NEWSLETTER

SURFACE

Spring 2016

Surface imaging, analysis & metrology news from Digital Surf

In this issue

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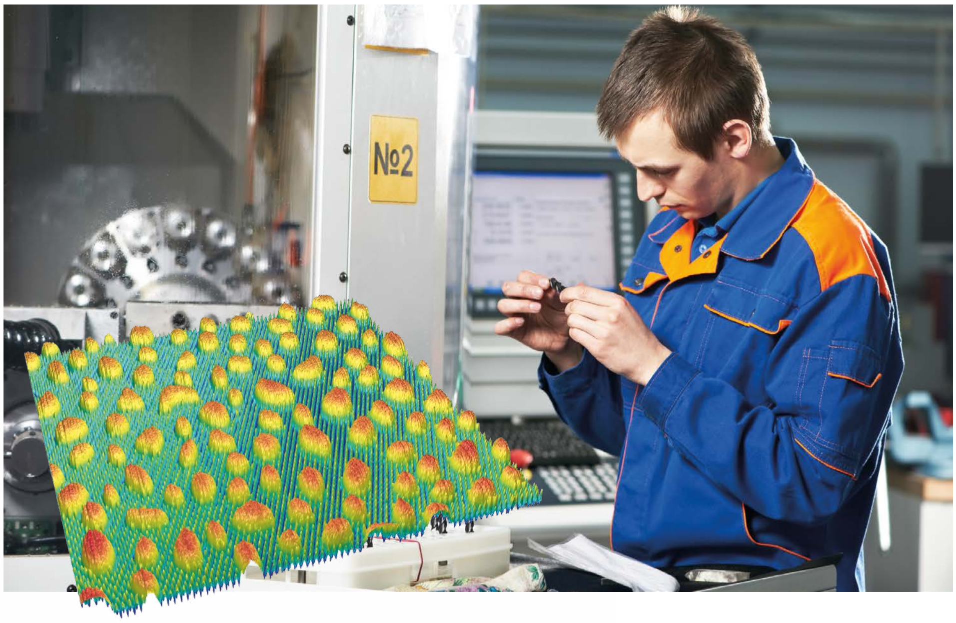
Grains & particles analysis

For accurate quality control

Quality control of materials such as metals and plastics using grain analysis allows engineers and researchers to verify manufacturing processes and detect anomalies.



In this issue, we discover a wide range of tools available in Mountains® for performing this type of analysis, vital to many sectors of science and industry.

Read more overleaf

Prehistoric human behavior under the microscope

p. 6

How reliable is my data analysis software?

p. 8

PLUS

Visitors to **Control 2016 International trade fair for quality assurance** in Stuttgart, Germany (April 26 - 29) are invited to discover new Mountains® 7.3 features at Digital Surf's booth 3518.

5 TIPS FOR ANALYZING GRAINS & PARTICLES

Analyzing micro and nanosurface structure?

Grains & particles analysis is useful in a variety of fields of industry and science, from quality control of structured materials such as metal alloys to evaluation of nanostructural detail. In this issue, we take a look at just some of the tools available in Mountains® software for visualizing and analyzing this kind of surface data.

On what kind of data can I use grains & particles analysis tools?

The tools presented here are ideal for use on surface data collected by profilers & microscopes including:

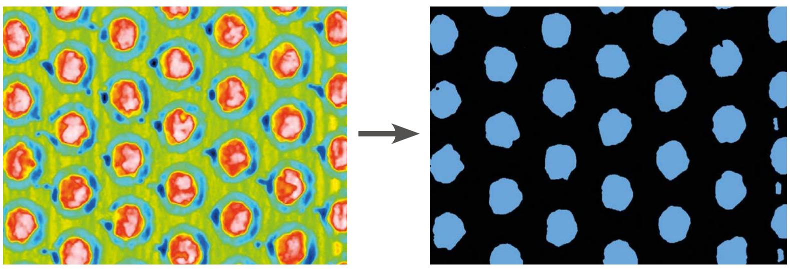
1. Horizontal planes with bumps or holes
2. Irregular surfaces with "hills" and "dales"
3. Multi-plane surfaces with sharp rises or falls
4. Scanning Electron Microscopy (SEM) images in which object contours are clearly defined

1. Detect grains using binary thresholding

Before you begin analysis, you will need to separate your surface data into grains (particles, pores or other structures). This is known as binarization. In Mountains® there are two methods for doing this.

The "Binary threshold" operator allows you to define a threshold level for grain detection.

The result is a binary image which can be displayed in monochrome or multicolor.



