FAST AUTOFOCUS FOR HIGH-CONTRAST HIGH-SPEED PUPILLOMETRY

Task

In a diagnostic pupillometry examination, 1000 images per second are taken using a high-speed camera. The diagnostic measurement may or may not succeed depending largely how long the process lasts since a patient is not allowed to move his/her eye, thus requiring constant concentration. For this purpose, the focusing process preceding the measurement should be completed within one second, and the eye should be exposed for a very short period of time to avoid causing it any damage. To accomplish these – preventing damage and ensuring a short exposure – the Chair for Technology of Optical Systems TOS is helping design a fast (F# < 2.4) as well as high contrast (MTF > 0.6 @30 lp/mm) autofocus system.

Method

The system consists of three elements: a fast zoom lens, a fast focusing unit, and a fast and precise image evaluation algorithm that controls the focal length of the focusing unit. To achieve the highest possible resolution, TOS has designed an optical system to fully expose the camera's sensor size and developed a low-cost, robust, high-contrast system using optical components available from a catalog. The average distance between the objective and the eye is 45 mm and varies individually by ±10 mm. Since a liquid lens has been integrated into the system, the focal length of the objective can be changed by adjusting the lens curvature. The speed can be adjusted within a few milliseconds, and the objective has an adjustable focal length from -500 mm to +330 mm.

Results

By combining a liquid lens with a high-contrast, high-speed objective (MTF > 0.7 @30 lp/mm; F# < 2.4), TOS has developed a high-performance optical system available for medical pupillometry. As the optical system is robust, the lenses can be held by spacer sleeves in a tube without needing further adjustment. The software-based autofocus requires an average focusing time of less than 0.65 s for image evaluation and focus tracking. This increases the time window for the subsequent diagnostic measurement by several seconds compared to manual focusing.

Applications

This autofocus system is primarily designed for medical diagnostics. Further fields of application can be found in police traffic control, facial recognition, camera surveillance and monitoring of driving ability.

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3 High-speed pupillometry in use.