

NEW TECHNIQUE FOR COMBINING PANCHROMATIC AND MULTISPECTRAL SPOT IMAGES FOR MULTIPURPOSE IMAGE-MAPS

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ABSTRACT:

Satellite images offer an efficient and quick data source to obtain the most recent and the urgently needed topographic or thematic maps. Present technology provides the possibility of accelerating the production of these maps. A new technique for combining SPOT satellite images with two different ground resolutions is described. Using various image processing methods, including enhancement techniques, a good quality image suitable for multipurpose image-maps can be produced within a short time.

1. INTRODUCTION

From early times, maps have served to give an image of the earth's features, as a guide for the traveller, as a record of locations, and as an identifier of geographical features. Systematic national development is not possible without adequate accurate and synoptic information on the nature, amount and distribution of human and natural resources. The conventional methods of production of topographic and thematic maps do not provide a satisfactory answer to the demand for maps because they are slow and expensive. Developing countries are still at the stage of completing their map coverage and in many cases most of the existing maps are of low quality and/or outdated.

During the past decades, the use of satellite remote sensing data for generating topographic and thematic maps has been the subject of much research and study.

The urgent need for maps, on the one hand, and the development of technology, on the other hand, will unquestionably provide countries with the opportunity of making active use of the new data acquisition technology from satellites and the possibility of accelerating base map production.

In this paper, a new technique is described for producing an improved image by combining SPOT panchromatic (10 m) and multispectral (20 m) bands. This product is the result of data pre-processing, feature enhancement, colour enhancement and image combination (Essadiki, 1987).

2. DATA PRE-PROCESSING

The basic processing (level 1B) of the raw data was performed at the receiving station in Toulouse, France. This level includes radiometric and line-by-line geometric system corrections with regard to the Earth's rotation and curvature, viewing angle, registration, etc. Some other processing needed for this study is described in the following paragraphs.

2.1 Haze correction of the multispectral bands

Haze correction (atmospheric correction) using only a first

order additive haze model was applied to the multispectral bands. The cut-off points were derived from the histogram showing the minimum value of each band. The estimated haze contribution to the signal is subtracted from the photon count value in each band for all elements in the numerical image.

2.2 Image to image registration using ground control points

The selected test area (Kasserine, Tunisia) gave a sufficient variety of terrain types, *je*, urban and rural, forest, arid, agricultural, etc. Figure 1.



Figure 1. The standard image (original)

2.2.1 Ground control point file

Image resampling involves the generation of a new digital data set which normally has scene element size, geometry and radiometric characteristics different from the original data set (Colvocoresses, 1986). The panchromatic and multispectral images in this study were acquired in the same orbit on the same day. For this reason, an affine transformation was used. The specific error model was derived from:

- the position of actual grid of scene elements (x, y) and

the indices in the numerical matrix: $(x, y) = f(\text{row}, \text{column})$,

- the position of grid cells in the ideal grid (u, v) and the corresponding indices: $(u, v) = g(\text{row}', \text{column}')$.

For resampling the 20 m multispectral data into 10 m scene elements, a file containing ground control point coordinates was needed. This was achieved by identifying sets of features (six were sufficient) that were common to both images using the 20 m resolution image as “slave” and the 10 m image as a “master”. Features taken as ground control points (GCPs) were line intersections, field boundaries and intersections of roads.

The registration process was executed by running the interactive ground control point selection program to generate the control point file.

2.2.2 Resampling the SPOT data

Three methods are generally used for resampling: nearest neighbour (NN), bilinear interpolation (BI) and cubic convolution (CC).

The NN method was used for this study because it was readily available. Its advantage is in copying existing values but it has the disadvantage of producing geometric artefacts, as does CC. BI does not introduce geometric artefacts. CC may be acceptable for visual interpretation but not for further spectral classification methods where the radiometric distortion will increase.

The differences between GCP locations on the slave image and the master image were submitted to a least squares regression analysis that interrelated both image coordinates. The resulting residuals were less than one-half element spacing in both row and column, which meant a good registration was achieved. Three files were created, representing the resampled three multispectral bands, and were merged afterwards.

3. FEATURE ENHANCEMENT TECHNIQUES

The usefulness of digital image processing techniques has been demonstrated many times for extracting information about land use, forestry and so on. To assist the work of interpreters and to improve the visual impact of the image, the data are usually enhanced after correction.

