REPPERGER RESEARCH INTERN PROGRAM

RESEARCH PROJECT #: AFRL-RHD-26-06

Quantifying Secondary Aberrations Induced by Defective Lenses

PROJECT DESCRIPTION: The United States Air Force (USAF) develops protective eyewear to guard pilot vision against the effects of directed energy. The optical quality of such eyewear is measured against military standards to ensure that they meet specific metrics. One metric referred to as optical distortion is difficult to quantify because manufacturing defects can introduce secondary aberrations, which are subtle distortions in how light passes through the lenses. These need to be addressed early, before visual evaluations, as they can significantly impact perceived image quality. Aberrations directly blur otherwise perfect imagery when viewed through protective eyewear with imperfections. The amount of blur and distortion can be quantified using physical measurements of aberrations and visual threshold testing. Each aberration is described by a coefficient, representing a specific type of distortion that contributes to deviation from ideal image formation. This project will focus on the quantitative analysis of these aberration coefficients measured through the eyewear lenses. A key analytical method will be Principal Component Analysis (PCA), a dimensionality reduction technique that helps identify the most significant contributors to optical distortion by analyzing variance in the aberration data. PCA will allow us to detect dominant distortion patterns, improving our ability to assess visual acceptability and make informed pass/fail decisions on prototype eyewear.

LEARNING OBJECTIVES: Participants will learn about: ray-trace aberrometry and phase retrieval measurements used to characterize optical distortion, Zernike polynomials as defined in the ANSI Z80.28-2022: Ophthalmics – Methods of Reporting Optical Aberrations of Eyes for describing and reporting aberrations in wavefront data, the relationship between measured aberrations and visual performance thresholds, and how to use PCA to interpret high-dimensional aberration data. To complete this project, interns will gain experience in developing software tools to read raw measurement data and performing PCA to analyze aberration patterns. The primary objective is to determine which aberrations frequently co-occur and those with the greatest impact on image quality degradation. The outcome will assist with development of a quantitative framework for evaluating optical distortion in prototype eyewear based on measurable visual impact.

ACADEMIC LEVEL: Undergraduate**;** Masters

DISCIPLINES NEEDED: Physics; Mathematics and Statistics; or Computer, Information, and Data Sciences

RESEARCH LOCATION: JBSA Fort Sam Houston, Texas

RESEARCH MENTOR: Brenda Novar
Master's of Engineering Management, Drexel University, 2010

Ms. Novar holds a master's degree in engineering management, a bachelor's degree in electrical engineering and an associate in electronics engineering. She has worked in industry as an RF Electronic Technician for Mobile Communications Corporation of America troubleshooting electronic circuits to component level, interned at Motorola Corporation working with Sr. RF Engineers to develop bandpass filters for LoJack systems and as an Electrical Engineer providing instrumentation for data collection and building optical systems at Northrop Grumman. At present, she is a primary investigator at 711 HPW/RHDO working on

The material was CLEARED on 10 Dec 2025; Reference Number: AFRL-2025-5591.

developing models, conducting optical metrology measurements and leading visual performance evaluations that will inform a military standard. She is published in the peer-reviewed literature for her research work related to vision science and laser eye protection. During her employment at Northrop Grumman, she was awarded a United States Patent 7232240: Extended source laser illuminator, Kosnik, William D., Novar, Brenda J., Villavicencio, Victor I., 2007-06-19. She has also served as a science mentor through the Repperger Research Intern Program and actively promotes science and education as a participant for the Junior Academy of Science.

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