MountainsMap® Universal

Modular surface imaging, analysis & metrology software

for confocal microscopes - optical interferometric microscopes - scanning probe microscopes – contact and non-contact profilometers – form & vision systems – more + extensions for scanning electron microscopes - hyperspectral microscopes

- Incremental customizable software for microscopes and profilers
- Cutting edge surface imaging and overlays to speed up location of surface features
- Correction of measurement defects and anomalies – intelligent image enhancement
- State of the art analysis of surface geometry and texture at any scale
- Full set of optional modules for advanced applications
- Smart metrology report creation with powerful automation features
- Easy integration into any research or production environment
See everything that you measure

Real time 3D imaging of surface topography

- Zoom in, rotate and amplify heights in real time.
- Apply image enhancement tools.
- Choose the best lighting conditions & renderings.
- Define your own color palette.
- Define a flight plan, fly over features of interest and save your flight as a video for presentations
- Extract 2D profiles from a 3D surface for visualization and analysis.

Topography of a US coin measured using a scanning profiler equipped with a chromatic single point sensor: MountainsMap Universal® easily manages not only non-rectangular data, like this coin, but also more complex or random patterns containing measured/non-measured areas. This is essential when working with optical profilers that generate data sets with missing points or outliers.

Data preparation and correction prior to analysis

Normalize spatial position

- Level with respect to the whole surface or selected zone(s).
- Flip and rotate the surface.
- Extract regions of interest for independent analysis.

Eliminate data acquisition defects

- Correct/remove bad lines (scanning profilers).
- Remove outliers (optical profilers).
- Minimize tip shape effects using deconvolution (contact profilers, AFM’s)
- Fill in missing data points (optical sensors)
- Resample & smooth to enhance the visual resolution
- Remove local defects, automatically or manually

Above left: outliers are detected and converted into missing data points.
Right: surface after the application of an intelligent operator for filling the missing points.
Overlays speed up location of surface features and properties

Use natural color or intensity for 3D rendering

- Manipulate multi-channel image layers (topography, color image, intensity) generated by a 3D optical profiler simultaneously.
- Overlay color and intensity images on surface topography - see your 3D surfaces in the true colors captured by your microscope!
- Overlay a photo on the 3D surface topography measured by your profiler.
- Define transparency percentage level and mix layers to achieve the best rendering.

False color 3D topography makes it easy to monitor this thick ink deposit - but a true color overlay on the surface topography provides a more natural visualization.

Fine tuning the transparency of an image overlay on 3D surface topography between natural color (0% transparency) and pseudo color (100%)

Map other layers onto 3D topography to locate physical properties

- Manipulate multi-channel images (topography, deflection, phase, current, etc.) generated by scanning probe microscopes simultaneously.
- Overlay any non-topography image (phase, current, etc.) from an atomic force or other scanning probe microscope on 3D surface topography - locate physical properties.

Left: image of current intensity signal mapped on 3D topography shows conductivity of fibers in a doped xerogel (current-sensing AFM image courtesy of ICMAB-CSIC).
Assemble surface data
Increase the field of view or vertical range of your instrument virtually

Sometimes the field of view of an optical microscope or an SPM is too limited to measure the whole surface under study. In other cases, it is the vertical range of the gauge that is the limitation, for example with single-point scanning contact or non-contact profilometers. In all instances, MountainsMap® Universal can virtually push the instrument limits, by sewing successive data acquisitions together using the Stitching and Patching tools.

Stitching
✓ Automatically stitch together multiple measurements that overlap on the horizontal plane.

Patching
✓ Interactively patch together two or more surface measurements at different heights.
Analyze surface geometry
From distance, area, step height and volume calculation to full dimensional analysis

Geometric analysis

MountainsMap® Universal assures the fast and accurate analysis of surface geometry with tools for measuring distances, angles, areas of peaks and valleys, volumes of bumps and holes, step heights on surfaces and profiles, and coplanarity.

Extract a region of interest and analyze it just like a complete surface

Area extraction
✓ Extract rectangular or non-rectangular zones
✓ Remove a slice from a surface by thresholding.
✓ Automatically partition a surface into motifs (texture cells), then use the Partition and Level operator to extract a sub-surface and level it.

Calculate parameters for a sub-surface only
Once a sub-surface or region of interest has been extracted it can be analyzed in exactly the same way as a full surface - parameters are calculated on the sub-surface only: a very useful path for the study of roughness, flatness and coplanarity of planes on MEMS and micro-mechanical and electronic components.

