Atta texana leafcutting ant colony: a view underground

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Abstract

The *Atta* project maps tunnels and chambers of a vast leafcutting ant colony. An 8x8 meter Ground Penetrating Radar scan was translated into a 3D model that can be viewed on an immersive visualization system, scaling the viewer to ant size. The system developed by our team is nondestructive to the ants and is the first time GPR has been used to map a living ant colony. To achieve this goal, the project combined the site-specific nature of an indexical system, GPR, with the ability of an algorithm to parse the data. As a result, the model retains a formal connection with its subject and can be transported anywhere, to be viewed in many different ways.

One of Texas's smallest natives is also one of its largest: myrmecologists refer to ant colonies as superorganisms. *Atta texana*, indigenous to Texas and Louisiana, harvests tree leaves to farm a fungus in vast, underground cavities that can spread over more than an acre of land and reach to great depths, with over a million ants in residence. [1] Excavated leafcutting nests have proven large enough to contain a 3-story house. [2] Scientists believe the ants' symbiotic relationship with the fungus could lead to discoveries in medicine and sustainable agriculture. [3]

I set out to map an *Atta texana* nest. I imagined lifting a section out of the ground and turning it around in space, to view it like a sculpture.

Previous attempts to model ant colonies have been undertaken by myrmecologist Walter Schinkel, whose technique involves pouring casting material into the nest, digging it up and piecing it back together. Schinkel has stated, however, that an *Atta* colony is so large this technique would be quite a challenge. [4] [Figure 1]

Another means to map ant colonies involves using a bulldozer to scrape away successive layers of soil and measuring the diameter of the holes. This results in a kind of abstract image composed of disconnected shapes. Tunnels collapse with this method and cannot be tracked. [5]

If measurement is the goal, either approach would be ideal. But what I wanted was to gain a unique view of this subterranean architecture using a method that would not disturb the colony.

Ground Penetrating Radar (GPR) provided a means to map the *Atta* nest. Using GPR, high frequency radar pulses are sent from a surface antenna into the ground. Elapsed time between when the pulse is transmitted—reflected from buried materials or sediment and soil changes—and when it is received, is measured. The sender and receiver are moved along the surface, following transects of a grid. [6] Typical uses of GPR include mapping buried archaeological ruins, and locating unmarked graves, unknown caverns, earthquake faults, and lost pipes or power lines.

GPR provides an indexical image, formed by the action of radar pulses passing through substances over time and distance. In this way it can be compared to a photograph, formed by the pattern of light striking a photosensitive surface. Photographer Henri Cartier-Bresson described taking a photograph as fixing a "decisive moment," a confluence of the artist's position in relation to the geometry of an unfolding event. [7] Photography offers what Roland Barthes termed the *punctum*, the preservation of a specific feature of the subject that cannot be separated from time or place. The punctum gives rise to a "third meaning," an indefinable experience of specificity which cannot be essentialized. [8]

Conversely, digital representations often rely on generalization of physical phenomena. Gravity, water, or terrain are simulated with algorithms, freed from substance and geographic locale. Because of its mathematical structure, the algorithm attains a level of fluidity, and can be repurposed from one form to another. [9]

In mapping an *Atta* nest, I wanted to maintain a connection with this particular subject, deep in the soil of a Texas field, while simulating the colony architecture in a form distributable across time and space.

Geophysicist Carl Pierce worked with me to scan a portion of the site. It was a vast area, but only a small section of the entire nest. It took three days to cover the 8-meter grid in 10-centimeter slices. We used 200 Mhz antennas, which provided the best balance between resolution and depth. The scan penetrated 3 to 5 meters beneath the surface.

Typically GPR scans contain noise which can interfere with the results. [10] Soil composition, radio interference, and magnetic properties of substances can all contribute noise. The area scanned had once been trucked-in, sandy soil. Besides air, sand is one of the best mediums to conduct a GPR signal. Carl Pierce used proprietary GPR software to "dewow" the data. This is technically known as a signal saturation correction. It accounts for the inductive response of the transmitted radar pulse. The data can then be filtered in many ways to reduce or eliminate noise. In this case a spreading and exponential compensation (SEC) filter was used to account for the geometric spreading (picture the pattern made by a single raindrop in water), and exponential decay of the radar wave strength with depth. This is the closest filtering that mimics reality at the time the data was processed.

