

SOFTWARE TN ESTUDIO V2.0: INTEGRATION OF DIGITAL IMAGES PROCESSING TOOLS WITH PATTERN RECOGNITION TO SUPPORT THE REMOTE SENSING STUDIES

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ABSTRACT

Over the past years, digital imagery applications had a strong growth. In scientific fields, this technology is fast becoming mainstream in many applications and is implanted solidly in remote sensing domain. This fact produces the necessity of software to process digital images. Tn Estudio software joins the tools developed in Cuba since last ten years in digital image processing applied to mapping and remote sensing. The software was developed taking into consideration the working experience with national and foreign software, using object oriented programming with C++ language for Windows 98/NT platform. There are available both, general and transform operations to apply on images. Among the last kind of operations, the user will find pixelwise operations, binary operations (arithmetical, logical, comparative, vegetation index), multi band operations (principal component analysis, statistical, comparative, false color, color decomposition), enhancement, linear and non linear digital filtering with internal and external filters, filter design in space and frequency domain (low pass filter, high pass filter, band pass filter, second and fourth vertical derivative filter), edge and line detectors, local segmentation, global segmentation (histogram based segmentation), region based segmentation (region growing, split, merge and split – merge). In our digital image processing system, a set of supervised and unsupervised classification techniques is added. of Some examples of applications in different scientific fields such as remote sensing, geoscience, agriculture, forestry, environmental studies are presented. This system has been used as an useful tool to teach digital image processing in postgraduate courses at Universities and research institutes in our country.

1. INTRODUCTION

Digital Image Processing (DIP) has as objective the improvement of the graphic information for the human interpretation and the data processing of the scene for the automatic perception for computer (González and Wintz, 1977). This technique has presented an impressive development in last decade, so much in the theoretical aspects as in the applications, in accordance with the technological progress that facilitated the development of the hardware and the software. DIP constitutes the main technology of work in a great variety of areas; in digital telecommunications, broadcasting, medical applications, medicine, biology, robotics, multimedia systems, materials science, earth sciences, Remote Sensing, graphic arts and painting. The application tasks have created the necessity to build a variety of analysis algorithms to digital image treatment, being dispersed most of them, in excellent scientific magazines and in specialized books (Pitas, 1992).

Many of those algorithms have been automated in different software dedicated to the DPI with scientific and artistic goal. In our country they have also been developed different software of general purpose for the DPI of which the main exponents are the IMAG PC V1.2 (Valdés, Gil, Hita, et al., 1992), TeleMap (De Armas, et al., 1994), MADIP (Rodríguez, 1994), DIPSY V1.0 (Valdés, Gil, Hita, et al., 1993), RSI (García, 1996), Tx Estudio (Gil, 1996) and DPI (Sepúlveda, 1996).

The experience of several softwares as IMAG-PC (treatment of two-dimensional information), DIPSY (treatment of images up to 64KB) and RSI (guided to multi spectral images in Remote Sensing), all of them with a high calculation power, were taken as reference for the design and programming of Tn Estudio System, reason why they are considered their predecessors.

Tn Estudio System allows to process images in gray tones of 8 bits/pixel, which are from the different applied field, included multi spectral images of more than 100 MB. In this version the treatment of two-dimensional information was not included.

2. CHARACTERISTICS OF TN ESTUDIO SYSTEM V2.0

The present version is written applying the object oriented programming technology for which was used as programming tool the Visual C++ Version 6.0 created by the Microsoft Corporation. The Microsoft Foundation Class library is the base on which the application was developed. It is a software for Windows 32 bits that runs on the Windows 95 operating system, or superior. The BMP format image file is used in Tn Estudio as the standard to store image files. It admits the reading of image groups that are thrown them from the Windows Explorer.

