Applied Perception

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Computer graphics puts ideas into our heads. In a peculiar way, it lets us see inside our computers by showing us pictures made from the data it holds. If the pictures are well made, we can grasp important ideas and information at a glance. It's this easy transfer from machine to mind that makes computer graphics important and appealing.

Computer graphics helps us make pictures of any sort, from graphs, plots, and charts to line drawings and watercolors to photography to physically accurate modeling, rendering, and animation. Each type can vividly convey ideas in well-made pictures.

The goal of computer graphics isn't to control light, but to control our perception of it. Light is merely a carrier of the information we gather by perception.

But what, exactly, constitutes a well-made picture, and how might a computer make it better? What arrangement of display outputs is most likely to transfer useful information from the computer into our heads accurately and effectively? Given the wide and growing range of picture types and displays we have available, no single best answer exists, and as researchers, we're not yet satisfied with what we have. Most current work in computer graphics stops at the frame buffer, but this is only the first stage of the machine-to-mind transfer we want to achieve.

This special issue on applied perception directs your attention to the other half of computer graphics—the part of the machine-to-mind information transfer that begins as light reaches your eye and ends at the edge of conscious understanding. Perception informs every aspect of computer graphics, including our ability to see important trends in plots and graphs, the entire field of color science, and all forms of visual quality metrics for modeling, rendering, and display (see the sidebar "What is Perception?"). Perceptual effects aren't confined to abstract pictures such as plots or vector fields—even the most rigorous physically accurate pictures concern both physics and perception in equal measure. No matter how carefully we compute the displayed image, perception determines how much and how accurately we'll understand what we see.

We're pleased to present this special issue. Although we both know this area of research has grown steadily, from a trickle of papers in Siggraph, Eurographics, and IEEE conferences and journals to discussions of a separate conference at the Siggraph/Eurographics Campfire on Perceptually Adaptive Graphics (see http://isg.cs.tcd.ie/campfire/), we were still surprised to receive no less than 14 submissions for this one special issue. Based on the careful work of more than 50 reviewers, we filled the entire issue with the six highest-ranked articles and a tutorial article by co-editor Jim Ferwerda. Although we almost exceeded the magazine's page limit, we wish we had space for more.

Overview of articles

Each of the seven articles in this issue address a different perception-related topic in computer graphics systems and applications:

- Ferwerda's tutorial offers a survey of the mechanisms and processes of early human vision, summarizing well-established results from physiology and psychophysics that are important for computer graphics but often overlooked by computer-science-oriented readers.
- Studies by Reinhardt et al. have found that straightforward color statistics can capture some important subjective notions of style and appearance in images. Their article shows how to transfer them from one image to another to copy some of the atmosphere and mood of a good picture.
- Tiddeman et al. address an important perceptual problem in facial modeling systems. Their system gives much better control of perceived age in facial modeling systems. By improving the representation of wrinkles, stubble, and subtle changes in facial contours, the authors' wavelet-based method allows smooth warping of a set of facial images to any desired age. Their approach should prove useful in a wide range of applications, including medicine, psychology, facial identification, and entertainment applications.
- Smallman et al. challenge widespread assumptions that 3D pictures are always the best way to rapidly convey critically important 3D spatial information. From their extensive studies of air-traffic control search tasks, they offer both a better understanding

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of how we assess 3D displays and studies that show that we can get even better results by using properly modified 2D picture-making methods.

- Stone addresses perceptual problems in large, tiled, display systems. Although these aggregates of many display devices are increasingly popular and affordable, they pose surprisingly difficult matching problems. Her article offers new ways to methodically eliminate display-to-display variations that would otherwise spoil its appearance.
- Reddy's article introduces several important basic perceptual limitations of human vision useful to anyone in computer graphics.
- Irani et al. offer new ways to improve the machine-to-mind transfer for graphs and diagrams. By decomposing such diagrams into geons, a set of rule-based 3D visual primitives used successfully in the computer-vision community, they offer ways to automatically generate 2D and 3D graphs that we can more easily analyze and remember.

Because every measurable quantity we simulate in computer graphics has a corresponding perceived amount, exploring perception offers many opportunities for exciting new research work. As these articles amply demonstrate, applying explicit computed models of perception lets us improve both the accuracy and the effectiveness of computer graphics. We look forward to many more exciting developments in this field. ■

What is Perception?

Perception connects our minds to the world around us. It's the host of processes that converts all the measurable physical stimuli that our bodies receive into a conscious awareness of our surroundings. Its inputs are physical and measurable, but its outputs are purely psychological. Perception supplies us with an immediate, moment-by-moment estimate of reality, it gives us the basic notions of where we are and what's happening around us—the starting information we need to understand and interact with our environment.

Perception is much more than a simple metering of physical stimulation. It's not a passive measurement of the light, sound, pressure, or chemical vapors that impinge on our sensory organs. It's a set of processes that actively construct mental representations of the world from raw, noisy, and incomplete sensory signals.

We routinely perceive much more than we can directly sense, especially with the visual system, where we can perceive sensed light patterns as illumination, shadow, reflectance, shape, occlusion, position, movement, color, and other fundamental components of our 3D environment.

Perception and understanding are so tightly interwoven that we use their words interchangeably in casual conversations: "I see what you mean," "I don't know where to look for an answer," or "Look, this is important." It's easy to confuse what we look at (stimulus) with what we see (perception).

__Jack Tumblin__ will become an assistant professor of computer science at Northwestern University this fall, after completing a two-year postdoctoral research appointment at Cornell University. His graduate research explored perception and graphics, and he published work on tone mapping methods for displaying high-contrast images on low-contrast displays, models of human visual adaptation and appearance, and antialiasing. Before earning his PhD in computer science at the Georgia Institute of Technology in 1999, he worked as an electrical engineer designing real-time graphics hardware for commercial and military flight simulators at IVEX in Atlanta, where he was one of the company's founders. He earned both his BS (1978) and MS (1990) in electrical engineering at Georgia Tech. He is an associate editor of ACM Transactions on Graphics.

__James A. Ferwerda__ is a research associate in the Program of Computer Graphics at Cornell University where he leads an interdisciplinary group studying perceptual issues in computer graphics. His current work focuses on developing computational models of human vision from psychophysical experiments and implementing graphics algorithms based on these visual models. He received a BS in 1980, an MS in 1987, and a PhD in 1998, all from Cornell University. He is a member of Siggraph and the Society for Imaging Science and Technology (IS&T).

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