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CLASSIFICATION AND ESTIMATION OF GROUND FEATURES USING THEMATIC MAPPER LANDSAT SCENES

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In this paper we present two algorithms [1] for ground features classification and area estimation, using thematic mapper (tm) landsat scenes [2], and apply these algorithms for measure of cultivated land (estimation of crop coverage in hectars).

I. ALGORITHMS

1st method

We consider a multispectral band scene S, e.g. TM LANDSAT scene,

$$S = [p_{ij}^k] = [v_{ij}]$$

with image vector elements:

$$v = (p_{ij}^1, p_{ij}^2, p_{ij}^3, p_{ij}^4, p_{ij}^5, p_{ij}^6, p_{ij}^7),$$

where $i, j = 0, \ldots, 512$, are scene dimension indices (512 x 512 pixels), k=1, ..., 7, is the radiometric band number, and $0 \leq p_{ij}^k \leq 255$, is the gray level dynamic range (8 bit).

We consider also a picture element, real or subjective, called the reference or training pixel:

$$r = (\sigma^1, \sigma^2, \sigma^3, \sigma^4, \sigma^5, \sigma^6, \sigma^7),$$

and calculate the matrix $D = [d_{ij}]$, with "distance" vector elements

$$d_{ij} = \mathrm{dist}(r, v_{ij}),$$

where we define as a "distance" d_{ij}:

$$d_{ij} = (|\sigma^1 - p_{ij}^1|, \ldots, |\sigma^7 - p_{ij}^7|) = (\beta_{ij}^1, \ldots, \beta_{ij}^7)$$

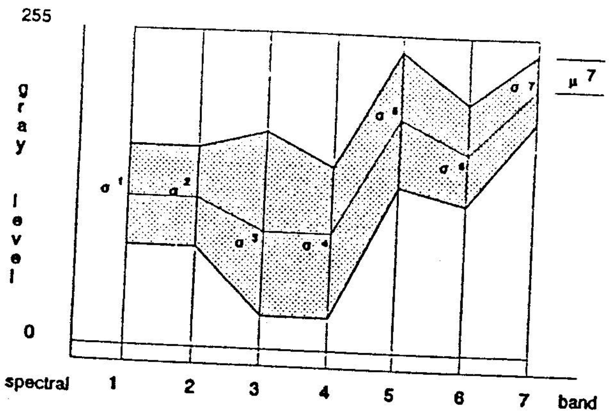

Fig. 1.

or a similar metric e.g. square of differences e.t.c.

We consider also a vector

$$m = (\mu^1, \ldots, \mu^7), \quad \text{with} \quad 0 \le \mu^k \le 255,$$

and compute the binary scenes (images):

$$Q^k = [q_{ij}], \quad q_{ij} = \begin{cases} 0, & \beta_{ij}^k > \mu^k \\ 1, & \beta_{ij}^k \le \mu^k \end{cases}, \qquad k = 1, \ldots, 7$$

where m allows to specify the "distance interval", on which the picture elements fulfil the selection criterion. Fig. 1 depicts this relation.

In these binary scences we "recognize" only those (ground) picture elements, whose gray-levels for each spectral band separately, have a distance less than or equal the absolute value of the difference β_{ij}^k. This is the logical (AND) section of the seven binary images Q^k.

2nd method

In this second method we use again the "distance" term in a sense similar to the statistical nature of metric, as one of the least square methods. We consider a multispectral scene S and a reference picture element r and compute the matrix

$$D = [d_{ij}]$$

with elements d_{ij} defined by the relation:

$$d_{ij} = w^1 * (\sigma^1 - p_{ij}^1)^2 + \ldots + w^7 * (\sigma^7 - p_{ij}^7)^2,$$

or

$$\mathbf{D} = [d_{ij}] = \sum w^k * (\sigma^k - p_{ij}^k)^2$$

with $k = 1, \ldots, 7$, where

$$d_{ij} = w^1 * |\sigma^1 - p_{ij}^1| + \ldots + w^7 * |\sigma^7 - p_{ij}^7|,$$

or

$$D = [d_{ij}] = \sum w^k * |\sigma^k - p_{ij}^k|,$$

with $k = 1, \ldots, 7$ and

$$W = (\omega^1, \omega^2, \omega^3, \omega^4, \omega^5, \omega^6, \omega^7)$$

a weighting vector.