3. GENERAL OPERATIONS AVAILABLE IN TN ESTUDIO V2.0

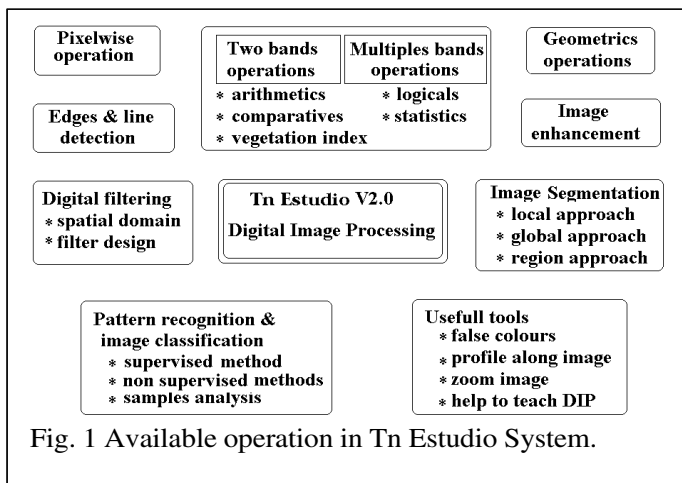


Fig. 1 Available operation in Tn Estudio System.

- ◆ Displaying and manipulation of the images taking advantage of Windows facilities.
- ◆ Processing the complete image, or only certain region of the same one, defining an active work area previously.
- ◆ Displaying of image details using a “glass magnifying” (zoom).
- ◆ Creation of the false color images, using three gray tones images.
- ◆ Obtaining of general information about the image and its statistics properties (taking account the active work area of the image).

4. TRANSFORM OPERATIONS AVAILABLE IN TN ESTUDIO V2.0

In Fig. 1 are shown the groups of available operations, among them, are included preprocessing tools and analysis tools. The access to these tools is organized in two different menu; the DPI menu and the Classification menu where the listings of treatments appear.

4.1 Pixelwise operations

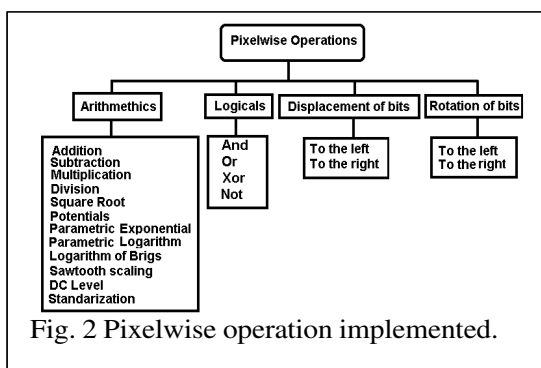


Fig. 2 Pixelwise operation implemented.

The pixelwise transformations (Fig. 2) are those in which each pixel of the output image is the result of the application of a function whose only argument is the pixel value in the original image.

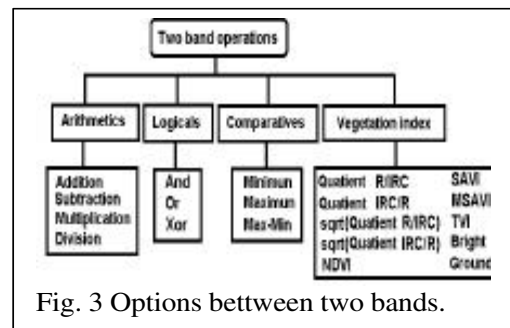


Fig. 3 Options between two bands.

4.2 Two bands operations

The binary operations or also operations among matrix are made between two images (Fig. 3). These operations are those in which each pixel of the output image is the result of the application of a lineal function between two pixels (i, j) of both images. The procedures applied are interpreted as the overlapping of the images whose have the same size. Some specific operations like the calculation of different vegetation index very useful in forest studies are included

4.3 Multiple band operations

Among more than two images or spectral bands, statistical and comparison operations can be executed (Fig.

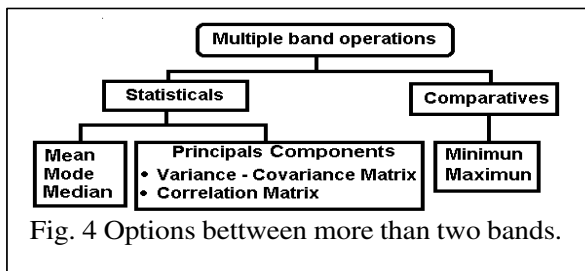


Fig. 4 Options between more than two bands.

4). They allow to build a new image of the statistical parameters like media value, median value, modal value, minimum value and maximum value. The calculation of the principal components, as an statistical multiple band operation is implemented.

4.4 Image enhancement operations

It consists on the improvement of the visual information

of the image on the basis of operations that are carried out on their histogram or using different statistical techniques (Fig. 5).

