REPPERGER RESEARCH INTERN PROGRAM

RESEARCH PROJECT #: AFRL-RHD-27-05

Quantifying Secondary Aberrations Induced by Defective Lenses

PROJECT DESCRIPTION: The United States Air Force (USAF) develops protective eyewear to guard pilots' vision against the effects of directed energy. The optical quality of such eyewear is measured against military standards to ensure that specific metrics are met. 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 deviations 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 researchers to detect dominant distortion patterns, improving the ability to assess visual acceptability and make informed pass/fail decisions on prototype eyewear.

**Qualified students should have a strong background in statistical analysis.*

LEARNING OBJECTIVES: Under the guidance of a mentor, the participant will engage in research activities and gain experience in several areas, including but not limited to:

1. Learn about ray-trace aberrometry and phase retrieval measurements used to characterize optical distortion.
2. Develop an understanding of Zernike polynomials, as defined in ANSI Z80.28-2022, *Ophthalmics—Methods of Reporting Optical Aberrations of Eyes*, for describing and reporting aberrations in wavefront data.
3. Examine the relationship between measured aberrations and visual performance thresholds.
4. Learn how to use Principal Component Analysis (PCA) to interpret high-dimensional aberration data.
5. Develop software tools to read raw measurement data and perform PCA to analyze aberration patterns under the guidance of a mentor.
6. Identify which aberrations frequently co-occur and which have the greatest impact on image quality degradation.
7. Contribute to the development of a quantitative framework for evaluating optical distortion in prototype eyewear based on measurable visual impact.

ACADEMIC LEVEL: Undergraduate**;** Master's
DISCIPLINES NEEDED: Probability and Statistics, Computer, Information, and Data Sciences
RESEARCH LOCATION: JBSA Fort Sam Houston, Texas
RESEARCH MENTOR: Brenda Novar
Master's of Engineering Management, Drexel University, 2010

The material was CLEARED on 19 Oct 2026; Case Number: AFRL-2026-1821

Ms. Novar holds a master's degree in engineering management and a bachelor's degree in electrical engineering. She has worked in industry at Motorola Corporation and as a contractor for Northrop Grumman. Currently, she is a principal investigator at the 711 HPW/RHDO, developing models, conducting optical metrology measurements, and leading visual performance experiments to inform a military standard. She has published in peer-reviewed literature on vision science and laser eye protection. During her employment at Northrop Grumman, she was awarded 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 research mentor through the Repperger Research Intern Program and actively promotes science and education as a participant in the Junior Academy of Science.

The material was CLEARED on 19 Oct 2026; Case Number: AFRL-2026-1821

.