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Identifying candidate temporal changes on Mars through image matching

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Abstract

Starting from Viking Orbiter 1 launched in August 1975, several robotic orbiters have been sent to Mars to map its surface. Recently, interest has shifted towards high resolution mapping, which allows the identification of previously undiscovered surface changes as well as greater examination of surface composition and geological history. The increasing number of Mars' orbiters, supplied with high resolution cameras, make possible the analysis of the temporal evolution of certain areas that reveal natural processes that change over time. On the other hand, the multitude of available images acquired over the same areas with similar spatial resolution permit the application of novel automatic techniques that are able to filter out the majority of image pairs, returning only those that might be associated with a change in appearance of the surface. This work describes some preliminary results towards this direction, using a novel planetary image matching technique.

1. Introduction

Initial analysis of early Martian surface imagery indicated a planet with apparently similar characteristics to the Moon, pitted with craters and large volcanic and tectonic features but seemingly "dead" from a geological perspective. However, higher resolution imagery obtained for a few places by these early robotic explorers did hint at the role of water in shaping the surface. Since ESA's Mars Express which includes the High resolution Stereo Camera (HRSC) started acquiring systematic imagery up to 12.5m, the surface revealed a large number of apparently fluvial features and even some dynamic features such as dust devils and water deposits in craters. Since 2007, there have been imagers with resolution down to 25cm and this high-resolution image mapping of the Martian surface has allowed the discovery of new dynamic surface features. These include both processes that happen periodically each and every Martian season (e.g. seasonal flows on high latitude areas [1]) and events that do not follow some iterative pattern but are rather sporadic (e.g. new impact craters [2]).

As a result, techniques that aim at automatic surface change detection are being introduced [3], [4]. However, these few approaches tackle only the last part of a fully automatic temporal change detection pipeline, which is the change identification and classification. This assumes that the input would be a pair of images, which are known a priori to both map the same area and have a high probability to include different surface features. The abundance of available Martian imagery and the limited knowledge we have about Mars natural processes ensures that manual identification of such candidate image pairs is not a trivial task.

2. Methods and Results

We are currently building a fully automated temporal change detection system, which will be able to identify temporal changes given any set of input images. The first part of this pipeline tackles the issue of filtering the vast majority of image pairs, which aren't associated with any temporal change and detecting sub-images of candidate temporal changes. This is accomplished through a technique that is based on image registration, i.e. the transform of a target image so as to fit pixel-by-pixel on top of a reference image. Image registration has been employed in a similar manner for medical imaging purposes, in order to identify new potentially malignant tumors in mammographs acquired at different time [5].

In this approach, images are initially segmented to a set of corresponding sub-images that are subsequently independently matched, thus implying a registration of the one image to the other. It is assumed that if a sub-image has been modified then the poor registration results would signify the change. Two examples of sub-images that were identified as possibly changed are shown in Figures 1 and 2.

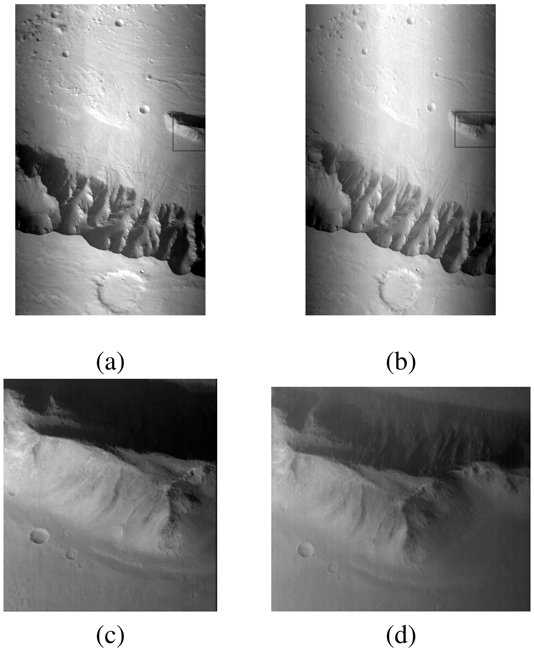

Figure 1: (a) and (b) CTX images B01_009894_1665_XI_13S042W and B02_010606_1666_XN_13S042W. The rectangles signify candidate temporal changes. (c) and (d) A closeup of the enclosed area inside. The close-up reveals that the north slope of the hill can not be distinguished in the former image due to the shading conditions at the time that the image was acquired, while it is not so severely shaded in the latter image.

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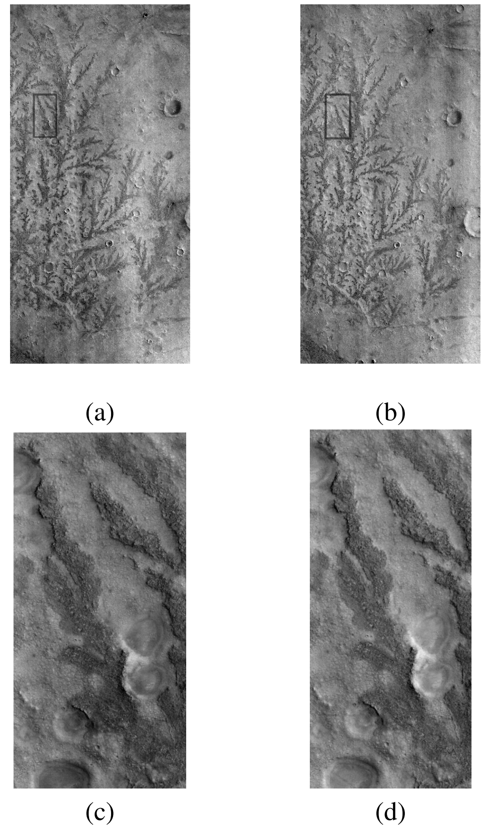

Figure 2: a) HiRiSE images ESP_012435_2015_RED and ESP_012725_2015_RED. The rectangles signify candidate temporal changes. (c) and (d) A close-up of the enclosed area. The close-up reveals that the surface in some regions of the left image (e.g. the double crater plateau) is depicted darker than the corresponding surface in the right image.

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