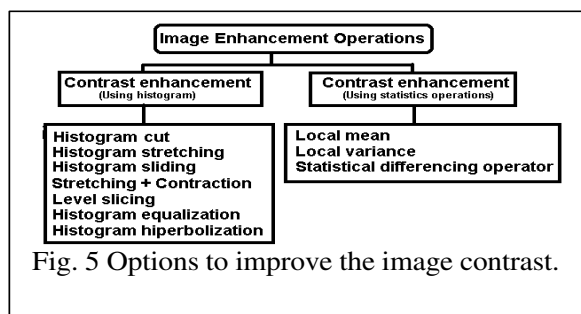


Fig. 5 Options to improve the image contrast.

4.5 Edge and line detectors

The edges are basic features of the images. They contain useful information about the limits of the objects which can be used in the image analysis, the objects identification and filtering operations. The edges detection operators (Fig. 6) are based on the local characteristics that usually reflect abrupt changes in the values of the scene. The edges are characterized by gray tones strength and direction. In this sense Tn Estudio offer several operators to determine both magnitudes. As a particular case, the skeletonization is a process where the output image has the edges with one pixel width.

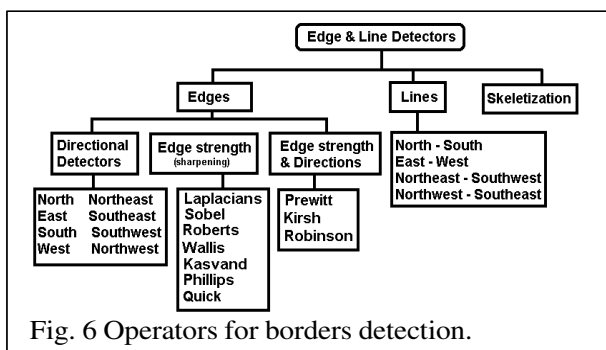


Fig. 6 Operators for borders detection.

4.6 Digital filtering

The digital image filtering is a technique of improving the graphic data numerically, causing the attenuation of certain components of a signal based on some appraisable property present in the image, as the frequency, the amplitude or the gray tone. The digital

filtering can also be seeing as the process that allows the decomposition of the original information in its constituent parts. Tn Estudio gives the possibility to use internal filters (lineal and not lineal), external filters from a file text and the option of creating its own masks (Fig. 7).

4.7 Design of filters

The operation of building a digital filter in frequency domain, consists on calculating a group of coefficients whose have the capability of modifying the spectral composition of the image according to the characteristics the researcher defines. The design of two-dimensional digital filters is an additional usefulness of our system that allows to built filters with specific properties, to transform the image data in the space domain. The design of low pass filters, high pass filters, band pass filters, second vertical derivative filters and fourth vertical derivative filters are admitted.

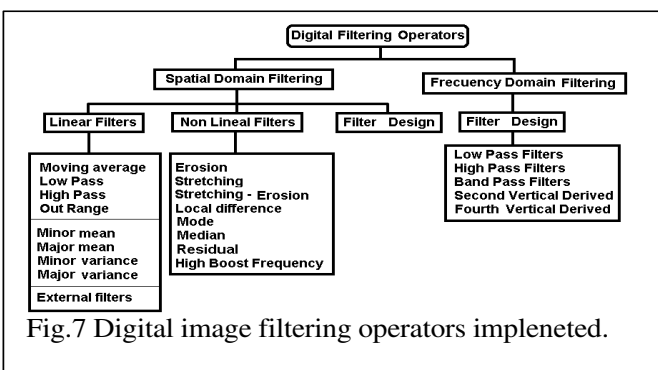


Fig.7 Digital image filtering operators impletened.

4.8 Segmentation operators

The purpose of the image segmentation is to split the image in significant regions. Three different concepts of image segmentation were implemented. The first one, named Local Techniques are based in the local properties of the pixels and their 8 neighbors. The second one, named Global Techniques use the information contained in the histogram of the whole image and the last one, named Regional Techniques are based on the

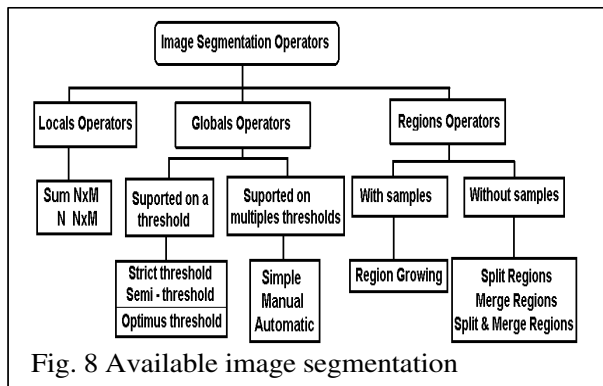


Fig. 8 Available image segmentation

treatment of regions from image using jointly the notions of homogeneity of the areas and the geometric vicinity of the pixels. The operators are shown in Fig. 8.