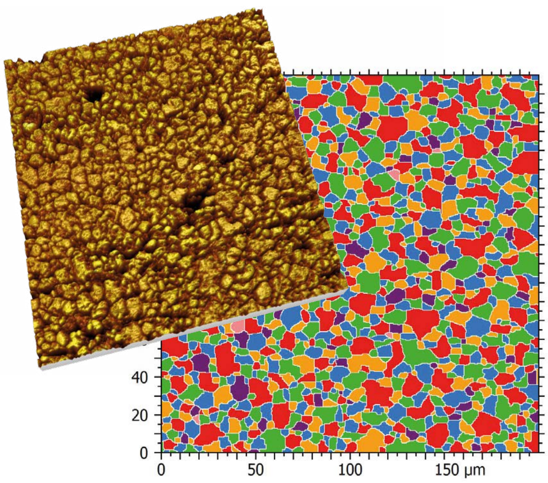
Binary thresholding of a textured metal surface

2. Detect grains using binary segmentation

Another technique for detecting grains is binary segmentation. This is ideal for partitioning surfaces featuring hills, dales or other shapes.

You may fine-tune partitioning by defining minimum zone height and area settings.

Again, the result is a binary image.



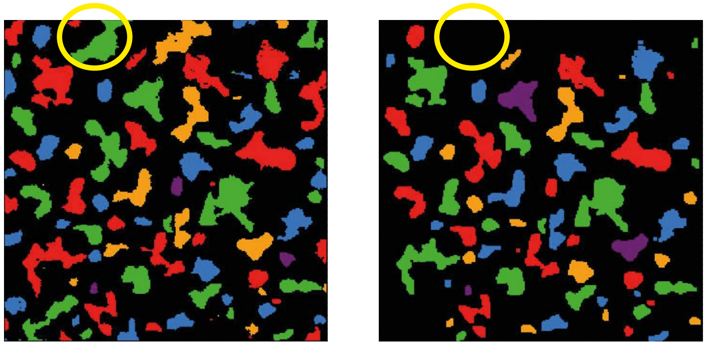
Binary segmentation of a steel surface

3. Correct your data

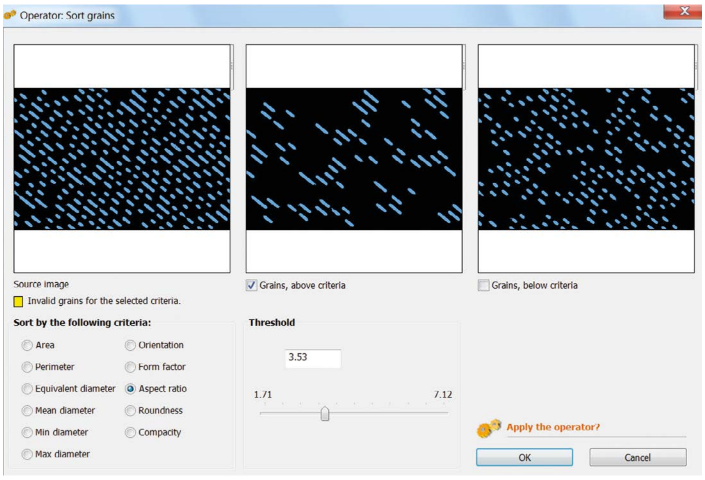
After grain or particle detection, the next step is to fine-tune your data by separating, merging or deleting specific grains.

The "Morphological correction" and "Separate grains" tools in the Operators tab are particularly useful for doing this.

You can:
- dilate grains to merge them or erode grains to separate them
- remove grains touching the edges
- click on grains to select & delete them



Removing edge grains using the Morphological correction operator



Grains on the left are sorted into two groups based on user-defined aspect ratio

4. Sort grains

Sorting grains is another way to eliminate or include grains in your data.

You can select criteria such as area, perimeter, diameter etc. and define a threshold.

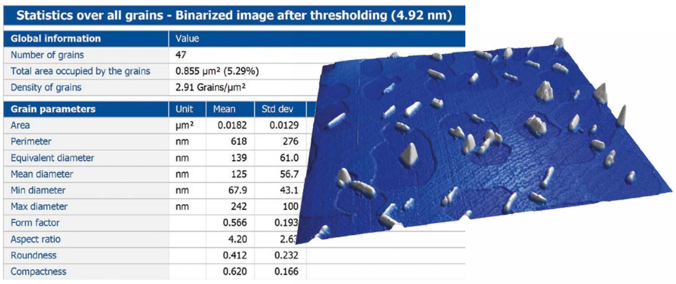
Two windows show the result in real-time of grains above and below the defined threshold.

5. Generate statistics

Mountains® can calculate a wide range of statistics for grain & particle populations.

You can choose to display parameters for all grains such as:
- number of grains
- density
- average grain area
- average grain perimeter etc.

You can also analyze individual grains by simply selecting them with the cursor. Calculate area, diameter, form factor and many more parameters.