Image enhancement includes a large range of techniques which usually transform a given image into another two-dimensional representation more suitable for either machine or human decision making (Mulder, 1986; Holderman, 1976).

Features can be divided into spatial features and spectral features. The three classes of spatial features are homogeneous areas, edges (boundaries) and lines. Feature detection follows the evaluation of the “evidence” (*le*, indicators of their presence) for one of these classes. If there is sufficient evidence, a feature is said to be “detected”. Detected features can be represented in an enhanced image or the evidence can be strengthened. Evidence is derived from a set of feature extraction operators; for example:

- smooth areas → averaging operator;
- edges → gradient operator;
- lines → Laplacian operator.

These enhancement operations are characterized by

operations over a limited neighbourhood (sub-image) in the image, using a 3 x 3 kernel filter (convolution) moved across the image which yields a transformed image.

Every element of a sub-image is processed with its eight neighbours in the input image by multiplying all elements by their respective weighting coefficients and the results are summed. The result is assigned to the central element in the output image.

4. EDGE AND LINE ENHANCEMENT OF THE PANCHROMATIC IMAGE

Most digital images are handicapped by noise (unwanted variation in a signal) and blurred edges caused by the sampling process. The aim of the experiment was the visual improvement of the image using enhancement techniques to make it “sharper” and easier to interpret. Linear features, such as roads, railways and rivers, are major components of topographic maps. The enhancement of edges and lines is therefore very important and an effective means of increasing geometric detail in the image.

Blurring is an averaging or integrating operation (Rosenfeld, 1976). The image can therefore be sharpened through differentiation operations. Laplacian operators (which are differentiating filters) are the most useful for this sharpening (Rosenfeld, 1976; Dawson, 1985). The Laplacian filter is an omni-directional operator and enhances noise as well as signal, figure 2.

It has been demonstrated in many studies (Rosenfeld, 1976; Baxes, 1984) that our eye/brain system applies a Laplacian-like enhancement to everything we view. Consequently, if an “edge” image is added to its original, the resultant sum image will have a “natural sharpening”.

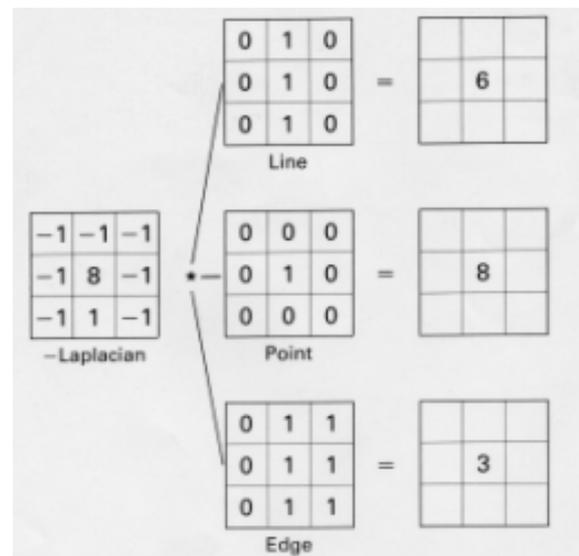


Figure 2. Effect of Laplacian filter on a line, a point and an edge

5. COLOUR SATURATION ENHANCEMENT

Colour coding and image enhancement aim to present the data in such a way that the eye/brain can extract the maximum information for a given purpose and under given

limitations (Mulder, 1986). Enhancement is used to improve the image's interpretability. Saturation enhancement, which is a part of the colour coding, is implemented by using the linear 3 x 3 matrix transformation on the multispectral data:

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} M^{-1}A & M \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} m1 \\ m2 \\ 1 \end{bmatrix} = \frac{1}{I} \begin{bmatrix} M1 \\ M2 \\ I \end{bmatrix} = \frac{1}{I} M \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The main purpose of M mapping is to transform the RGB domain into the intensity normalized R' G' B' where we can specify change in colour balance, change in hue and change in saturation, independent of intensity. m1 and m2 are orthogonal axes in the two-dimensional colour triangle R' G' B' derived from the colour space (colour cube). "The colour space is a linear space in which the mixture of two additive colours is equivalent to a colour vector which is a linear interpolation of the mixing colour vectors" (Mulder, 1986) (see Figure 3).

