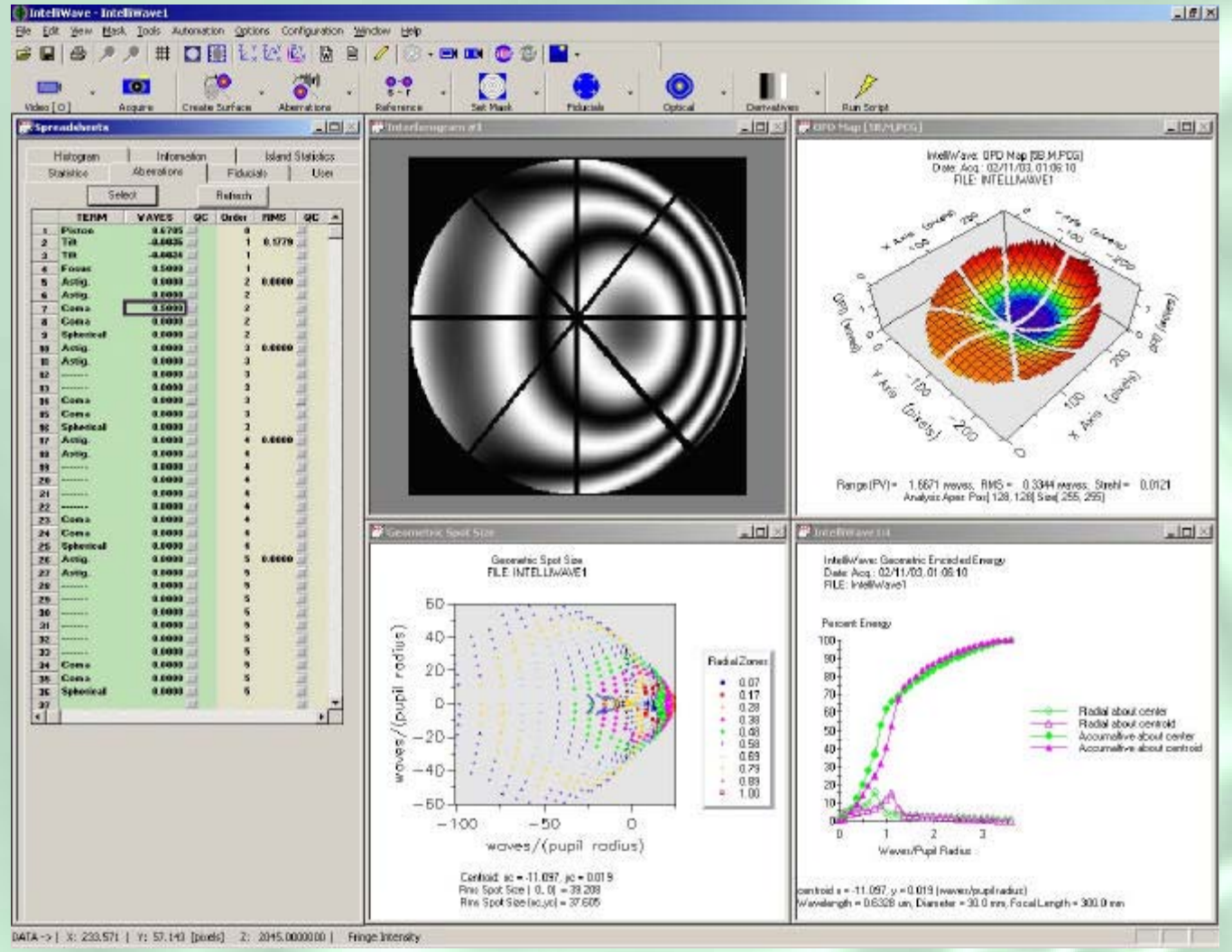
IntelliWave™

Comprehensive Software for Interferogram Analysis



MAIN FEATURES

User Interface

- Intuitive user interface
- Graph, image, & text windows
- Interactive spreadsheets
- Popup menus for all objects

Data Acquisition

- Many interferometers supported
- Fast data acquisition for static and phase shifted data
- Use any camera or scanner
- 8,10,12,14,16 bit gray scale
- Resolutions up 4096x4096

Analysis

- Classical, Shearing, & Speckle analysis
- Multi-Region unwrapping & masking
- Statistical & Zernike/Seidel analysis
- Geometric & Diffraction analysis
- Fiducial & Image transformations

Data Import and Export

- Binary, ASCII, BMP, TIF, JPG files
- CODE V Import/Export
- Send images/graphs to clipboard
- Publication quality on any printer
- Publish to HTML or the Internet

Automation

- Automate any complex task
- 130 functions to choose from
- Real-time user interaction
- While/Repeat loops
- Quality Control

ActiveX Interfaces

- Research Systems' IDL™
- Math Works' MATLAB™
- Microsoft Excel™
- National Instruments' LabVIEW™
- Add your own Plug-Ins

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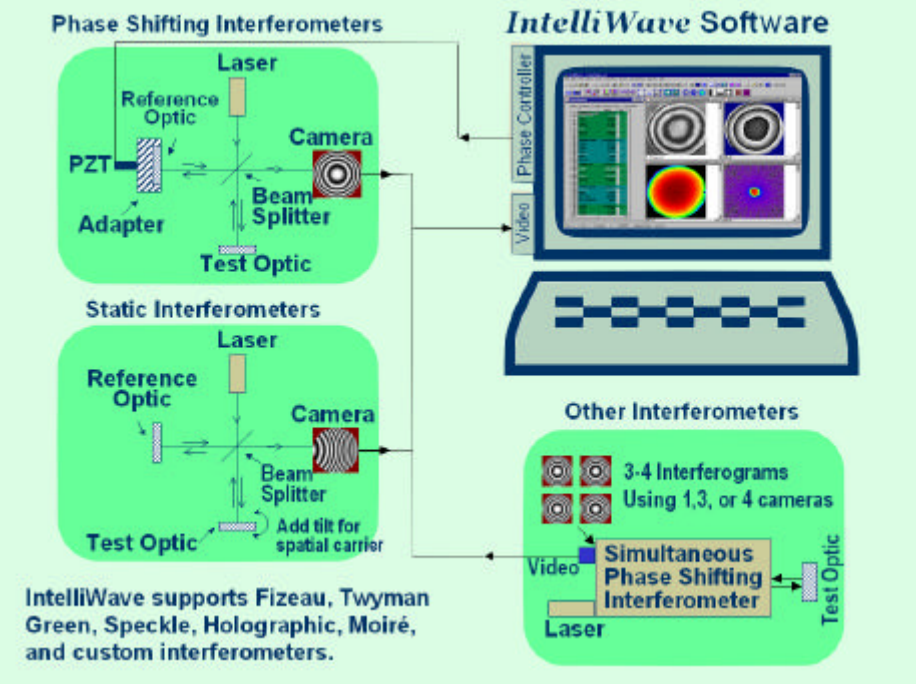
INTELLIWAVE™ OVERVIEW

IntelliWave™ is a powerful interferometric acquisition and analysis program that is used to measure the optical shape (or other characteristics) of many types of surfaces (or materials) including mirrors, lenses, semiconductor wafers, and many other reflective and non-reflective surfaces. To compute surface shape, IntelliWave requires interferogram data to generate an *Optical Phase Difference* map (OPD or surface map). An interferogram is the wavefront phase in an interferometer corresponding to the relative difference between the test and reference optical paths. By processing interferograms, the surface shape representation of a test optic can be generated.

IntelliWave integrates all the features required to acquire, import, analyze, and document virtually any type of interferogram data. IntelliWave offers power, speed, flexibility, ease of use, and value in one comprehensive package.

