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Model to simulate impact of eye oculomotor behavior under imaging condition

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Abstract

Purpose : Fixational eye movements influence the measurement process of anterior and posterior examinations and effect the reliability. We developed a model of these movements in order to study their impact on simultaneous measurement processes, e.g. retina imaging by laser scanner ophthalmoscopy (SLO).

Methods : Geometrical eye: Based on published schematic eye models a geometrical model (cornea, bulbus oculi) was implemented in three degrees of abstraction. The highest degree considers all components as spheres whereas the medium degree provides ellipsoidal shapes. The lowest degree takes into account complex surfaces for cornea and retina. The lens was generally simplified by a plane characterizing the optical effect.
Oculomotor behavior: Based on published parameters individual oculomotor movements like micro saccade, drift and tremor were modelled as synthetic data. Specific eye movements from measured data of different eye tracker devices were also included. The rotation was implemented following Dondor's law and Listing's law. The plane of rotation is positioned 13.5 mm behind the apex of the cornea.
Measurement procedure: Based on current technical parameters for SLO, a rectangular scanning pattern was modelled covering a 30° x 30° field of view with 768 x768 pixel at 96 ms and 1,536 x 1,536 pixel at 192 ms scan time per image.
Validation: A phantom eye performing defined movements was constructed. It consists of a biconvex lens as anterior part and a concave posterior part covered with a printed vessel tree, at the ends of a water filled tube in their anatomical distance. The movement was realized by a Gimbal-Mirror-Mount (Newport) stirred by two stepping motors.

Results : For a most sensible setup we decided for a diagonal direction of motion in the phantom eye as well as our simulation. Therewith the first visible artifacts occurred in horizontal rather than in vertical direction. The movement of the phantom eye in one direction was

visible over 35 frames. A displacement of 3.4° with a maximum velocity of 2° per second lead to the first horizontal artifacts in two consecutive images in both our SLO video data and our model.

Conclusions : Our customizable model allows simulation of monocular fixational behavior of the human eye during a measurement process. This provides comprehensible information regarding intended vs. real measurement position and measured value to specify measurement errors more precisely.

This is an abstract that was submitted for the 2017 ARVO Annual Meeting, held in Baltimore, MD, May 7-11, 2017.