4.9 Digital classification

This is the process of finding inside the image, the areas that possess a similar behavior using pattern recognition techniques of supervised or non supervised procedures. The classified output image offers the objects grouping into categories or classes. The analysis takes place automatically obtaining as results, thematic images (maps) of easier interpretation from its colored

representation. In the present version of Tn Estudio it has a representation of statistical methods for the supervised and not supervised classification (Fig. 9). A comfortable user interface to locate the samples in the multi spectral image, to extract the values that represent the control and learning matrix is added. A procedure to execute the samples cleaning previous the classification was programmed. At the end of the classification process our application offers a statistical chart containing the errors ocurred (confusion matrix) where the investigator picks up quantitatively the accuracy of the image classification according with the sample set selected (García, 1996; Gil, 1995).

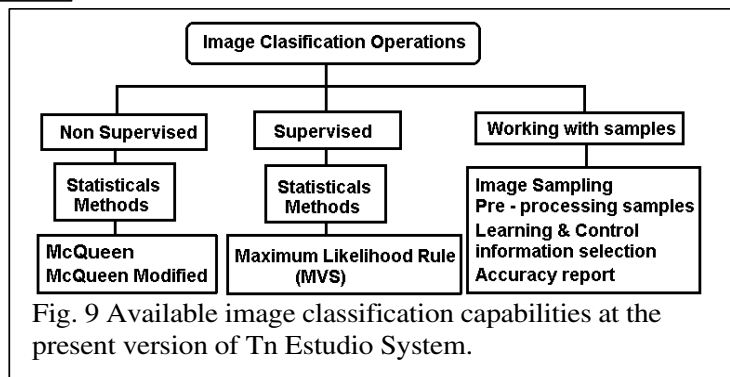


Fig. 9 Available image classification capabilities at the present version of Tn Estudio System.

5. EXAMPLES OF REMOTE SENSING APPLICATIONS

5.1 Localization of sand bars

The image contained in the Fig. 10 (left) corresponds with the spectral interval of the band 3 tacked from a multi spectral image registered by the Landsat TM satellite. The visualized area displays the vicinity of Cayo Coco in the north of the Cuban archipelago. The main objective in this processing was to specify the extension of sand bars. The segmentation technique using the method of region growing with a threshold of 10 was applied. Several seeds were sowed in different parts of the original image in order to recognize the present classes, such as roads, vegetation, marshy areas, low marine depth, deeper depth and the beach sands. As a result, in Fig. 10 (right) the segmented image appears, standing out in yellow color the presence of the sand bars. Observe that, independently of the segmented regions, in the image appears some areas with black color, that represent the non - classified parts on the image because they could not be associate to none of the defined categories. The method of interpreting natural classes inside an image, based in the sows of seeds that grow inside the regions until defining the extension of their homogeneity is incorporated for the first time in Cuba for the Remote Sensing applications.

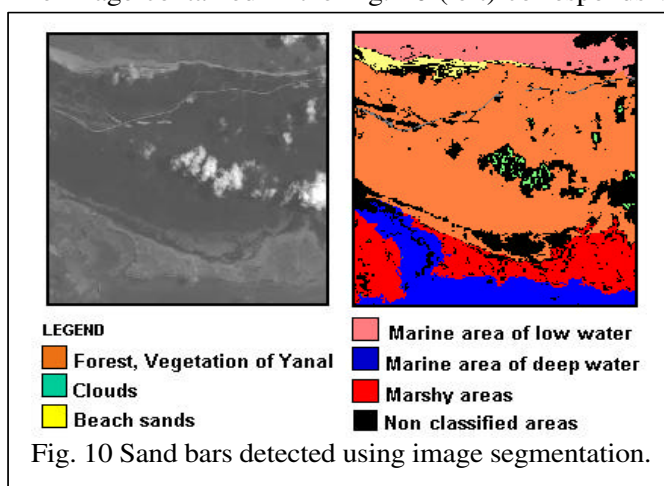


Fig. 10 Sand bars detected using image segmentation.

represent the non - classified parts on the image because they could not be associate to none of the defined categories. The method of interpreting natural classes inside an image, based in the sows of seeds that grow inside the regions until defining the extension of their homogeneity is incorporated for the first time in Cuba for the Remote Sensing applications.

