MERGING OF IMAGE DATA FROM MULTIPLE SENSORS

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1 Introduction

In remote sensing an important and persistent problem is the comparison of images of the same scene taken by different sensors or even different spectrometers of the same sensor. The problem is that the geography and varying lighting of the scene as well as the positions of the sensors make it extremely difficult to match the pixels in the two images using a model based approach, that is, calculating where each pixel should be on the basis of accurate (but not exact) information on the positions of the sensors and the topography of the scene.

The study group noted, however, that there are a number of situations where this can be done. Some of these situations are purely automatic, others involve some human interaction. One example is the co-registration of the different spectrometers in the ASTER satellite sensor. There are several codes which allow the three different spectrometers to be co-registered. These exploit the fact that there are relatively small errors which arise between the different spectrometers.

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Within one sensor, data is often collected at different spatial resolutions for different spectral resolutions. Thus, for example, Quickbird produces four colour bands (RGB and infrared) and one panchromatic band. However, the panchromatic band is at a resolution of less than a meter, while the colour bands have resolution around 4 meters. Marrying these data sets allows us to produce a colour image at an apparent resolution of 1m. An example of a pan sharpened image is given in Figures 1 and 2. The original three band colour image is Figure 1.

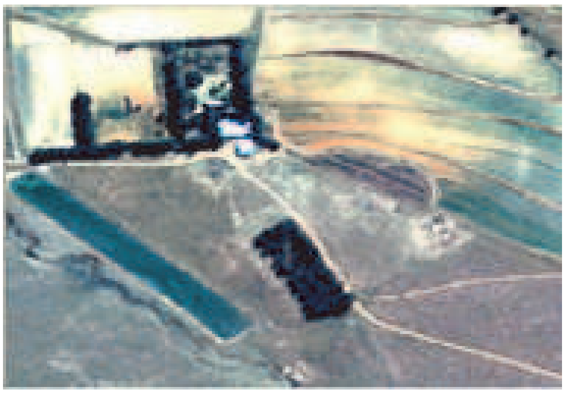


Figure 1: Original three band colour image.

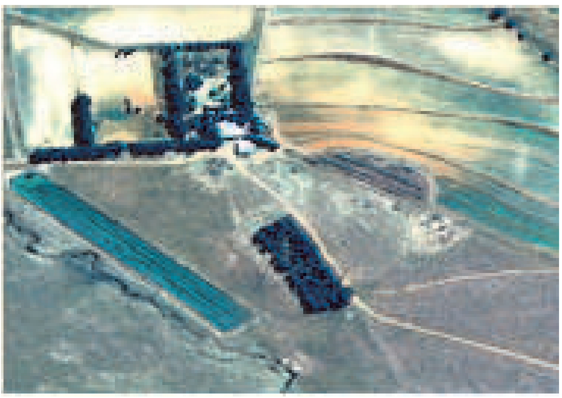


Figure 2: The pan sharpened image.

However, the difficult and more interesting problem is when multiple sensors are used to collect images over the same area. Now the issues referred to above come to the fore. Such co-registration is usually addressed by picking control points (manually or by use of large image analysis programs) and then warping one of the images so that the matching control points are mapped to each other. The data in between is then warped by some type of triangulation process. Thus the intrinsic information in the intermediate points is not used, and often the warping procedure (if it is non-linear) damages the spectral integrity of the data. This is especially true of hyperspectral data.

Figure 3: Example of a proprietary system.

Nevertheless, it is possible to address this issue in an at least semi-automated way. Figure 3 is an example of a proprietary system in which Eros 4 data has been merged with ASTER data to produce a pan-sharpened multispectral image.

2 Hyperspectral Core Imager

The group investigated this issue initially in general terms as outlined in the presentation at the beginning of the MISG. However, it soon became clear that the problem was too diverse and challenging in that context; just the literature review would take more than the week available. We therefore focussed on a particular problem which had a variety of aspects of the general problem, and thus could provide insights into the general problem, yet also had additional specific information that would be available to provide a method of attack. Furthermore the particular case addressed had real interest to the industry.