Hardware Independence

IntelliWave processes interferograms from many sources including cameras, scanners, standard image file formats, and industrial scientific file formats. Since IntelliWave is hardware independent it can acquire and analyze interferograms at any wavelength from virtually any type of interferometer including Twyman-Green, Michelson, Fizeau, Simultaneous Phase Shifting, and Holographic Speckle interferometers.



Temporal and Spatial Phase-Measurement Interferometry

Phase Measurement Interferometry (PMI) can be used to directly measure wavefront phase in an interferometer corresponding to the relative difference between the test and reference optical paths. PMI is supported by IntelliWave and is the most widely used technique today for measuring wavefront phase in interferometers.

Phase Measurement Interferometry can be divided into two categories: those which require multiple interferograms phase-shifted sequentially, and those which require a single interferogram. Methods of the first type are known as Temporal PMI or TPMI, and those of the second type are known as Spatial PMI or SPMI. IntelliWave supports both of these methods.

Fringe Tracing

Fringe Tracing is a means of tracing the maxima or minima contour lines or fringe lines of a single interferogram. Once all fringes lines are traced, a process called *fringe numbering* is used to assign contour levels to each fringe line. These contour lines are then used to interpolate a surface map. IntelliWave supports the fringe tracing technique which can be used whenever any of the PMI (see above) techniques cannot be used.

Analysis Features

IntelliWave offers a complete set of analysis tools including statistics, aberrations, diffraction analysis, image processing, and fiducial based geometric image transformations. IntelliWave supports a wide variety of interferogram processing techniques for converting interferograms (surface and slope fringes) into Optical Phase Difference (OPD) maps or surface maps. This flexibility allows IntelliWave to process well-behaved data in near real-time or use more robust methods to process extremely noisy data.

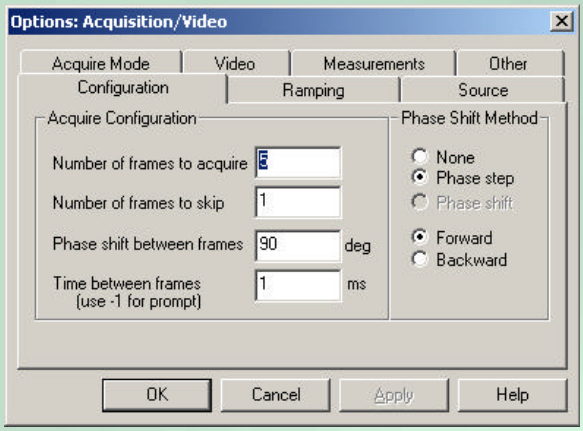
Automation and Quality Control

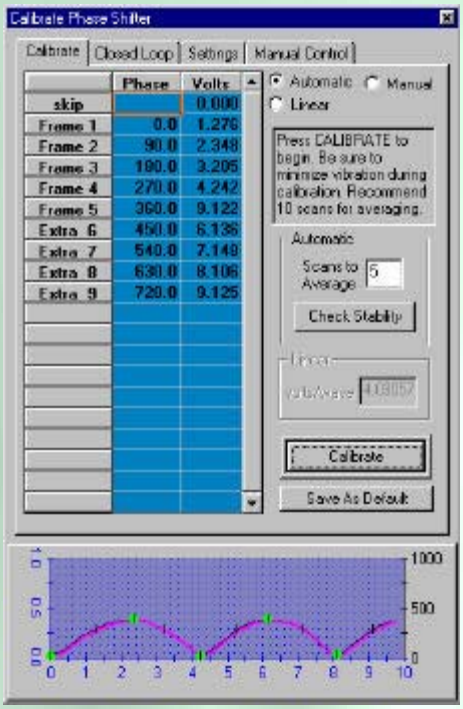
IntelliWave has powerful automation and quality controls features that allow repetitive measurements or analyses to be automated. Also, virtually all parameters such as statistics and/or aberrations can be automatically quality tested against user specifications.

Plug-In Architecture and ActiveX Interfaces

IntelliWave's plug-in architecture allows the user or third party developers to seamlessly add powerful customized features such as instrument control or custom analysis routines. Using this architecture, several ActiveX modules have been added to IntelliWave including program interfaces to National Instruments LabVIEW™, Research Systems' IDL™, Math Works' MATLAB™, and Microsoft Excel™. Through these program interfaces, interferometric data can be transferred bi-directionally and processed in the native environments of those programs.

DATA ACQUISITION





Acquire from Virtually Any Source

- Cameras (analog/digital, any resolution)
- Scanners
- Custom acquisition from external programs

IntelliWave Allows Complete Control of Data Acquisition

- Selection of the *input device* and the *phase-shifting device*
- Number of interferograms to capture
- Amount of phase-shift between frames
- Time delay between captured frames
- Linear/non-linear phase-shift calibration and shifting direction
- Optional user prompts between frames
- Real-time quality control of measured interferograms

When acquiring interferogram data, a camera is placed at the interferogram plane, and optionally, a phase-shifting device is placed in a reference beam. The data is then recorded rapidly while optionally phase-shifting the reference beam. IntelliWave acquires data for both static and phase-shifted analyses.

Temporal Phase-Shifted Interferogram Acquisition (TPMI)

To create an Optical Phase Difference (OPD) Map representation of a surface, a set of interferograms is required. Each interferogram is sequentially phase-shifted by a specified amount (usually 90°). IntelliWave generates surface maps from three (3) to twelve (12) phase-shifted interferograms. Higher frame algorithms are more tolerant of phase-shift errors, while lower frame algorithms are usually better suited for high vibration environments.

Spatial Phase-Shifted Interferogram Acquisition (SPMI)

Spatial Carrier static interferogram analysis is a powerful means of generating a surface map from a single interferogram without any fringe tracing or user interaction. IntelliWave supports two spatial carrier methods providing significant flexibility depending on your application. One of these methods can produce high resolution output similar to phase-shifting.

Static Interferogram Acquisition for Fringe Tracing

Interferograms can be acquired from a camera, scanner, or imported from many file formats. The fringes can then be traced, and an OPD map can then be generated.

Speckle Interferogram Acquisition

IntelliWave offers real-time image subtraction and filtering for viewing, acquiring, and analyzing of speckle interferograms. After data acquisition, IntelliWave has all the image processing and analysis capabilities for generating OPD maps from speckle interferograms.

Infrared Interferogram Acquisition

Infrared interferometers usually require special treatment due to the characteristics of infrared cameras. IntelliWave has special features for making sure the camera has even temperature distribution and high contrast interferograms during active video display and data acquisition.

Shearing Interferometry

IntelliWave can acquire or import two complete sets of orthogonally sheared interferograms. The interferogram data can then be unwrapped and integrated into a surface map.

Scanning White Light Interferometry

Scanning white light interferometry is in development and will be supported in a future release of IntelliWave. This method allows measurement of very rough surfaces.

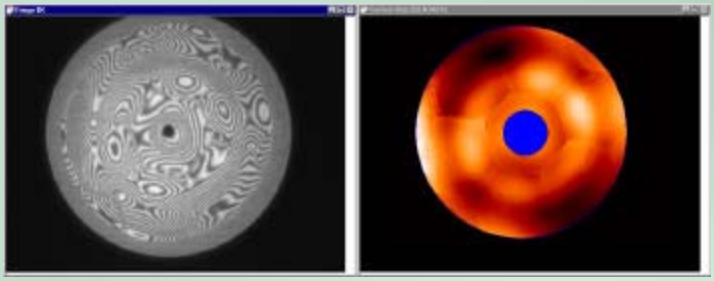
LabVIEW™ and Serial Port Measurements

IntelliWave can monitor any parameter from a serial port device or any parameter being measured with National Instrument's LabVIEW™. This allows IntelliWave to measure interferometric data as a function of real-world events such as changes in temperature, stress/strain, or vibration in real-time.

