected by thousands of feeding relationships and compose just one food web. Studying a food web that connects all of these plants and animals can quickly become a daunting, unwieldy and confusing task – even to advanced scientists.

So when a group of scientists from separate institutions set as their goal to gather data for various food webs, invent new ways of storing and analyzing the data, create interactive three-dimensional images of the feeding relationships, and share these new tools with as many researchers as possible over Internet, they gave the ambitious project an appropriately awesome name:

Webs on the Web, or WoW.

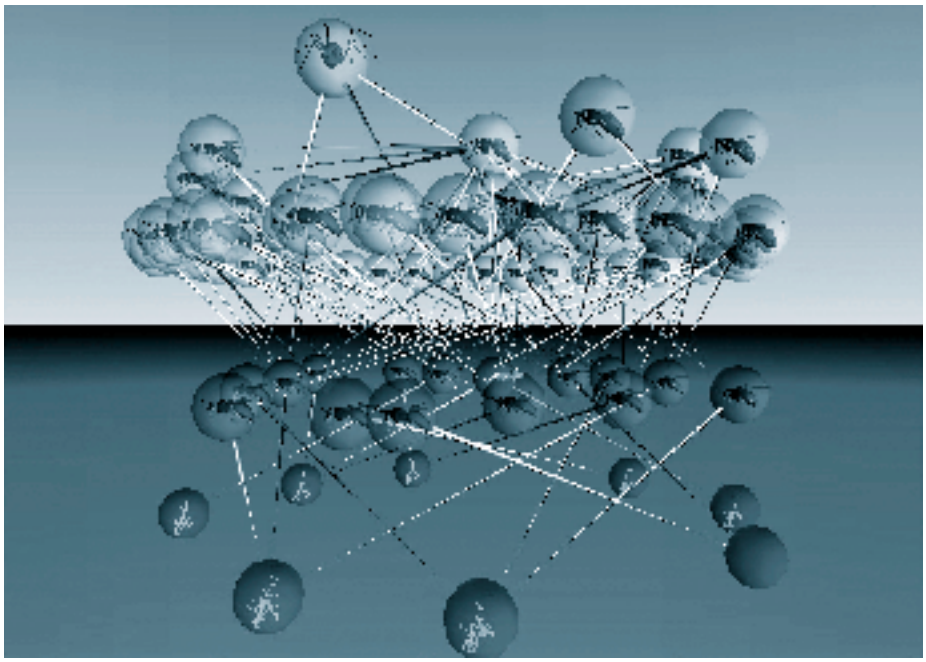
www.FoodWebs.org

Ilmi Yoon
Computer Science Department

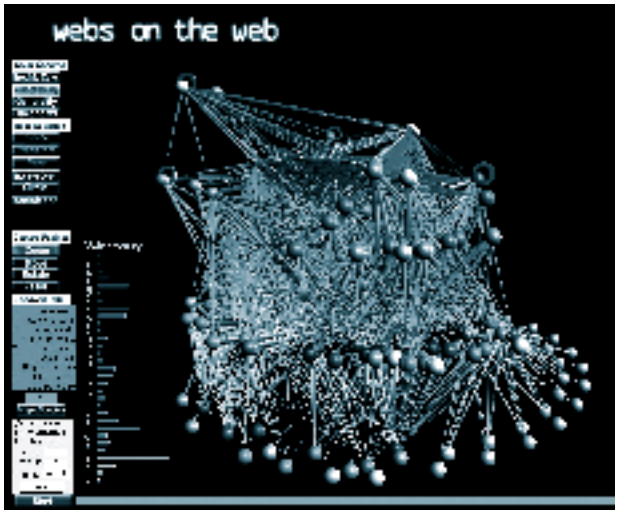
A crucial member now on that team is Dr. Ilmi Yoon of the Computer Science Department at San Francisco State University. But when the WoW project began in 2000, there were no computer scientists involved and the team was unable to utilize many cutting edge visualization technologies and thus lost a bid for National Science Foundation NSF funding. Then Dr. Neo Martinez, of Pacific Ecoinformatics and Computational Ecology Lab (PEaCE Lab), met Yoon, a new SFSU Computer Science faculty member. Excited by Yoon's background in creating three-dimensional graphics with web technology, Martinez recruited her to the WoW team. By February of 2003, the NSF awarded the WoW team a $1.5 million grant to continue development of WoW ecoinformatics tools that use computers to store, compute, and graphically display ecological data.

The grant money helped the team acquire needed computers and office equipment. With the support of the grant through 2005, Yoon spends her fall semesters focusing on her research developing the WoW tools and guiding graduate students on the project. During spring semesters, Yoon balances her roles at SFSU, teaching classes and writing papers summarizing her WoW developments for NSF review.

Webs on the Web



Right:
Foodweb visualization experiments with actual species in 3D gemotry. When species are represented with real appreance rather than sphere, intuition for the foodweb structure increases substantially for experienced research as well as for students.



