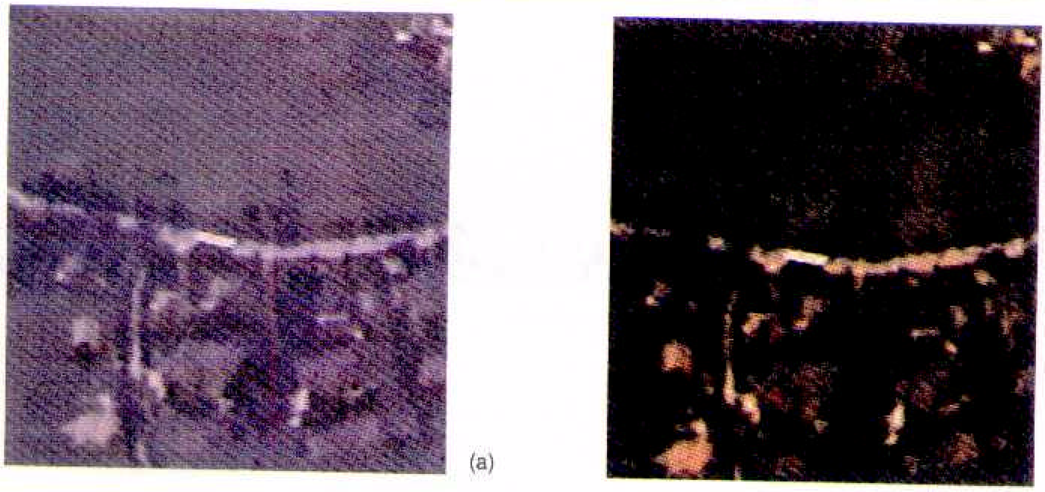

Figure 5: A radiometric calibration tool has been developed that corrects spectral errors caused by atmospheric scattering or absorbtion, as well as by sensor or processing errors. The operator finds pixels of known identity in the source image (a), and the algorithm modifies the spectrum in (b) to match spectral library entries for those substances.

the identity of the ground pixels. In practice, however, the method produces images with spectra that are significantly more correct than the source images and it has the advantage of working, if necessary, when no radiometric control points are available. Figure 2 illustrates how the clarity of an image can be improved by this form of atmospheric correction.

4.4 Mosaicking Sequential Images

Viewers are helped in the interpretation of video image sequences by the way that each frame exists in the context of surrounding frames. When a single frame is extracted, however, much of the context is lost. Mosaicking combines a sequence of images so that all the context information is visible in a single (larger) image. This also has the advantage of removing redundant information because only one version of the overlapping parts of the scene are presented.

A fully-automated tool has been developed [15] for mosaicking image sequences such as those transmitted by UAVs. Figure 2 shows a mosaic produced from Predator UAV video data [1] by the tool. The tool works in the following way:

1. it finds geometric tie points where the frames overlap, using the coregistration tool described in 4.2.1;
2. the operator identifies a set of known materials in the first patch, and the software creates a set of radiometric control points for absolute calibration;
3. it resamples the newly-added frame to the grid of the pre-integrated frame, using the geometric tie points;
4. it uses a least-squares algorithm to select a spectral correction that matches the spectra at identified "radiometric tie points" in the overlapping region.
5. if necessary, it applies a spectral "correction kernel" to every frame to accommodate spatial variations in brightness (due, for example, to systematic variations in the bidirectional reflection distribution function or "brdf").

A similar mosaicking capability has been demonstrated by the Sarnoff labs using data from an Unmanned Ground Vehicle [4].

4.5 Co-Display

Mosaicking doesn't work for images that have significantly different content. It would not be useful, for example, to form a mosaic using a topographic map, a video image frame, and a SAR image, because the information in the overlap areas is complementary rather than redundant. Yet there is clear value in viewing a SAR image in the context of an underlying map.

One solution is to *co-display* the images, so that they maintain their individual identities while being viewed in context. Two approaches to co-displaying were prototyped and evaluated, as discussed below.

4.5.1 Co-Moving Cursors

The co-moving cursor approach displays two or more images side by side with co-moving cursors under the operator's control. If a SAR image and a video sequence are co-displayed in this way, for example, then the operator can point to a feature in the SAR image, and look on the video to find the corresponding point. The SAR image is thus being interpreted in the context of the video image.

Figure 7 shows an example use of co-moving cursors in a change detection application. The two lower windows show the two source images with detected changes overlaid. The small upper windows show details of the cursor vicinity. The operator can use the co-moving cursors to relate features in the source images to each other, and to the detailed views. In this example, the images have all been coregistered and resampled to a common grid.

Co-moving cursors can also be used for sets of images that have very different projections. Consider the example of two images of a common scene, in which one view is from nadir and the other is oblique. In order to coordinate the cursors, a homeomorphism must be established between the two scenes. Generally this will take the form of look-up tables that are the same size as the images and that are derived from a digital elevation model and view-angle parameters.