

3D Visualization of Multiple Variables

CS137 Assignment #3

1. Dates

Out	Thursday, October 5, 2017
Part A sketches Due	Tuesday, October 10, 2017
Part B VR version Due	Tuesday, October 17, 2017
Questions Due	Tuesday, October 17, 2017

2. Goals

1. Identify and understand the perceptual and technical issues involved in 3D gradient visualization as compared to 2D gradients.
2. Consider issues with transparency, visibility, color, and interaction with foot surface.
3. Learn how new scientific and perceptual variables become important when a problem is in 3D.
4. Learn about targeting visualization toward an exploratory scientific goal.

3. Readings

- Check out [Steve's slides](#) ([topview](#), [video1](#), [video2](#), [video3](#))
- Check the [Calendar page](#) of the website.

4. Scientific Background

Steve's main interest is in how animals move themselves around, but there is a chain of reasoning that moves from that interest to the more specific problem that he is studying and that you will work on in this assignment. He is studying fossilized dinosaur footprints. Those tracks contain clues about the feet and about the animals that made them, but not as directly as might be hoped. In studying these fossils, he has used x-ray videos of live birds to elucidate footprint creation, as well as computer simulations of how the footprints are made. Even so, the full story of how animals created these prints is not clear.

Some dinosaur footprint fossils have turned out to be very challenging to understand. Unlike the familiar footprints we see and make on firm surfaces, these footprints come about through a complex interaction between foot anatomy, foot motion, and substrate consistency. When the mud is relatively soft and pliable, the foot penetrates deeply before being drawn out along a different path as the animal moves forward. What is left on the surface has some visible characteristics of the foot, but not like the kind of shallow footprints we make on a beach.

Much of the structure lies deeper, and can be exposed when the rock breaks open at different levels.

Steve has some theories about how this process generates the broad diversity of track shapes found in the fossil record. One of your goals, in this assignment, is to create a visualization supporting some of Steve's theories and not contradicting any of them.

Steve's Theories

1. A footprint is rarely a direct mold of the foot; a single foot can generate many different track shapes.
2. Substrate consistency affects sinking depth, which alters track shape.
3. Substrate consistency affects foot motion, which alters track shape.
4. Within each deep track, shape varies with depth.
5. Sloppy substrates quickly seal behind the descending toes, leaving just closed seams in the deflected laminations.
6. In deep tracks, we should find evidence of foot withdrawal.
7. To understand track formation, substrates need to be considered at multiple scales (volumes, surfaces, and particles)

Steve is pretty sure about these theories based on available data, but he also has plenty of unanswered questions. For these, your goal is to create an illustration that would help clarify whether they are true or not, perhaps by illustrating what it would look like for both cases: truth, and falsity.

Steve's Big Questions

1. Can a better grasp of animal/substrate interactions allow us to reconstruct foot movement from deep tracks.
2. Can we identify repeated patterns in how foot motion and sediment deformation relate to one another?
3. Can we unify surface-based and particle-based perspectives?
4. Can we integrate CT scan images with particle data in the Yurt, comparing real and simulated data for specific fossil tracks?

Steve's Questions for this Assignment

Assume that each thin layer or boundary between layers began as a horizontal plane. Forces will deform each plane, causing its topography to morph like a possibly perforated, rubbery sheet of particles throughout the step into a final track shape.

1. Can we work backwards from a track surface to determine the original configuration of its particles in the starting plane? Where did each particle come from?
2. Alternatively, can we trace the fate of particles in the starting plane forward in time? Which particles will descend, ascend, move forward, or collapse?

3. How do foot-particle and particle-particle forces move sediment? When and where do compression (push), tension (pull, cohesion), shear, or gravity dominate?
4. How can dynamic, simulated data of moving particles be compared to static, CT data of a fossil dinosaur track?

5. Assignment

Design a visualization strategy that can achieve the following goals:

- Clearly indicate the pathway of selected particles (representing grains in the mud) through the step sequence. You may concentrate on a part or the sequence, or try to show the whole, from the moment of immersion of the foot in the substrate to the moment of withdrawal and “sweep” (the final dragging of the toes across the surface.)
- clearly illustrates some of Steve’s theories from above,
- does not contradict any of them,
- portrays the interaction of the foot and the substrate in such a way that Steve can add to his lists of theories and conjectures,
- would be able to answer or partially answer at least one of “Steve’s Questions for this Assignment”

5.1 Part A: 3D Fossil Footprint Creation

Towards the final design goal, you should begin by making sketches showing various approaches to displaying data and volumetric configuration in 3D, keeping in mind what your visualization would look like once executed in the Yurt. You should feel free to bring in as many sketches as you like, perhaps comparing different ideas, structures, connections and gradient choices as they occurred to you during your design process. Sometimes a “dead end” will actually show something interesting that the rest of the class might pick up on.

Choose a specific aspect of Steve’s theory, as listed above, for the focus of your project. As an example, consider Steve’s question about when and where compression and tension move sediment. Study the animations and other materials from Steve, and then create a visualization that shows how compression might have moved some of the particles directly under the descending foot by compressing them. As mentioned above, you may concentrate on a part or the sequence, or try to show the whole sequence.

Your visualization will be of a 3D phenomenon, but can portray one or more thin slices through the fossil or cutaway views, transparency, or any other method to visually penetrate into the heart of the configuration to achieve your design goals. Your visualization is also of a process that happens over time, which may suggest frames that are spread out spatially in the Yurt.

Your designs or “sketches” should be executed in a medium that allows you to address the 3-D character of the situation under study, with an eye toward eventual implementation in the Yurt, utilizing the unique qualities and capabilities of immersive VR to make your design

more legible or explorable. You can actually sketch in the Yurt, saving and printing enough snapshots to clearly show what's happening in your model. Or you can construct a 3-D model using physical materials such as acetate, foil, cardboard, wire, string, paint, clay etc. You might also use a 3-D digital program such as Maya or cinema 4-D, or sketch in a 2-D mode Photoshop, or with paint/pencil etc. If you are using 2-D means, you will have to suggest qualities of three-dimensionality thorough illusionism, perspective etc. and include as many views as is necessary for the class to understand you idea.

The crit will be in the classroom.

Try to incorporate applicable ideas from the 'Force and Form' assignment and explicitly target the interaction between substrate and foot. The 2D gradients assignment should help you with what types of icons, textures, or other indicators can show data. If you have any other intuitive elements of the phenomenon that you'd like to display, please do so, but be ready to explain why you think they are important and how they relate to the other variables. Also, think about your legend for the 3D environment. Where will it be placed? Will it be interactive or animated?

5.2 Part B: VR Implementation

Put your design in CavePainting. If appropriate, you may use the 'frame-by-frame' feature of CavePainting to show your visualization move (see the [CavePainting manual](#) for more information). You should include your legend in the 3D environment.

6. Questions (answer briefly)

Questions are due, emailed to the TA, by 9am on the date listed above. Most of these are very short questions intended to help guide you through the assignment. They should not take long to answer. Most of the time, a very brief, one sentence or less, answer is sufficient.

1. How did your knowledge of 2D data visualization translate into 3D?
2. What challenges did that transition present to you?
3. Did you think going from 2D to 3D would be easier or harder? why?
4. What are the factors behind your choice of visual characteristics to represent this phenomenon and its associated data?