EPSC Abstracts
Vol. 5, EPSC2010-162, 2010
European Planetary Science Congress 2010

The Cyborg Astrobiologist: Compressing Images for the Matching of Prior Textures and for the Detection of Novel Textures

A. Bonnici (1), C. Gross (2), **P.C. McGuire** (2,3,*), J. Ormö (4), S. Walter (2), L. Wendt (2);
(1) Univ. Malta, Malta, (2) Freie Univ., Berlin, Germany, (3) Univ. Chicago, Chicago, IL, USA, (4) Centro de Astrobiología, CSIC-INTA, Torrejón de Ardoz, Madrid, Spain, (*, mcguire@geosci.uchicago.edu)

Abstract

We describe an image-compression technique of Heidemann and Ritter [4] that is capable of: (i) detecting novel textures in a series of images, as well as of: (ii) alerting the user to the similarity of a new image to a previously-observed texture. This image-compression technique has been implemented and tested using our Astrobiology phone-cam system, which employs Bluetooth communication to send images to a local netbook server in the field for the image-compression analysis. By providing more advanced capabilities for similarity detection and novelty detection, this image-compression technique could be useful in giving more scientific autonomy to robotic planetary rovers, and in assisting human astronauts in their geological exploration.

1. Introduction

In prior work, we have developed computer algorithms for real-time novelty detection and rarity mapping for astrobiological and geological exploration [1-3,5-8]. These algorithms were tested at astrobiological field sites using mobile computing platforms – originally [5-7] with a wearable computer connected to a digital video camera, but more recently [1-3,7-8] with a phone camera connected wirelessly to a local or remote server computer. The image features used in the novelty detection and rarity mapping in prior work were based only upon RGB or HSI color.

Nonetheless, even with image features limited to color, the mobile exploration systems worked very robustly. The 'color-only' Cyborg Astrobiologist was able to identify novel or uncommon areas of image sequences in very different desert environments, ranging from mostly white-colored gypsum to mostly red-colored 'redbed' sandstones. The system was able to identify, for example, lichens of varying colors within the desert landscapes as being novel features (when first observed) of those landscapes [2-3,7-8].

Herein, we implement and test an image-compression technique of Heidemann and Ritter [4] that is capable of (i) detecting novel (colored) textures in a series of images as well as of (ii) alerting the user to the similarity of a new image to a previously-observed texture. Such a capability could be useful in giving more scientific autonomy to robotic planetary rovers, and perhaps in assisting human astronauts in their geological exploration. For example, suppose a semi-autonomous planetary rover equipped with texture-based novelty detection is observing a long series of textures corresponding to hematite concretions embedded in mineral deposits. With texture-based novelty detection, this rover would report that a particular previously-unobserved horizontally-layered texture is novel, and hence merits further investigation.

2. Heidemann and Ritter's Image-Compression Technique

Following [4], we "calculate the similarity of two images I_1, I_2 as:

$$D_{SIM}(I_1, I_2) = S(I_1) + S(I_2) - S(I_{12}). \quad (1)$$

$S(.)$ denotes the bit size of a compressed image. I_{12} is the 'joint' image obtained as juxtaposition of pixel arrays I_1 and I_2".

3. Field Tests

The Astrobiology phone-cam system sends images wirelessly by Bluetooth to a nearby netbook computer, dynamically building an image libary with examples of different terrain. Each incoming image I_N is processed by the netbook computer by using

Eq.1 to compute the similarity $D_{SIM}(I_N, I_J)$, with each previous image, I_J. If $D_{SIM}(I_N, I_J)$ is less than a chosen threshold for all previous images I_J (for all J<N), then we consider image I_N as 'novel' and return a text message to the phone-cam by Bluetooth informing the explorer that the image is novel. If the image is novel, the explorer might decide to perform a more detailed analysis of the ground or rocky outcrop that image I_N represents. If $D_{SIM}(I_N, I_J)$ is greater than the chosen threshold for one or more of the previous images I_J, then the image I_K, which has the highest similarity score (highest value of $D_{SIM}(I_N, I_K)$), is returned to the phone-camera via Bluetooth, juxtaposed with I_N, in order for the user to assess the similarity visually. We have performed tests of this procedure for detecting novelty or similarity -- one example image in the test sequence and its best-matching prior image are juxtaposed in Fig. 1.

Fig. 1: Incoming image I_N is on the left, and best-matching image I_{37} is on the right.

4. Outlook

Our initial tests of this texture-based algorithm for image comparison show promise for both novelty detection and for similarity matching. Our next step is to perform more extensive field testing of this algorithm with the Astrobiology phone-cam at geological/astrobiological field sites.

Acknowledgements

We thank Helge Ritter for suggesting the image-compression technique to us. PCM acknowledges current support by a research fellowship from the Alexander von Humboldt Foundation and current support from the Freie Univ. Berlin. CG acknowledges the Helmholtz Association through the research alliance "Planetary Evolution and Life".

References

[1] Bartolo, A., *et al.* "The Cyborg Astrobiologist: Porting from a Wearable Computer to the Astrobiology Phone-cam", *International Journal of Astrobiology*, vol. 6, issue 4, pp. 255-261 (2007).

[2] Gross, C., *et al.* "The Cyborg Astrobiologist: testing a novelty detection algorithm at the Mars Desert Research Station (MDRS), Utah," *LPSCXLI, Lunar and Planetary Science Conf.*, Houston, Texas, extended abstract #2457 (2010).

[3] Gross, C., *et al.* "Testing the Cyborg Astrobiologist at the Mars Desert Research Station (MDRS), Utah", *European Planetary Science Congress (EPSC)*, Potsdam, Germany 13-18, September, Vol. 4, extended abstract #548 (2009).

[4] Heidemann, G. and H. Ritter, "Compression for Visual Pattern Recognition", *Proceedings of the Third International Symposium on Communications, Control and Signal Processing (ISCCSP 2008)*, St. Julians, Malta, IEEE, pp. 1520-1523 (2008).

[5] McGuire, P.C., *et al.* "The Cyborg Astrobiologist: First Field Experience", *International Journal of Astrobiology*, vol. 3, issue 3, pp. 189-207 (2004).

[6] McGuire, P.C., *et al.* "The Cyborg Astrobiologist: Scouting Red Beds for Uncommon Features with Geological Significance", *International Journal of Astrobiology*, vol. 4, issue 2, pp. 101-113 (2005).

[7] McGuire, P.C., *et al.* "The Cyborg Astrobiologist: Testing a Novelty-Detection Algorithm on Two Mobile Exploration Systems at Rivas Vaciamadrid in Spain and at the Mars Desert Research Station in Utah", *International Journal of Astrobiology*, Vol. 9, pp. 11-27 (2010).

[8] Wendt, L. *et al.* "The Cyborg Astrobiologist: Teaching Computers to Find Uncommon or Novel Areas of Geological Scenery in Real-time", *European Space Agency International Conference on Comparative Planetology: Venus - Earth - Mars*, ESTEC, Noordwijk, The Netherlands, 11-15 May (2009).