Cindy Grimm: Research goals 2005

My primary research interests are in three areas. I have well-developed research programs in two areas, surface modeling and illustrative rendering, and am developing a third one in the field of manifolds for animation. The first of these areas is focused on answering fundamental questions in shape representation, in particular in the field of medical analysis. Within the next five to ten years I will have developed and deployed a reliable set of automatic methods for *quantifying* morphological variation.

Illustrative rendering is my term for process of controlling the display of data so that it conveys specific information. Computer graphics has come a long way in creating and rendering complex scenes, but the rendering process still has more in common with photography then artistic, or illustrative, depiction. Designing effective interfaces and techniques that support illustrative rendering is a long term, on-going process. In the short term, I am focused on creating perceptual editing tools that will support more intelligent and automated systems in the future.

Modeling animation with manifolds is a collaboration which takes advantage of my expertise in data fitting and representation, Prof. Pless's (WU) expertise in finding structure in data, and Prof Boddenheimer's (Vanderbilt) expertise in animation. My goal is to bring the mathematical formalisms of surface modeling to bear on the problem of representing and manipulating animation data.

- **Quantitative evaluation of shape for medical applications.** The last few decades have seen a dramatic increase in both availability and quality of imaging data such as MRI and CT. Making quantitative measurements from these data (such as volume, shape, growth rate, etc.) is currently a time-consuming, largely manual task, which relies heavily on human expertise. I will continue to bring novel, high-impact automated techniques to this area, working in close collaboration with researchers in the Washington University School of Medicine. The two key challenges are:

  1) Designing better automatic methods for extracting structured representations from the raw imaging data, such as surfaces, volumes, and finite element models. Automatic methods require models that are more "intelligent" than those in current use, and that can incorporate both information about the acceptable range and variation of the shape they are fitting to, and also human-supplied constraints. Better user-interface tools are essential, both to allow expert users to verify the results and to quickly and easily manipulate the representations.

  2) Develop quantitative measurements beyond simple length and volume calculations. How do you reliably identify features, such as the shape of a hip socket, a tumor, etc, and present meaningful quantitative assessments about that shape? For example, in conjunction with my collaborators at Brown University, I have identified the cause of mobility loss with an ulna fracture to be, in part, a change in the way a ligament joins the ulna to the radius. The attachment point has changed because the shape of that part of the ulna changed when it fractured. How do we determine what the "correct" shape should be? I will continue to develop mathematically valid, feature-based metrics and comparison techniques that can answer these types of questions.

- **Visualization of 3D scenes for illustrative purposes.** This is a complex problem involving projection and perceptual lighting, color, and detail cues.[1] I have made advances in the control of non-linear projections, automating the choice of projection to meet compositional criteria, and novel approaches for color and lighting editing based on perceptual metrics. Currently, these are disparate algorithms. I will combine them into a system that lets a novice user select what elements of the scene

[1] Where do objects appear on the screen? What part of the image is most important?

are important, and automatically presents them with renderings that make those elements the most perceptually visible.

- **Expanding manifold technology to human animation** (jointly with Bobby Bodenheimer, Vanderbilt and Robert Pless, WU). Human animation is a physical process, which implies that the underlying motion lies on some smooth manifold. Currently, human animation data are represented as a collection of joint angles (shoulder, elbow, etc) over time. Reasonably accurate skeletal models can contain over forty degrees of freedom. Clearly, most motions (such as walking) can be described with far fewer degrees of freedom. The problem of recovering this reduced set is essentially the problem of recovering underlying manifold structure from the animation data, reconstructing the manifold embedding, then resampling to produce new animations.