The Limits of Human Vision

By
Josef F.Bille

Adaptive optics and femtosecond laser surgical systems have allowed the measurement and correction of the optical properties of the human eye, extending the knowledge of the limits of human vision.

The use of adaptive optics was initiated by efforts to develop high-energy laser weapons. The powerful beams of the lasers perturbed the atmosphere, prompting developers to devise adaptive optical systems to compensate for those perturbations and deliver more laser power to the target. Astronomers realized that adaptive optics could improve seeing through the turbulent atmosphere, which otherwise limits even the best ground-based telescopes to resolution far below the diffraction limit imposed by their size. Although limited to imaging small regions at one time, adaptive optics have been an impressive astronomical success.

The breakthrough of the new technology in use with the human eye was the development of an instrument called a wavefront sensor to detect distortions in human vision in the living eye. A light-beam is imaged into the eye and observed through hundreds of tiny lenses in the sensor. The aberrations in patterns created by those lenses serve as a map of the eye's optical imperfections. Customized surgical techniques have been developed to implement the results of patients' wavefront measurements, in order to correct their vision beyond normal (Visus 1.0). Some adaptive-optic systems are already used in research, most often to clearly image individual retinal cells, which are normally blurred by the imperfections of the human eye. Others are being developed for diagnosis of eye problems, such as an automated adaptive-optic system that can measure the optical imperfections of the living eye to prescribe corrective lenses or customized laser eye corrections. In recent developments, the post-cataract-surgery fine-tuning of eye-implants, so-called Intra-Ocular Lenses (IOLs), has been demonstrated.