OBJECT BASED IMAGE ANALYSIS FOR REMOTE SENSING OF PLANETARY SURFACES.

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Introduction: Traditional pixel-based remote sensing analysis, while a useful tool, has its limitations. The method has especial difficulties processing high-resolution imagery resulting in a 'salt-and-pepper' effect where pixels cannot be aggregated properly which later results in readability issues [1]. Notably, the method is also unable to always distinguish child-objects from their parents (e.g. shadows are classified as separate objects from their craters). With the growing field of applying object based image analysis (OBIA) to remote sensing of Earth, this study attempts to utilize the method for analyzing the surface morphology of other planetary surfaces with an emphasis on Mars and Venus.

Previous studies have shown that OBIA is leading a paradigm shift in the classification and analyses of terrestrial satellite data. By examining the high-resolution data as a whole, the software is able to take into account homogeneity, shape, texture, position, and various other conditions in addition to traditionally looking at various band levels [2]. This study develops rulesets in eCognition® for object based classifications in an attempt to show the validity of such a method for use in extraplanetary remote sensing.

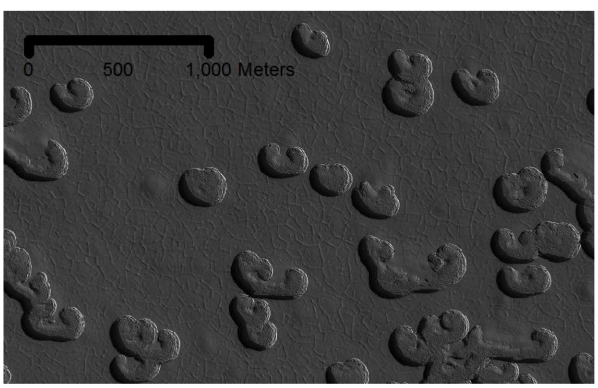

Fig. 1: HiRISE data segment of ESP_020734_0930 displaying the characteristic pitted A1 terrain.

As a test of the software in a non-terrestrial envirnonment, the A1 layer's 'pit' features of the Mars residual south polar cap (RSPC) were chosen for their ability to be easily recognizable (Fig. 1). These morphological features are found exclusively on the RSPC of Mars and are catergorized as round depressions in the perennial CO_2 ice layer [3]. It has been observed that these pits expand over time and prior research has examined the rates and lifetimes of such features. [4].

Images were retrieved from the High Resolution Imager and Science Experiment (HiRISE) on the Mars Reconaissance Orbiter (MRO) [5]. For an initial ruleset, two images taken 498 calendar days (~0.725 ♂y) apart were clipped and processed using geographic information systems (GIS) software in preparation for use in eCognition® (Fig 3A,C).

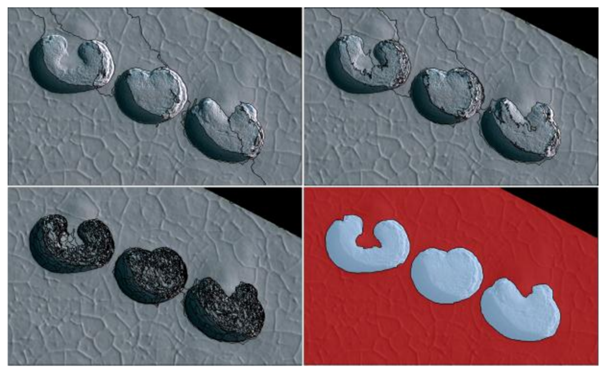

Fig. 2: The results of three multiresolution segmentations from the OBIA. Each corresponds to a different scale used to aggregate the pixels. Larger segments indicate a greater scale used.

Methods: OBIA software utilizes rulesets created by the user to identify and categorize features found within the dataset. The method used here was to apply various layers of multiresolution segmentation which aggregates pixels together with a top-down/bottom-up approach (Fig. 2). Using conditions based on homogeneity, brightness thresholds, shape, and compactness, smaller image-objects were merged after the segmentation and given appropriate classifications. Brightness thresholds were used as a way of counteracting the effects of bidirectional illumination. Smooth regions between pits tended to be much more homogenous and optically brighter, whereas the pits tended to have relatively darker brightness layers. Afterwords, morphology tools were able to cleanup the images to prevent extraneous pixels from appearing on the objects. A strength of OBIA over pixel-based image processing is the ability to include shadows as a child-object of the whole pit.