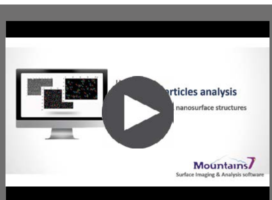


Statistics over all grains - Binarized image after thresholding (4.92 nm)

Global information	Value
Number of grains	47
Total area occupied by the grains	0.855 µm² (5.29%)
Density of grains	2.91 Grains/µm²

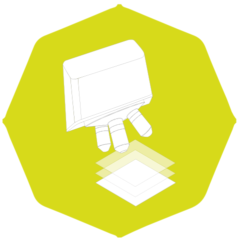
Grain parameters	Unit	Mean	Std dev
Area	µm²	0.0182	0.0129
Perimeter	nm	618	276
Equivalent diameter	nm	139	61.0
Mean diameter	nm	125	56.7
Min diameter	nm	67.9	43.1
Max diameter	nm	242	100
Form factor		0.566	0.193
Aspect ratio		4.20	2.6
Roundness		0.412	0.232
Compactness		0.620	0.166

Statistics on grains in a nanostructure assembly



Online resources
at www.digitalsurf.com
- Watch the Mountains® video tutorial
- Read the Grains & Particles data sheet

WHAT IF MY MEASUREMENT DATA CONTAINS ERRORS?

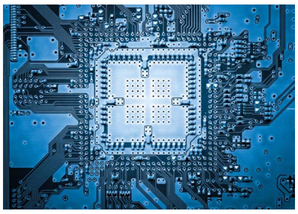


Removing outliers and non-measured points from your optical profiler data

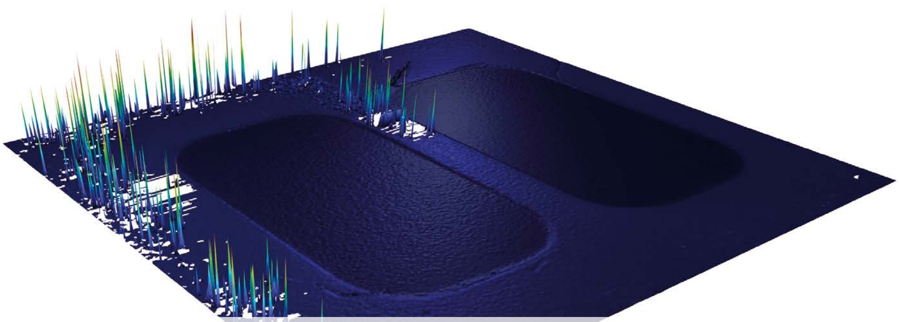
Have you ever noticed that the data obtained by your profiler contains areas in which the points measured clearly do not reflect reality?

The existence of these incorrect values often indicates a measurement error and in particular the poor quality of the signal detected by the sensor.

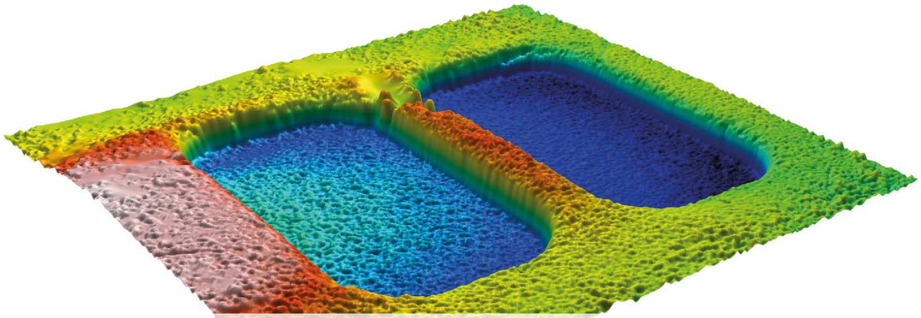
In Mountains®, we call these points "outliers", and thankfully help is at hand to remove, and even replace, them.



Example:
Contact pads on a circuit board



1. Mountains® 3D view of the measurement
Outliers appear as spikes on the surface



2. The same measurement after application of the Remove outliers operator

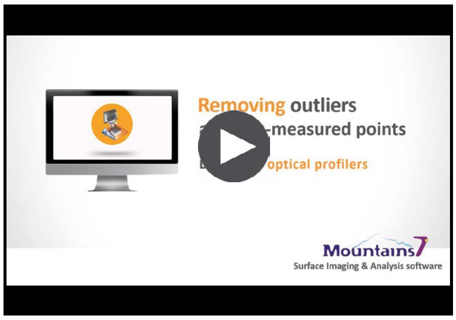
The spikes have been smoothed out using interpolation and the surface is ready for metrological analysis

3 options for removing outliers in Mountains®

1 Isolated outliers
Sometimes it is useful to be able to eliminate outliers spread over the surface.

2 Outliers around edges
Profilers often incorrectly detect heights at the edge of a measurements thus producing outliers. Use this option to correct.

