The Institute of OPTICS

Colloquium

UNIVERSITY of ROCHESTER

Overthrowing some old optical principles in the new world of computational imaging

Dr. David G. Stork
Richoh Innovations

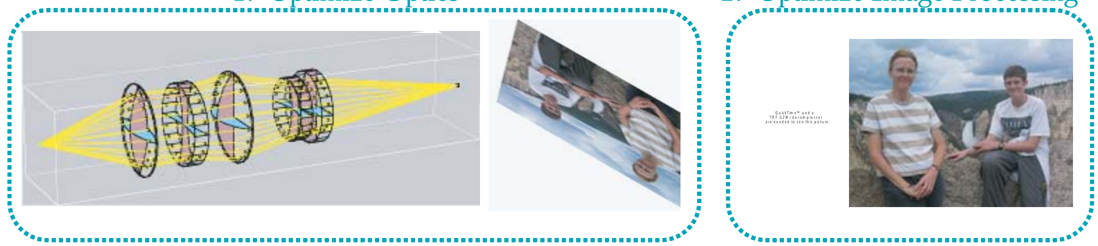
David G. Stork is Chief Scientist of Ricoh Innovations. He holds 38 US patents and has published over 130 technical papers and six books.

In this talk he will show that simultaneous joint design of the optics and image processing for the end-to-end merit function differs in fundamental ways from traditional optics-only and from sequential optics then image processing methods.

Traditional design method

1: Optimize Optics

2: Optimize Image Processing



Joint design method

1: Optimize Optics and Image Processing

Special day and time
3:30-4:30 pm, Thursday
March 26, 2009

Sloan Auditorium, Goergen Building

Refreshments served

Overthrowing some old optical principles in the new world of computational imaging

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Abstract

Traditional principles of optical imaging guide the search for designs that yield high-quality optical images (e.g., small point-spread functions and low aberrations). In the new world of computational imaging, optical images are digitally sensed and processed before presented on a display screen and as such only the quality of the *final digitally displayed image* is important, not that of the intermediate optical image. Simultaneous joint design of the optics and image processing for the end-to-end merit function differs in fundamental ways from traditional optics-only and from sequential optics *then* image processing methods. The resulting trend is for imaging design to rely less upon the physics of light, optical elements and photons and more upon the information theory of digital signals, image processing algorithms and bits.

In the new world of computational imaging, large PSFs (blurry optical images) that lack zeros in the MTF are superior to small PSFs (sharp optical images) because the information can be recovered through digital Wiener filtering. Moreover, because some optical aberrations are easier to correct through digital processing than other, traditional optical merit functions for comparing aberrations are of little use when designing electro-optical imaging systems. In fact, certain optical aberrations can be advantageous in a digital-optical system: severe chromatic aberration can, through digital processing, yield enhanced depth of field. Because more of the imaging burden is carried by image processing, for a given imaging performance (measured in MSE), these new systems can be smaller, have fewer optical elements, have higher manufacturing yield--and thus lower cost--than imaging systems designed through traditional sequential methods.

These new principles apply not merely to systems employing esoteric optical elements (such as cubic phase plates for enhanced depth of field) nor new imaging architectures (such as lightwave sensing) nor radical designs (such as ultra-thin multi-lenslet integrated cameras) but also to traditional spherical-lens imagers such as a simple singlet and Cooke triplet.

Given the relentless trends...

...away from chemical image sensing toward digital sensing and display
...toward more powerful, less-expensive digital image processing hardware
...toward more application-specific imagers

these new electro-optical imaging design principles are likely to prove more useful than traditional optics-only design principles throughout an ever expanding range of imaging applications.

Biography

David G. Stork is Chief Scientist of Ricoh Innovations. He holds 38 US patents and has published over 130 technical papers and six books/proceedings volumes, including ***Seeing the Light: Optics in nature, photography, color, vision and holography***, ***Pattern Classification*** (2nd ed.), and ***Computer image analysis in the study of art***. He is a Fellow of the International Association of Pattern Recognition ("For contributions to pattern recognition education, machine learning, speech recognition, and the application of computer vision to the study of art") and founding General Chair of the Optical Society of America's forthcoming conference series, Digital image processing and analysis (DIPA). He is currently Consulting Professor at Stanford University, where over the last 20 years he has held appointments and taught in the departments of Psychology, Electrical Engineering, Computer Science, Statistics and Art and Art History.