We consider also two values A and B in the interval

$$0 \le A \le B \le \max(d_{ij})$$

and compute the (artificial) binary scene (image):

$$\mathbf{Q} = [q_{ij}], \quad q_{ij} = \begin{cases} 1, & \text{if } A \le d_{ij} \le B \\ 0, & \text{otherwise} \end{cases} \qquad k = 1, \ldots, 7$$

The d_{ij} elements define the "distance" of each pixel of the multispectral scene, with elements the vectors v_{ij}, from the reference vector **r**. In the recognized binary image appear only those elements (pixels) whose corresponding distances d_{ij} are inside the selected interval $[A, B]$, e.g. there appear all the pixels q_{ij} with the value of 1. The weights w^k allow the variation of inclusion of specefic pixels in the final recognized scene with usual weight values of 0 and 1.

II. APPLICATION OF THE METHODS, COMPARISONS, REMARKS

We give an application example of each method of recognition. In the first example the ground pixel (255,315) was chosen as a reference point, which by inspection we found to lay inside the interesting crop area and which has a vector value of (82, 33, 26, 106, 59, 136, 16). The radiometric components represent the radiation intensities in the 7 remotely sensed wave lengths of the LANDSAT radiometers with a ground pixel coverage of $30m \times 30m$, except the 6th component, which corresponds to the far-infrared band with an IFOV (instantaneous field of view) of $120m \times 120m$. A distance vector was chosen with a value of (5,5,5,5,5,255,5) which signifies that with this metric we want to recognize all the possible ground points lying in a range of five DN (Digital number - gray level) from the corresponding values of the radiometric measures of the reference pixel, except the points of the band 6 (far-infrared) which play no role in the recognition, since all pixels are candidates for recognition with the choice of a weight value of 255 DN, i.e. band 6

