Analytical Tools for Intraocular Lens Design with Aspheric Surfaces

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1. Motivation
   - To present a complete methodology to develop Intraocular Lens (IOL) designs and evaluate their performance based on an analytical formulation.
   - To explore the possibilities of the methodology to propose more efficient optical designs using aspheric surfaces.

2. Background
   - Ray tracing methods [1]: Exact computations of the rays trajectories through an eye model. Exact but expensive and blind procedure.
   - Analytical methods [2,3]: Provide equations relating the optical performance with the different parameters of an eye model. Efficient and controlled way of searching for different possible designs.

3. Methods
   - Pseudoaphakic eye model
   - Defocus and spherical aberration
     - Ray transfer formalism:
     - Defocus (Taylor term) equation: $W_{20} = f(R_i, t_i, \lambda)$
     - Third-order aberration theory
     - Spherical aberration (Taylor term): $W_{40} = f(P, R_i, R_e, t_i, \lambda)$
   - Principal Plane
   - Paraxial image plane
   - Plane shift equations [6]

4. Results
   - Custom pseudoaphakic eye model for IOL design
   - Bi-dimensional exploration of IOL designs
   - Pupil size in IOL design
   - Ocular biometry uncertainty

5. Conclusions
   - We achieved optimum designs using gradient (Quasi-Newton) or non-gradient (Nelder-Mead) algorithms, but with different design parameters.
   - Quasi-Newton algorithm is more efficient because the number of iterations is smaller than using Nelder-Mead algorithm (30 versus 480).

6. References