TECHNIQUES OF IHS TRANSFORMATION IN THE CHARACTERIZATION OF SPECTRAL FEATURES OF AGRICULTURAL LANDSCAPE IN EASTERN AMAZONIA

Orlando dos Santos Watrin
Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA
Centro de Pesquisa Agroflorestal da Amazônia Oriental - CPATU
P. O. Box 48 - Trav. Dr. Enéas Pinheiro, s/nº - CEP 66095-100. Belém, PA - Brazil

Mario Valério Filho
National Institute for Space Research -INPE
P. O. Box 515 - Av. dos Astronautas, 1758 - CEP 12210-012 - São José dos Campos, SP - Brazil

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ABSTRACT

Orbital remote sensing is strongly required for vegetation monitoring and land use changes to evaluate the occupation process in the Amazonian region. To support this study, the IHS transformation technique is proposed to be used for characterizing spectral features in the agricultural landscape of Bragantina micro-region, in Pará State. A study module of 16 km x 13 km was selected from Landsat Thematic Mapper (TM) in order to apply the IHS transformation technique. Considering TM4-R /TM5-G /TM3-B color composite, it was done a mean equalization among these bands and their decomposition into I (intensity), H (hue), and S (saturation) components. Three distinct approaches were performed considering the application of linear contrast stretch for "I" component, axis rotation of "H" component, and addition of "offset" in the "S" component. The resulting images were converted to the RGB format, and then the generated photographic products were evaluated in the fieldwork, by observing the agreement between the enhanced spectral characteristics with the vegetation cover and land use patterns observed on the field. It was noticed that, in general, the generated products had a very good performance to record the different phytophysiognomic formations in the region, and a moderate limitation for accurate discrimination of the other land use classes.

1. INTRODUCTION

In the Bragantina micro-region, in Pará State, one of the first area to be disturbed in the Amazonia, the natural landscape is very modified caused by the intense human activity. In this area, the remained forest is not insignificant by several utilization process, and the predominant unit in the landscape corresponds to secondary succession in different stages. The secondary succession is part of the traditional system of food production in many areas in the Amazonia, acting as fallow component, generally in small dimension properties.

In that way, the dynamic characteristic of the production and economic exploration process represent the necessity of collecting and analyzing huge amount of data quickly and, more desirable, the development of integrated studies.

The use of remote sensing techniques permits to obtain valuable information that can support actions related to planning and socio-economical development of those areas. This refers to the fact that the information related to the targets in the terrestrial surface acquired by the orbital platforms, in particular the Landsat/TM, present spectral, spatial, and temporal characteristics that are required by this kind of study.

The digital image processing permits the manipulation and numerical transformation of data in the way that provide a significant improvement for extraction of information from the products obtained by remote sensors. According to Gillespie et al. (1986), the multispectral images generally are prepared for analysis, considering three images and/or bands corresponding to the distinct spectral interval. The color red (R), green (G), and blue (B) in the color additive system are assigned to selected band.

The IHS color domain is an alternative way to the RGB system to represent colors, defined by the intensity, hue, and saturation attributes. According to Gillespie et al. (1986) the IHS attributes describe the color formation in a manner very close to the way the human visual system recognize the color, presenting in this way, clear advantages compared to RGB system. According to Haydn et al. (1982), the IHS-RGB color transform is done through mathematical operations that act rotating the cartesian coordinate axis of RGB system to the spherical coordinates of the IHS system.

The use of this technique is indicated in cases that it is desired to produce color composites with reduced interband correlation, improving the utilization of the color domain as emphasized in the works done by Gillespie et al. (1986) and Dutra and Meneses (1987). Additionally, the IHS transformation has wide application in studies related to the image combination of different type or nature, such as Landsat/TM and Spot/HRV images and the results are significative as presented by Dutra et al. (1988) and Pinto (1991). Harris et al. (1990) utilizing the IHS domain, showed the potentiality of the integration of radar images and other remote sensing data to enhance the lithologic features.