3 Maximum slope
Based on your instrument's specifications, you can define a limit above which Mountains® should consider a point as an outlier.



Watch the Mountains® video tutorial at www.digitalsurf.com

Once you have defined how you wish to remove outliers, you may replace them with **non-measured points**, which can then be filled in by interpolation.

A NEW WINDOW ON LOCAL SURFACE TEXTURE

Extending segmentation possibilities in Mountains®

Segmentation is a powerful tool for isolating individual features on a surface in order to characterize them.

The new ISO 25178-2 introduced a watershed segmentation algorithm together with a discrimination tool (Wolf pruning) making it possible to retain only significant features and eliminate smaller ones. Topography information is used to determine where to put the limits around motifs, the same way geographers define catchment basins. But the human eye is also capable of segmenting an image using other types of information such as color, brightness, roughness, etc. and this kind partitioning is of interest for some applications.

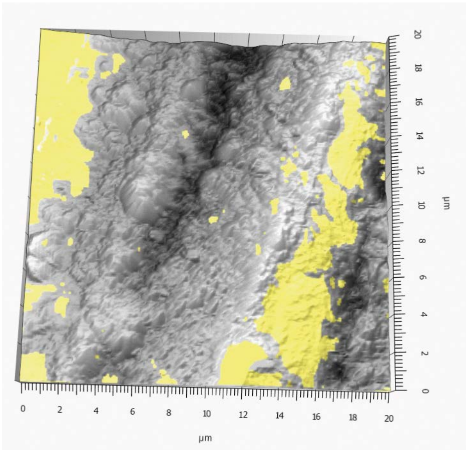
In MountainsMap®, it is possible to calculate local surface texture for a given window size using the "Map Local Properties" Operator. This approach allows users to create color maps of parameter values that can be overlaid on 3D topographic views or thresholded.

However, Nicola Senin, visiting professor at University of Nottingham within the Manufacturing Metrology Team and Prof. Richard Leach, team leader and longtime partner of Digital Surf, are now pushing the concept even further as explained in "Three-dimensional surface topography segmentation through clustering" published in *Wear* in 2007 and in the 2013 article "Characterisation of individual areal features" in the book "Characterisation of areal surface texture" edited by Richard Leach for Springer.

They propose a new technique, in which several parameters are simultaneously calculated for each point of the surface and a hypercube of parameter values is generated. Statistical methods are then applied to the hypercube to create clusters of points that have similar properties in the X-Y plane. Finally, the surface is segmented based on these clusters.

This project opens doors for new and improved features in MountainsMap®. Mathematical methods such as k-means, PCA (Principal Component Analysis) and other advanced tools have already been developed in recent years by Digital Surf for spectroscopic applications. They will now be adapted for surface topography segmentation. So stay tuned!

Clustering of local properties
Zr02 surface coated with diamond-like carbon by means of PVD process, measured with an atomic force microcope (AFM)



The University of Nottingham Manufacturing Metrology Team

The Manufacturing Metrology Team carries out research on next-generation metrology tools for advanced manufacturing methods including:

- precision manufacturing
- additive manufacturing
- high dynamic range manufacturing

Research areas include:

- the concept of "information-rich" metrology
- dimensional metrology
- internal geometry measurement and characterization
- mathematical techniques for characterization of advanced surfaces
- calibration and verification of instruments in industry
- precision instrument design

USING SURFACE TEXTURE TO UNDERSTAND THE PAST

Prehistoric human behavior under the microscope

The analysis of microwear on archaeological stone tools to identify tool function is integral to our understanding of past human behaviors.

Traditionally, archaeologists have used a combination of stereomicroscopy and reflected-light microscopy to identify wear traces on stone tools. However, blind tests of experimentally used stone tools have shown that these optical methods often result in the misidentification of tool use.

Thus, archaeologists are beginning to experiment with the application of surface metrology methods, such as confocal microscopy, for the quantification of wear traces.

Our current project is using confocal microscopy to understand how hunter-gatherers at large aggregation sites used stone tools approximately 20,000 years ago.

During this period, most people lived in small, mobile bands. However, they periodically came together in large groups at aggregation sites. We are exploring the range of activities at these sites and how domestic space was organized in large groups.

We suggest that the social activities at large hunter-gatherer sites set the stage for later sedentism during the origins of agriculture.