We set out to differentiate voids from soil and other materials. The velocity of radar waves in air is the speed of light — 3.0 x 10^8 meters per

Figure 1: Myrmecologist Walter Tschinkel with Pogonomyrmex badius colony plaster cast. Photograph by Charles Badland.

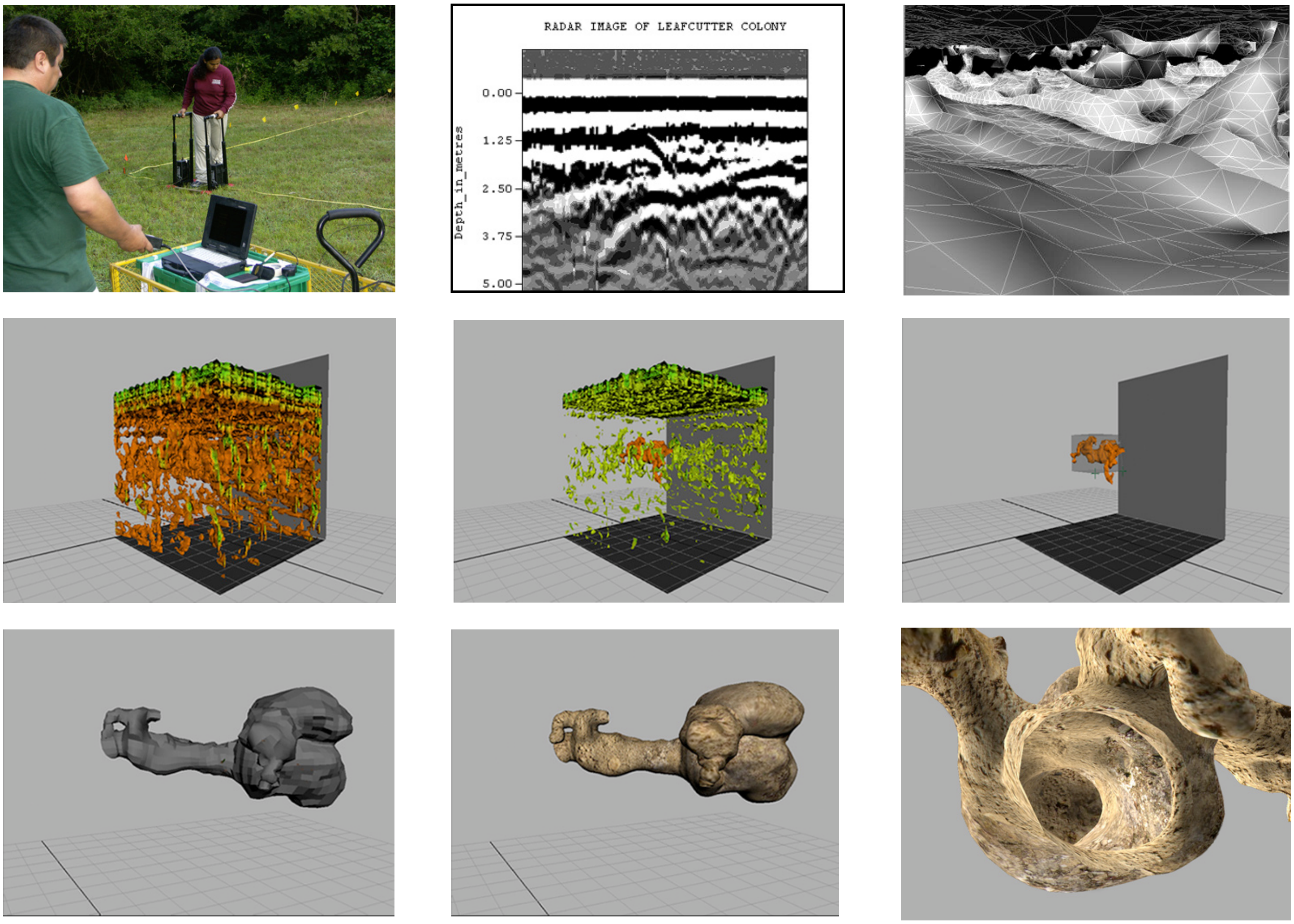

Figure 2: The process of scanning the ant colony and translating the data into a polygonal model.

