Automatic registration of multi sensor remotely sensed Images from the Mars

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The HiRISE and CRISM instruments are two orbital imagers carried by the Mars Reconnaissance Orbiter (MRO). The HiRISE instrument acquires remotely sensed images on the Mars with extremely high spatial resolution (0.25m). While the CRISM, which stands for The Compact Reconnaissance Imaging Spectrometer for Mars, acquires hyperspectral images covering the 3000-3900nm wavelength range (with 544 bands) of moderate spatial resolution (18m). The two instruments allow us to obtain complimentary information on the surface and the atmosphere of the Mars. However, the accurate and automatic registration of the images taken by the two instruments still remains a question, which is issued in this paper.
On a given scene, the images of HiRISE and CRISM are taken at the same moment. For the registration, the resolution of HiRISE image is at first degraded to the same resolution of CRISM (18m). For the registration, we use a coarse-to-fine scheme proposed by Florence in [1]. The Fourier-Mellin transform is firstly used in order to obtain the rotation and scaling between the two images for a coarse registration. More concretely the Fourier-Mellin transform extends the phase correlation to get the rotation and scaling between two images by using a log-polar transform. Since it requires, the Canny operator is used to get the edges of the images .And the Fourier-Mellin transform is applied on the edge images to get the rotation and scaling for the coarse registration. After the coarse registration, the deformation between the two images is small. The positions of the matching points on the both images are very close. The Harris corner points of the HiRISE image are extracted. The mutual information between the HiRISE image and the CRISM image is computed on the neighborhood of the corner points. The points on the CRISM image which has the maximal mutual information is chosen as the matching points, on which the registration is based.
The experiment is carried on the CRISM frt000042aa image and the HiRISE PSP002482_1255 image which taken on the Russell Dune of the Mars. We use a mosaic of the two images for a visual evaluation. The registered CRISM and HiRISE images are shown in Figure 1(a) by the following pattern.
HiRISE CRISM HiRISE
CIRSM HiRISE CRISM
HiRISE CRISM HiRISE
Since the reflectance values between the CRISM and HiRISE images are not comparable, for the quantitative evaluation, we cannot directly compare the registered images by their reflectance values. For this purpose, we follow the intercomparison scheme in [2]. According to [2], the minerals on the observed site are mainly dust and CO2 ice. The dark pixels in the HiRISE image corresponds to the “dark source” which is mainly dust with a few residual CO2 ice. The HiRISE image is classified according to the pixel values for obtaining the abundance of the dark source (which is shown in Fig. 1(b)). The registered CRISM image is unmixed based on the linear mixture assumption for obtaining the abundance of the dark source (which shown in Fig. 1(c)). The local correlation coefficients between the dark source abundances obtained by the two images are computed (shown in Fig1. (d)). It can be seen that the correlations are quite high at the center

of the image. While on the top and the bottom part, the correlations are not quite satisfactory due to the fact that the matching points are mainly found at the center of the image.
For conclusion, we have registered the images taken by HiRISE and CRISM instruments carried on the Russel Dune by using a coarse-to-fine scheme proposed in [1]. The Fourier-Mellin method is used for a coarse registration; while Harris corner points and mutual information are used for the fine registration. By the intercomparison of the dark source abundances obtained respectively on the two images, the registration results are good at the center of the image. The top and bottom parts of the image are not well registered due to the small number of matching points.

[1] Tupin Florence et al, 2008. Registration of metric resolution SAR and optical images in urban areas. Proc.Synthetic Aperture Radar 2008 7th European Conference,Friedrichshafen,Germany,2-5 June.1-4.
[2] X. Ceamanos, 2011. Intercomparison and Validation of Techniques for Spectral Unmixing of Hyperspectral Images: A Planetary Case Study. IEEE Trans. Geoscience and Remote Sensing, 2011, to appear.