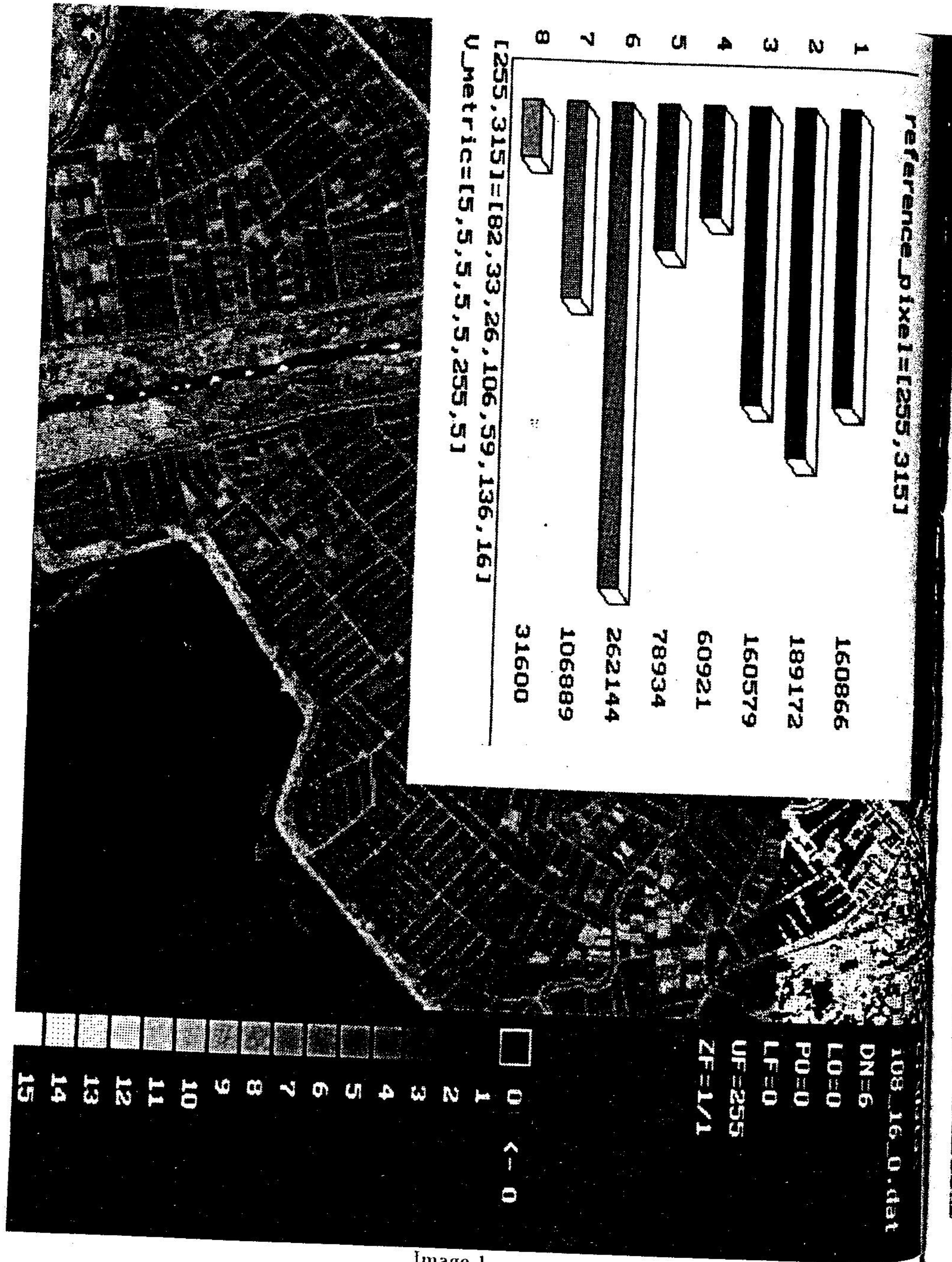

Image 1.

