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AUTOMATED IMAGE MATCHING TECHNIQUES FOR PLANETARY PHOTOGRAMMETRIC MAPPING

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Introduction:

Image matching techniques are a key component in several of the most critical tasks in photogrammetric mapping. While significant successes have been achieved in automating matching techniques for Earth-based photogrammetric mapping, there still exists a need to introduce production-oriented methods into planetary mapping. These matching techniques can be classified into categories such as area-based, e.g., cross-correlation and least squares methods (LSM); feature based methods, e.g., SIFT and SURF; statistical measures, e.g., Mutual Information (MI); and those applied in the frequency domain, e.g., Fourier transformation. In the case of the operational planetary image analysis toolset, ISIS, (The Integrated Software for Imagers and Spectrometers), there are specific embedded routines for point matching, such as pointreg and coreg, which are fundamental to production of high precision cartographic products. Even with these existing tools, the current level of manual validation and editing of data is quickly making global control products of modern missions a practical impossibility. Reliable image alignment, as shown in Figure 1, is necessary for mapping from large data sets by reducing the amount of human interaction required controlling them. For example, the Lunar Mapping and Modeling Project funded the production of enormous controlled polar mosaics from Lunar Reconnaissance Orbiter Camera (LROC) images. These mosaics included over 7,500 images – and required hundreds of hours of labor yet they will use only 2% of the total LROC NAC image dataset.

