Data Fusion

Prof. Chris Oliver, CBE

Mapping imagery, both photographic and SAR, shares common scene structures, such as the boundaries between fields, woods, roads and buildings. Though the brightness of the features is completely different, the information contained in the edges can be combined in various data fusion techniques.

Data fusion can operate on various levels:

1. When one sample of information can be regarded as exact, such as ground truth, it can be used as prior knowledge in interpreting another data source. An example would be supervised classification.
2. High-level data fusion is concerned with combining the processed output from each sensor. In this context we might segment each image separately and then compare the findings.
3. Low-level data fusion is concerned with combining the original images into a joint image-interpretation process. For example, we might segment registered SAR and optical images jointly, followed by joint classification.

Supervised classification

To illustrate the use of ground truth in classification we show results of combining ground truth with both ERS and Landsat TM band 5 data for a region of Northern Italy.

The ground truth has established the following classes:

1. Dry rice (red)
2. Wet rice (yellow)
3. Woodland (green)
4. Corn (cyan)
5. Urban areas (blue)

These are illustrated on the following page . The identified areas are split into training and test sets for use initially in supervised classification of each image separately.

The results demonstrate:

- the advantage of data fusion, in the form of joint segmentation and classification.
- the superiority of the adaptive filter approach of segmentation compared with the fixed 3x3 window.

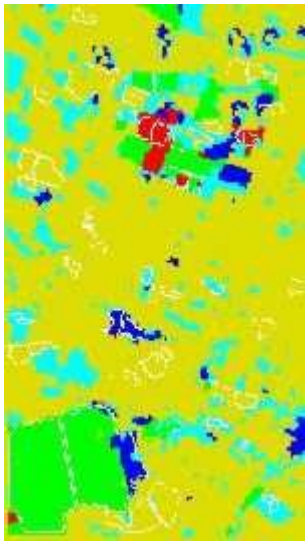
Original Images

TM band 5

ERS

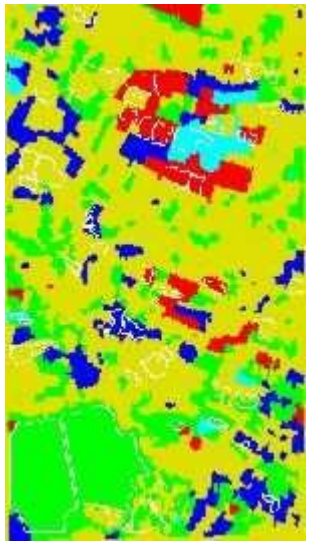
Ground truth

Individual classification performance



TM

Comparison of ground truth region boundaries with the individual ML classifications of the TM and ERS segmentations. The actual fraction of correct classifications is 0.786 for TM and 0.792 for ERS. Note that the ERS classification has much larger regions of dry rice (red) and urban (blue), whereas TM yields more corn (cyan).

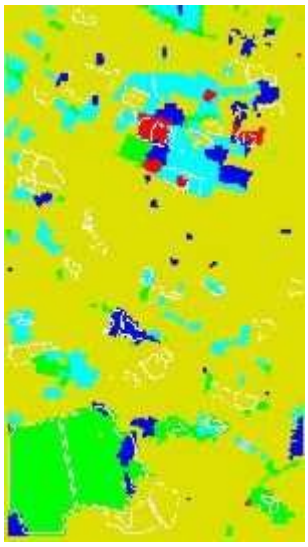


ERS

Image Fusion

Since both images are registered, the boundaries between structures in the scene should be identical. This implies that the edges in the segmentations should be similar, even though the mean value within each segment will differ.
For image fusion we perform a joint two-dimensional segmentation of both images. The total likelihood for independent processes is simply the sum of the individual contributions. The resulting joint segmentation should show improved boundary definition compared with the individual results. Image fusion could also involve joint classification which should yield better performance.
The advantage of supervised classification is that we can assess this improvement by observing the classification performance compared to the ground truth.

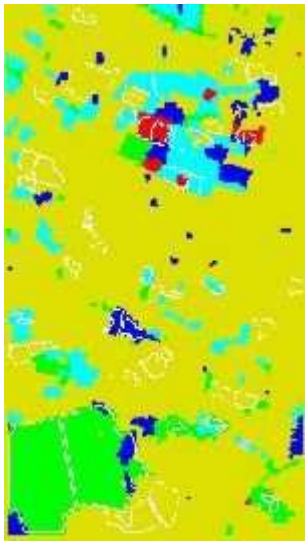
Joint classification result



Joint TM and ERS

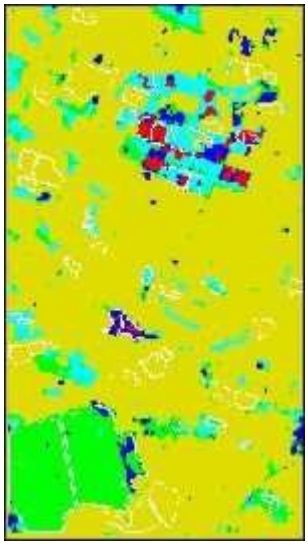
The comparison of the joint classification result with the ground truth region boundaries shows less ambiguity than the individual classification results. Indeed, the average probability of correct classification is now 0.883, a significant improvement compared with 0.792.

Joint segmentation versus 3x3 average



Joint segmentation

Finally, we compare the classification result for joint segmentation and classification with that for joint classification of the averages over a 3x3 window. The latter clearly shows many small errors. The average probability of correct classification is 0.883 for joint segmentation and classification compared with 0.738 for joint classification of the 3x3 average



3x3 average

Reference:
T. Macri Pellizzeri, P. Lombardo, C.J. Oliver
A new maximum likelihood classification technique for multitemporal SAR and multiband optical images
IEE Int. Symposium IGARSS, 2002, Toronto, Canada, June 2002.