The objective of this work is to present and discuss some image enhancement techniques for Landsat TM digital data that can contribute in environmental studies. In particular, it is emphasized the applicability and potentiality of this methodological approach to detect the vegetation cover and land use spectral features considering one selected area in eastern Amazonia, Brazil.

2. MATERIAL AND METHODS

The study area, represented by Igarapé-Açu municipality, is located northeast of Pará State, in the Bragantina micro-region. It comprises a area of 756 km^2 between latitude of 0° 55' S and 1° 20' S and longitude of 47° 20' W and 47° 50' W (Figure 1). The study area is located in the quadrant B of Landsat TM path/row 223/061 of June 13, 1991.

The subset of spectral bands considered more appropriate to the objectives of this work was defined by previous analysis based on Jeffreys-Matusita or J-M distance (Swain e King, 1973) and the classification matrix by maximum likelihood (Yool et al., 1986). Then, the TM 3-4-5 bands were selected among twenty possible sets considering all TM reflective (TM 1-2-3-4-5-7) bands.

The Interactive Image Processing System (SITIM) developed by INPE was employed for defining the study module and processing the Landsat/TM digital data. It was selected a well representative study module of 512 x 472 pixels (16 km x 13 km approximately) within the municipality due to the large extension of the study area and the huge amount of data to apply the IHS technique. The characteristics of TM 3-4-5 bands for the study module is showed in Figure 2, by their respectives histogram of frequency of digital numbers.

From Haydn et al. (1982) suggestion, it was done the decomposition of the three selected bands into intensity (I), hue (H), and saturation (S) components which were analized and manipulated individualy because they are independent. It is pointed out that before implementing the IHS technique, the mean equalization of the gray level of the three bands was performed to avoid that the color assigned to bands with lower mean were minimized in the color composite obtained (Dutra et al., 1988). For this, a previous inspection of the mean of these three bands was done and it was added a "offset" value to the bands with lower mean to have the means equalized. The histograms of frequency of digital number for the IHS components generated from the mean equalization of the original RGB components are showed in Figure 3.

Based on Dutra and Meneses (1987) and Correia and Dutra (1989) analysis, after the transformation of RGB to IHS products, it was performed three distinct approaches involving the individual manipulation of "I", "H", and "S" components as follows:

a) Approach 1: applying linear contrast stretch to the "I" component; no axis rotation of "H" component; and adding a "offset" of +30 to "S" component.
b) Approach 2: applying linear contrast stretch to the "I" component; rotation of +30° in the "H" component axis; and adding a "offset" of +45 to "S" component.
c) Approach 3: applying linear contrast stretch to the "I" component; rotation of -30° in the "H" component axis; and adding a "offset" of +45 to "S" component.

The rotation of +30° and -30° in the "H" component axis was performed as presented in Figure 4. The resulting images from approaches 1, 2, and 3 were then converted to the RGB system to be able to display on the video monitor as TM4-I-R/TM5-H-G/TM3-S-B color composite form.

After applying those approaches, it was generated the photographic products that were enlarged to approximately 1:50,000 scale to be evaluated in the fieldwork. In the fieldwork, the spectral features of the Landsat/TM were correlated to the vegetation cover and land use patterns observed on the landscape. Lately, in the Laboratory, the photographic products were visually analyzed based on information collected previously, and on the spectral and spatial attributes presented by digital products, permitting to define a thematic legend.

Considering the comparative analysis and to evaluate the resulting color composite from IHS technique, the information refered to the potential of detection and discrimination of features of interest were extracted in the study module. Then, from this analysis, it was selected the products that showed to be more adequate to support the kind of mapping proposed in this work.