second. Most geologic materials have an average velocity of 1.0 x 10^8 meters per second. [11]

As much as possible, the GPR scan represented the difference between voids and soil or other materials, such as tree roots. Carl developed a model that showed air as green, and other materials as red, yellow, and orange. [Figure 2]

For some purposes, a low-resolution model is all that is needed to review a GPR scan. GPR had not been previously used as the basis for a work of art. I needed a way to translate the data for use with a high end, 3D modeling program.

With consultation by computer science professor Fred Parke, graduate assistant Tatsuya Nakamura transformed the data into 3-dimensional polygons. Carl and Tatsuya began by importing the data into spreadsheets corresponding to each slice of the GPR scan, containing 80 rows and 80 columns. Each value in a cell represented a measure of the density of the signal at a specific location.

The files were then converted into a 3D point array with a scripting program, written by Tatsuya, for the modeling software. Color-coded density values were maintained from Carl's model. Next, volumetric data was created. An algorithm was used to form isosurfaces. These are surfaces of constant density, the 3D analog of contour lines. The method finds the vertices of triangles that interpolate the 3D array of density values. When connected together, these triangles formed polygonal surfaces. Polygons were formed in layers that corresponded to the different densities in the GPR scans. Thus, one could open a file in the modeling program and select successive layers surrounding the voids to reveal tunnel structure and fungus caches. [12]

We were excited to see the 3D model of the *Atta* colony on screen, to zoom into it and travel through the tunnels and chambers. Scale changes were necessary for the viewer to be transformed into the size of an ant surrounded by the tunnel architecture. With the help of Lauren Simpson, graduate Visualization Sciences student and artist, a portion of the colony model was prepared for viewing on a large-scale, immersive visualization system designed by Dr. Parke in the Texas A&M University Visualization Lab. [Figure 3] [13] Lauren carved away a portion of the model so that it could be textured, lit, and animated. [Figures 2 and 3]

A second objective was to create a cinematic voyage through the ant tunnels. This animation takes a viewer past many ants into the depths of the tunnel to reveal fungus caches, a queen as she lays eggs, and nurse ants

Figure 3: Atta texana colony on immersive visualization system designed by Fred Parke, Ph.D., Texas A&M Visualization Sciences Laboratory

attending her. Lauren's considerable artistic skill was crucial to the task of wrapping textures around the irregularly shaped forms of the tunnel and in researching *Atta* images for morphology and placement of each element and character.

The *Atta* project depended upon translation — not only data translation — but translation between disciplines and languages: art, geophysics, entomology, computer science. The word *Atta* is a palindrome. It mimics the path of the ant from field to colony and back again, as well as the radar beam in its path from sender to receiver. Along the path, the *Atta* colony is mediated by its means of expression, but it retains some particular quality of its creators — part ant and part algorithm.

Acknowledgements
Carl J. Pierce, M.S., P.G., Geophysics, St. Lawrence University, directed GPR scanning and filtration and contributed related text. Fred Parke, Ph.D., Visualization Program, Texas A&M University, consulted on data translation and related text. Graduate assistant Tatsuya Nakamura, MSVS, contributed programming and related text. Lauren Simpson, MSVS candidate, contributed 3D model and animation production. I'm grateful for advice from Maria Tchakerian, Research Assistant, and Bob Coulson, Professor of Entomology, Department of Entomology, Texas A&M University. The project was supported by the Texas A&M Vice President for Research, The Texas A&M Academy for the Visual and Performing Arts, and the Vizlab.

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http://www-viz.tamu.edu/faculty/lurleen/main/attatunnel/

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