PHASE MAP GENERATION

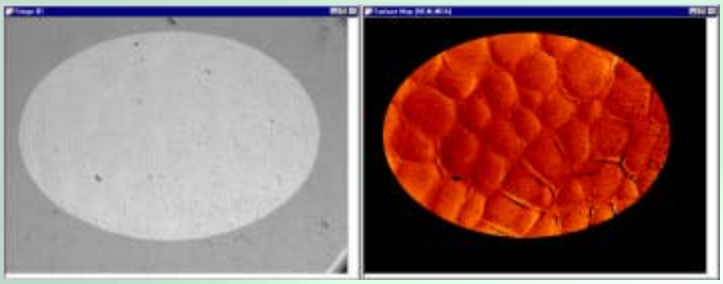
IntelliWave can process single interferograms or phase-shifted interferograms using several methods.

Temporal Phase-Shifted Interferogram Analysis (TPMI) with Multiple Region Unwrapping



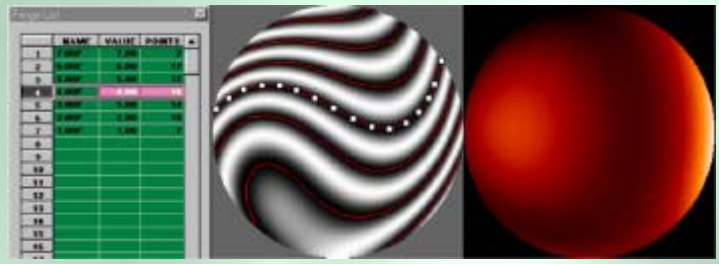
Phase Measurement Interferometry (PMI) is used to directly measure wavefront phase in an interferometer corresponding to relative differences between test and reference optical paths using multiple interferograms. The precision of phase-measurement techniques is a factor of ten to a hundred greater than *Fringe Tracing.* The image at left shows how IntelliWave can unwrap highly complex interferograms. Also, multiple regions can be processed and analyzed within a single image (see front page).

Spatial Phase-Shifted Interferogram Analysis (SPMI)



The Spatial Carrier Method is a powerful means of allowing interferogram analysis to be performed on a single interferogram without any user interaction, fringe tracing, or interpolation. All that is required is that the user add tilt to the wavefront such that it is the dominant frequency (dominate aberration). In this case the tilt carrier frequency is too high to see in the image (far left). However, IntelliWave can still process it as shown in the image at the right.

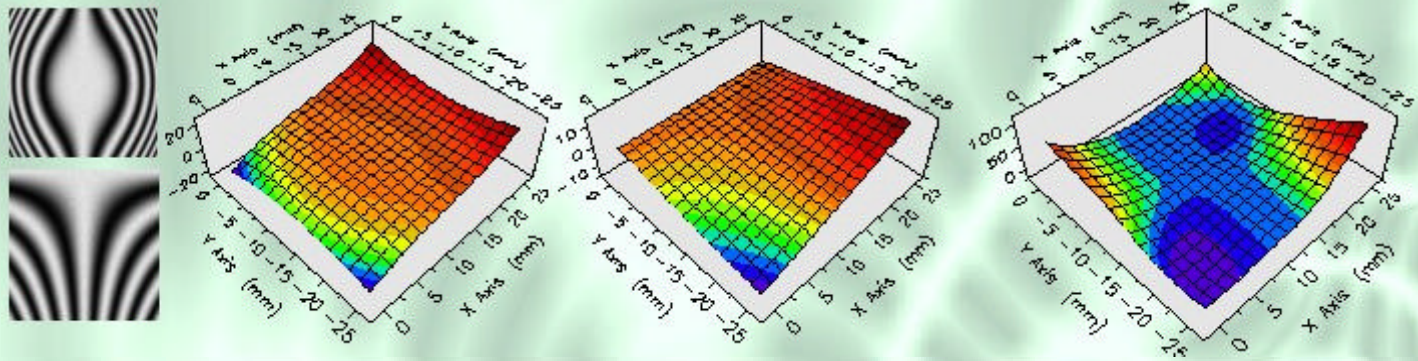
Static Interferogram Analysis with Fringe Tracing



Fringe Tracing allows the user to define fringe lines using fringe objects. Points can be moved, added, or deleted at any time. For reference, an interferogram image can be captured by camera or read from standard image file formats. Once defined, the points are used to generate a surface map.

Shearing Interferometry

IntelliWave has all the tools required to process bi-lateral sheared interferogram data. Two sets of orthogonally sheared interferogram data can be acquired (or imported), unwrapped, and then integrated into a single surface map. In addition, IntelliWave can compensate for errors introduced by the shear itself. In the images below from left to right: X and Y Slope Interferograms, X-Slope Map, Y-Slope Map, and Integrated Surface Map.

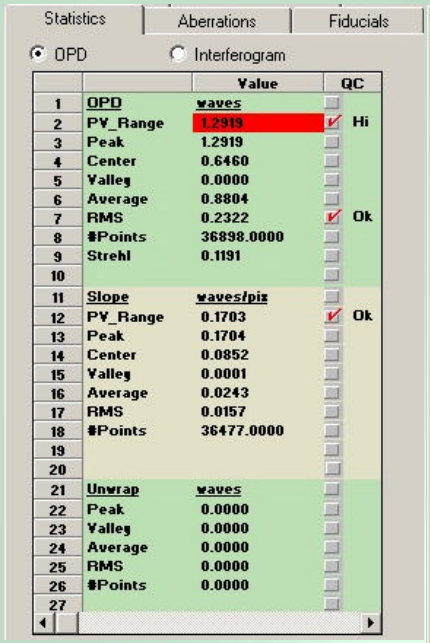


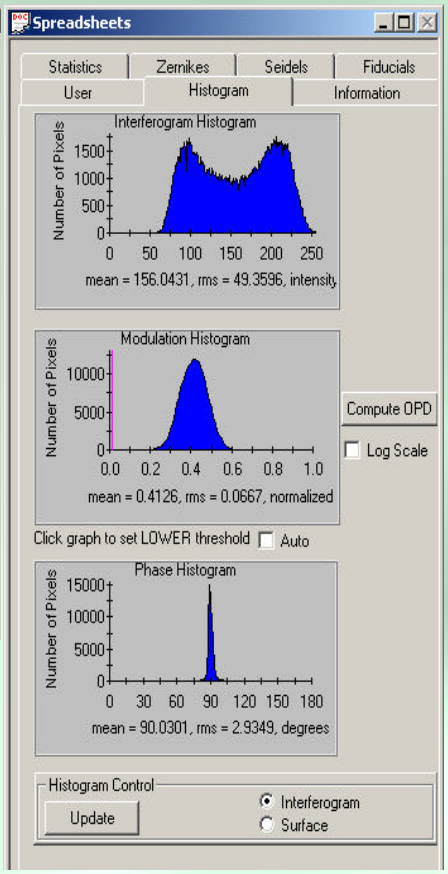
Flexible Analysis Tools for Adapting to the Environment

Many environmental and hardware conditions can effect the quality of interferogram data such as phase-shift error, detector/shifter non-linearity, vibration, low contrast fringes, optical noise, and optical surface contamination. IntelliWave has many features to minimize errors due to these conditions including:

- 3 to 12 point wrapped phase algorithms.
- 4 unwrapping methods ranging in speed and complexity.
- Gaussian, Median, and Erosion noise filters.
- Automatic removal of badly contaminated data regions.
- Apertures/obscurations for regional processing.