3. RESULTS AND DISCUSSION

From the analysis of the products generated by the enhancement processing performed, it was obtained a thematic legend for the study area, including four classes of vegetation cover and five land use classes. For vegetation cover, it was defined dense humid forest class and three secondary forest stages (advanced, intermediate, and initial). While for land use, summer crops/semiperennial crops, perennial crops, bare soil, improved pasture and rangeland classes were defined. It was considered texture, border, and shape aspects besides the color and tonality attributes to define this legend.

The processing performed it is based on IHS transformation presented variable results due to the modification performed individualy in the "H" and "S" components. For "I" component the modification performed (linear contrast stretch) remained constant for all three approaches. The linear contrast stretch applied to the "I" component distributed the histogram of frequency of gray levels to the entire dynamic range (0 to 255) permitting a increase of contrast among colors.

The rotation applied to "H" component axis, in general, provided an increase in the definition of secondary colors, helping in the separability of spectral classes of interest. The +30° and -30° rotations created secondary colors respectively in the red and blue region. Best results were observed for the first region which according to Sheffield (1985) the human eyes are more sensible to red than blue color.

The addition of "offset" in "S" component has the tendency to emphasize the general balance of color assigned to it, as observed by Correia and Dutra (1989). This procedure promotes a shift of the histogram of frequency to the right of the gray level interval in order to centralize and consequently improve the color exposition without its saturation. Then, to accomplish this objective, the +45 value showed to be more convenient than +30 value.

Considering those premise, the approach 2 (linear contrast stretch in "I" component; rotation of +30° in "H" component; and addition of "offset" of +45 in "S" component) was defined as the most adequate to accomplish the proposed objectives. The results obtained from approach 2 are presented in Figures 5 and 6 in a histogram form.

Approach 1 presented predominance of pastel shaded probably due to non-manipulation of "H" component and of low "offset" value added to "S" component (+30). The results from this approach showed a certain confusion between initial secondary forest and summer crops/semiperennial crops. On the other hand, the approach 3 presented a relatively low performance to detect especially the features related to land use, probably because they were assigned to blue color that is less sensible to be detected by visual analysis as mentioned before.

In general, the products derived from the approaches performed using IHS transformation technique presented a moderate limitation to complete discrimination of land use classes. However, those approaches obtained an excellent performance to record the different spectral classes associated to phytophysiognomic variations, especially those of secondary successional stages which subtic spectral separability when composed with other land use classes.

4 . CONCLUSIONS

From those three distinct approaches defined with the objectives to test the performance of IHS transformation to enhance the spectral features of vegetation cover and land use in Eastern Amazonia, it was observed that, in general, those approaches increased significatively the contrast between targets and the scene became more favorable for visual interpretation.

The good results obtained in this work are explained in part by the data pre-processing using mean equalization of the bands utilized, in a way that the colors assigned to them could be displayed on the video monitor of SITIM in equal condition.

Among those approaches tested it was verified that approach 2 was the most convenient in a way that permitted a good contrast and separability among spectral classes present in the landscape, especially when considered the sensibility of this product to detect the different phytophysiognomic units mapped.

The approaches 1 and 3 presented a moderate potential to detect the spectral features of interest due to that individual components "H" and "S" were not suficiently adjusted in a way to maximize the information extraction from color composites produced.

The technique of IHS transformation presents a good potential for the characterization of different spectral patterns of the landscape in eastern Amazonia, especially for the detection of vegetation cover classes, associated with small physiognomic variations.

