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Getting in the Game: Out on the Landscape without Leaving Your Desk with GNNViz

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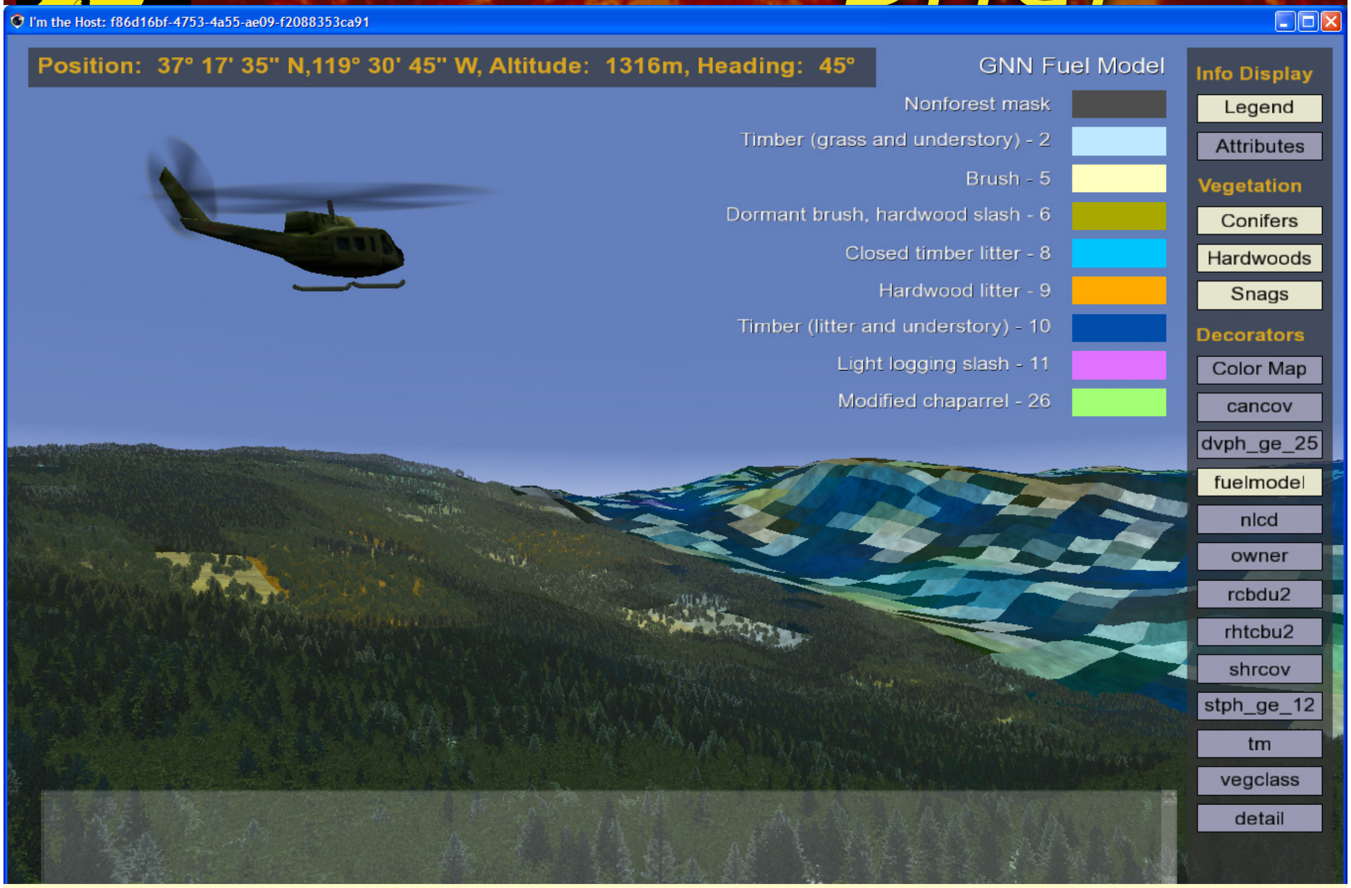
Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS



A screenshot from GNNViz showing a tree layer with a fuel model overlay and a game participant in the helicopter.