STATISTICAL ANALYSIS





Complete statistical analysis is available in both spreadsheet and histogram formats. *Peak-to-Valley, Peak, Valley, Average, RMS, and Strehl Ratio* are displayed in real-time. Statistics are available for all types of data including surface, surface slope, fringe intensity, modulation, and phase-shift data.

Interactive Histograms

Real-time histograms offer a fast visual inspection of fringe and surface (OPD) quality. The histogram graphs are interactive. For example, simply clicking the modulation or slope graph automatically sets the noise threshold.

Quality Control

Statistical terms can be automatically quality control tested in real-time. Spreadsheets can be scrolled to the right to enter minimum and maximum specifications. IntelliWave automatically tags terms that are below or above specifications.

Precision of Measurements

Precision is almost always a function of the interferometer and environment. Typical values are:

Phase Shifting: 20th to 1000th wave or higher
Carrier methods: 20th to 50th wave

Fringe Tracing: 10th wave

ABERRATION ANALYSIS

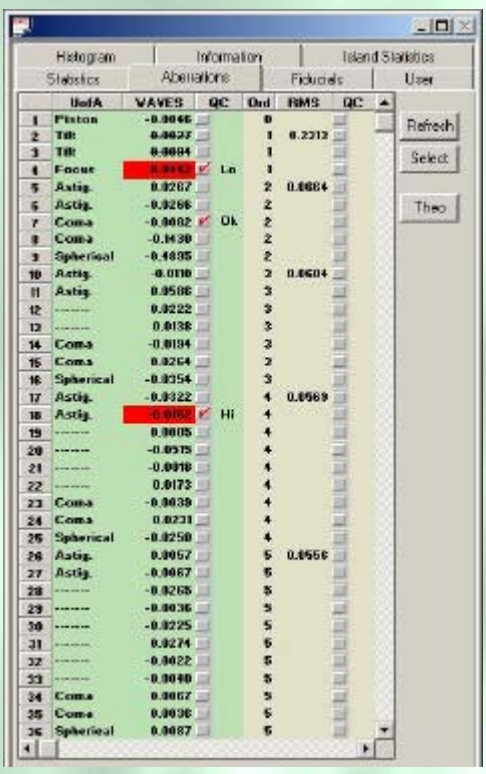


Figure: Right click on a spreadsheet for a popup menu.

Fitting Aberration Polynomials

Polynomials can be fitted to optical phase difference data (surface map) to determine the aberrations. The following operations can be performed in IntelliWave:

- Selectable polynomials: Zernikes (UofA, OSA, Perkin Elmer, Annular) Seidels
- Compute or generate aberrations in any specified aperture region
- Any combination of aberration terms can be added or subtracted
- For non-orthogonal applications, only selected terms can be fitted

Generating Interferograms and Phase Data with Aberrations

Any combination of Zernike terms can be used to generate theoretical interferograms and/or surface phase data. This is a powerful way of generating a reference surface for experimentation or subtraction from real data.

- User specified Zernike values can be used to generate data
- Aberrations from a real test optic can be used to generate data
- Multiple interferograms can be generated using a specified phase-shift

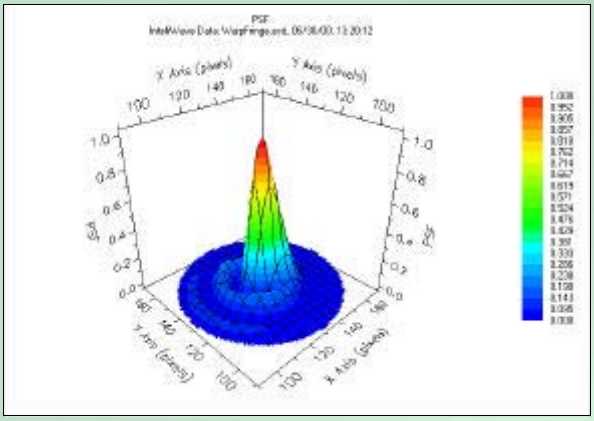
Determining RMS Fit

The RMS Fit of the polynomials to the surface data can be computed for each order of the polynomial. This is a good measure on how well the surface data computed from the polynomial matches the actual surface data. For most optics, increasing the number of terms in the polynomial usually produces a better fit.

Quality Control

All aberration terms and RMS fit values can be automatically quality control tested against user specifications in real-time. The spreadsheet can be scrolled to the right to enter minimum and maximum specifications for each term. IntelliWave automatically tags any term that is below or above specifications whenever the aberrations are computed.

DIFFRACTION ANALYSIS

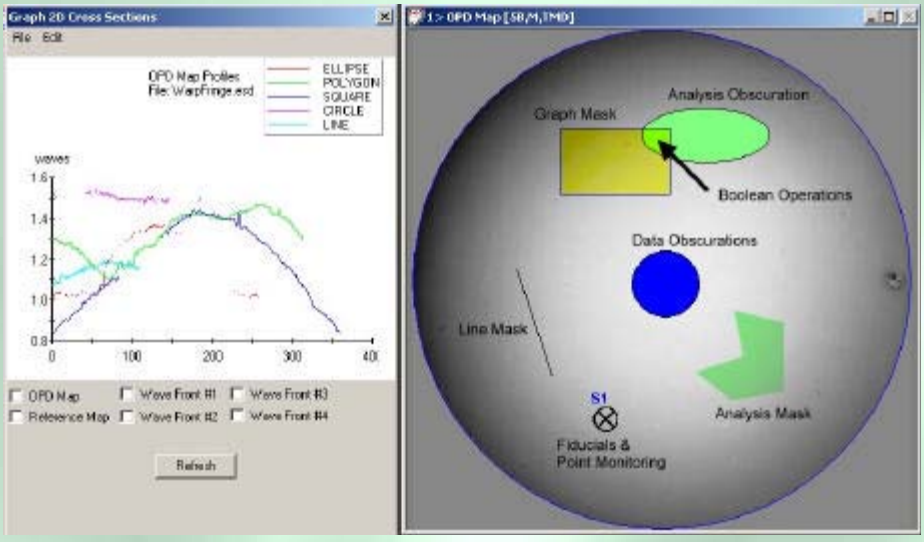


Complete diffraction analysis is available in IntelliWave. Diffraction data can be displayed as color images or 3D perspective plots. Any of the analysis aperture types can be used as windowing functions when using diffraction analysis.

The following diffraction functions are available:

- Fast Fourier Transforms (FFT)
- Point Spread Function (PSF)
- Modulation Transfer Function (MTF)

APERTURES AND OBSCURATIONS



Cross Sectional Graphs

The perimeter of any mask object can be used as a path for plotting one dimensional cross-sectional plots. The above figure (left) plots the perimeter of all the mask objects displayed on the right.

A complete set of aperture types is available for defining regions of interest where analysis is to be performed. Apertures and obscurations are used to insure that statistical processing and aberration analysis are applied only to valid regions of an image. IntelliWave supports circular, elliptical, rectangular, and polygonal objects shapes. Any number of these mask objects can be defined.

Data Apertures

Data apertures (dark blue unfilled region) encloses a region where valid fringe data is defined. The data apertures can be applied automatically or manually.

Data Obscurations

IntelliWave automatically removes bad points or regions. However, it is often required to manually block out data (using obscurations, dark blue filled regions) where data is corrupted or non-existent.