> “Archaeologists are beginning to experiment with the application of surface metrology methods

The Kharaneh IV site

To understand these social processes we are analyzing a collection of stone tools from several hut structures at the archaeological site of Kharaneh IV, Jordan (see photo above). Kharaneh IV is the largest aggregation site from the period before agriculture and contains several structures dating to approximately 19,000 years ago.

1. Prior to microwear analysis, the tools are cleaned using chemical cleaning methods to remove traces of sediment and grease.

2. Using a white-light confocal microscope (Sensofar S-Neox) housed in the Surface Metrology & Tribology Lab at the University of Tulsa, Oklahoma, each tool is evaluated to identify microwear traces.

3. Scans of worn areas are taken and the resulting data is processed in MountainsMap®. The worn areas are isolated to remove any unworn surface from the measurements. Next, the scans are filtered to remove form and waviness to measure surface texture. Surface parameters from ISO 25178 are applied to characterize the texture of the worn areas on each tool.

Sample preparation & analysis

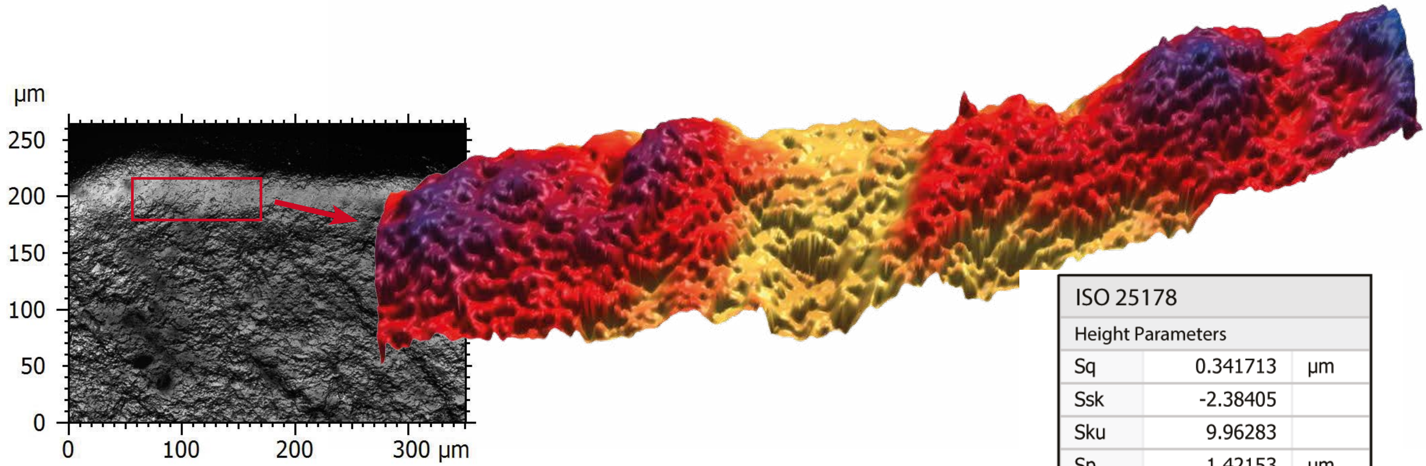
Previous experimental work has shown that Sa (Arithmetical mean height) and Sq (Root-mean-square height) parameters yield significant differences in the texture of polish for stone tools used to work different materials (such as bone, wood, meat and antler).

Some preliminary results

Although the research is ongoing, our current results show that people at Kharaneh IV stored tools used to scrape hide, possibly to use as clothing, in their houses but did not keep hunting weapons in their domestic space.

Using MountainsMap® for the quantification of wear traces on stone tools allows us to identify past human activities. The results from this research contribute to our knowledge of the activities performed at aggregation sites prior to sedentism and to our understanding of how hunter-gatherers interacted and negotiated social relationships in large complex groups prior to the origins of agriculture.

Hide working stone tool analyzed with the Sensofar S-Neox



ISO 25178		
Height Parameters		
Sq	0.341713	µm
Ssk	-2.38405	
Sku	9.96283	
Sp	1.42153	µm
Sv	2.58631	µm
Sz	4.00784	µm
Sa	0.225526	µm

Stone tool used to work hide analyzed with MountainsMap®. The worn area of the tool is isolated, visualized in 3D mode and surface parameters from ISO 25178 applied to quantify the worn surface texture.

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Projects:

- Kharaneh IV Excavation Project. Co-directed with Dr. Lisa Maher (University of California, Berkeley)
- Fragmented Heritage Project (University of Bradford)

HOW RELIABLE IS MY DATA ANALYSIS SOFTWARE?

3 questions to our expert

Surface measurement instruments can be calibrated using physical reference specimens. But how does one go about verifying the accuracy of surface analysis software?

