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Applying the Google Earth™ Paradigm to Microscopical Specimen Mapping

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The Google Earth™ mapping service and similar web-based map applications have become ubiquitous in assisting individuals and organizations in finding locations and being found. Variations have been used to provide maps of the Moon, Mars and the heavens. The procedure for Earthly maps is simple – type in location (zip code, postcode, or address) into the user interface and an overview map is returned, whose magnification can be adjusted up or down and the field of view can be panned to bring nearby locations into visibility. In scanning electron microscopy, modern computer-controlled instruments and extremely accurate specimen stages means that mapping a sample at any given magnification should be a matter of careful "macro" programming, filament stability, patience and sufficient disc storage. Commercial software and many "virtual" microscopes already utilize image stitching to create panoramas and montages for presentation and training applications [1].

In addition to methodical area-by-area mapping of a sample, there are also advantages to *opportunistic* specimen mapping where images are captured as a microscopist investigates the sample. This could be used to create a montage of the examined regions of the sample, enabling the microscopist to review previous work in a more integrated fashion than sorting through a series of individual pictures and without the time loss and potential specimen damage of revisiting areas of interest, the latter of particular benefit when working with delicate samples. Opportunistic mapping must deal with issues of overlapping images, gaps between images (where the beam has been moved at speed between regions), out-of-focus features and images, noisy images and differing microscope parameters (not just magnification).

We have been developing a prototype software application to support opportunistic specimen mapping. The programs are being implemented in Adobe® Flex® as this provides a rapid prototyping environment with extensive image manipulation features. It also provides a route by which the Carl Zeiss SEM API may be utilized to acquire images live from the microscope. Google Earth™ has its own associated Application Programming Interface (API), enabling third-party developers to use it with their own images. This API does not currently support TIFF images. The private tags in the TIFF images contain valuable information about instrument parameters, so converting captured images to another "lossless" format would forfeit a rich source of image meta-data. Core mapping functionalities such as panning and zoom have been implemented in Flex®.

Full-size SEM images start at 1024-by-768 pixel resolution with larger sizes available on many instruments. To reduce computational effort in terms of system memory and processor time, algorithms for displaying individual image elements only load in the minimum number of images (the image of interest to be viewed). Likewise dynamic image stitching remains practical on single-processor average computers if only the minimum set of images are used. Unlike geographical mapping services where the map can be continuously panned in any direction eventually wrapping around, an opportunistic specimen map will have edges where no images have been captured and its overall shape is likely to be a jagged and asymmetric blocky polygon. Demarcating where the sample ends and a default "terra incognito" begins is important to ensure the latter are not misconstrued as featureless areas of the specimen. The current prototype is shown below in Fig. 1.

Ongoing development of the system is investigating the use of sharpness measures to facilitate the detection of in-focus images and image areas [2]. This will allow the system to select the best focused image when multiple images have been captured for a particular area and may assist in improving the stitching process. A further avenue of work is exploiting the proprietary tags of the saved TIFF files to improve the organization of image sets and linking the software to the SEM for live capture of micrographs [3].

References

[1] G.C. Martin et al., *Microsc. Microanal.* 12 (Suppl. 2) (2006) 218.
[2] C.F. Batten et al., *Scanning: J. Scanning Microsc.* 23 (2) (2001) 112.
[3] The Google Earth™ mapping service and Google™ are trademarks of Google Inc. Adobe® and Flex® are registered trademarks of Adobe Systems Incorporated. This research was supported by funding from Carl Zeiss SMT. The authors gratefully acknowledge the assistance of Carl Zeiss personnel, especially Daniel Aldridge, David Hubbard, and Roger Rowland.

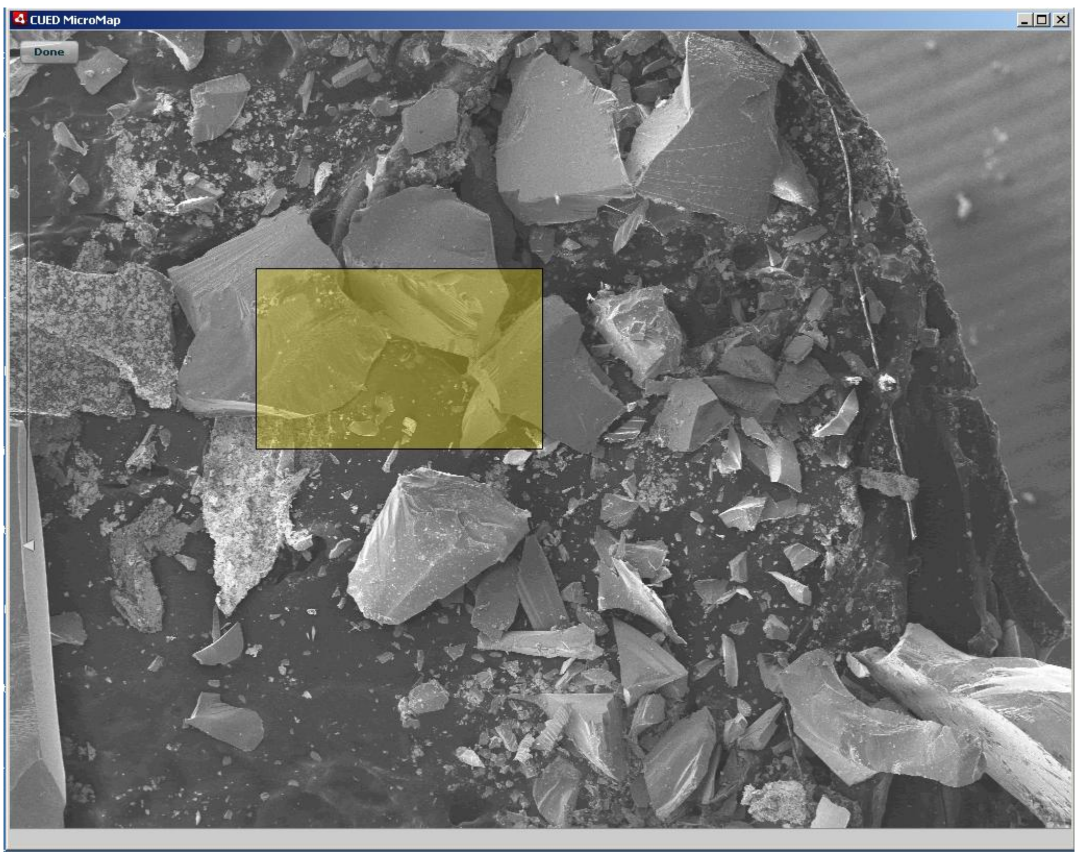

FIG. 1. Screenshot of the display interface of the current prototype software. The shaded rectangle is highlighting an area of interest for "zooming". The slider on the extreme left can also be used to increase or decrease magnification, and a user may double-click on a feature to increase magnification of it and the surrounding region.

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