Analysis and Graph Apertures

Separate *analysis (transparent green) & graph (transparent yellow) apertures* can be applied to see statistics and zoomed graphics over any sub region.

IMAGE PROCESSING

Depending on the quality of the interferogram or surface data, some image processing may be required to assist the phase map generation process. IntelliWave supports the following image processing methods:

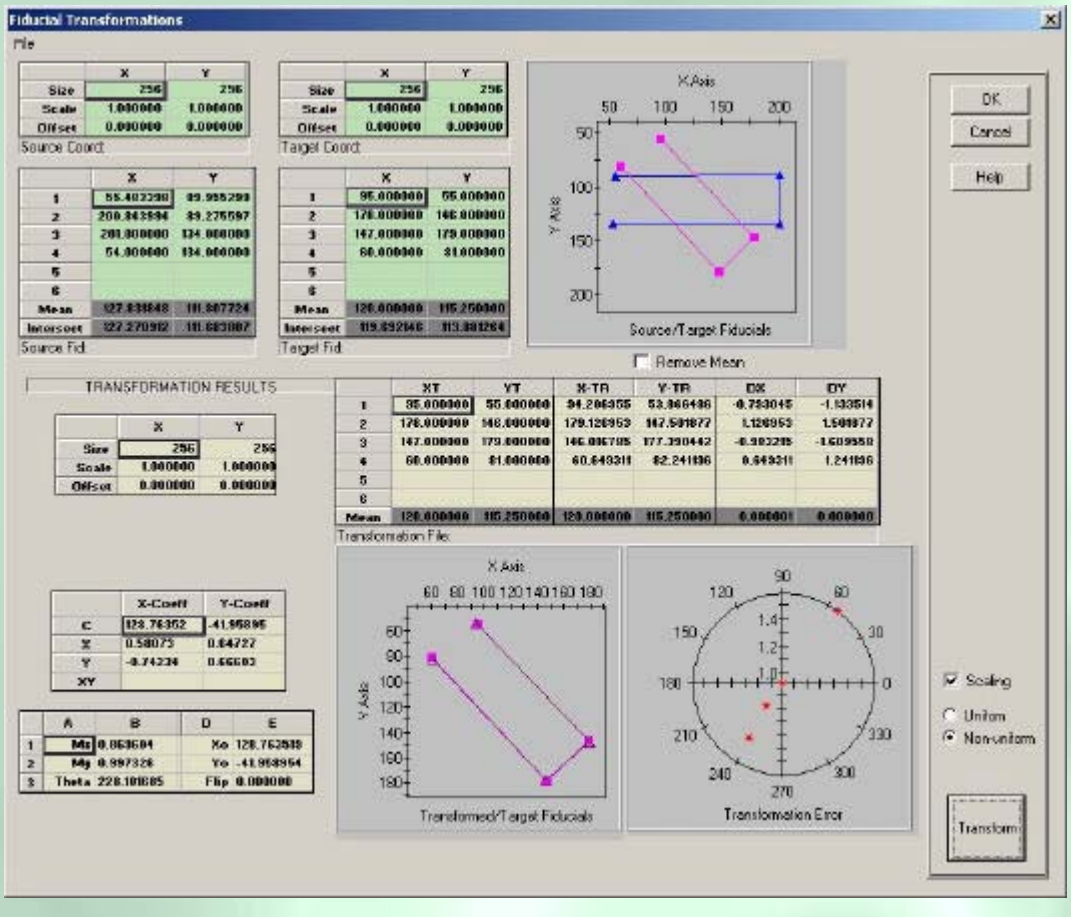
Interferogram Image Processing

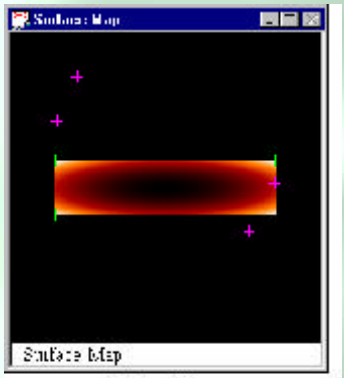
- **Gaussian Filter:** The Gaussian filter removes high frequency noise using a Gaussian distribution mask made from neighboring points.
- **Median Filter:** The median filter removes long tailed noise such as negative exponential and salt and pepper type noise from an image with a minimum blurring of the image.

Phase Map Image Processing

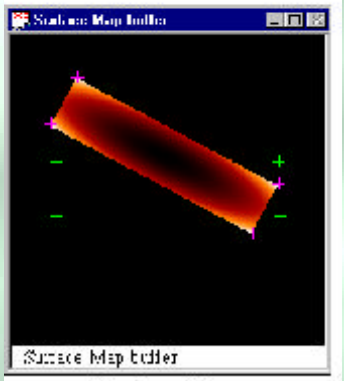
- **Median Filter:** This filter is the same as the interferogram filter except it is applied to the surface map data.
- **Spike Filter:** The spike filter removes spikes in an image without affecting good data.
- **Clipping:** Clipping removes data off the top and bottom of a surface by a specified amount.
- **Erosion:** This filter is applied to remove edge effects.

FIDUCIALS AND IMAGE TRANSFORMATIONS





Original Image



Transformed Image

IntelliWave has powerful image transformation capabilities for correcting or transforming images. An image transformation can include translation, rotation, scaling, and skewing. Transformations can be used for any purpose and are commonly used to align surface maps (OPD's) such that they can be averaged or subtracted.

User Specified Transformations

Direct transformations can be applied to any type of image data including interferograms, surface data (OPD), and masks. The transformation is composed of user specified values for translation, scaling, rotation, and center of rotation. Simple horizontal/vertical flipping and multiple ninety-degree image rotations are performed by direct pixel-to-pixel placement, thus, avoiding any image degradation.

Fiducial Transformations

Fiducial based transformations are performed by transforming a set of *source* fiducial points onto a set of *target* fiducial points. The *source* and *target* fiducial points are usually a set of matching points on two separate images. Once the points are entered by mouse or through a spreadsheet, the *source* image is transformed such that its fiducial points overlay the *target* image points. The transformation can be *uniform* or *non-uniform* depending on whether or not the image must maintain its geometric shape. The fiducials can be graphically transformed as shown above to test the transformation before transforming the actual image. The transformed fiducials, transformation coefficients, and transformation error can be viewed graphically and in spreadsheet format.

Fiducial Transformation Features

- Graphical/Spreadsheet real-time interface
- Enter fiducials by mouse or spreadsheet
- Enter fiducials using real-world units
- Save/Open sets of source, target and transformed fiducials, and coordinate systems for repetitive use.
- View transformation results before applying to image.
- Uniform and non-uniform transformations

Performing the Transformation

The actual transformation can be performed by one of the following methods:

- Direct pixel-to-pixel placement
- Bi-linear interpolation
- Bi-cubic interpolation.

IMPORTING AND EXPORTING DATA

IntelliWave analyzes interferometric data from many sources including data that has been acquired completely outside of IntelliWave.

File Import/Export

IntelliWave imports/exports from/to a wide variety of data formats including standard image formats, scientific formats, simple text files, and standard optical industry formats. A flexible means of importing the data is available so that interferogram data such as *wavelength* and *waves per fringe* can be assigned to all file types including image files such as TIFF files.

Clipboard Transfer

Any image, graphic, or spreadsheet can be transferred to the clipboard and pasted into any application such as Microsoft Word or Microsoft Excel™. Graphics can be copied as vector *metafiles* so they can be easily scaled in size without loss of image quality.