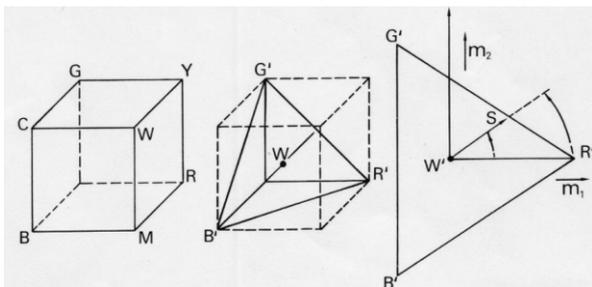


Figure 3. The colour cube and the colour triangle

A is a matrix which performs an affine transformation of the data triangle onto the corners of the colour triangle by bringing the vegetation to green, the soil to red and the water to blue (Figure 4).

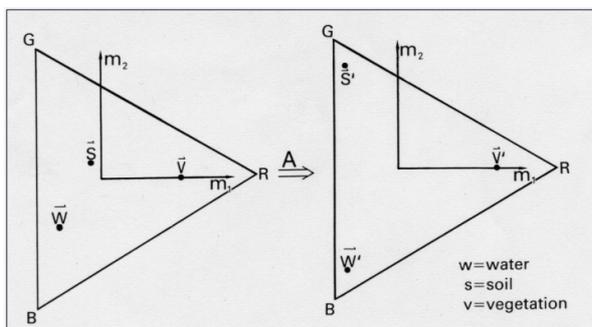


Figure 4. Affine transformation with A matrix

M^{-1} is the inverse of M which brings back the data from the M1, M2 I domain into the RGB coordinate system (the colour cube). Before the execution of the matrix multiplication, however, parameters for colour enhancement were derived

from the scatter diagram on m1, m2. A two-dimensional scatter diagram of m1 and m2 was made for this purpose. The colour triangle was drawn onto the scatter diagram (Figure 5). In this study, the A matrix implements only a saturation enhancement (stretching and shifting on the m1, m2 axes).

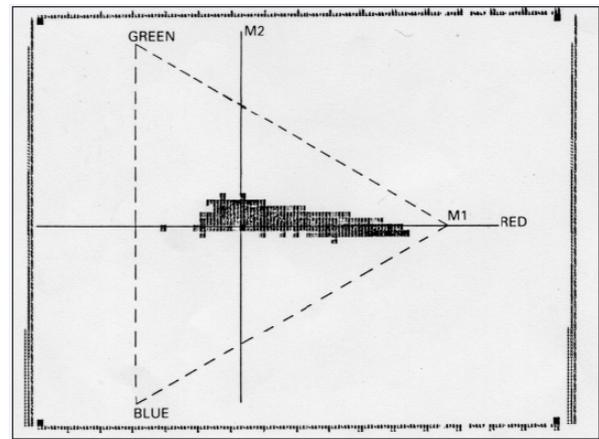


Figure 5. A two dimensional scatter diagram of m1 and m2

The saturation enhancement is implemented by using the resulting matrix as a multiplication factor to the RGB coordinates of the original image to obtain the new R'G'B' coordinates (as new feature files) of the colour enhanced image. Figure 6 shows the scatter diagram after saturation enhancement.

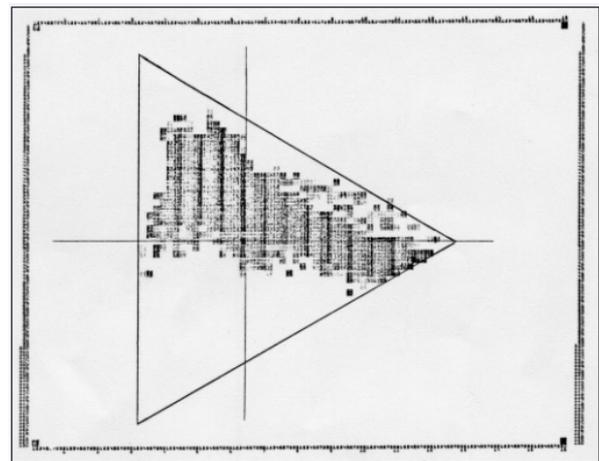


Figure 6. Scatter diagram after saturation enhancement

6. COMBINATION OF PANCHROMATIC AND MULTISPECTRAL BANDS

Many applications of remote sensing image data require two or more images of the same area to be represented together for various purposes (eg, change detection). Having the high resolution panchromatic 10 m ground resolution and the multispectral 20 m, the basic idea was to merge them to use the double data set to get a better image with more details.