We considered the case of the Hyperspectral Core Imager owned by AngloGold Ashanti. The instrument generates hyperspectral data of split drill core which enables the identification of minerals present but also takes high resolution digital images in natural colour using a separate digital frame-grab camera.

(a) Figure 4

(b) Figure 4

Figure 4: (a) A tray of split core ready to be scanned.
(b) The HCI owned by AngloGold-Ashanti.

The problem of matching the hyperspectral data to the much higher spatial resolution camera data is exactly in the context of the general problem discussed above. It is complicated by a number of factors not least that the camera takes its pictures sometime after the hyperspectral data is captured so that the motion of the belt on which the core is transported has often slightly

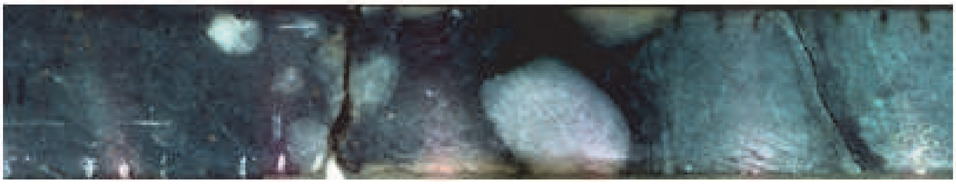


Figure 5: Image of the core captured by the frame-grab camera.

changed the cores position. Also the camera is not perfectly aligned to the direction of the belt so that if the images are joined to produce a collage of the full length of the core, then they curve slightly. We called this the banana effect.

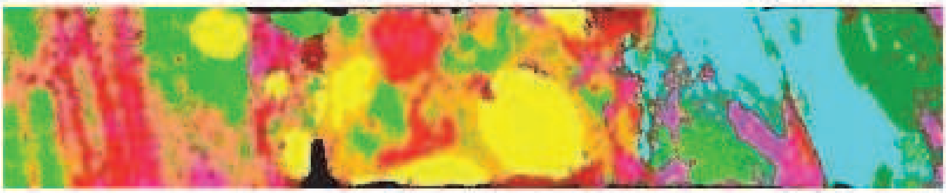
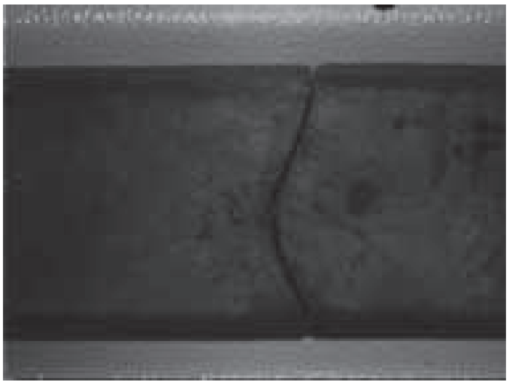


Figure 6: Analysis of minerals in the core using the hyperspectral data at lower spatial resolution. Approaches taken by the Study Group.

A number of different approaches were considered by the study group. The most natural is to obtain accurate offset information between the scanner itself and the camera taking the frame grabs. Theoretically it should then be possible to rigidly shift the one data set to the other and have the pixels match. Unfortunately the disturbance caused by the belt and the unsatisfactory camera features mentioned above meant that the data was not sufficiently accurately matched by this method. Pixels matched often corresponded to neighbouring points and the problem became worse over time due to the banana effect.

Various techniques were attempted using the overlap between successive camera images alone. These are illustrated in Figures 7 to 10.