Camera and Scanner Support

Interferogram data can be scanned directly into IntelliWave using any camera or TWAIN compliant device such as a scanner. Multiple interferograms can be scanned simultaneously to average static interferogram data or perform phase-shifted analysis.

Real-time Data Transfer to/from Other Programs

Using IntelliWave's real-time interfaces to programs such as Excel™, MATLAB™, and IDL™, data can be transferred bi-directionally in real-time. Data that can be transferred include interferograms, surface data (OPD), masks, statistics, and aberrations.

Image File Formats Supported

- BMP - Microsoft Windows Bitmaps
- TIFF - Tagged Image File Format
- PNG - Portable Network Graphics
- JPEG - Joint Photo Expert Group

Scientific File Formats Supported

- HDF - Hierarchical Data Format
- RAW - Simple raw binary format

Industry File Formats Supported

- CODE V ™ and ZMAX ™.
- MetroPro ™ and OptiCode ™

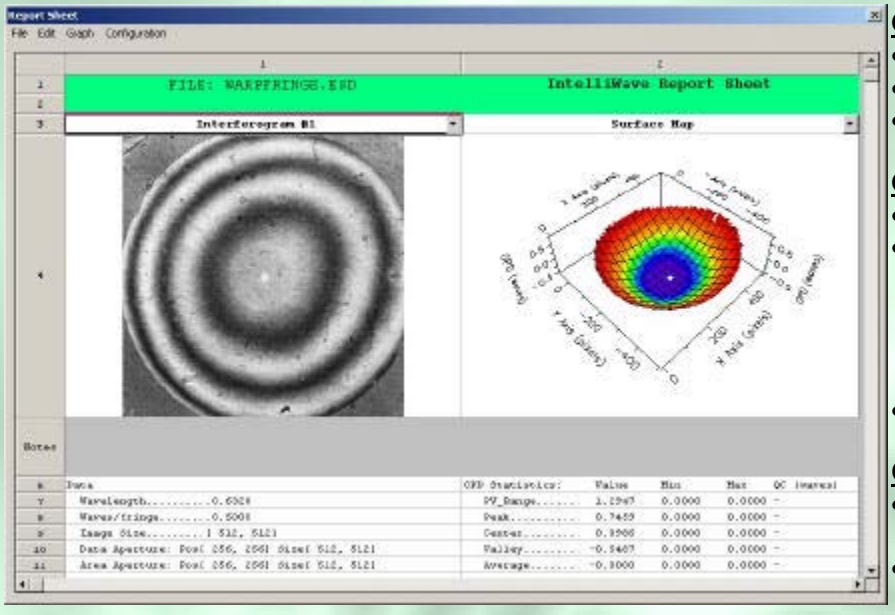
Application Independant File Formats

- ASCII - Simple text formats
- PDF - Reports
- HTML and XML - Reports and Data

Other Data Transfer Methods

- **Clipboard** - Transfer bitmaps, metafiles, or spreadsheets to the clipboard which can be pasted into other applications.
- **Scanner** - Data can be scanned using any TWAIN compliant scanner.
- **ActiveX** - Through ActiveX interfaces, data can be transferred bi-directionally to programs such as Excel™, MATLAB™, and IDL™.

PUBLISHING YOUR RESULTS



Graphic Types Supported

- 3D Perspective Plots
- 2D Color Contour Maps
- 1D Cross-sectional plots (real-time)

Graphics Features

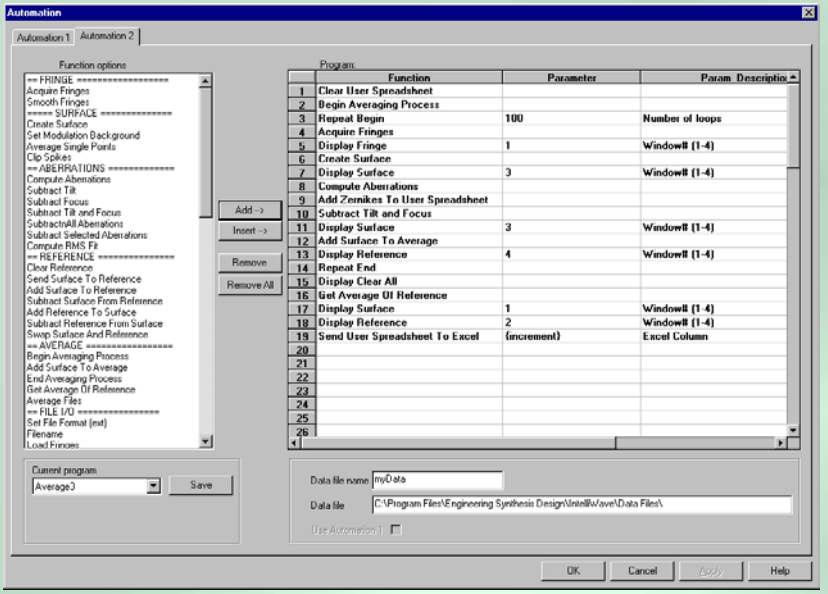
- Real-time rotation, scaling, and zooming
- Customizable
  - Add annotations & change palettes
  - Set custom axis scaling & contours
  - Numeric spreadsheet data display
  - Save/Open graphic settings
- Copy/Paste from/to the clipboard

Customizable HTML Reports

- Create your own reports with only the data and graphics you want.
- Publish your reports to printers, HTML, the Internet, or any email address.

IntelliWave has a complete set of publication quality graphics features including perspective plots, color contour maps, and cross-sectional plots. Any type of data can be graphically displayed including interferograms, wrapped phase maps, modulation maps, surface maps (OPD), and surface slope maps. All graphical displays can be transferred to other programs as bitmaps or vector metafiles for instant publication. Real-time interactive features (using the mouse) include translation, rotation, scaling, zooming, and cross-section displays. Right clicking on any graph brings up a popup menu that allows complete customization of the graph including annotations, axis scaling, color and contour level selection, the addition of background images, and much more. Customize your own report sheets (see back page), and publish them to any printer, web browser, or email address.

AUTOMATION AND QUALITY CONTROL

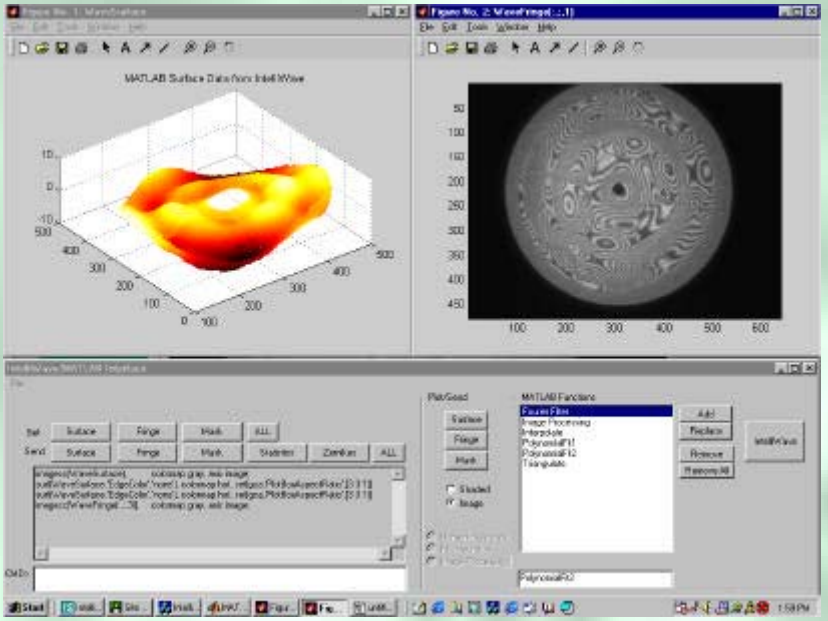


Automation Functions

- Data acquisition and display
- Interferogram processing
- Surface map (OPD) processing
- Statistics and aberrations
- Image transformations
- Real-time quality control
- File input/output
- Real-time communications, data transfer, data processing, and instrument control using other programs.
- User interaction during automation
- Repeat and While Loops
- Automatic file naming
- Functions can take parameters
- Point & click programmability—no programming experience required.