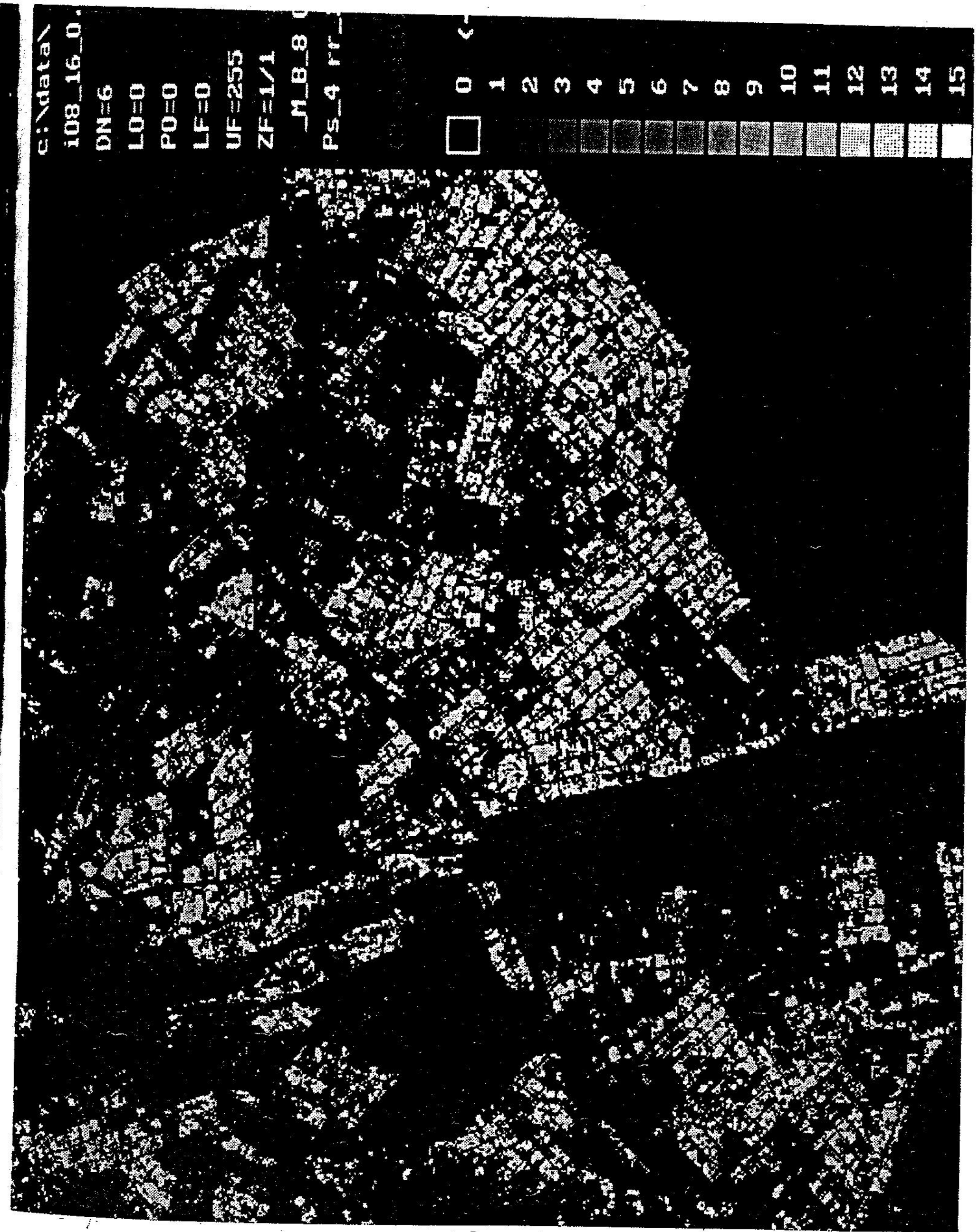

Image 2.