(a) Figure 7

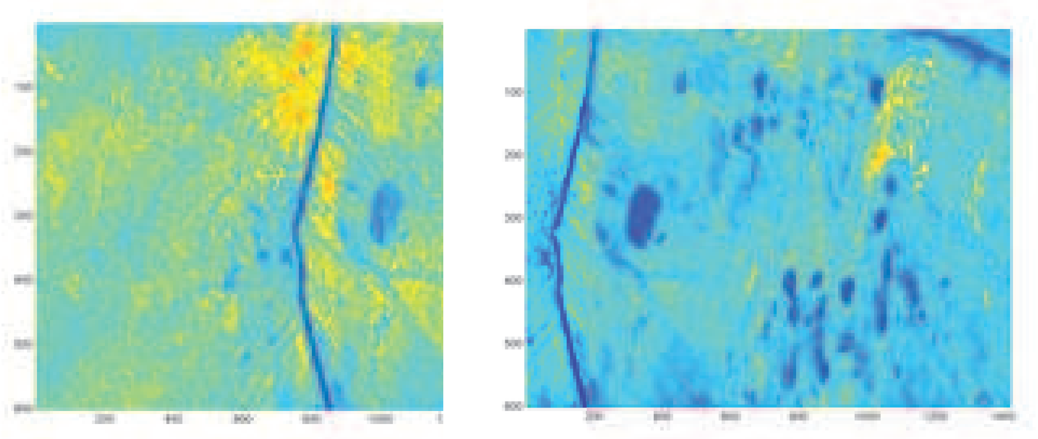
(b) Figure 7

Figure 7: (a) and (b). Original digital photo of successive images.

(a) Figure 8

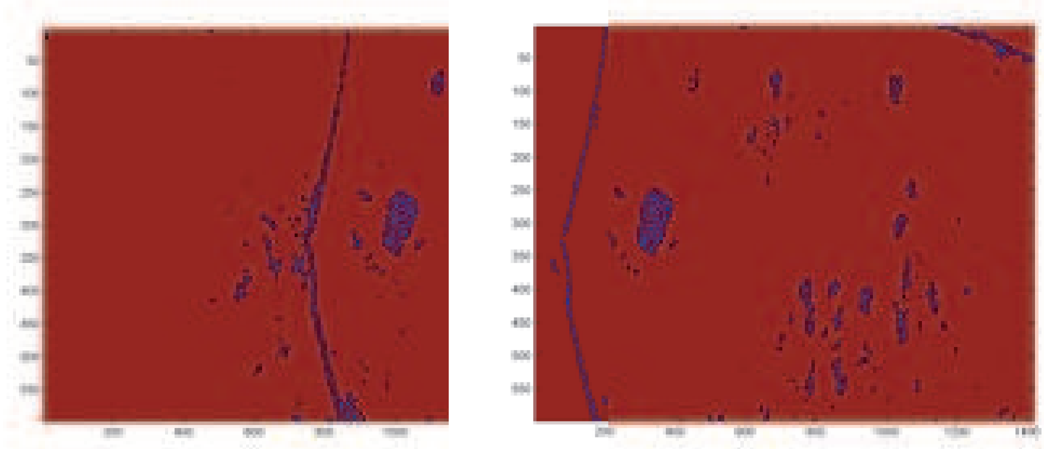
(b) Figure 8

Figure 8: (a) and (b). Images showing the impact of the misaligned flash positions and brightness variation.



(a) Figure 9 (b) Figure 9

Figure 9: (a) and (b). Normalised images.



(a) Figure 10 (b) Figure 10

Figure 10: (a) and (b). Special features grouped for matching and coregistration.

It seemed clear that the problem could only be effectively addressed by exploiting information contained within the hyperspectral data itself. The most innovative idea was to use the multiple hyperspectral images, that is, the images at each wavelength recorded - as multiple pictures of the data, in a similar way to the approach of looking at temporal change detection by looking at multiple images taken at different times. The intrinsic redundancy of the data, we felt, should allow us to essentially reconstruct the RGB pixels at the higher spatial resolution, that is, the data would be matched by its spectral signature rather than by the spatial one.

Preliminary work undertaken at the MISG suggested that the approach was interesting and had merit. Unfortunately by the time we focussed on this particular application and this particular approach, there was inadequate time to take the method further. It was decided that it would be excellent for a good student to work on the data for an honours project during the year. Unfortunately no student took on the project in 2009, so the idea has not been tested in practice. It is hoped that the project can be taken further in this or another context under the umbrella of the Centre for High Performance Computing flagship project in Image Processing currently underway at the University of the Witwatersrand.