IntelliWave has a powerful automation and quality control system that allows repetitive and/or complex tasks to be automated. For example, averaging fifty (50) data sets at 10 different field points on an optic is a simple task using automation. Quality control can be performed on any statistical or aberrational value in real-time during an automation process. For example, 1) IntelliWave can acquire interferogram data continuously until the data reaches a minimum noise threshold, or 2) Continue acquiring and processing interferogram data until the resulting OPD Peak-to-Valley meets specifications. The user can interact with IntelliWave or other programs during an automation process. With IntelliWave's combined automation, quality control, and reporting features, assembly lines have a fast, concise, repeatable, and documented means of making sure production parts meet specifications.

ACTIVE-X INTERFACES AND PLUG-INS



The Figure above shows the MATLAB™ ActiveX interface.

- Send/Receive IntelliWave data to/from programs with a mouse
- Define and call any external function with a mouse click

ActiveX Interfaces

IntelliWave allows interferograms, surface data (OPD), masks, statistics, and aberrations to be transferred bi-directionally in real-time to/from external programs. Any native or user-written function from these external programs can be used to process IntelliWave data. IntelliWave has ActiveX Interfaces for the following:

- Math Works' MATLAB™
- Research Systems' IDL™
- Microsoft Excel™
- LabVIEW™ (see LabVIEW, page 3)

Plug-Ins

IntelliWave's plug-in architecture (similar to AutoCAD™) allows virtually any new feature to be seamlessly added by ESD, customers, or third party developers. Plug-Ins have complete access to IntelliWave data and functions. Plug-Ins are detected and loaded at runtime.

Example uses of Plug-Ins are customized *instrument control*, *data analysis routines*, *custom interfaces*, and *automation* of various tasks.

INTELLIWAVE LIBRARY

IntelliWave's internal data processing engine is available as a developer's library that can be called from virtually any programming environment. Most functions for processing interferograms, optical phase difference data (surface map), statistics, and aberrations can be performed with the library.

Currently, there are interfaces for the following programming languages (items marked with an asterisk will appear in a future release): Microsoft Visual C++, Research Systems' IDL™ , Math Works' MATLAB™.

TURNKEY SYSTEMS AND HARDWARE SUPPORT

Complete Turnkey systems are available including interferometers, computers, cameras, and phase-shifters. IntelliWave acquires data from any analog/digital camera (or scanner) at any resolution (such as 4096^2) and speed (such as 1000 frames/second). It controls phase-shifters of any type such as piezo transducers and crystal retarders. Supporting new hardware simply requires replacing hardware drivers like replacing a driver for a graphics card on a computer.

Interferometers

- Twyman-Green & Fizeau
- Holographic & Speckle
- Moiré & Projection
- High Speed Interferometry
- Simultaneous phase-shifting interferometers

Wavelengths

- X-ray, UV, and Visible
- Mid Infrared, Far Infrared

Cameras

- Any analog or digital camera
- Any resolution & bit depth
- Any frame rate

Frame Grabbers (Video Capture)

- Any analog or digital frame grabber
- USB and Fire Wire 1394

Scan Interferograms from Printed Matter

- Use virtually any TWAIN scanner

Phase-Shifters

- Piezo transducers (PZT)
- Liquid crystal variable retarders
- Any analog or digital device
- None required for static analysis

Customized Devices

Need customized hardware? We can write drivers to control virtually any video capture or phase-shifting device to meet your requirements.

INTELLIWAVE FOR OEM SUPPLIERS

IntelliWave is available to original equipment manufacturers (OEM) as an integrated part of their interferometric product line. Customized or simplified versions of the program can be provided to meet individual product or application requirements. Call Engineering Synthesis Design, Inc. for details.

INSTALLATION AND TRAINING COURSES

Installation

Installing IntelliWave on a computer is relatively straight forward. However, installation services are available upon request.

Onsite Training Courses

Engineering Synthesis Design, Inc. offers complete one, two, and three day IntelliWave courses with hands on training. These courses are recommended for those wishing to:

- Master IntelliWave quickly
- Master IntelliWave's power and flexibility in solving unique and difficult problems.
- Combine all of IntelliWave's features including acquisition, analysis, automation, quality control, Plug-Ins, and ActiveX External Program Interfaces to create powerful customized applications. Applications such as real-time mirror actuator control, measurements versus temperature, and automated assembly line quality control are all possible.

INTELLIWAVE IN THE INDUSTRY

IntelliWave is used in a variety of industries including small companies, large corporations such as Kodak and Dupont, and major research labs such as NASA and Lawrence Livermore Labs. See our website for a recent customer list.

High Resolution Aspheric Optic Applications: Aspheric optical manufacturing is extremely sensitive to vibration environments due to ultra high density fringes. IntelliWave's *Spatial Carrier Method* is allowing high-speed high-resolution measurement testing in these difficult conditions.

Extreme Temperature Applications: IntelliWave is currently being used with extreme cold vacuum chambers to monitor mirror deformation as a function of temperature.

Astronomy Applications: Some of the nations top astronomical mirror manufacturers including the University of Arizona's Optical Sciences Mirror Lab and the National Optical Astronomy Observatory are using IntelliWave to manufacture optics for next generation telescopes.

High Power Laser Applications: IntelliWave's hardware independence is a major boost in the research of our nation's next generation power plants by measuring the shape & reflective properties of high powered laser optics and coatings.

Semiconductor Applications: IntelliWave's powerful measurement and automation capabilities are ensuring micro lithography steppers for semiconductor manufacturing are optically aligned before being shipped to companies like Intel.

Holographic Speckle Applications: IntelliWave's holographic speckle measurement capabilities are providing valuable information on the stress and strain characteristics of state-of-the-art composite materials.

Cutting Edge Research and Development: Universities from all over the world are using IntelliWave for cutting edge research in interferometer design, mirror manufacturing, and optical materials design.

Dynamic Control of Optical Systems: IntelliWave's Plug-In architecture is allowing the development of *real-time monitoring and control systems* for adaptive optics of new ground based-telescopes.

Mom and Pop Applications: IntelliWave offers three price performance levels allowing the smallest companies to the largest corporations to incorporate IntelliWave in their research & development and manufacturing businesses. IntelliWave's simple interface is allowing small companies to quickly test and ship out their optical products.

FEATURE SUMMARY

IntelliWave comes in three versions to meet your individual requirements. Many features beyond those listed below are available. Only those features that differ between versions of IntelliWave are listed here.