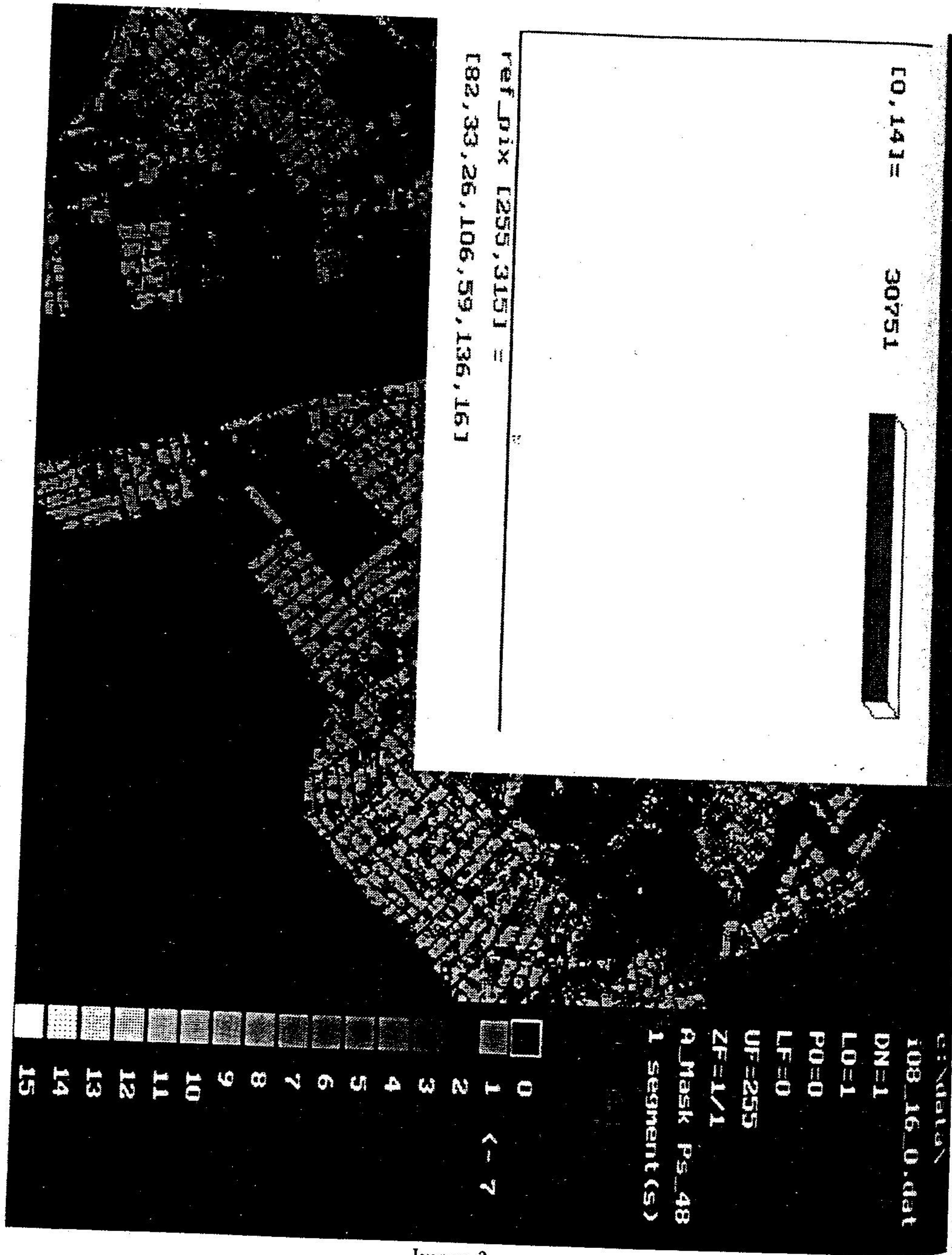

Image 3.

Image 4.

is excluded from the computations. So the binary scene produced by considering band 1 pixels includes all points having a radiometric value in between abs(82-5) and abs(82+5), i.e. in the range of 77 to 87. Similarly the rest of binary scenes from 2nd to 7th include all the pixels with indensities in the range of 28 to 28 for band 2, 21 to 31 for band 3, 101 to 111 for band 4, 54 to 64 for band 5, 0 to 255 for band 6 and 11 to 21 for band 7. The final (recognized) scene includes only those points which have been recognized commonly to belong to all binary images, that is the logical section (AND) of binary scenes 1 to 7 (same pixel location in all bands).

Image 1 displays the graph of distance vector range in the seven bands. The area in between the vector graph includes all pixels which have been recognized to belong to the ground field area with the same spectral characteristics (in our case rice cultivated fields).

In concluding, in relation to the chosen reference and distance vectors in each binary scene have been recognized to belong: 160866 pixels in band 1, 189172 pixels in band 2, 160579, 60921, 78934, 262144 and 106889 for bands 3 to 7. In the final recognized binary scene, Image 2, appear 31600 pixels which includes all the ground points that most probably have the same spectral characteristics with the chosen reference pixel (255,315), which by visual image inspection has been chosen to represent rice crop. The total coverage of rice crop is $30 \times 30 \times 31600 = 28440000$ square meters or 28440 hectars.

In the second example we use the same scene. Image 3 displays the segment of the area, which includes all points with a distance difference of 0 to 14 (pure number) from the reference point (255,315). Image 4 displays the final recognized segment, which includes 30751 pixels in comparison with 31600 pixels recognized by the 1st method. The area coverage is $30571 \times 30 \times 30 = 27675$ hectars. So there is a difference of 764 hectars. So far there is no evidence which of the two methods is more accurate, but we believe that each gives results more or less accurate with respect to the ground morphology and the spectral characteristics of it. Varying the distance and weight vectors no significant change has been observed in the recognized areas with the scenes used so far. The common areas recognized by the two methods combined give 24096 pixels as belonging to the rice crop cultivated area. The total area of an image 512×512 pixels is 235930 hectars, so the 764 difference pixels corresponds to a deviation of 0.3 % or 2.5 % of the recognized rice cultivated area.

The processing of image data has been made in a VAX 8350 system in cooperation with a VISION ONE / 20 COMTAL of 3M digital image processing system and the final scenes have been transferred to a PC-AT system for final processing and printing to an HP LASER II printer.

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