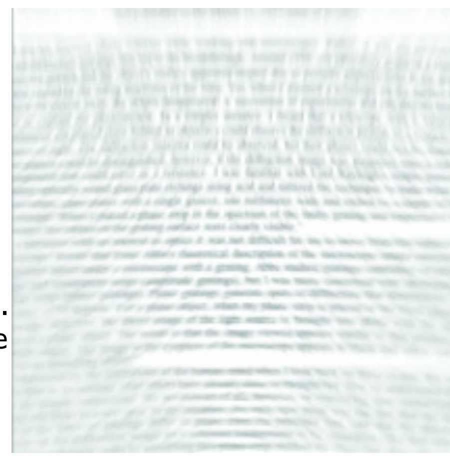
OPHTHALMOLOGY NEWS

Computer program simulates visual perception

by Matt Young EyeWorld Contributing Editor

Tool attempts to simulate conditions that arise from aspheric surfaces



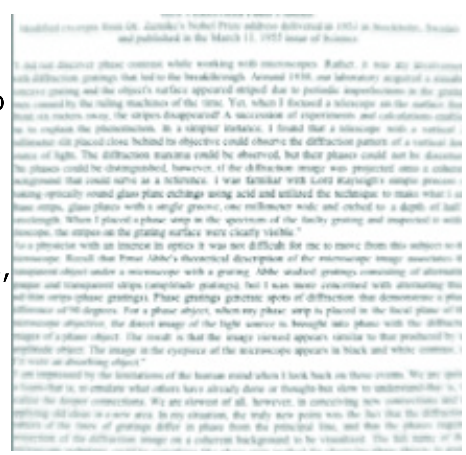
SimEye simulation of irregular astigmatism. Source: Wolfgang Fink, Ph.D.

An experimental vision model that simulates the visual conditions of various diseases could someday help ophthalmologists better communicate with their patients.

SimEye is a new computer-based simulation of visual perception using Zernike polynomials. SimEye provides both still images and animated movies.

Wolfgang Fink, Ph.D., visiting associate in physics, Visual and Autonomous Exploration Systems Research Laboratory, California Institute of Technology, Pasadena, Calif., described this new software tool in the September/October 2006 issue of the Journal of Biomedical Optics together with co-author Daniel Micol. Some ophthalmologists have welcomed the idea as a potentially helpful addition to their patient consultations.

Dr. Fink, indeed, has high hopes for simEye—although it does not yet have a manufacturer—because he sees its potential applications in science, optics, and education.



What is simEye?

SimEye certainly isn't the first model

to attempt simulating visual perception. But it is new in that it attempts such simulation of visual conditions that arise from aspheric surfaces.

Dr. Fink noted that the Gullstrand exact schematic eye model has been used previously to study visual perception under various eye conditions including myopia, hyperopia, cataract caused by microvacuoles, and dislocated IOLs.

"Gullstrand's exact schematic eye model also has its limitations, predominantly because of the sphericity of its surfaces and, resulting from that, a very limited customizability," Dr. Fink reported. "To obtain more realistic and quantitative results, aspheric surfaces must be considered."

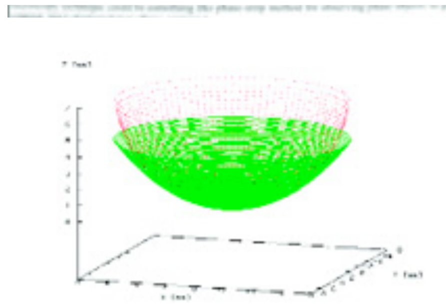
That's exactly what simEye does. Using ray-tracing techniques, simEye can, for example, imitate visual perception characterized by emmetropia, regular astigmatism, irregular astigmatism, and central symmetric keratoconus—which are all marked by aspheric corneal surfaces. It's also quite customizable. Even the diameter of the pupil is user-adjustable in simEye.

Life-like vision

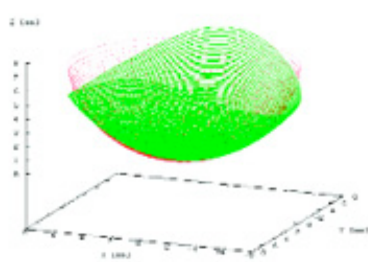
Indeed, Dr. Fink put those four conditions to a test with simEye. To do this, Dr. Fink adapted the simEye ray-tracing procedure to Gullstrand's exact schematic eye model. He fitted the spherical refractive surfaces—except for the anterior corneal surface—and the spherical retina with Zernike polynomials for both distance viewing and maximal accommodation.

"We would like to emphasize that any of these surfaces can be replaced by surfaces that are fitted to more elaborate and realistic eye models, otherwise modeled data, or to actual biometric data," Dr. Fink said in his study.

During his test, Dr. Fink set the



A SimEye simulation of aspheric astigmatism.



SimEye can simulate what it looks like to have irregular astigmatism and other eye

diameter of the pupil to 4 mm.

conditions, which could help ophthalmologists communicate better with their patients.
Source: Wolfgang Fink, Ph.D.

In the test of emmetropia, or normal vision, simEye produced an image clear in the center as opposed to the periphery, which is the result of the assumed sphericity of the cornea (which leads to spherical aberration). "It resembles the naturally occurring blurry perception in our peripheral vision due to the reduced retinal receptor density," Dr. Fink reported.
Under one particular instance of regular astigmatism, the produced simEye image shows an arc-like, structural image distortion along the vertical y axis with the horizontal x axis being the symmetry axis.
Under one particular instance of irregular astigmatism, Dr. Fink reported: "The resulting visual perception exhibits five distinct areas: the upper left and right are characterized by a more arc-like, structural image distortion akin to the visual perception under regular astigmatism, whereas the lower left and right are characterized by a more Gaussian-type, fuzzy blur without any apparent structure to it. In the image center, a relatively undistorted viewing channel is visible."
Finally, visual perception under one particular instance of central symmetric keratoconus shows just the kind of detail that simEye can achieve.
The image produced three areas of varying amounts of distortion.
"In the central region, image blurriness paired with slight image enlargement is exhibited because of the increased central corneal thickness due to the central symmetric keratoconus compared to the 'normal' central corneal thickness," Dr. Fink reported. "This central region is surrounded by an annular region of image blurriness because of the reduced corneal thickness due to the central symmetric keratoconus compared to the normal corneal thickness in that region. Surrounding this annular region is a peripheral region where the regular image blurriness due to the spherical aberration of the anterior corneal surface is exhibited."

Ophthalmologists imagine uses

"I could see a significant role" for simEye, said Eric D. Donnenfeld, M.D., Rockville Centre, N.Y. "Patients would be able to visualize possible complications of surgery."
Dr. Donnenfeld said that understanding the experiences of glare and halo with multifocal lenses or corneal refractive procedures would be particularly useful, although Dr. Fink did not test those conditions specifically in his study.
"Anything that gives the physician a better tool to explain surgical outcomes is going to be a benefit for patients," Dr. Donnenfeld said.
Mark Packer, M.D., clinical associate professor, ophthalmology, Casey Eye Institute, Oregon Health and Science University, Portland, Ore., also was fairly optimistic about simEye's potential benefits in private clinics.
If a clinician can show a patient what astigmatism or other visual defects are like in a movie, "That's very interesting," he said.
"It is a useful educational idea," he said.

***Editors' note**: Dr. Fink reported no financial interests related to his study. Drs. Donnenfeld and Packer have no financial interests related to their comments.*

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