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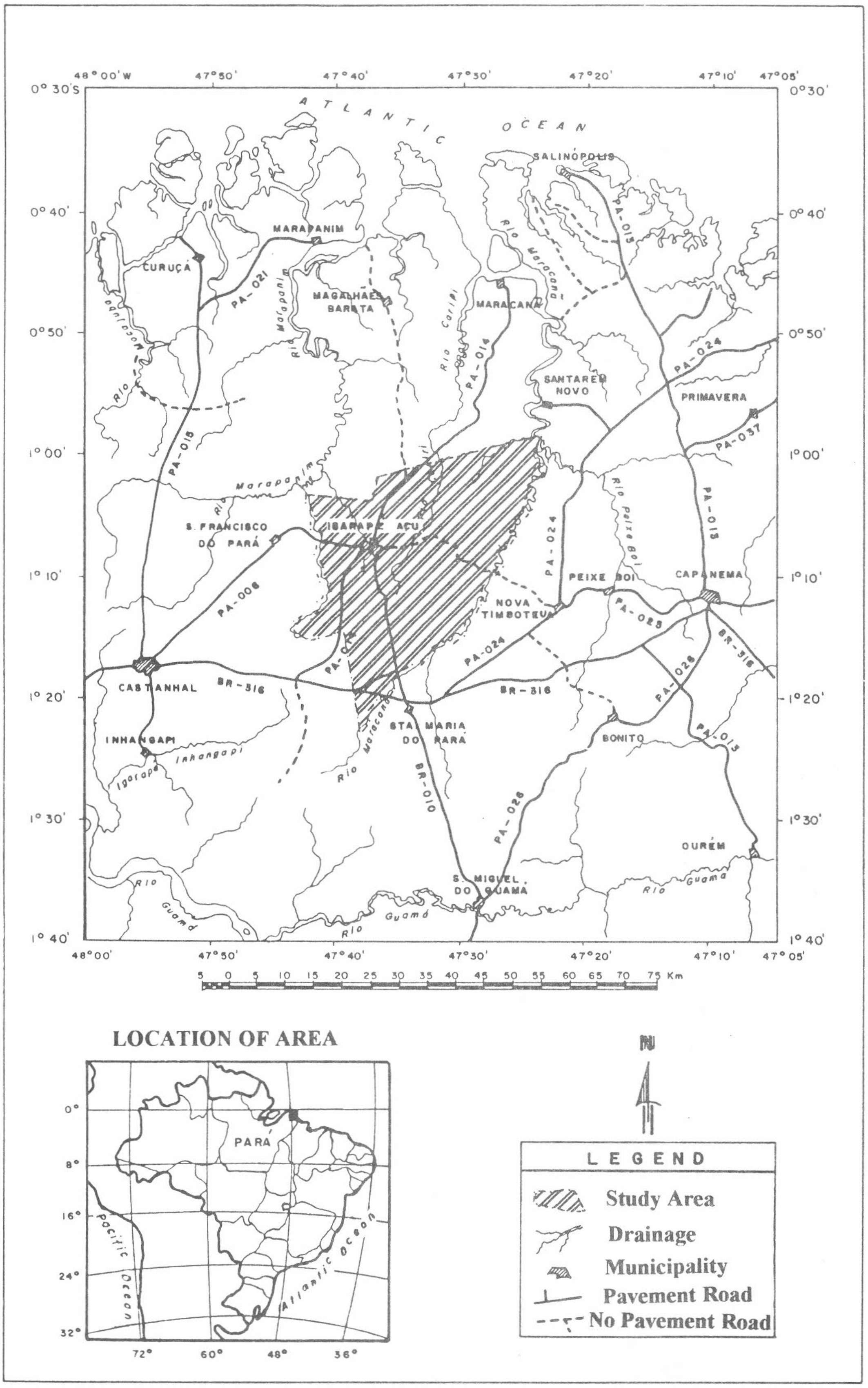
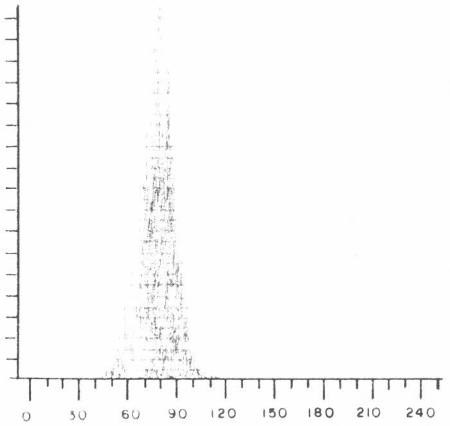
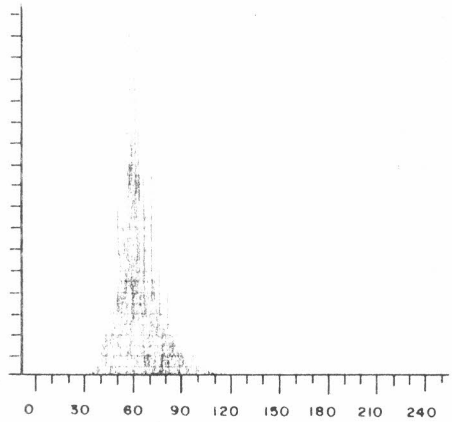