5.2 Land use map

Another possible application of the software is the geographical studies and the data collection from images about the natural environment. In Fig. 11 appear a map with the current uses of soils in a territory. The initial data is an aerial photograph that was processed in Tn Estudio using the region growing. The output image was geocoded and finally edited as a map. It is also possible to use a satellite image instead an aerial photograph.

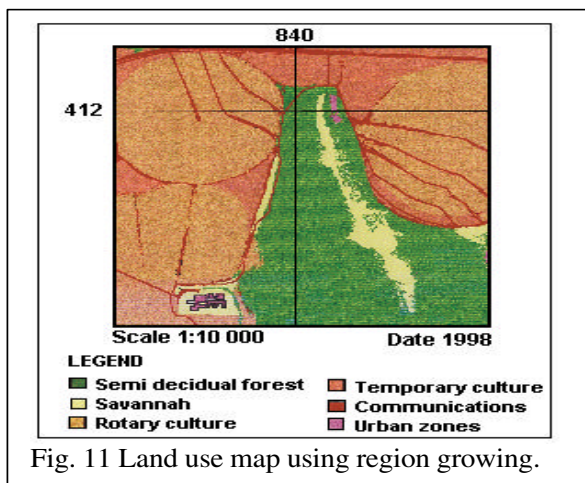


Fig. 11 Land use map using region growing.

the limits of the three areas, being demonstrated the usefulness of the software for environmental impact studies.

5.4 Basic preparation of the image

The pre-processing operations prepare the input image for their interpretation. Among these, the enhancement operations, improve the image radiometric composition, redistributing the frequencies of its histogram to achieve a better contrast. In Fig. 13 we have been applied some of these techniques on an aerial panchromatic image of the core area of the biosphere reservation at Sierra del Rosario, Pinar del Rio, Cuba. That image was cutted and equalised without division of the grey tones. To eliminate the salt and pepper noise, a first step of digital filtering with the median filter was applied and finally, a false color image was synthesised with three artificial bands.

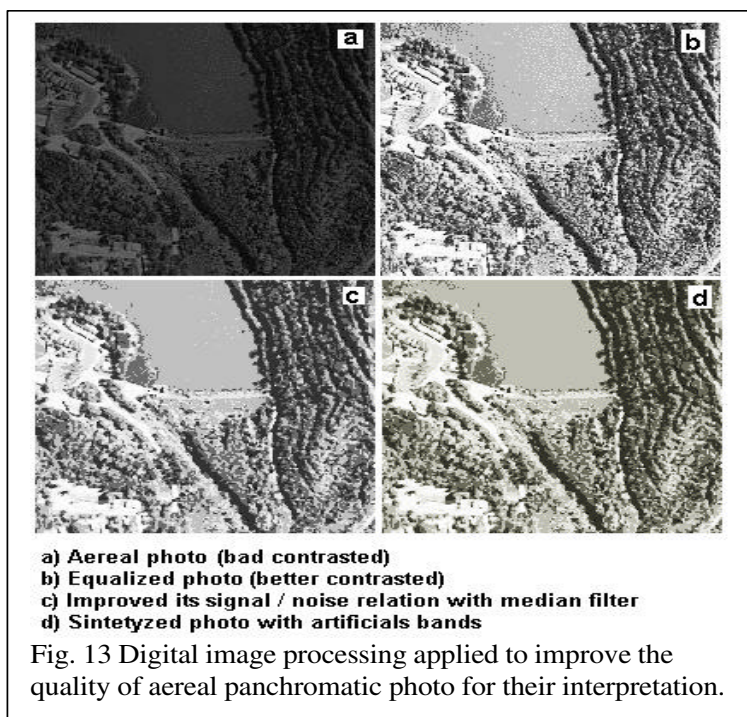


Fig. 13 Digital image processing applied to improve the quality of aerial panchromatic photo for their interpretation.

binary image (Fig. 14d). Third step, skeletization (Fig. 14e) where was possible to eliminate the isolated noises