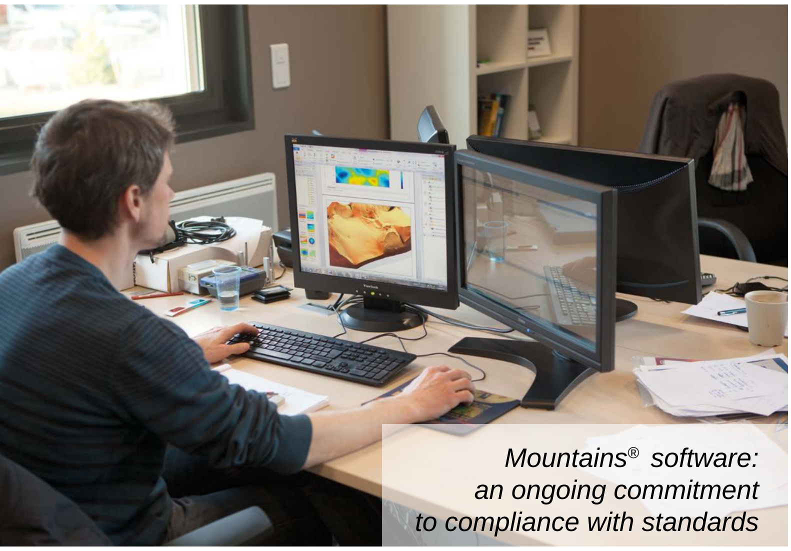
François Blateyron, Digital Surf's ISO surface metrology expert, has the answers.

1 I know how to calibrate my instrument, but how can I verify my analysis software?

Profilometers can be verified and adjusted by measuring physical representations of known surface texture for which profile parameters have been certified. Measurement is performed by accredited laboratories. Standards such as ISO 5436-1 and ISO 12179 provide guidance for this task.

You may verify analysis software packages using "soft-gauges" which are known profile or surface data files, either mathematically generated or measured by an instrument. The ISO 5436-2 standard defines a file format (.SMD) that can be used by National Metrology Institutes (NMIs) to provide reference profiles together with certified parameter values. Other standard formats are sometimes used, such as .SDF or .X3P. MountainsMap® users can load such files, calculate parameters and compare them with reference values stored in the file.

Another way is to compare values calculated by your software on a reference profile with values given by reference software on the same profile (see question 3).



Mountains® software: an ongoing commitment to compliance with standards

2 When I calculate profile parameters with MountainsMap® and with my instrument software, I get different results. Which are correct?

Comparing two surface analysis software packages or one commercial package with reference software from a NMI is not as straightforward as it seems.

Each software package uses its own set of default preferences which makes it difficult to compare things in the same context, i.e. using the same filtration conditions.

In particular, users should make sure that the following points are configured the same way in both packages:

- **λs filter**
- **Leveling or form removal** (association method)
- **Roughness or waviness λc filter**
- **Compatibility with non-measured points.** Are they excluded, interpolated or not managed at all?
- **Number of cut-offs removed in the running-in and running-out.** ½ or 1 cut-off? Or are end-effects managed according to ISO 16610-28?
- **Number of sampling lengths used to average parameters.** Or are the parameters calculated on the evaluation length?
- **Reference according to which parameters are calculated.** ISO 4287:1996, ISO 4287:1984, ISO 4287 Amendment 1, VDA 2006 or B46.1? This is particularly important for certain parameters such as Rz, RPc, Rc or RSm.

These points can usually be configured via software preferences, but depending on your package you may not be able to change them all.

Bear in mind that if the context is not the same, then the comparison is meaningless! Similar considerations also apply to surfaces and areal parameters.

3 Are there any official references to rely on if I want to verify my commercial software package?

Yes and no!

Yes, as some NMIs offer reference software or provide reference profiles and reference values.

- PTB in Germany offers online reference software for profiles, with the ability to load profiles, select the form removal operation and filtration conditions. It displays calculated values for ISO 4287 and ISO 13565-2 parameters.
- NPL in the UK has a website where a set of profiles can be downloaded and the corresponding parameters values are given. Only the main profile parameters of ISO 4287 are given. Another page allows the user to download reference software which calculates areal parameters.
- NIST in the USA also has online reference software for profiles, with the possibility to upload a profile and calculate parameters or download one of the profiles from their database and check values.

No, because as stated earlier, if you compare these three “reference software” packages on the same profile, using the default configuration, you will obtain three different sets of values!

A much better result is obtained by carefully checking preferences, as explained in the answer to question 2.

However, the issue with preferences aside, the main reason you will obtain different values is that the standard itself is interpreted differently by different NMIs. For example, the vertical discrimination used in RSm may not always be the same (some use +/- 5% of Rz, others +/- 10%). On this particular parameter, NPL uses the “corrected algorithm” whereas PTB and NIST stick strictly to the ISO 4287 definition. This underlines the need for an updated profile standard (see the previous Surface Metrology Q&A in our Fall 2015 issue).