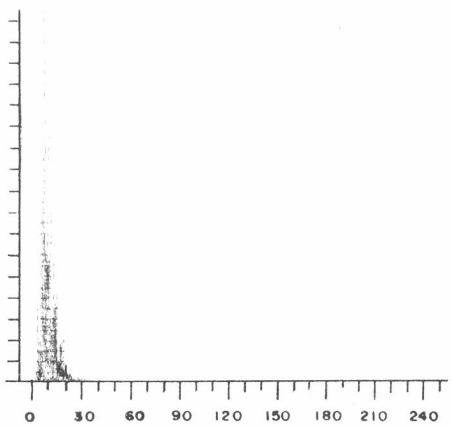
Fig. 1 - Location of study area.



a) TM 4

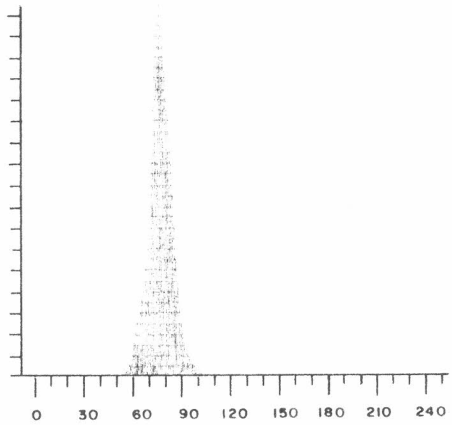


b) TM 5

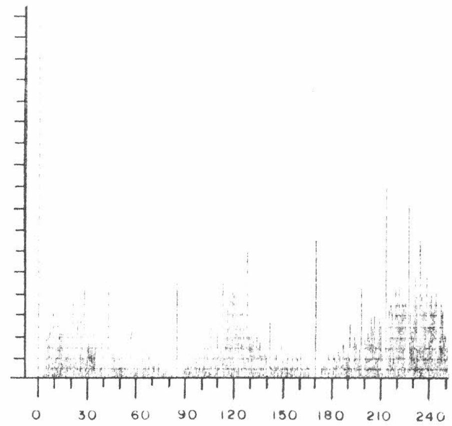


c) TM 3

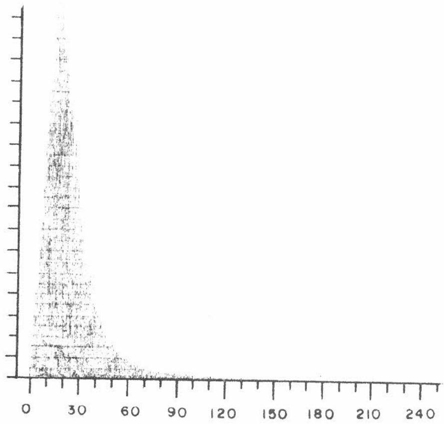
Fig. 2 - Histogram of original components (RGB).



a) "I" Component



b) "H" Component



c) "S" Component

Fig. 3 - Histograms of IHS components with equalization of the means of RGB componentes.