MEMS: extraction of leveled sub-surface and parameters for sub-surface only.
Characterize surface texture in accordance with international standards

Advanced ISO 16610 filtering techniques and ISO 25178 3D parameters

From Gaussian to advanced ISO 16610 filtering techniques

The roughness and waviness components of surfaces are separated using the latest ISO 16610 advanced filtering techniques, including robust Gaussian and spline filters. Older filtering techniques are also supported.

From Ra to ISO 25178 3D parameters

MountainsMap® Universal includes a basic set of ISO parameters:
• new 3D parameters defined in ISO 25178 including height (Sa, Sq, Ssk, Sku, Sz, etc.) and functional (Smr, Smc, Sxp) parameters.
• ISO 12781 flatness parameters (FLTt, FLTp, FLTv, FLTq)
• ISO 4287 primary and roughness parameters (Ra, Rq, Rsk, Rmr, Rdc, Rdq, RPC, etc.).

More parameters are available with optional modules.

The right standards, wherever you are

In addition to ISO parameters MountainsMap® Universal calculates ASME B46.1 2D and 3D parameters (USA), displays GB/T (China), DIN (Germany), JIS (Japan), NF (France), BSI (UK), UNE (Spain) and UNI (Italy) equivalents of ISO parameters when they are available, and calculates the older EUR 15178 3D parameters.

Functional analysis

Functional studies include the Abbott-Firestone bearing ratio curve and depth distribution histogram, the subtraction of one surface from another (wear), and the calculation of the material/void volume ratio and thickness of up to three vertical slices of a surface.

ISO 25178 parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Sq</td>
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<td>Sp</td>
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<tr>
<td>Sv</td>
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<tr>
<td>Sz</td>
<td>331.5 μm</td>
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<tr>
<td>Sa</td>
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**Functional Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smr</td>
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<tr>
<td>Smc</td>
<td>38.14 μm</td>
</tr>
<tr>
<td>Sxp</td>
<td>70.50 μm</td>
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</table>

Bearing ratio curve and depth distribution histogram

Raw surface

Roughness surface

Waviness surface
Highly intuitive desktop publishing environment

Full metrological traceability, automation, fine tuning on the fly

Visual analysis reports
In MountainsMap® Universal you build a visual analysis report frame by frame, page by page, working in a comfortable desktop publishing environment. Frames contain 3D and other views of surface data, the results of applying filters, analytical studies, ISO and national parameters, measurement identity cards, comments and illustrations. You can navigate to any frame in a report by selecting it in the page viewer.

Smart user environment
The smart user environment - with logical top-down organization of all functions and contextual object-oriented ribbons - means that you can go from idea to action with minimum effort. A full screen mode provides maximum comfort when you are carrying out a specific analytical study. Furthermore you can work in your own language thanks to the fact that the user interface - including expanded graphical tooltips that provide a first level of help - is available in ten languages (EN, FR, DE, ES, IT, PL, BR, JP, CN, KR). In addition, a complete reference manual (EN, FR, DE, JP) with illustrations and examples can be accessed simply by pressing the F1 key.

Full metrological traceability
Every analysis step is recorded in a hierarchical analysis workflow to assure full metrological traceability. Analysis steps in the workflow can be fine tuned at any time. All dependent steps are recalculated automatically.

Powerful automation features
Once an analysis report has been completed it can be applied as a template to automate the analysis of multiple measurement data files. In addition common sequences of analysis steps can be saved in a library for insertion into future analysis reports to gain time.

Pass/fail with tolerancing
Pass/fail criteria with tolerances can be defined for any parameter. Green/red pass/fail traffic lights are displayed automatically and the parameter value and tolerance limits are shown graphically.

Data export
Frames and pages can be exported as bitmaps up to 1200 dpi for poster sessions. Finished reports can be exported in PDF and RTF formats for easy circulation. All numerical results, including pass/fail status, are accessible in the Results Manager panel and can be exported in Excel-compatible text files for interfacing with 3rd party software, including quality management software.

