Image processing based automatic pupillometry on infrared videos

György Kalmár, László G. Nyúl

Pupillometry is a non-invasive technique that can be used to objectively characterize pathophysiological changes involving the pupillary reflex. It has long been utilized in humans to measure the pupil diameter and its dynamic changes. In animal models of human disorders, pupillometry derived reflex metrics could potentially be used to monitor the extent of disease and response to therapy [1]. Specially designed computer algorithms provide faster, more reliable and reproducible solutions to the measuring process. These methods use a priori information about the shape and color of the pupil [2, 3].

Our research focuses on measuring the dynamics and diameter of the pupil of rats from videos recorded with a modified digital camera under infrared (IR) illumination. In these experiments the left eye of the animal is being imaged while the right eye is stimulated with a visible light impulse. The main goal is to analyze the relative size change of the pupil and the velocity of the contraction and recovery. During the recordings, the rats are breathing and moving slightly that changes their distance from the camera. Since the lens is very close to the animal, the video is distorted by scattering movements and also significant blur due to the eye getting out of focus. Essential pre-processing of the videos includes motion compensation and contrast enhancement. To avoid scale related errors, eye segmentation is performed on each frame to give a reference measure to later phases. Then the centre of the pupil is found by an energy-based ray-tracing voting system with Least-Square Estimation. In the last phase, the diameter of the pupil is determined in each frame, and at the end, the required features from the video are extracted. We developed a new, robust method that can reliably measure the size of the pupil under the mentioned difficult circumstances, compare our results with measurements obtained using manual annotation and discuss the reliability and accuracy of our method.

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References

[1] R. Z. Hussain and S. C. Hopkins and E. M. Frohman and T. N. Eagar and P. C. Cravens and B. M. Greenberg and S. Vernino and O. Stuve, *Direct and consensual murine pupillary reflex metrics: Establishing normative values*, Autonomic Neuroscience, vol. 151, no. 2, pp. 164-167, 2009.

[2] D. Iacoviello and M. Lucchetti, *Parametric characterization of the form of the human pupil from blurred noisy images*, Computer Methods and Programs in Biomedicine, vol. 77, no. 1, 2005.

[3] A. De Santis and D. Iacoviello, *Optimal segmentation of pupillometric images for estimating pupil shape parameters*, Computer Methods and Programs in Biomedicine, vol. 84, no. 2-3, pp. 174-187, 2006.