A few final thoughts...

MountainsMap® is constantly checked by our team of developers and metrologists to ensure the algorithms it contains are correctly implemented and optimized. Each change made to the code is rigorously tested to prevent regressions and allow the developers to correct any mistakes immediately. Thousands of automatic tests are carried out by our servers on a daily basis and our testing team actively verifies each version before releasing it publicly.

Digital Surf participates in ISO committee meetings

Digital Surf also works in close cooperation with NPL, PTB and other leading research laboratories to carefully check parameters and filters, understand mathematics and find solutions to unsolved questions. International standards do not cover everything and sometimes intermediate decisions have to be made.

Digital Surf's experts are heavily involved in this process, working with other professionals to reach these decisions which then provide the basis for improving standards. We also continue to play an active role in international standardization committees.

Mountains® is adopted by almost all instrument manufacturers as their platform for profile and areal surface texture analysis. Digital Surf does not shy from the responsibility this implies. Users and manufacturers can rest assured knowing Mountains® technology is trusted for its accuracy as well as its compliance with the very latest standards.

Key points

> Checking parameter values with reference software requires good knowledge of filtration conditions to ensure comparability.

> Users may change filtration and calculation conditions (in Preferences) to ensure results are comparable with reference software.

> Digital Surf invests heavily to constantly improve software quality and compliance with standards.

More information

Free online surface metrology guide:
www.digitalsurf.com/guide

TRADE FAIRS & EVENTS

HIGHLIGHTS

MRS Fall Meeting & Exhibit

The MRS Fall Meeting and Exhibit is a global event that offers the opportunity to get a look at the latest innovations in the field of materials science. The 2015 edition was held November 29-December 4, 2015 at the Hynes Convention Center in Boston, Massachusetts.

The Digital Surf team had the opportunity to meet with a wide range of partners, distributors and end users from all around the world and to exclusively showcase the latest Mountains® 7.3 software release.

Arnaud and Anne from the sales team met with attendees to discuss the benefits Mountains® offers researchers working in physics, chemistry, biology, mathematics and engineering.

Many thanks to all our visitors. See you in 2016!

International Conference on Surface Metrology (ICSM)

The ICSM, already in its 5th edition, aims to provide an international forum for the exchange of scientific information on surface metrology.

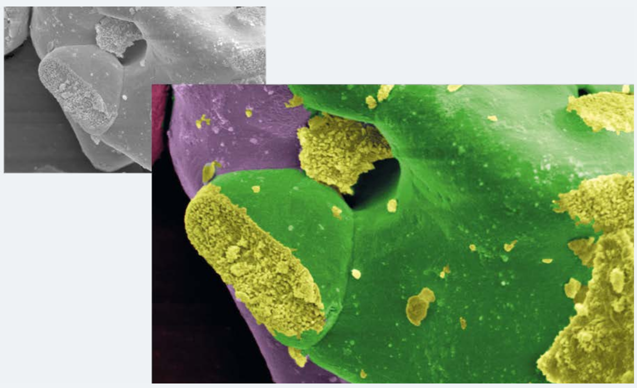
Digital Surf has been a partner of this event for years so it was with great pleasure that Anne (sales) and François (COO) made the trip to Poznan, Poland on April 4-7.

Over 100 papers were presented in a wide variety of areas (archeology, biology, geology, mechanical engineering etc.) Despite a busy schedule, attendees were able to enjoy the sights of historical and modern Poznan including a guided tour of the Lech Brewery (sponsored by Digital Surf).

Check out one of our new Mountains® applications

Whatever your field of research or industry, whatever your measurement instruments, Mountains® software can help you analyze and report on your data.

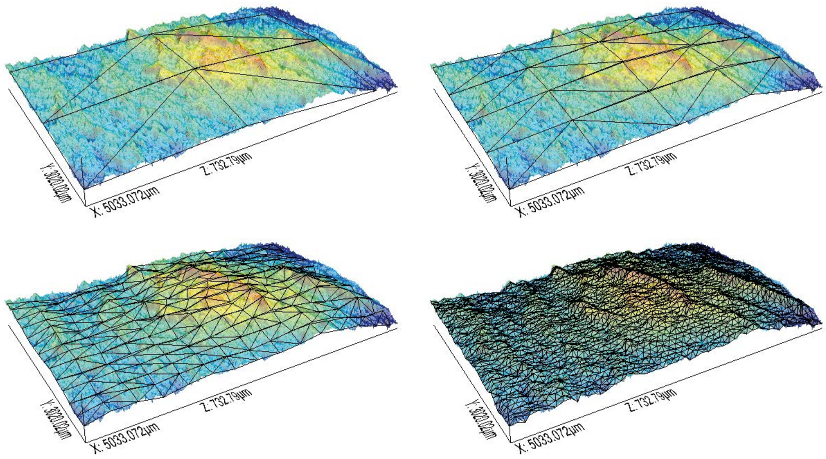
Visit www.digitalsurf.fr/en/applications.php to see all the latest examples including:



- Materials science – solid electrolytes on high temperature fuel cells using a Scanning Electron Microscope (SEM) + 3DSM Metrology software based on Mountains® technology (see colorized image).
- Engineering – cladding on heavy duty seals using a 3D Optical Profiler, a Scanning Electron Microscope (SEM) + MountainsMap® Premium software + SEM Extension module.

SFRAX® OR HOW A SURFACE CAN LOOK VERY DIFFERENT AT DIFFERENT SCALES

Digital Surf and Professor Chris Brown from Worcester Polytechnic Institute (MA) signed an agreement earlier this year to allow the multiscale methods implemented in Brown's Sfrax® software package to be included and further developed in MountainsMap®.



Four tiling exercises at different scales

Sfrax® implements multiscale (or scale-sensitive) methods for analyzing geometric properties of surfaces and their scale derivatives, known as complexities, which also vary with scale. The complexities are related to the fractal dimensions. They can result in stronger functional correlations and more confident discrimination at certain scales.

In addition, Sfrax® performs F-tests for discriminating surfaces based on the above analyses as a function of scale. It is also possible to carry out regression analyses between multi-scale length, area or filling parameters and processing or performance parameters, then plot regression strengths (R) versus scale.

A companion application, Toothfrax®, was also developed as a superset of Sfrax®, in order to offer dedicated parameters for the characterization of dental wear and scratches.

During an initial period, Digital Surf will ensure the maintenance of Sfrax® "as-is", providing maintenance of the existing version and ensuring compatibility with the latest versions of Windows.

At the same time, Digital Surf will work on importing algorithms into MountainsMap® in order to create an optional module that will provide Sfrax® parameters and curves, while integrating them with other Mountains® features. This new module should be ready for release early 2017.

Existing users will be able to access this module providing they already have a Mountains® 7 license. It is anticipated that the multiscale methods currently offered by Sfrax® will interest a wider audience and find new application areas amongst the 10 000+ users of MountainsMap® worldwide.

What are the applications of Sfrax® & Toothfrax® in research?

Prof C. Brown, creator of Sfrax®

The following papers illustrate just some of the practical applications of multiscale analysis methods in various fields of research.

Dental microwear

- Mahoney P et al, "Deciduous enamel 3D microwear texture analysis as an indicator of childhood diet in medieval Canterbury, England", J Arch Sci., 66:128-136, 2016.
- Souron A et al, "3D dental microwear texture analysis and diet in extant Suidae", Mammalia, 2014.
- Schulz E et al, "Feeding ecology and chewing mechanics in hoofed mammals: 3D tribology of enamel wear", Wear, 300:169-179, 2013.
- Ungar P et al, "Dental Microwear Texture Analysis of Varswater Bovids and Early Pliocene Paleoenvironments of Langebaanweg", J Mammal Evol., 14:163-181, 2007.

Food engineering

- Moreno M C et al, "Effect of food surface roughness on oil uptake by deep-fat fried products", J Food Eng., 101:179-186, 2010.
- Cantor G S, Brown C A, "Scale-based correlations of relative areas with fracture of chocolate", Wear, 266(5):609-612, 2009.

Friction/abrasive wear

- Jordan S E, Brown C A, "Comparing texture characterization parameters on their ability to differentiate ground polyethylene ski bases", Wear, 261(3-4):398-409, 2006.

Introduction to Areal fractal methods

- Brown C A, chap. 6 in "Characterisation of areal surface texture", Leach R ed, Springer, 2013.

USEFUL LINKS

FREE TRIAL

TRY MOUNTAINS MAP®

MountainsMap® Premium Software with all the options, free for 30 days!

CONTACT US FOR AN UPDATE

Contact us for information about updating MountainsMap® 6 or earlier software to the latest version of MountainsMap® 7

WATCH A MOUNTAINS® 7 TUTORIAL

Get the most out of Mountains® 7 by watching one of our tutorial videos

DOWNLOAD OUR BROCHURES

Learn more about Mountains® 7 software by downloading a brochure in English, French, German, Japanese, Korean or Polish

MEET DIGITAL SURF

Control 2016 International trade fair for quality assurance
Stuttgart, Germany - Apr 26-29, 2016
Booth 3518

Software solutions for surface metrology, designed for instrument manufacturers, research laboratories and industry

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