5.3 Study of an environmental impact

The objective in this example is to study a coastal area which was invaded by the sand, generating affectations in the mangrove vegetation. To determine the extension of the affected area in terms of high, mean and low, a panchromatic aerial image was used. To this purpose a supervised classification, employing the Maximum Likelihood Method was carried out. The procedure consists of taking representative samples patterns of each one of the classes (categories of affectation) that are wanted to be identify, in our case, the damaged mangroves. In Fig. 12 appears the image classified with

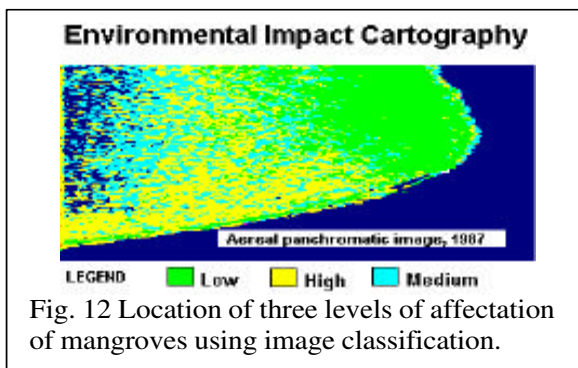


Fig. 12 Location of three levels of affectation of mangroves using image classification.

5.5 Preparation of an image for its vectorial representation

Fig.14 show a sequence of steps to achieve that a scanned image of a contour map (Fig. 14a) be ready for its vectorial representation (vectorization). The process of direct binarization, starting from the original image, generated an image of bad quality, unacceptable for its later vectorization (Fig 14b). Using Tn Estudio System the following steps were executed to improve the result. First step, a procedure of digital filtering was applied with the high – boost filter (high frequency emphasis filter using A=1.1) where the output image, Fig. 14c, looks better than the original image, with a relative degree of edge enhancement. Second, a segmentation step using the strict threshold, with a threshold equal to 80, being obtained a new

that were appreciated. Now, under these conditions the image be ready for their input to a vectorization software.

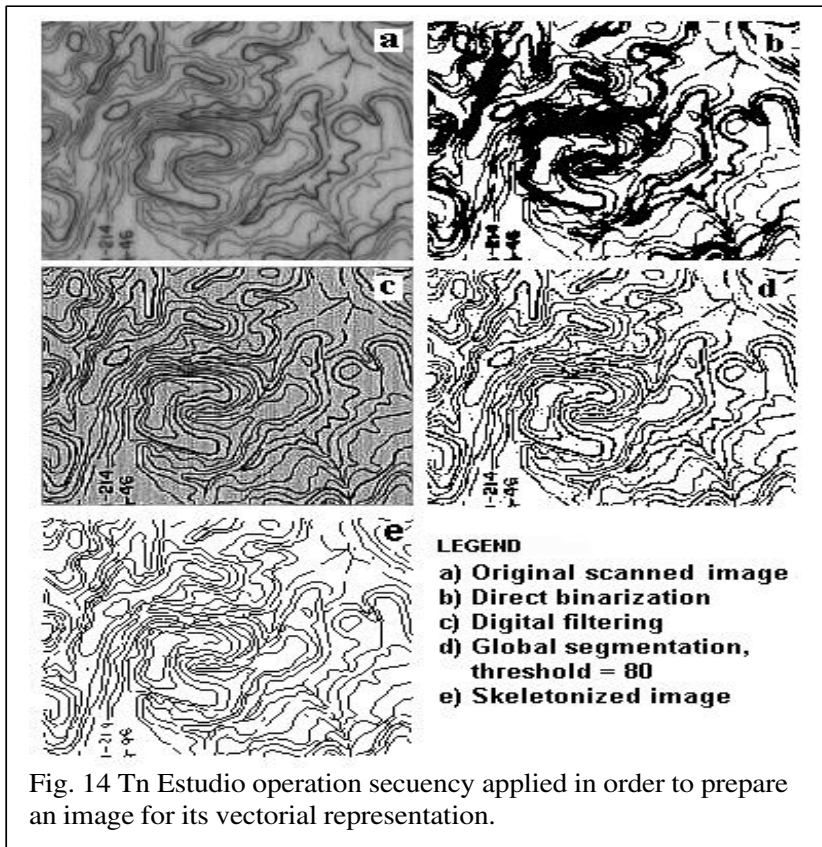


Fig. 14 Tn Estudio operation secuency applied in order to prepare an image for its vectorial representation.

