nanoflight®

A Synoptic View of Microstructures

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Introduction

The scientific community and with it, every researcher, should be committed to sharing the aesthetics of microscopic structures, with as many people as possible.

In the past it was mostly still shots of the specimen that were available. We thought it would be worth it to bring movement, color and lighting effects into the microworld and so developed a modular software called "nanoflight.creator" [1] with the goal of taking control of parameters like specimen movement, detector values, focus and colors of each detector channel in the scanning electron microscope (SEM).

***Trichomes on Tomato Stem**: see nanoflight SEM movie at https://vimeo.com/70724371*

nanoflight SEM System

The nanoflight system [3] integrates and remotes equipment from different manufacturers:

- FEI / Philips 525 Large Chamber SEM
- Kleindiek Eucentric E5AT Substage
- Heiland Electronic Remote Modules
- DISS5 Scanning System
- Up to eight SE and BS detectors
- nanoflight.creator software [4]
- Used post processing software: Adobe After Effects, Premiere

More than 40 parameters per frame will be send during the „flightpath" around the microstructures. A 4-channel frame at HDTV resolution takes 80 sec scanning and manipulating time.

***Honeybees**: see nanoflight SEM movie at https://vimeo.com/68715716*

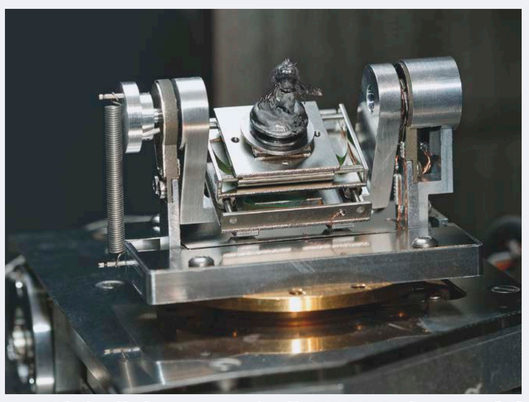
Development of the Control Software – A Challenge!

The modularity of the system and its convenient expandability for other remotable SEMs, or even stereoscopic light microscopes in natural colors, has been the most demanding challenge during the development of the control software. The main program handles only data and "User Interface" functions and supplies a framework for all plug-ins used.

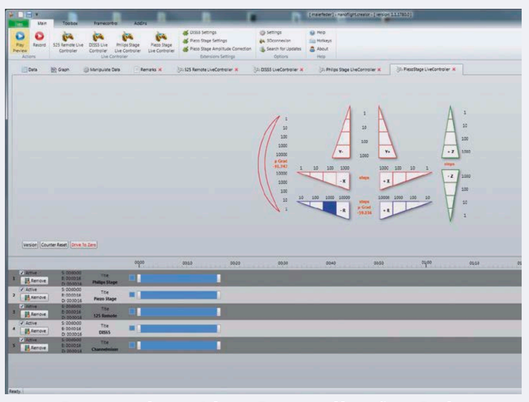
We have different levels of software modules: extensions for proprietary hardware like specimen stages, remote functions on the SEM and so on; live-controllers to control this hardware; add-ins like timelines, to control the execution of programmed sequences within the overall time-schedule; pre-effect plug-ins like Autofocus and after-effect plug-ins like color-correction or sharpness.

Within each timeline, the user can read, correct and send microscope values in correlation with sequence time, thereby setting up multi-dimensional waypoints. Frames between these waypoints are automatically generated with different possibilities of interpolation and graphic manipulation "on-the-fly", where applicable using multi-dimensional splines to get smooth curves and functions.