Different experiments were carried out to illustrate this combination:

- (1) enhanced panchromatic plus the haze-corrected multispectral with saturation enhancement of colours;

- (2) enhanced panchromatic plus the haze-corrected multispectral.

The various steps for integrating the panchromatic and multispectral images were described above. These were followed by the normalization of bands and their combination.

7. NORMALIZATION AND COMBINATION OF BANDS

Knowing that intensity I (photon count) depends mostly on external factors, such as sun angles, surface orientation, shadow, band normalization was used which splits the intensity and reflectance(s) for proper feature extraction. This was carried out by dividing the intensity of the panchromatic band by the sum of intensities of the three bands of the multispectral for each image element (resampled to 10 m scene element).

I_p/I_d x scaling factor,

I_p is the intensity of panchromatic and I_d is $R+G+B=$ sum norm

First, for all image elements the sum of bands (R, G, B) which represents the total photon count (intensity) was calculated and the result was merged with the enhanced panchromatic image to get the ratio. The final step was to merge the ratio result and the enhanced multispectral image. Figure 7 shows the result.

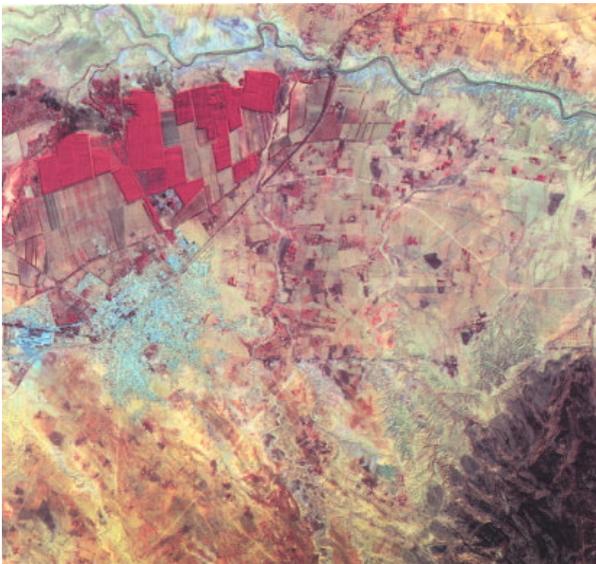


Figure 7. Combination of enhanced panchromatic and multispectral with saturation enhancement

Another test was carried out by merging the enhanced panchromatic image with the non-enhanced (original) multispectral image.

8. CONCLUSIONS

The products were shown to more than 30 persons, including specialists in various earth science and mapping disciplines. Their reactions were positive to the combination of the enhanced panchromatic and the saturated enhanced bands of the multispectral data. It seems likely that this result could be a

multipurpose image- map.

If it is used as a background of an image- map, it will be incomplete without indication of other information, such as utilities, names, administrative boundaries, etc. Annotation is therefore needed.



References

- Baxes, G A. 1984. Digital Image Processing, a Practical Primer. Englewood Cliffs, New Jersey.
- Bernstein, R. 1975. Digital image processing. . PERS journal, pp 1465-1476.
- Colvocoresses, A P. 1986. Image mapping with the Thematic Mapper. PERS journal, Vol 52, No 9, pp 1499-1505.
- Dawson, M B. 1986. Image filtering for edge enhancement. Photonics spectra, pp 93-95.
- Essadiki M. (1987). Evaluation of SPOT images for topographic mapping at scales 1:50 000 and 1:100 000. Msc thesis, Cartography Department, ITC. Enschede, The Netherlands.
- Holderman, F, M Bohner , B Bargel and H Kazmierczak. 1976. Review of image processing. Proceedings of ISPRS Congress, Helsinki.
- Mulder, N J, 1986. (Personal communication, including various ITC lecture notes on "colour encoding and image enhancement, pattern recognition and decision making", and "image processing, pattern recognition and artificial intelligence").
- Rosenfeld, A and C A Kak. 1976. Digital Picture Processing. Academic Press, New York and London.