Feature	LE-1	LE-2	PE
Static interferogram analysis (Spatial carrier method and fringe tracing)	x	x	x
Phase shifted interferogram analysis		x	x
Aberration analysis (choose from a variety of polynomial sets)	x	x	x
Diffraction analysis (PSF, MTF, PSF Encircled Energy)		x	x
Shearing Interferometry			x
Programmable automation			x
Automated quality control	x	x	x
Automated Microsoft Excel™ data transfer			x
Interferogram data sizes up to 800x600x8 bit	x	x	x
Interferogram data sizes up to 1024x1024x16 bit, 4096x4096 custom			x
RS170/CCIR analog cameras	x	x	x
Non-standard analog and digital cameras			x
Interfaces with Research Systems' IDL, Math Works' MATLAB, & MS Excel			x
Plug-Ins (add your own customized features)			x

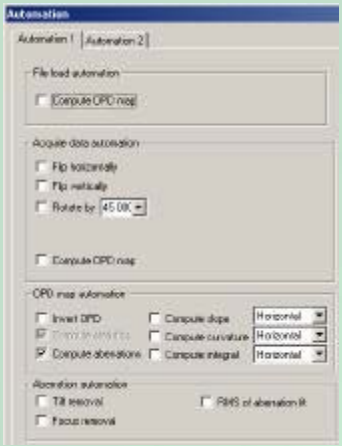
IntelliWave Analysis Only Versions

Analysis only versions offer full analysis capabilities without the data acquisition capability (free and/or at a reduced cost).

Download a copy of IntelliWave from the Web: www.engsynthesis.com

IntelliWave™ User Interface

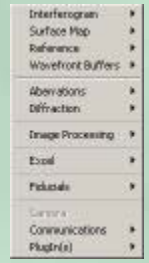
Tasks To execute after a previous task.



File Menu

View Menu

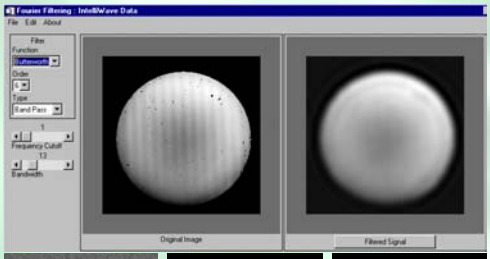
Tools Menu



Options Menu

Configuration Menu

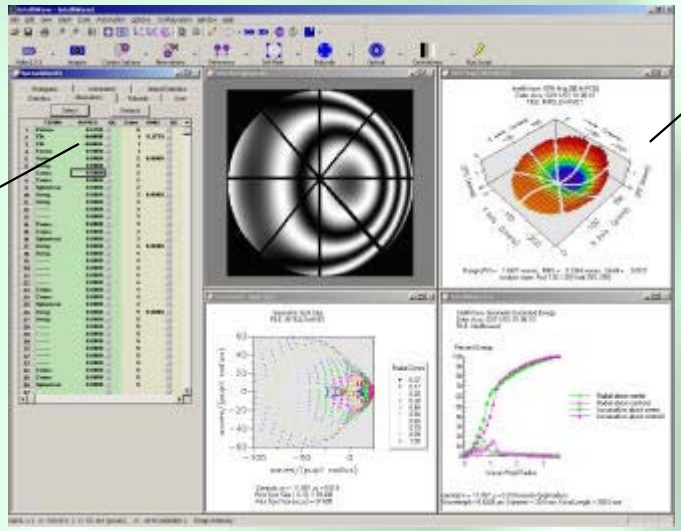
Mask Menu



Power Spectrum Before | Band Pass Filter | Power Spectrum After

Fourier filtering is an ActiveX example of interfacing with Research System's IDL. The ghost fringes have been removed with a band pass filter.

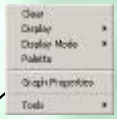
Right click a spreadsheet to pop up its menu.



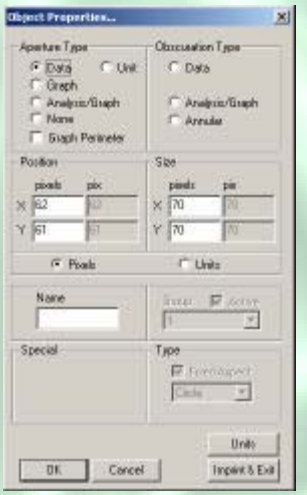
Subtracted terms are struck out.

Red terms are out of range.

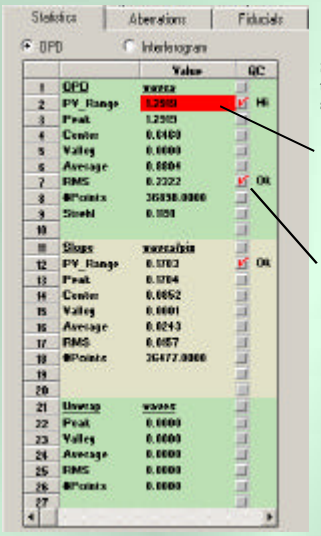
Check terms for quality control.



Right click an image to pop up its menu.



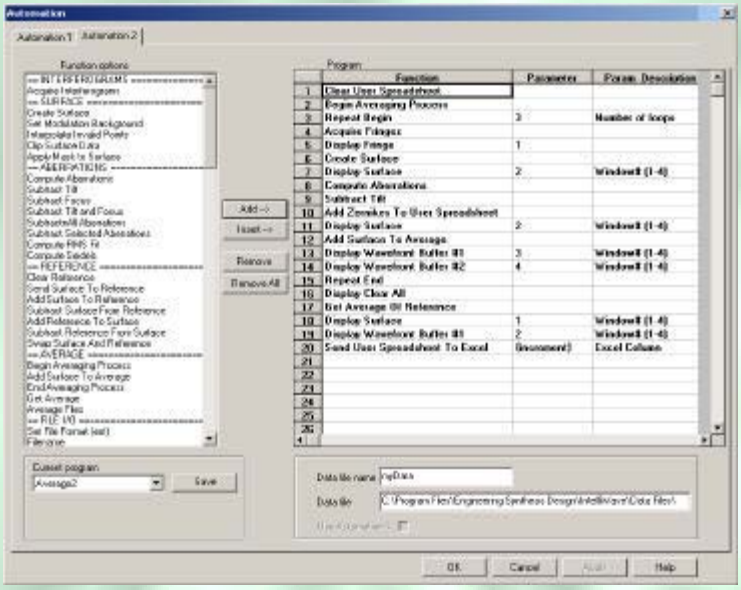
Right click a mask object to edit properties. Use the mouse to move/resize a mask object.



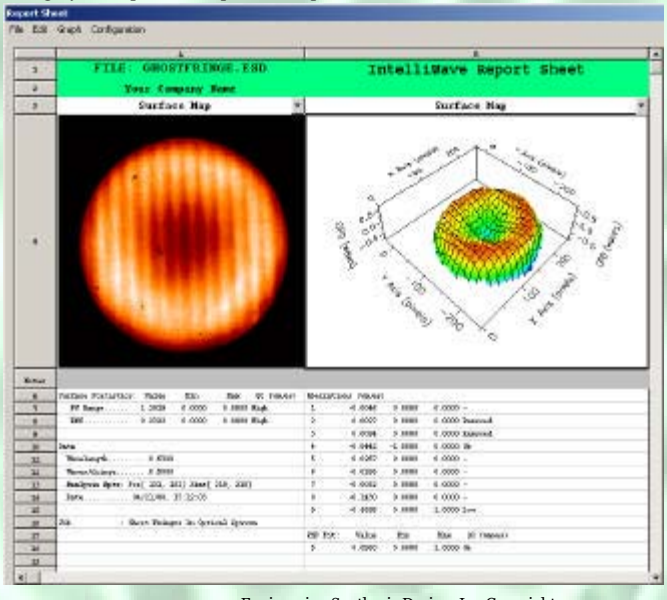
Real-time statistics for all data types.
Scroll the spreadsheet to enter QC ranges.

Calculate, subtract, and generate Zernikes. Scroll the spreadsheet to enter QC ranges.

Automate repetitive tasks. The script below averages data & sends the result to Excel.



Design your reports then publish to printers, HTML, XML, PDF, and e-mail.



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