AUTOMATED SEARCHING OF STARDUST INTERSTELLAR FOILS

R. C. Ogliore[1], C. Floss[2], A. T. Kearsley[3], J. Leitner[4], F. J. Stadermann[2], R. M. Stroud[5], A. J. Westphal[1]. [1]U. C. Berkeley, USA. (ogliore@ssl.berkeley.edu); [2]Washington U. in St. Louis, USA; [3]Natural History Museum, UK; [4]MPI Chemie, Germany; [5]Naval Research Lab., USA.

Introduction: The Stardust Interstellar Dust Collector collected possibly dozens of contemporary interstellar dust particles (ISPs) during the Stardust mission. Finding impacts from the micron-sized and smaller ISPs is a challenging task. Impacts into Al foil (~15% of the collector area) create 2-d impact features of relatively consistent shape, whereas impacts into aerogel (~85%) generate 3-d impact tracks of complicated and varying morphology. The aerogel has been successfully searched by a team of volunteers [1] who have located interesting features and possible ISPs that computer algorithms would struggle to identify. Searching of the Al foils is just beginning [2]. Each foil is scanned at ~50 nm/pixel resolution by SEM, yielding ~11,000 2048x1536 pixel images per long foil. Manually searching each of these images has yielded interesting crater-like features [3, 4], but the number of foil images to search by a handful of individuals is daunting. A computer algorithm to search these SEM images would not be prone to human mistakes and inefficiencies, and could search foils quickly, in parallel, and in a predictable, reliable way.

Methods: We employ a template matching approach to locate craters of imperfect shape and varying size and structure. Templates are matched to the image to be searched using normalized two-dimensional cross-correlation [5]. A template library is compiled from hundreds of SEM crater images of varying size and shape from the Stardust cometary foils. Each crater image is rotated 90°, 180°, 270° and again added to the library. This crater image library is then cross-correlated with itself and highly degenerate crater templates are removed from the library in order to minimize computation time. The minimum cross-correlation value that must be exceeded to eliminate false crater detections is determined for each template by cross-correlation with a set of crater-free images. Implementation of the normalized cross-correlation function is from OpenCV [6] written in C++, which is called from MATLAB code. The crater searching program, compiled to run on Windows PCs, is freely available: http://jake.ssl.berkeley.edu:8000/groups/westphalgroup/wiki/14e52/ISPE_SEM_Crater_Search.html.

Results: Using a library of 1000 crater templates, the crater searching code takes ~10 minutes to search one 2048x1536 pixel SEM image using one processor core on a circa 2009 PC. We tested the accuracy of the automated search on cometary foils with known craters along with scratches and debris that make searching difficult. The code located nearly all craters found manually, along with some craters missed in the manual search. With high accuracy, the code located micron-sized craters like those expected on the IS foils. Improvements in the software, such as increasing the diversity of craters in the library, speeding up the code, and decreasing the false-positive rate, will make automated searching more efficient and accurate.

References: [1] Westphal A. J. et al. 2010. 41st Lunar and Planetary Science Conference. #2050. [2] Kearsley A. T., et al. 2010. 41st Lunar and Planetary Science Conference. #1593. [3] Floss C., et al. 2010. 73rd Met. Soc. [4] Leitner J. et al. 2010. 73rd Met. Soc. [5] Lewis J. P. 1995. Vision Interface. pp. 120-123. [6] http://sourceforge.net/projects/opencvlibrary/