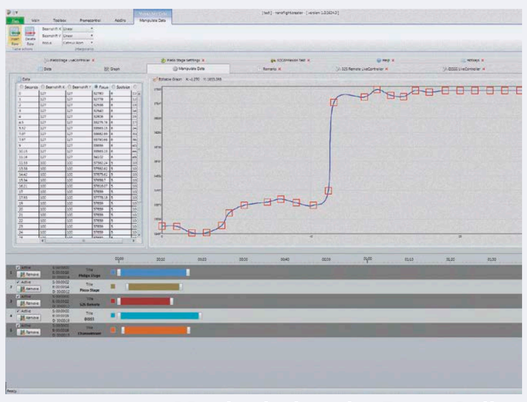
All these target-point function values are represented by vectors in a multi-dimensional space that stand for the settings of all axes used. We use eight motorized axes, three with the motor-stage of the SEM and five with the piezo-controlled eucentric substage. Within the image sequence we send out more than forty hardware-specific parameters per frame.



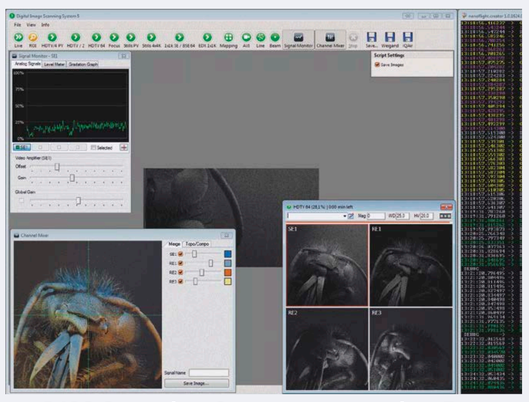
Kleindiek nanotechnik E5AS Substage [2]



Screenshot: Live Controller for Substage



Manipulating the Focus Spline



DISS Scanning System sequencing Frames

nanoflight SEM Movies

When preparing the movie, different target points or function values are selected with the live-controllers in the software; the 3dconnexion [5] six axes controller (which can control the substage movements and all the remote values of the microscope and the scanning system) or, within the graphic user interface of the specially adapted scanning system DISS5 [6], a hardware / software solution, to bring older SEMs up to date for active scanning and image acquisition of up to four detector channels. The DISS5 provides a script language which we used to integrate its functions within the "nanoflight.creator" software.

To achieve smooth transitions in the final movie, the transfers between the target points should be interpolated with the aid of splines. For this purpose, we use a special cubic Hermite spline, the so called Catmull / Rom approach. Thus, we generalize the basic principle of creating a smooth curve through all data points (normally in two dimensions or three dimensions) to arbitrary dimensions. Tangents at all points are calculated with respect to adjacent points to obtain a continuous path.

Conclusions

The software can be used to remotely control the SEM in all the accessible functions available within the extension modules. The "nanoflight.creator" has a very extensive framework to facilitate programming of own extensions for specific hard- and software.

The "nanoflights" are still a "project under construction" and depend on the availability of modern hardware for nearly-analog viewing of the SEM sequences (field emission microscopes...). Anybody interested in this visual approach is invited to join us. My personal wish would be that the response of stage movements become so fast that multidimensional encoded tracking and spline-generation be possible on the fly. That would enable users to really "fly around" microstructures using even lower image resolution and still get impressive image tracking for the high resolution scans.

Some of the resulting nanoflight SEM movies can be seen on „http://www.nanoflight.info" or „https://vimeo.com/stefandiller"

We hope you enjoy this new way of visualization.

Acknowledgements

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References

[1] Magnification, Focus, Gain and Blacklevel add-on units made by Heiland electronic Gmbh, Wetzlar, Germany
[2] E5AT Piezo Substage made by Kleindiek nanotechnik, Reutlingen, Germany
[3] „nanoflight" is a registered trademark of Stefan Diller, Wuerzburg, Germany
[4] Developed by Max Holder, IRIS Solutions GmbH, 97070 Wuerzburg, Germany
[5] „3dconnexion" is a trademark of 3Dconnexion, 330 Bear Hill Road - Suite 301, Waltham, MA 02451, USA
[6] Made by point electronic GmbH, Halle, Germany

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