

Pupil Swim Simulation and Inspection Method for XR Optical Modules

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Abstract: XR technology utilizes computer simulations to create digital environments that engage multiple senses such as sight, sound, and touch, allowing interaction through auxiliary devices. It has broad applications in fields like aerospace, military, education, and entertainment. Near-eye display optical modules are critical components in XR technology, and responsible for the simulation and output of visual information. Currently, near-eye display optical modules on the market commonly experience image jitter issues (often referred as Pupil Swim), which significantly impair the realism of virtual environments and can cause symptoms like dizziness and visual fatigue. This paper proposes a simulation and testing method for Pupil Swim in XR modules. A quantification method for Pupil Swim, defined as the peak variation of the chief ray angle (CRA) when the eyeball moves within the eye socket, is introduced. Considering typical eye movement, CRA of a standard near-eye display optical module is calculated using ray tracing, and this result is taken as the theoretical Pupil Swim value for the system. Based on the ray tracing results, a series of visual response video were simulated. The correlation between Pupil Swim value of the system and subjective vision feeling of human was derivate using these videos. Finally, a home-build testing setup, with an VR/AR lens (with a field of view of 140°) and a six-axis numerical control system to mimic human eye vision and movement, is used to test the pupil swim values of the near-eye display optical module (same as the ray-traced system), and the actual test results correlated nicely with the simulated results.



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Liefeng Zhao received his Ph.D degree at Zhejiang University, China. He worked as optical design leader at Samsung, Korea, since 2008. He joined Zhejiang Sunny Optics Co. LTD. in 2018 and currently serves as the Deputy General Manager. He was supported and rewarded by the “Young Talents Program” of Zhejiang Province. Dr. Zhao’s work focused on the development and industrialization of mobile phone camera lenses and Virtual Reality optical modules. He has filed for over 1300 patents, and related technologies have been used in several pronounced products. He is the member of Advanced Optical Manufacturing Youth Expert Committee.