

Perceptual Optimization for Data Visualization

Project Summary:

This proposal is aimed at helping to establish a discipline of *information psychophysics*. The essence of information psychophysics is to apply the methods of classical psychophysics to the perception of common information structures, such as elementary flow patterns, surface shapes or paths in graphs. Much of human intelligence can be broadly characterized as the ability to identify patterns, and the visual system is the most sophisticated pattern finding mechanism that we have. Of all of our perceptual systems, vision dominates. It is estimated to engage 50% of the cortex and 70% of all our sensory receptors are visual, but is only just becoming possible to display as much information as the human visual system is capable of absorbing. The proposed research has the following five elements.

1. A display that supports real-time animation at the limit of the resolution of the human visual system. The applicants propose building an 18 megapixel stereoscopic display, capable of real-time display of complex information structures with motion and stereoscopic depth.
2. The development and evaluation of perceptual optimization processes. Because there can be an almost infinite number of mappings between data and graphical representation, the researchers will explore ways of developing perceptually near-optimal solutions through the development of human-in-the-loop optimization techniques.
3. A set of experiments that apply display psychophysics to understanding issues relating to the limits of information density. These experiments will measure the efficiency of different ways of displaying common information structures, including paths in graphs, aspects of flow patterns, and the shapes of overlapping surfaces.
4. The development of algorithms that support the mapping between data attributes and visual display primitives in a flexible adaptive or tunable process. The perceptual optimization process will require the invention of parameterized algorithms that can enable effective solutions to readily emerge.
5. The application of the techniques to visualization problems in three areas: flow visualization, overlaying surface visualization and large network visualization. In order for the results to be meaningful, researchers will work closely with scientists in the domains of Environmental Fluid Mechanics, and Oceanography, Biological Fluid Modeling, Geological Imaging, Meteorology, and Building Environmental Controls.

The applicants are experts in graphics algorithm development, perceptual issues in information display and one of the application areas of flow visualization. The bulk of the research will be carried out at the University of New Hampshire (visual psychophysics, perceptual optimization, flow visualization) and Texas A&M (algorithm development, and perceptual optimization). Part of the funding will be used to support collaborative projects at Brown (perceptual optimization) and at Dartmouth (flow modeling).

The intellectual merit of the proposed research will be to firmly establish information psychophysics define the field as an intellectual endeavor, welding together existing techniques into a cohesive discipline. The high resolution display will enable the researchers to work at the limits of human perceptual capability endowing the results with long-term value.

The propose research will also have a broader impact in producing a variety of valuable products including design guidelines, immediately useable design solutions, as well as algorithms and information display theory. The researchers also expect to make material contributions to a number of application areas: especially flow visualization, network visualization, and overlapping surface visualization and to provide software tools to scientists working in these disciplines. The research results will be made available to parties of schoolchildren and to the general public through programs at three institutions.