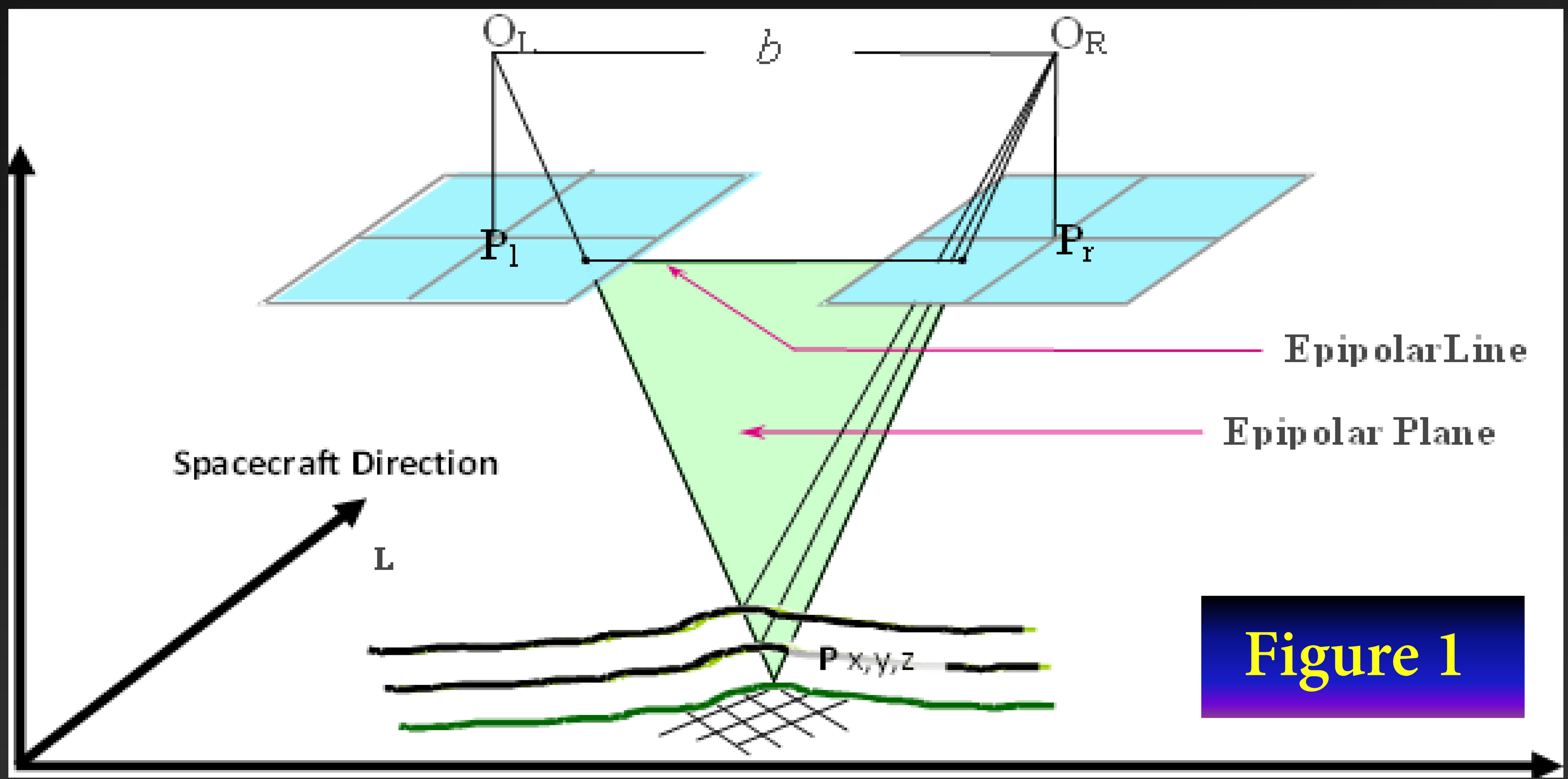

Figure 1

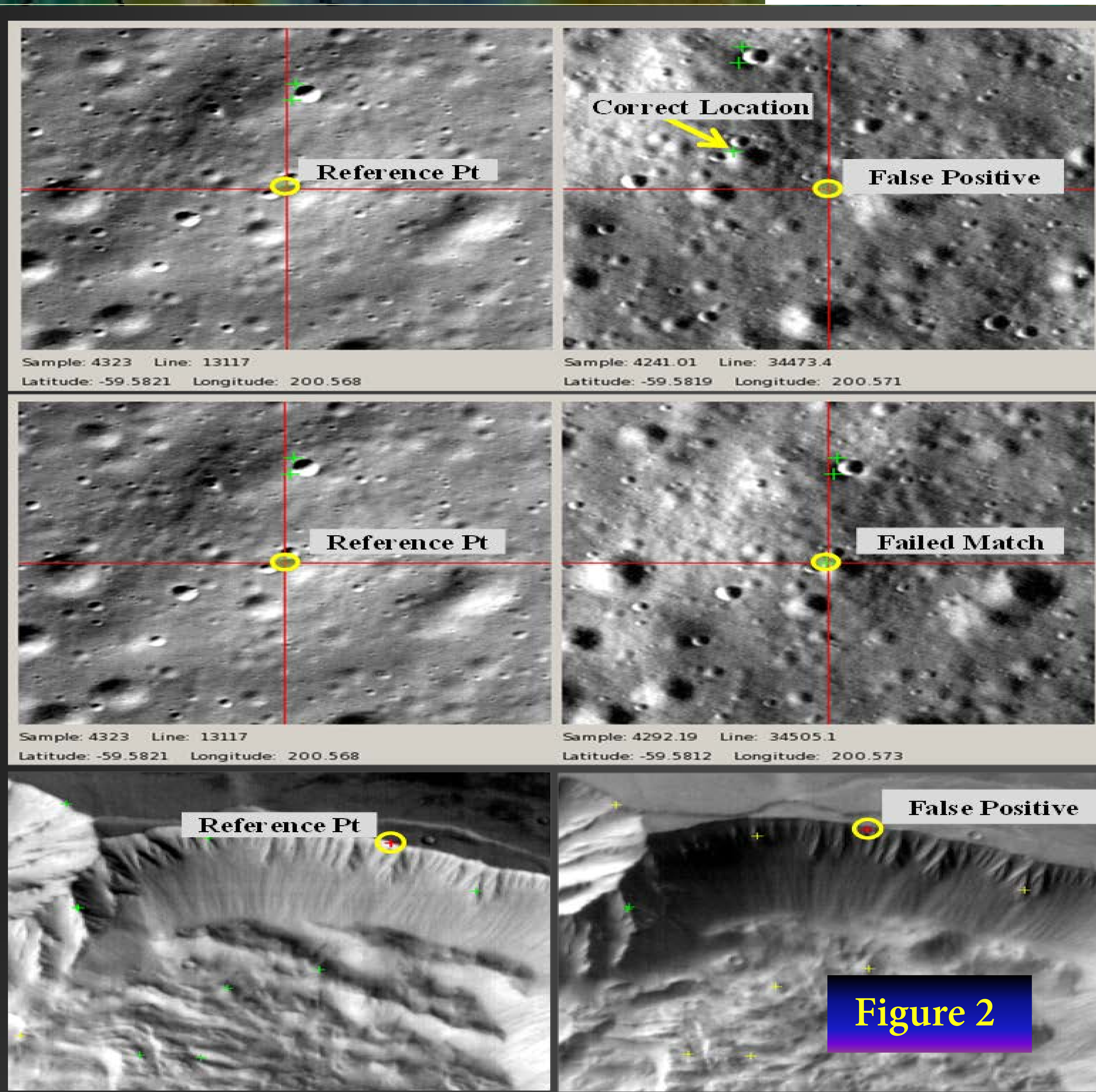

Figure 2

Current Status:

The underlying matching techniques currently used in ISIS functions is the cross-correlation method. In this method, the difference between the image patches is modeled as linear functions of the intensity values combined with two-dimensional integer shift. This shift is typically one pixel at the search direction line, and once exhausted, the search shift to the next line in the search direction. As it currently stands, matching in ISIS does not model geometric and radiometric differences, except crudely at the level of the whole matching patch. These differences affect success, efficiency and accuracy of matching; hence geometric rectification and radiometric filtering can be applied to partially compensate for these differences. The outcome requires substantial manual editing of the list of candidate matches to eliminate blunders, which is very costly in comparison to the previous automated matching step. As size and complexity of image datasets increase due to the number of different sensors, different illumination conditions, etc., the amount of editing required renders controlling these image datasets cost prohibitive.

Proposed work:

The initially proposed work involved three phases, each focusing on a different aspect of the automated matching problem. Phase One focuses on improving matching algorithms already available in ISIS, with the primary goal of eliminating "false positives," i.e., matches that pass simple statistical tests and thus appear valid to the software but are incorrect. The second phase will involve the introduction of more advanced matching techniques such as advanced least squares matching, Fourier domain correlation, matching based on Mutual Information (MI), as well as combinations of these methods. The third phase would include the introduction of even more advanced and robust approaches based on identifying and matching features such as points, lines, areas, and complex constructs such as impact craters.

