

# CODE V Image Simulation

## Visualize and Communicate Optical System Performance

### Features at a Glance

- Simulates the appearance of a 2D input object as imaged through the optical system defined in CODE V
- Fast, accurate Fast Fourier Transfer (FFT) based calculation includes geometrical aberrations, illumination variations, and other effects
- Effects include image orientation, distortion, diffraction, vignetting, axial and lateral color, relative illumination effects, and blurring due to detector pixel size
- Output can be either a grayscale or RGB image
- Supports analysis of systems with hyper-hemispherical fields of view

### Overview

With CODE V® Image Simulation, you obtain fast, accurate visual assessments of system image quality, including diffraction. Use Image Simulation to:

- Communicate optical concepts and trade-offs to non-optical engineers during design evaluations and product presentations
- Improve qualitative understanding of traditional performance measures such as MTF and spot diagrams
- Determine image orientation issues for complicated folded systems

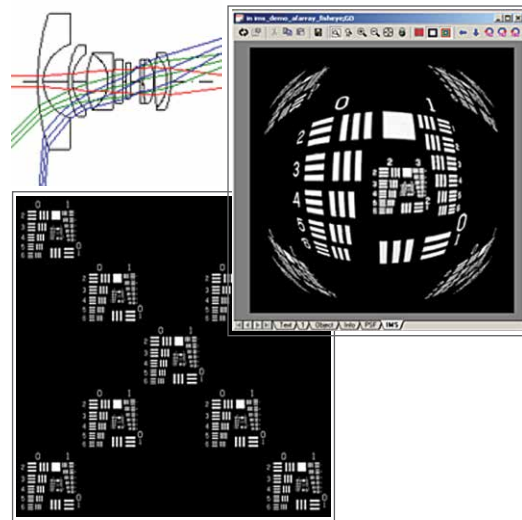


Figure 1: Image Simulation of a fisheye lens, showing distortion effects

### What You Get Is What You See

CODE V Image Simulation (IMS) lets you visualize the performance of your optical designs directly, as an alternative to traditional charts and tables. It is the ideal tool for communicating optical performance to non-optical engineers.

IMS is a diffraction-based computation that includes the effects of geometrical aberrations, diffraction, relative illumination variations, and distortion. Blurring due to a finite-sized detector can also be included. The algorithm uses the power of the FFT calculation, and is much more efficient and accurate than geometrical ray-blasting techniques.

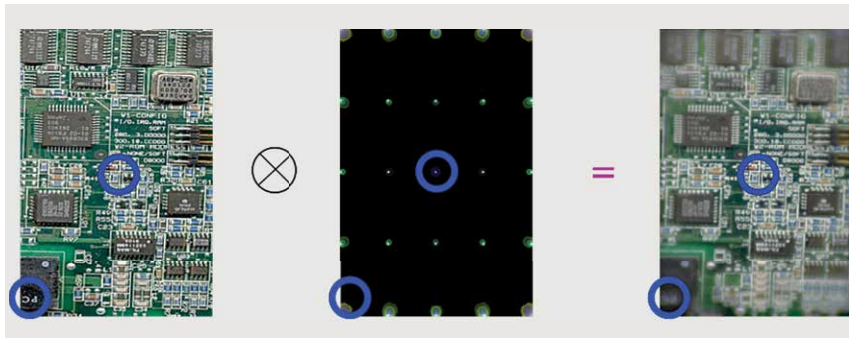


Figure 2: Circuit board image convolved with lens PSF, yielding simulated result

CODE V computes an array of point spread functions (PSFs) from the optical system that is convolved with the pixels representing the input object. Distortion is determined from the chief ray trace. As figure 2 illustrates, the narrow PSF along the lens axis produces relatively detailed imaging, while the aberrated, off-axis PSF causes extreme blurring of the image.

An extensive collection of macro functions allows you to access and manipulate the IMS image data to perform a wide variety of simulation and modeling tasks, such as:

- Modeling veiling glare, over- and under-exposure, and other image defects
- Simulating channel misalignments in a 3-color projection system
- Correcting relative illumination variations in the IMS result

Examples of various effects using combinations of CODE V macro functions with IMS results are illustrated in Figure 3.

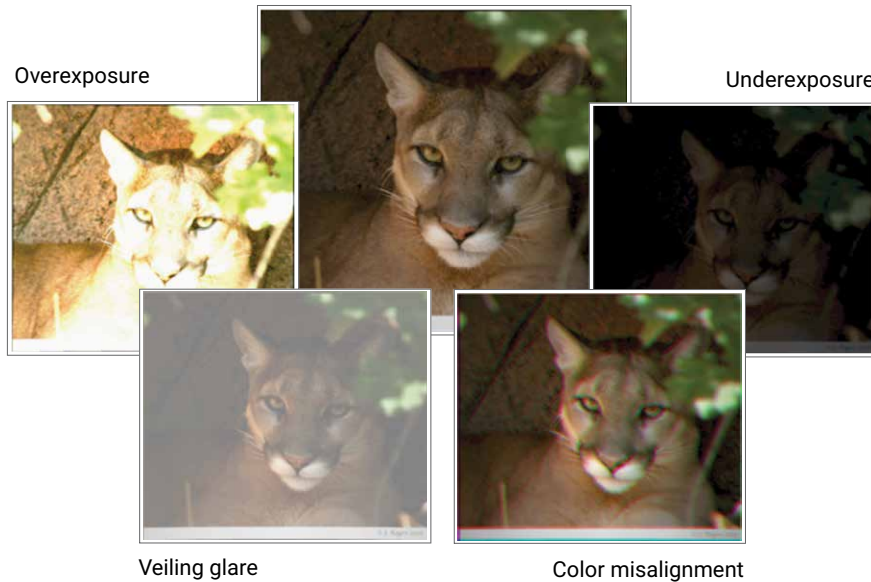


Figure 3: IMS result combined with macro functions

IMS includes mapping functions that allow you to define how the 2D input object is mapped into object space. The mapping functions support analysis of systems with hyper-hemispherical fields of view, which is useful for assessing performance of automotive navigation cameras, surveillance cameras, and DSLRs.

An interesting demonstration of the CODE V IMS using a real-world (or more accurately, out-of-world) object involves the images in figures 4a and 4b of the spiral galaxy M100. Figure 4a is an IMS result using the original conic constant of the Hubble Space Telescope primary mirror, before the first servicing mission, and figure 4b is an IMS result using the intended conic constant for the mirror. These simulation results closely match images taken, respectively, before and after the telescope was fitted with corrective optics.



Figure 4a: Simulation with actual conic constant and 4b: Simulation with desired conic constant

For more information about CODE V, visit <https://www.synopsys.com/optical-solutions.html> or send an email to [optics@synopsys.com](mailto:optics@synopsys.com).