Getting in the Game: Out on the Landscape without Leaving Your Desk with GNNViz

Summary

This project used computer game technology to create highly interactive forest data visualization and interaction not possible with the traditional geographic information system approach. Known as GNNViz (Gradient Nearest Neighbor Vegetation Map Visualization), the program was developed by applying it to three large regions in the western U.S., though it's readily extended to additional landscapes and spatial data formats. Developers leveraged the superior capabilities of video game technology to render realistic 3D environments and allow multiple users to interact with each other in a shared environment. Real time rendering allows users to move about and explore huge areas of terrain on many tens of kilometers across. It makes it possible for managers, planners, scientists and even members of the public, often physically separated by distance, to meet, interact and communicate in virtual versions of real world landscapes. With further development, applications like GNNViz could potentially revolutionize resource management communications, planning, training and education.

Key Findings

- 3D game engines provide unique possibilities for rendering at a variety of spatial scales. The choice of a game engine is an important decision that significantly impacts application development time and project direction. Game engines are evolving so rapidly, the technology presents a 'moving target' for application development.
- Multiple users can log on, interact and communicate within 3D, modeled environments, allowing far-flung stakeholders to see, move through, discuss and evaluate conditions together in real world landscapes—in real time.
- A hybrid view of attributed geographic information system (GIS) pixels and trees is an effective tool for communicating relationships among spatial datasets across large landscapes.
- GNNViz was applied to three large regions in the western U.S., but it's readily extended to additional landscapes and spatial data formats.

When managers fly

In today's increasingly complex world, traditional communication methods have begun to pale in comparison to the deluge of information available at our fingertips in the digital realm. With the click of a mouse, a tap on the cell phone or the twist of a game controller we can be awed, entertained, informed, educated and in touch. We can explore our own backyards or Antarctica. We can tour the human anatomy or the jungles of Peru, observe traffic patterns in Hong Kong or track the migration of grey whales.

Keyboards, keypads and webcams allow real time conversations with people oceans away. These tools of communication, observation and experience do it all without the requirement of *being there*. Physical presence in, or proximity to the places, people and information we want are not required.

With this project, software developers and researchers have taken the first step to bringing this experience into the world of resource managers and planners. Janet Ohmann of the Forest Service Pacific Northwest Research Station, and Matthew Gregory and Tim Holt of Oregon State University's Department of Forest Ecosystems and Society created a hybrid of geographic information system (GIS), Google Earth-like technology and computer games to bring communication about landscapes and resources up to speed with the technology many of us now use in our daily lives. The resulting program, known as GNNViz (Gradient Nearest Neighbor Vegetation Map Visualization), allows users to walk—or fly—through 3D modeled landscapes accompanied by far flung colleagues, policy-makers and stakeholders, while conversing about landscape condition and potential management actions along the way. "This is a totally new way of accessing information and interacting with people," Ohmann says. "Users now have the ability to be part of their data."

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The three test landscapes in this initial version of GNNViz were chosen because the team had done previous work in these areas developing their unique GNN (Gradient Nearest Neighbor) mapping method. GNN was tested for mapping forest vegetation in coastal Oregon, and extended to eastern Washington and the California Sierra. This was done to determine if the modeling technique would work in a wider range of fire-prone western forest ecosystems, and for mapping fuels-relevant attributes of vegetation.

A sample GNNViz landscape in multi-player mode. This image illustrates three different players; two represented by the helicopters and the third player playing from the current view. In multi-player mode, one player acts as the server and others join the game as clients. A chat window appears at the bottom of the screen.

Whatever happened to a walk in the woods you might ask? Often it's just not possible. "This isn't a replacement for getting out in the field," Ohmann says. "But the reality these days is that we just can't interact out on the forest as much as we'd like. This can be a viable alternative. When you have stakeholders in widely separated locations this will be a viable alternative for communicating."