5.6 Primary information for an environmental basic line study

The initial stage in an environmental basic line study includes the summary and the analysis of the archived materials, among those, are the use of the digital image processing. Inside the images are the lineal elements and the space distribution of events that characterise it, all them of supreme importance to make the synthesis and a correct evaluation of their interrelations. In our example we used the multi spectral image taken by Landsat TM sensor over Cayo Coco area. In Fig. 15 are shown the four bands used in a process of automated patterns recognition to obtain the image classified by the supervised method. The sample set extracted from the image identify 11 classes or different areas on the image and the digital image result is contained in Fig. 16. The 94% of effectiveness was obtained in the

recognition of classes and the calculation time was relatively brief.

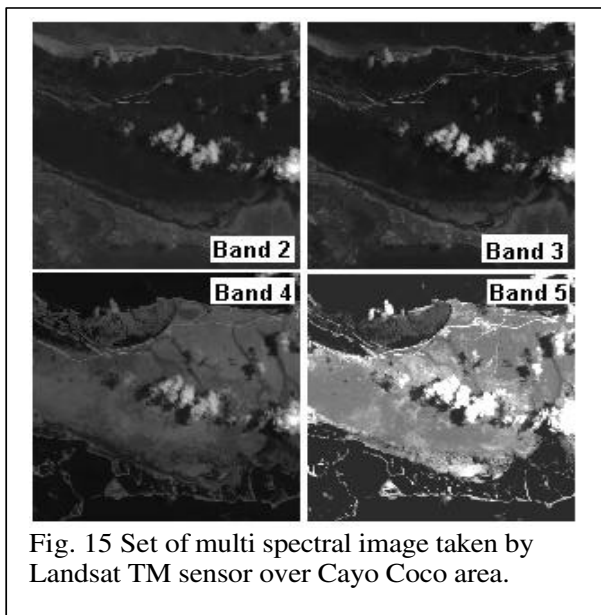


Fig. 15 Set of multi spectral image taken by Landsat TM sensor over Cayo Coco area.

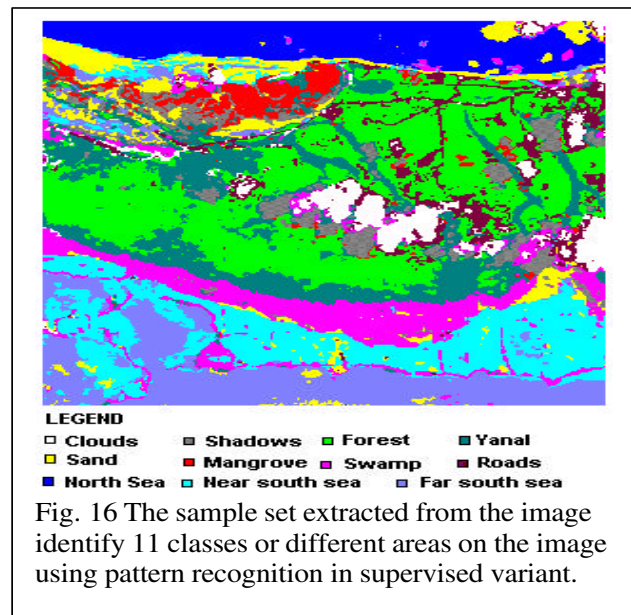


Fig. 16 The sample set extracted from the image identify 11 classes or different areas on the image using pattern recognition in supervised variant.

6. Perspectives of development of TN Estudio

Tn Estudio software development program foreseen until final of year 2000 includes the addition of new classification methods on images with statistical methods and neural nets models. The conceived idea include a module for image geocoding and a module for image resampling. As regards image input formats ,our application will have access to several of them, among those are the BMP (current format of work), JPG, TIF, GIF, PCX and a text format to accept two-dimensional information that contains matrix of real numbers like

those obtained by the geophysical measurements from the physical fields. It is also our interest to increase Tn Estudio Help system just to obtain a complete guide of learning Digital Image Processing in Spanish language.

7. Conclusions

Tn Estudio system V2.0 is a software of general purpose directed to those specialists dedicated to the digital treatment of images in varied fields of applications, in particular to those of earth sciences that make use of multi spectral images to assist the remote sensing studies. For the group of pre processing methods and analysis, included the digital classification of images that contains, is qualified as software of high level.

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