# *Colloquium given to the U.Bielefeld SFB360 (9/30/2004)* Robotics and Wearable Computing for Geological Exploration on Mars *

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***Abstract*— First, I will give an introduction to the current state-of-the-art in the geological exploration of the Martian surface by NASA's Mars Exploration Rovers, Spirit & Opportunity. Second, I will present the first field results from a wearable computing system that we are using in Spain to develop and test computer vision algorithms for geological exploration here on the Earth. Such computer vision algorithms (programmed using Bielefeld's NEO graphical programming language) could be employed in robots for future geological exploration of the Martian surface.**

**In March and June 2004, we tested the 'Cyborg Astrobiologist' at a white-and-tan-colored gypsum-bearing gological outcrop near Rivas Vaciamadrid. The Cyborg Astrobiologist is a wearable computer and robotic video camcorder system that we are using to test and train a computer-vision system towards having some of the autonomous decision-making capabilities of a field-geologist. The Cyborg Astrobiologist platform has thus far been used for testing and development of these algorithms and systems: robotic acquisition of quasi-mosaics of images, real-time image segmentation, and real-time determination of interesting points in the image mosaics. In addition to the proof-of-concept aspect of these field tests, the main result of these field tests is the enumeration of those issues that we can improve in the future, including: dealing with structural shadow and microtexture, and also, controlling the camera's zoom lens in an intelligent manner.**

**Despite these inadequacies, the Cyborg Astrobiologist has demonstrated its ability of finding genuinely interesting points in real-time in the geological scenery, and then gathering more information about these interest points in an automated manner. Particularly, the system was able to autonomously identify as unusual, and then proceed to study further, two mid-sized dark regions on the outcrop. These two dark regions were caused by water leaking out of the outcrop.**

**Keywords:** computer vision, image segmentation, interest map, field geology on Mars, wearable computers.

Fig. 1. Human Astrobiologist & Geologist Ormö is wearing the computer part of the Cyborg Astrobiologist system, as Human Astrobiologist & Roboticist McGuire looks on. During this pictures, the robotic part of the Cyborg Astrobiologist was slaving away, acquiring & processing the images of a $9 \times 4$ vertically oriented mosaic. These pictures were taken during the March 3rd expedition to Rivas Vaciamadrid. Note the absence of the black spots near the bottom of the cliff face; these black spots appeared sometime after this 1st mission and before the 2nd mission. Photo Copyright: Díaz Martinez, Ormö & McGuire

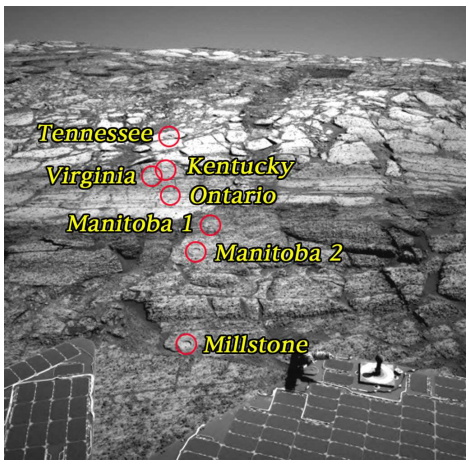


Fig. 2. This image taken by the navigation camera on the Mars Exploration Rover Opportunity shows the first seven holes the rover drilled into the slopes of "Endurance Crater." Starting from the uppermost pictured (closest to the crater rim) to the lowest, the holes were drilled on sols 138 (June 13, 2004), 143 (June 18), 145 (June 20), 148 (June 23), 151 (June 26), 153 (June 28) and 161 (July 7), respectively. Each hole is 4.5 centimeters (1.8 inches) in diameter. Each of the holes has a name for the rock it is on, and for the specific target on the rock. On the rock "Tennessee," the target is "Vols;" on the rock Kentucky, the target is "Cobblehill;" on the rock "Virginia," the target is Virginia; on the rock "Ontario," the target is "London;" on the rock "Manitoba," the targets are "Grindstone" and "Kettlestone;" on the rock "Millstone," the target is "Drammensfjorden." (Image courtesy of NASA: http://marsrovers.nasa.gov)

*This work is partially supported by three Ramon y Cajal fellowships to P. McGuire, J. Ormö and E. Díaz Martínez, and by a grant to J. Ormö (#AYA2003-01203), all from the Spanish Ministry for Science and Technology . The equipment used in this work was purchased by grants to our Center for Astrobiology from its sponsoring research organizations, CSIC and INTA.

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