Game on

Typically, users of geospatial data are accustomed to viewing GIS maps with a straight-down view. GNNViz combines real world data and modeled predictions by integrating Landsat Thematic Mapper imagery with GIS data, along with seek, find and zoom capabilities similar to Google Earth's. The kicker? It's wrapped up in a video game experience, giving users the ability to be there—even if they're not. At the coarsest scale, users are presented with a traditional top-down GIS view draped over a realistic, 3D topographic surface. As the user moves

GNNViz combines real world data and modeled predictions by integrating Landsat Thematic Mapper imagery with GIS data

Developers used vegetation and fuels maps developed for a previous Joint Fire Science Program project using the GNN method to create GNNViz-interactive, immersive tours of the study areas in the western U.S.

closer to the ground, he/she transitions into a more realistic view of the ground surface, achieved by combining textures of forest floor photographs. GNN-modeled canopy cover controls the ratio of each texture's contribution to the overall combination. For example, in dense conifer forests the user sees a ground texture that is almost exclusively needles with very little understory vegetation. In open hardwood stands various forbs and grasses tend to dominate. Forest landscape maps from GNN provide detailed, tree-level data across large, multi-ownership regions as well as detailed ground attributes of vegetation for each patch in a landscape. This feature is unique to GNNViz because it allows an entire tree list to be plugged into each pixel across a large region. All the trees in the tree list are then generated right before your eyes as you stroll along under their limbs—or fly above or through them. At the finest scale, users are presented with tree symbols representing GNN estimates of trees per hectare of conifers, hardwoods and standing dead trees (snags). Future improvements could allow display of these items to be even more data-driven rather than modeled. Although GNNViz landscapes aren't photo-realistic, the finest scale of rendering allows users to view model output more easily than is possible through traditional GIS programs. Part of the advantage is due to the way users can navigate through the visualized landscape as if they were there—while communicating with other users who are "there" with them.

See the video on page 5 that demonstrates how details like fuel models and average stand size change in response to the data content of each pixel below as the user flies over the landscape.

To make all these features possible, the GNNViz team needed a way to create a multiuser environment with the ability to render an enormous number of objects. These functions are provided by "game engines," programs responsible for the action in video games. Among other tasks, game engines convert data into 2D and 3D objects and determine when one object collides with another while generating and managing sound and animation. The game engine market is exploding with new versions and innovation and the team spent over a year wading through all the possibilities. After an exhaustive search with many dead-ends, they settled on *Delta3D* as the engine that could bring their digital environments to life. It efficiently renders detail across both large regions and local views. It's open-source, which allowed the researchers to add features specific to the project's needs. It provided the ability to quickly update surroundings based on user position, as well as upfront display of user location and heading, a symbolic guide to the contents of the current view and the controlled placement of objects and trees onto terrain surfaces based on underlying GNN data. A command window that doubles as a real-time chat center was also added, allowing users to communicate with each other as they evaluate and experience the landscape simultaneously.

Delta3D has greater 'geographical awareness' than many other engines, meaning it has a built in relationship with real geographic coordinates. This is the same feature used in real-world flight simulation programs that provide immersive, 3D training for flying in and out of real airports around the globe— allowing pilots to fail and learn without suffering the true consequences.

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GNNViz can be readily extended to additional landscapes and other spatial data formats. For example, fire risk within the wildland-urban interface could be visualized by symbolizing housing density with individual 3D house models layered over a landscape draped with a fuel model image. One could visualize fire by taking a map representing real or simulated fire densities and using it to control placement of flame models on the simulated terrain.

So where are the Orcs?

"Generally, for people who've played video games the first reaction is, 'Oh! Cool! But where are all the little Orcs running around?' That's just what they're used to seeing," Gregory explains. But once they got over the absence of machines, monsters and elves in battle—test users liked what they saw. GNNViz proved to be a powerful and effective visual communication tool for displaying relationships between different sets of data.