Page format
Pages in analysis reports have standard or user-defined portrait, landscape or onscreen formats. A master page can be set up with elements that will be repeated on all pages (company information, logo, page number, etc.).
MountainsMap® Universal optional modules
For advanced and specialized applications

+ **3D advanced surface texture module**

**Advanced 3D studies, parameters and filters**

- Calculate advanced 3D surface texture and form parameters - ISO 25178 functional volume (Vmp, Vmc, Vvc, Vvv), spatial (Sal, Str, Std) and hybrid (Sdq, Sdr) parameters - ISO 12178 flatness (FLTt, FLTp, FLTv, FLTq) parameters.
- Study functional volume parameters graphically - visualize friction, core and lubrication zones on tribological surfaces.
- Study surface isotropy, directionality and periodicity - view dominant surface directions on a compass rose and calculate parameters.
- Apply morphological filters to surfaces - erosion, dilation, opening, closing, and sequential filters.
- Analyze furrows - visualize furrows and calculate furrow parameters.
- Analyze fractal dimensions of surfaces using the enclosing boxes and morphological envelopes methods.
- Study circular profiles - with the abscissa in degree units.
- MATLAB™ compatibility - use MATLAB™ scripts to define custom filters for 3D surfaces - execute the scripts in MountainsMap®. (Note: MATLAB™ and MountainsMap® must be installed on the same PC.)

+ **Grains and particles analysis module**

**Study isolated surface features**

- Automatically detect and count grains, particles, islands, bumps, holes and motifs (texture cells) using multiple methods:
  - 2D grains and particles with respect to selected horizontal plane - separate grains from the background by binarization on a selected horizontal plane - sort grains into subsets with respect to any parameter.
  - 3D grains (islands) with respect to a selected height.
  - Motifs in accordance with a configurable ISO 25178 segmentation by watersheds algorithm and Wolf pruning.
- Calculate morphological parameters for individual grains, etc.
- Generate statistics for all grains, etc. and subsets.
- Calculate ISO 25178 features parameters (Spd, Spc, S5p, S5v, S10z, Sha, Shv, Sda, Sdv).
- Special features for microlens arrays - display spherical caps, calculate spherical parameters.
MountainsMap® Universal

4D series module
Visualize, filter & analyze series of surfaces & images

- Combine a series of 3D surfaces (z axis height) or converted images (z axis intensity) for 4D analysis with respect to time, temperature, magnetic field or another dimension.
- Visualize surface, profile and point evolution, even fly over a surface as it changes and record a movie for presentations.
- Generate statistics on surface texture parameter evolution.
- Filter out noise and highlight areas with different kinetic behavior using the Karhunen-Loève transform (principal component analysis).

Statistics module
Multiple static/dynamic surface data populations

- Prepare data automatically using templates - include all parameters for statistical analysis in a predefined analysis workflow - use it as a template for automatically generating analysis reports
- Generate statistical reports - select the static or dynamic population(s) to be analyzed and create a report with parameter tables, control charts, histograms, box plots and scatter plots as required - statistics for dynamic populations are updated automatically.
- Monitor key metrological and process parameters - control charts include standard deviation limits (1 to 3 sigma), control limits and vertical bars separating different populations, together with yield, capability (Cpk) and other parameters.

Contour analysis module
Straightforward component dimensioning

- Extract a vertical (x,z) or horizontal (x,y) contour (profile) from a surface.
- Define nominal form using straightforward interactive tools to associate geometric elements with contours.
- Calculate dimensions (including distances, radii, diameters and angles) using autodimensioning and interactive tools.

3D Fourier & wavelets analysis module
Analyze process-surface interactions

- Frequency analysis - interactive frequency spectrum, interactive power spectrum density, autocorrelation and intercorrelation.
- Calculate isotropy, directionality and periodicity - view dominant surface directions on a compass rose and calculate parameters.
- Denoise surfaces using the FFT plot editor.
- Discrete wavelet filtering (3D surfaces and 2D profiles) - visualize a surface or profile at multiple scale levels - select roughness and waviness scale levels.
- Continuous wavelet decomposition - study scale levels and spatial locations where phenomena occur.

Contour analysis module

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Yield</td>
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<td>Cpk</td>
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<tr>
<td>Cpk</td>
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</tbody>
</table>

Control chart for a parameter

FFI Plot editor

Surface evolution

Control Chart of “Vmc”
Advanced contour analysis module

Comprehensive form deviation analysis

- Includes all functions of Contour Module, plus:
  - Compare measured contours with CAD data (DXF) or user-defined nominal form.
  - Specify tolerances including large positional tolerances if required.
  - Visualize form deviations easily with magnified graphics.
  - Automatically generate a table of results including pass/fail status.
  - Gothic arch analysis of bearings.