Our current funding supports only Phase One as the highest priority that addresses false positive and failure to match conditions in ISIS. As shown in Figure 2 in the top row, the right image shows both a false positive matched in ISIS program called qnet along with the correct location next to it. The middle row shows a failure to match. The yellow circle shows the location where a successful match would have been found. In both cases, the illumination of the two Lunar Reconnaissance Orbiter Camera (LROC) images being compared is incompatible, so it is not obvious why the outcome was a false positive in one case and a failure in the other. The bottom row shows an example of a false positive on Mars (THEMIS Ir) images with inconsistent illumination.

Our approach in Phase One is to improve performance by addressing preprocessing, to be executed in 2013; core matching, in 2014; and post processing, in 2015. In reference to preprocessing, we will minimize the perspective distortions by a- improving ISIS 'fast geom' transformation, and b- introducing epipolar orientation of the transformed search image chips. Once we are certain that perspective distortion is minimal, core matching will be addressed by a- enhancing seeding mechanism to populate initial match points, and b- improving current ISIS matching functions. For post processing, we will develop tools to a- quantify and display errors and false matches; b- capture processor feedback; and provide user control over matching strategies.

Our testing plan to ensure that performance actually improves is by reducing false positive, hence improving throughput from the processor's stand point. Our metrics for measuring improvements will be based on reduction on false positives, increases in correct matches, and cost in terms of production time. We will use various planetary image datasets, to ensure the improvements are generic and not sensor/image specific. Specifically, we will use LROC NAC, HiRISE, Mercury Frame Camera, Cassini, and Themis.

Conclusion:

Image matching accuracy, matching success, and false positives are all affected by image quality issues such as differing image geometry, varying radiometric quality, differences in spectral responsivity, and especially the need to match radically different image types such as visible, infrared, and radar data. This poster describes work that aims at addressing these difficulties by enhancing current ISIS functions and adding specific improvements to produce efficient and accurate matches and drastically reduce false positive matches. In the current status, funding is allocated to support executing only Phase One, thus addressing preprocessing, core matching, and post processing. We expect to report results in late 2014.