Users appreciate the abstract view of GIS maps draped like fabric over 3D terrain, and the distribution of trees sourced from actual GIS data. Patterns not readily apparent in traditional GIS, like slope and aspect, are much easier to perceive in the 3D environment that allows a look from virtually any angle. The user maneuvers to change the perspective. A user can also request that colleagues walk or fly to his location so they can all see what he's seeing. The ability to turn vegetation layers on and off is a popular function that most GIS users are already familiar with. Vegetation sets can be viewed all at once, in select groups, or individually by toggling menu buttons. Only want to see conifers? Turn off hardwoods and snags and walk right in. **(See page 5 to watch a demonstration of the layer change feature.)**

Full suite of features awaits future development

Most computer games render a lot of detail in a small, fictional game space, but in GNNViz users need the opposite scenario: the ability to render extremely large landscapes/game space and millions of trees with information that is both real and modeled. The GNNViz development team is painfully aware that some features of GNNViz are 'computationally expensive,' meaning that the process gobbles up lots of computer memory and power, so overall performance is still hardware dependent. Gregory says most people have machines with the capacity for high-level view flights over the landscape. It's easy to move around in this mode and doesn't require a lot of memory. But when you're ready to swoop down into the details of individual objects like trees and snags, more powerful computers are needed. Target users and managers aren't likely to have machines like this yet. Gregory cites the program's ability to turn off layers of vegetation as a way to help lighten the processing load, but he concedes this may be contrary to what managers actually want—which is to view the mix of different vegetation types together. "There are a lot of things we could tweak that would make rendering these objects easier. It's incumbent upon us to do more work with level of detail," he says. "For instance, trees that are out in the distance could be rendered much more coarsely than those that are right in front of you."

There are plenty of additional features the team would like to add in future versions.

There are plenty of additional features the team would like to add in future versions. Not only would these expand the utility of the GNNViz, many would make it difficult for people to stop 'playing,' like most video games. That's the idea. The team has discussed how they might make GNNViz more temporally dynamic. For example, when dealing with an actual fire one could update real data and view it all in real time. Users could also benefit from having predictive layers of future landscapes that allow them to move through, experience and analyze possible alternative scenarios based on different assumptions about treatments, other disturbances and growth. Additional future work may include increasing the number of unique models used to symbolize densities of individual tree species, size classes, crown geometries and more. The team already has the data needed to represent understory vegetation and large downed wood, which could be incorporated in a future version. Adding information like roads, streams and political boundaries would improve the frame of reference and sense of realism. The team would also like users to be able to interact with objects in the game environment that have data associated with them. For example, a user could click on a tree; find out that it's a twenty-centimeter Douglas-fir, and that there are 12 such trees per hectare in the stand. They'd also like to provide a way for users to query information based on region. For example, a user could click on a tree and ask the game to show all the stands where the average tree diameter is equal to or less than that of the sampled tree. You could then inspect these stands with the other "players."

"It could be an amazing tool with this kind of functionality, not only for forest management but for almost any type of application you can think of"

"It could be an amazing tool with this kind of functionality, not only for forest management but for almost any type of application you can think of," Gregory says. Beyond simply visualizing forest environments, GNNViz may prove to be a framework for creating effective interactive training and simulation environments for both formal education as well as educational outreach. It should eventually be possible to create applications where multiple students can be exposed to simulated dangerous, difficult or expensive experiences such as wildland fire-fighting and prescribed burning techniques. Additionally, large scale training simulations could be managed online in an environment like GNNViz to teach resource management and coordination. This concept could also be applied to K–12 and public education to create "virtual field trips" for educational outreach, either in a classroom or a more general public setting.

Additionally, some of the lessons learned from creating GNNViz as a "macro" forest visualization system could be applied to creating much smaller and highly detailed visualizations of smaller areas, hundreds of meters across. These smaller scale visualizations would allow the user to interact with biological and ecological data at a much higher level of detail.

Fly into the future at a computer near you

Although GNNViz is still in its very early stages, it is an actual game that can be downloaded and played. The three initial study areas and all the associated maps are available for people to use along with a clear and simple user guide. But Gregory realizes that widespread adoption of GNNViz is still a long way off. "There are people who are certainly interested, and a handful of people running it because it's cool, but we need to make it more practical to use, and more people need to try it," he says.