2D advanced surface texture module

Advanced 2D analytical studies and filters

- Apply advanced 2D filtering techniques - remove form and apply roughness/waviness filters from Gaussian to ISO 16610 - apply morphological filters - denoise profiles using the FFT plot editor - subtract profiles.
- Correct measurement anomalies - use data correction tools (thresholding, retouching, resampling) to eliminate anomalies and improve resolution prior to analysis.
- 2D Fourier analysis - frequency spectrum - power spectrum density - autocorrelation - intercorrelation.
- Analyze fractal dimensions of profiles using the enclosing boxes and morphological envelopes methods.
- Overcome instrument limits virtually - join overlapping profiles.
- Generate statistics on series of profiles - the profiles in the series can be extracted from a series of surfaces or from the same surface.
- MATLAB™ compatibility - use MATLAB™ scripts to define custom filters for 2D profiles - execute the scripts in MountainsMap® Universal. (Note: MATLAB™ and MountainsMap® Universal must be installed on the same PC.)

2D Automotive module

2D functional parameters and studies

- Study Rk parameters associated with wear and lubrication graphically - visualize friction, core and lubrication zones on tribological profiles.

Lead (twist) analysis

2nd generation lead analysis (automotive industry)

- Automatically generate a lead analysis report (for manufacturing efficient radial seals that reduce oil consumption) in accordance with the Mercedes-Benz 2009 engineering standard, including lead parameters and visualization of dewobbled measured surface structure and lead surface topography.
**SEM extension module**

SEM image enhancement & metrology

- **Color and enhance SEM images** - convert SEM images into colored 3D intensity maps - improve image quality with image enhancement tools and denoising filters.
- **Analyze geometry** - distance and angle measurement.
- **Reconstruct 3D surface topography** from stereo image pairs, anaglyphs and quads.
- **Generate anaglyphs** from 3D topography for viewing with stereoscopic glasses.
- **Extract vertical (x,z cross-sectional) and horizontal (x,y) profiles** from reconstructed 3D surfaces.
- **Analyze contour dimensions** of extracted profiles.
- **Colocalize SEM images with other surface data** - for example colocalize SEM images with surface topography obtained by other instruments and then overlay the images on 3D surface topography.

**AFM force curves module**

Visualize and analyze force curves

- **Automated preprocessing** denoises force curves obtained by atomic force microscopes, normalizes baselines and calibrates cantilever sensitivity.
- **Visualize force curves and series of force curves** - display attract and/or retract curves, select axis units.
- **Detect adhesion events and calculate parameters automatically**, with optional fine tuning.
- **Generate wormlike chain (WLC) models** of protein unfolding.
- **Generate statistics** for series of force curves.

**Spectrometry module**

Visualize and analyze hyperspectral data

- **Visualize spectra, series of spectra and hyperspectral cubes** obtained by Raman and FT-IR spectrometers and other instruments.
- **Create compositional density maps** with respect to reference spectra.
- **Visualize 3D intensity maps** of "flattened" hypercubes in real time.
- **Colocalize** hyperspectral data with surface data from other instruments including overlays on 3D intensity maps and surface topography.

**Colocalization module**

Combine data from different instrument types for correlative studies

- **Colocalize surface data obtained by different instruments** - for example surface topography data obtained by 3D instruments with limited field of view with images obtained by microscopes with wider field of view (Note: instrument compatibility depends on the file formats supported by the installed MountainsMap software.)
- **Overlay images on 3D topography** - set overlay transparency level.
Selected standard and optional features

MountainsMap® Universal

Compatibility
Confocal microscopes - interferometric microscopes - digital holographic microscopes - focus variation microscopes - structured light systems - scanning probe microscopes (AFM, MFM, CSADF, STM, SNOM, etc.) - contact (stylus) and non-contact (chromatic confocal, auto-focusing, laser triangulation, single point WLI) profilometers - form measuring systems (vision, fringe projection, CMM with scanning mode) - portable roughness meters - standard RGB image file formats - plus (with optional extensions): scanning electron microscopes (including 3D reconstruction) and hyperspectral instruments (Raman, FT-IR, EELS, EDX, ...)

Smart desktop publishing user environment
Frame-based desktop publishing environment - logical top-down organization of all functions - contextual-object oriented ribbons - multi-language user interface (EN, FR, DE, ES, IT, PL, JP, CN, KR, BR) - integrated reference manual (EN, FR, DE, JP) - automatic analysis of series of measurements using templates - library of common analysis sequences - single-click in-document navigation via page viewer - analysis workflow for full metrological traceability - tolerances for any parameter with pass/fail traffic lights - frame and page bitmap export (up to 1200 dpi) - Excel-compatible ASCII export of numeric results - PDF and RTF export of multi-page documents - standard and user-defined portrait, landscape and onscreen page formats - master page with common elements (logo, etc.) - auto-save

