ABSTRACT

Alexandra A. Bokinsky
Multivariate Data Visualization with *Data-Driven Spots*
(Under the direction of Dr. Frederick P. Brooks, Jr.)

This dissertation addresses an important problem in the visualization of scientific data: Given a family of single-valued functions $F_k(x,y)$ in two dimensions, all sampled on a regular, finite, two-dimensional grid, *i,j*, devise visualizations that allow each function to be visually discriminated and studied separately and studied for comparisons and correlations with other functions in the family.

I developed a technique called *Data-Driven Spots (DDS)*, where each function $F_k(x,y)$ is sampled, by a random collection of circular Gaussians with a uniform standard deviation, rather than presented in full. Human visual perception estimates the function's values where it is not represented in the sample. These sampled functions, called *layers*, are presented overlaid. Each function is sampled and displayed in some regions where the others are not, thus each can be discriminated separately; since all are shown simultaneously, correlations can also be estimated.

Layers are displayed with *alpha-blending*, such that each layer is distinguished by hue and/or the standard deviation of the Gaussians. Data values are multiplied by the Gaussian at each *i,j* grid point; the result determines the opacity of that layer at that point. Blended with a neutral gray background, each layer has color saturation at *i,j* proportional to the modulated data value. Since opacities are displayed, lower layers are mostly visible between the spots on upper layers.

I built a DDS Toolkit that enables users to construct DDS visualizations of function families. Construction of effective DDS visualizations requires interactive exploration of visualization parameters, which the toolkit facilitates. I used the toolkit to prepare visualizations of many kinds of function families; a collection of images is presented.

To evaluate the effectiveness of the DDS technique, I performed user studies. These studies showed that performance on a spatial correlation task was better for overlaid DDS images than side-by-side DDS images, that alpha-blended layers are visually discriminable in the presence of up to seven distractors, and that animation of layers with respect to each other dramatically increases their visual salience. Animation permits a $F_k(x,y)$ to be seen at every *i,j* over time; human visual perception integrates non-simultaneously displayed values into a coherent understanding.