Ohmann points out that it takes dedicated and passionate people to move forward with projects like this. "Generally people are really good at grabbing onto the next greatest thing—but not at carrying on the less sexy work of maintaining, improving and marketing what's been started. We're hoping to make more headway on this." In the meantime, get in the game by visiting the project website at http://www.fsl.orst.edu/lemma/gnnviz. Invite some co-workers to come along too and be sure to tell them they'll be able to fly on the job—without aircraft. Who can resist that?

Further Information: Publications and Web Resources

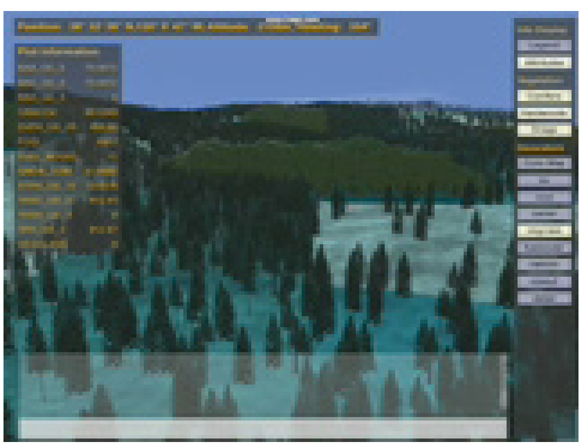
The GNNViz website:
http://www.fsl.orst.edu/lemma/gnnviz/

Gregory, M.J., J.L. Ohmann, and T.M. Holt. 2008. An application of computer gaming technology to visualize, query, and understand forest landscapes. Poster presented at Annual Symposium of the U.S. Regional Association of the International Association of Landscape Ecology; Madison, WI.

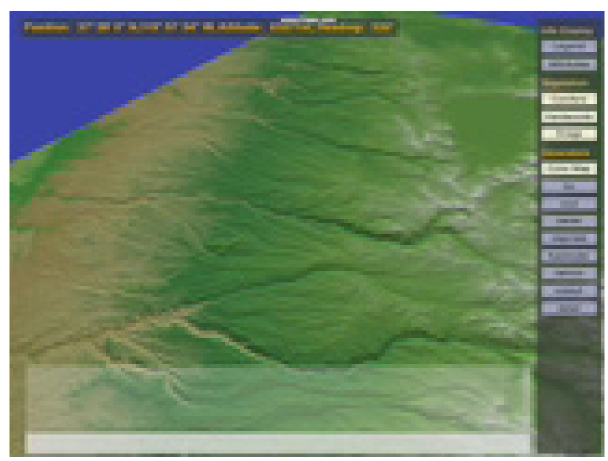
Ohmann, J.L. and M.J. Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, U.S.A. Canadian Journal of Forest Research: 32:725-741.

Pierce, K.B., Jr., J.L. Ohmann, M.C. Wimberly, M.J. Gregory, and J.S. Fried. 2009. Mapping wildland fuels and forest structure for land management: a comparison of nearest neighbor imputation and other methods. Canadian Journal of Forest Research 39:1901-1916.

Interactive Videos



The video above demonstrates how details like fuel models and average stand size change in reponse to the data content of each pixel as the user flies over the landscape (double click to activate).



Double click the video above to watch a demonstration of the layer change feature.

Scientist Profiles

Janet Ohmann is a Research Forest Ecologist with the Pacific Northwest Research Station, Forest Service, in Corvallis, Oregon. Her research focuses on understanding and mapping broad-scale patterns and dynamics of plant communities in western forests, and applications to issues in conservation and natural resource planning and policy.

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Matt Gregory is a GIS Analyst/Programmer and Database Administrator. His research focuses on creating customized software for vegetation modeling and visualization, web and graphic design, spatial analysis and working with forest inventory data. More broadly, his interests lie at the intersection of geography, ecology and technology.

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Tim Holt was recently told he's had "too much fun in his life," having worked in a diversity of jobs from oceanographic marine technician to computer game developer. He currently works as a consultant in the serious games space, helping others move towards using games for visualization, teaching, and other non-entertainment applications.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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