Surface visualization
Real time imaging of 3D surface topography (z axis in height units) - visualization and manipulation of multi-channel 3D optical profiler and SPM data files with overlays of non-topographical layers on 3D surface topography - selectable rendering, lighting and height amplification - color coded Z-axis palettes with data point distribution histogram - surface flyovers with video export - contour diagrams - photo-simulations - 2D profile extraction - conversion of RGB images into 3D images with z axis in intensity units

Data normalization & correction
Leveling - XY or Z inversion - rotation - zone extraction - thresholding - filling in missing points - retouching - resampling - tip deconvolution - scan line correction - scan line removal - stitching of overlapping measurements on the horizontal plane into a single surface - patching of measurements at different heights into a single surface

Filters
Form removal (surfaces) - roughness/waviness filters (Gaussian to ISO 16610) - spatial filters (including smoothing) - morphological filters (surfaces) - automatic outlier removal and filling

Analysis
Distance, angle, area, volume, step heights measurement - bearing ratio curve and depth histogram - material/void volume and thickness of vertical slices - surface subtraction - sub-surface extraction and analysis

Parameters

MountainsMap® Universal Optional Modules

3D Advanced Surface Texture

Grains & Particles Analysis
Automatic detection of grains, particles, islands, bumps, holes and motifs (texture cells) using multiple morphological parameters - statistics - ISO 25178 features parameters - spherical parameters (microlens arrays)

3D Fourier & Wavelets Analysis
Frequency spectrum - power spectrum density - surface autocorrelation and intercorrelation - FFT plot editor - discrete wavelet filtering (surfaces and profiles) - continuous wavelet decomposition (profiles)

4D Series
4D visualization, filtering and analysis of series of surfaces and images (z axis: height or intensity) - surface, profile and point evolution - surface flyover movie export - statistics on surface texture parameters - Karhunen-Loève transform (principal component analysis) for noise filtering and highlighting areas with different kinetic behavior

Statistics
Automated data preparation using templates - statistical reports on multiple static and/or dynamic surface data populations - control charts for monitoring metrological and process parameters

Contour Analysis
Extraction of vertical (x,z) and horizontal (x,y) contours (profiles) from surfaces - nominal form definition by association of geometric elements with contour - geometric dimensioning

Advanced Contour Analysis
Comparison of measured contours with DXF CAD data or user-defined nominal form - tolerance specification - magnified form deviation graphics - table of pass/fail results - Gothic arch bearings analysis

Colocalization
Colocalization of surface data (images and/or topography) obtained by different instrument types or detectors - overlay images on 3D surface topography for correlative studies

2D Advanced Surface Texture
Form removal - ISO 16610 2D roughness/waviness and morphological filters - 2D Fourier analysis including frequency spectrum and power spectrum density - FFT plot editor - profile data correction tools - profile joining - profile subtraction - 2D fractal analysis - statistical analysis of series of profiles - MATLAB™ compatibility (custom filters)

2D Automotive

Lead Analysis
Automatic 2D generation lead (twist) analysis report (for manufacturing efficient radial seals that reduce oil consumption) according to 2009 Mercedes-Benz engineering standard

AFM Force Curves
Automated pre-processing (baseline normalization, calibration) - visualization of force curves and series of curves - automatic adhesion event detection - interactive event definition - force curve parameters - WLC (wormlike chain) models of protein unfolding - statistics on series of force curves

SEM Extension
Extension for SEM’s - SEM image coloring and enhancement - basic geometric analysis - contour analysis - 3D reconstruction from stereo image pairs and image quads - colocalization

Spectrometry
Extension for hyperspectral instruments (including Raman and FT-IR spectrometers, EELS, EDX, ...) - visualization of spectra and hyperspectral cubes - compositional density maps - 3D intensity maps - colocalization

MountainsMap® Universal Upgrade to MountainsMap® Premium

Upgrade to Premium
Upgrade to MountainsMap® Premium - top of the line package containing all MountainsMap® Universal modules except for SEM Extension, Advanced Contour Analysis, AFM Force Curves, Spectrometry and Lead Analysis
## Requirements

### PC requirements

| Minimum requirements | Operating system | Windows 8 (64-bit or 32-bit) or  
|                      |                  | Windows 7 (64-bit or 32-bit) or  
|                      |                  | Windows Vista (64-bit or 32-bit)  
| RAM                  | 4 GB             |
| Graphics board       | Hardware accelerated OpenGL or Direct3D |
| Resolution           | 1280 x 768 in thousands of colors |
| HDD free space       | 800 MB |
| Other                | 1 free USB port |

### Recommended

| Operating system | Windows 8 (64-bit) or  
| Processor        | Quadcore |
| Resolution       | 1600 x 1024 in thousands of colors |