After much iteration an appropriate ruleset was developed to classify the pits, these shape objects were then exported to GIS software for further analysis and manipulation with the original images. Area, length, and width of these objects were extracted and used to determine the scarp retreat rates of the three pits for comparison with the literature. Figure 2 shows the changes in the two areas before and after the object shapes were included.

Results: The pixel length attribute – the widest horizontal swath of pixels of the image object – was used as a proxy for determing how these pits were changing from year to year. Table 1 displays the calculated length for each pit on 18 Aug 2009 and their respective retreat rates. An average scarp retreat rate of 3.8 m/♂y was found for the sample of three pits.

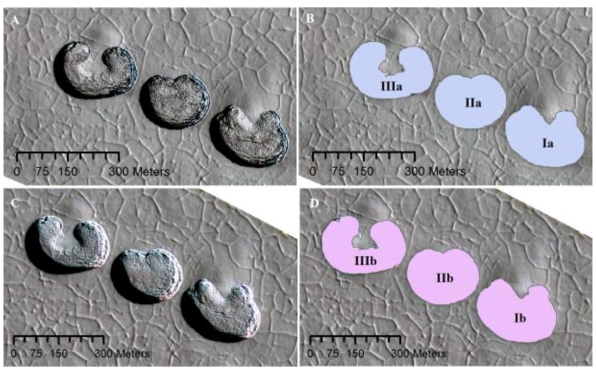

Fig. 3: The top images are clips from ESP_014352_0930 taken in Aug 2009 displaying three of *the 'pits' on the Mars* RSPC. The bottom images are clips from ESP_020734_0930 taken in Dec 2010. Both images show the raw data on the left and the image-object pits from the OBIA on the right.

Thomas et al. (2012) found that the average scarp retreat rate was 3.6 ± 0.2 m/♂y by using a sample size of 19 of layer A1 pit formations. These features are categorized as unimodal in size with a mean diameter of approximately 200 meters [4]. The average retreat rates, found through OBIA, are within standard error of the accepted values. Therefore, this study supports the conclusions found through previous methods, thus validating the effectiveness of object based image analysis for the use of remote sensing of other planetary bodies.

Pit	2009 Length (m)	Retreat Rate m/♂y
I	265.0	4.6
II	239.5	4.1
III	281.0	2.8
Average	261.8	3.8

Table 1: Displays the calculated scarp retreat rates for the three pits found in Fig 2.

Further Work: This study is meant to be a preliminary step in the integration of object based image classification into studies of planetary science. Work is currently being done by this group on applying the OBIA method to the data obtained from Magellan's synthetic aperture radar (SAR) of the Venusian surface. An additional ruleset is being developed specifically for analyzing the complex surface features of Venus including montes, arachnoids, tesserae, coronae, fossae, linea, and others.

Once a rigorous rule set is developed for the planetary surface, it can easily be applied to batch data sets for easy processing and analysis later. With the new dataset of object shapes and attributes, morphological distributions, feature evolution, and more detailed classification schemes can be analyzed.

It is suggested that further work be done on developing a rigorous ruleset for the Martian polar region and planetary surface. The current ruleset only looks for pit features, but on the RSPC there are a variety of other features that can be picked out by the OBIA software. With this ability to work with high temporal and spatial resolutions, the homogeneity of feature evolution should be determined. Seasonal variations alongside longer time scales sholud be analyzed and the possible effects of insolation and aeolian processes may be able to be taken into effect.

Conclusion: Object based image analysis has been rapidly growing as a tool of choice in the remote sensing of terrestrial data. With such capabilities, the emersion into the remote sensing of other planetary surfaces was inevitable and this study shows that such a method is viable and accurate. Prior research has shown that the OBIA method reduces misclassifications, and with future studies and more adaptive rulesets all misclassifications can eventually be eliminated [2]. By identifying a scarp retreat rate of 3.8 m/♂y with a known value of 3.6 ± 0.2 m/♂y this study finds that OBIA is an effective tool for applications in remote sensing of the Mars RSPC and can be extrapolated for use on other planetary bodies.

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