Left:
Visualization of the food web of Little Rock Lake, Wisconsin (181 nodes and 2375 links). The network shows strong connectivity, an average link (in-coming & out-going) per node is 26.24, requiring interactive 3D visualization. Nodes are placed closer to its prey or preditor, y axix represents tropic level.

WoW's ecoinformatic tools provide scientists not only with more accurate models, but also with detailed information and options to focus on particular species and attributes.

"I feel lucky to have an opportunity to interact with my students and to do research with the support of the NSF. It's a very good balance," says Yoon. "It's exciting to use very interesting tools and technologies that people have not used much before in certain directions."

Ecologists' analyses of food webs have been limited by simple models. Since the 1970s, ecologists have processed the data of two to eight species with linear mathematical models and generated two-dimensional graphics of food webs. Although these images are easy to generate, they do not realistically represent the complex and dynamic networks of organisms living and feeding in the diverse ecosystems.

And having accurate models of ecological networks, particularly food webs, is central to understanding the relation between an ecosystem's complexity and stability. explains Martinez.

WoW's ecoinformatic tools provide scientists not only with more accurate models, but also with detailed information and options to focus on particular species and attributes. From the project WoW link at foodwebs.org, users interact with the WoW database and choose from different ecosystems, ranging from Little Rock Lake in Wisconsin to the Coachella Desert in southern California. For any habitat chosen, the species count and the number feeding relationships involved appears. Users then select an organism living in the habitat and WoW displays how many predator and prey organisms interact with it.

For example, by using WoW to view a food web in Little Rock Lake shared by a swimming insect and a tiny crustacean, the complex structure of the feeding links in the ecosystem become clear. The resulting image contains four spiraling tiers of species, each represented as node, that are connected by a dense web of links depicting feeding patterns. Using a computer mouse, users can quickly rotate and move the image for a better view, click on a species' node to view its name and number of prey and predators, or manipulate the appearance of the web editing colors and focus. Because the Little Rock Lake database stores data for 181 species and can compute and illustrate 2,375 feeding relationships, WoW is a powerful learning tool.

The program uses color to describe the quality of the relationships. The vulnerability of a species measures how many predators consume it, while generality measures how many other species it eats. The graphics indicate these predator-prey ratios using shades of a color. "Use of color is a challenge. People can only recognize up to six or eight colors of distinction", Yoon explains. Gradual transition of color shades helps users intuitively see the hierarchical order of the species.

WoW's interactive database and detailed images also display Yoon's talents with interactive media and three dimensional graphics on the Internet. Before teaching at SFSU, Yoon earned her masters and doctorate degrees in Computer Science at the University of Southern California, in Los Angeles. She studied at USC's Computer Graphics and Immersive Technologies laboratory where she focused on web and image based techniques. At the CGIT lab, Yoon worked in a multidisciplinary environment composed of people from computer science, electrical engineering, the social sciences, and the arts. Now with WoW, Yoon collaborates with experts in ecology, ecoinformatics, computer science, and information technology from Martinez's PEaCE Lab, the Rocky Mountain Biological Laboratory, the National Center for Ecological Analysis and Synthesis, the Santa Fe Institute, and SFSU.

Yoon's experience with web-based images and working on a multidisciplinary team fit into the WoW goals of reaching many researchers. Being accessible to a wide audience requires that WoW generate diverse formats that give people options of using different computer programs as an interface. To support these different programs, WoW utilizes FoodWebML, a powerful program that Yoon developed with the help of her graduate students. FoodWebML allows ecologists and other scientists to compile research on hundreds of species and quickly view and analyze the relationships between them. FoodWebML is built with XML, Extensible Markup Language. An advantage of the flexibility of XML it that it allows FoodWebML to store data and visual presentation separately. The separate storage enables the WoW database to save graphics after they are processed once and recall them when another user requests the same information later. Saving the processed model information quickens future processing of the data .

The highly adaptable nature of XML and Yoon's FoodWebML also allows WoW's database to absorb data on new ecological habitats and interactions. Such open technology promotes the collaboration between scientists studying the same ecological networks. Just as no single component of an ecosystem can describe its surroundings, no single ecologist can analyze all the species found in a habitat and their interactions. "We are looking for ways that those experts can get connected and build whole food webs," says Yoon.

The innovative approach of the WoW team enabled it to gain NSF funding through one of NSF's priority areas, biocomplexity in the environment, an investment area that promotes new approaches to investigating the interactivity of organisms and their environment. All projects must address the idea of biocomplexity, which fosters research and education on the complex inter-dependencies within environments.

Although the WoW project is currently accessible through, www.FoodWebs.org, it is not complete. Yoon expects the project to continue past its current NSF funding through 2005. The research project continues to develop technologies and applications that describe, analyze, and view food webs. As computer scientists advance technologies and ecologists gather new data from more habitats, WoW will continue to adapt. ✣