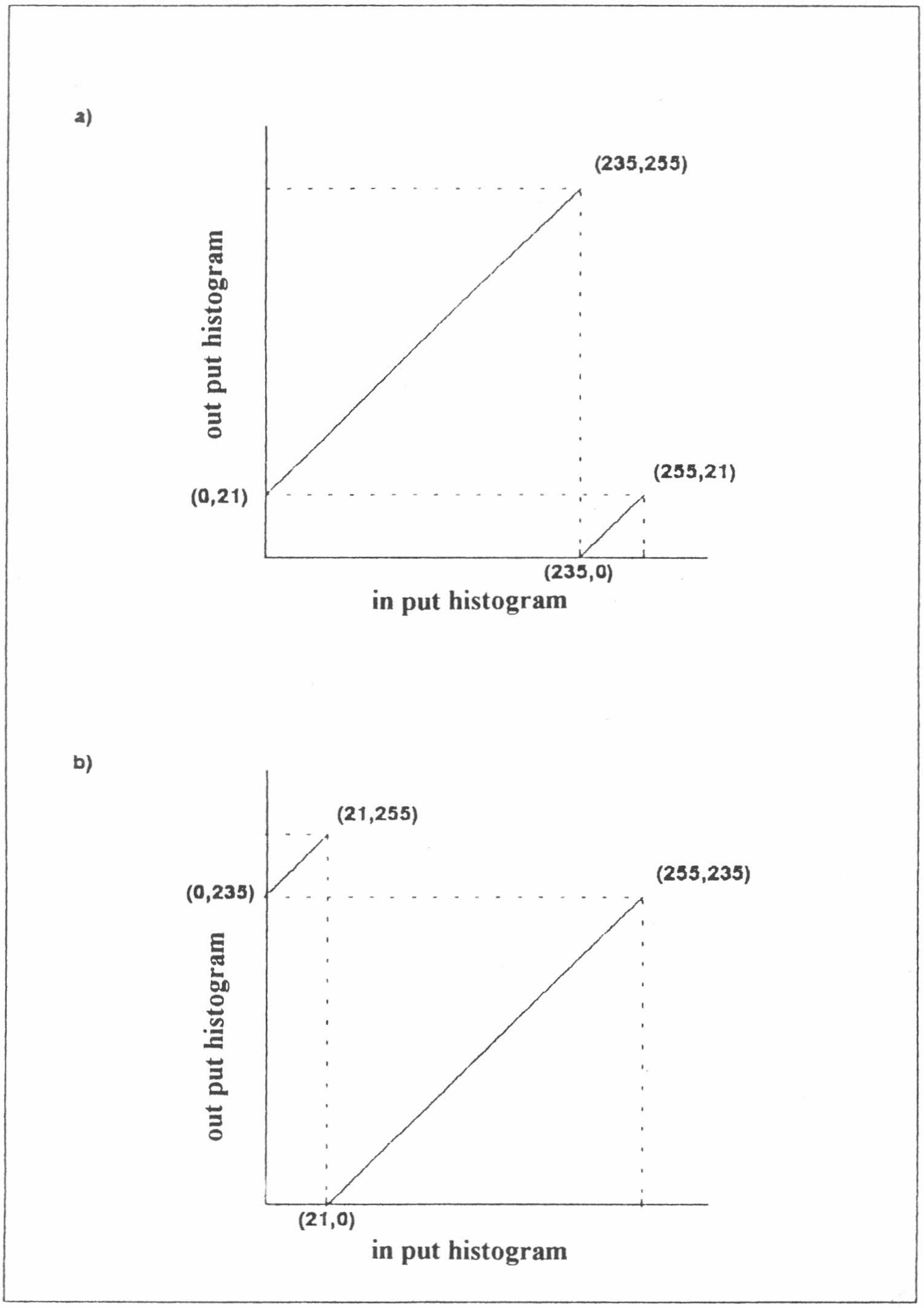
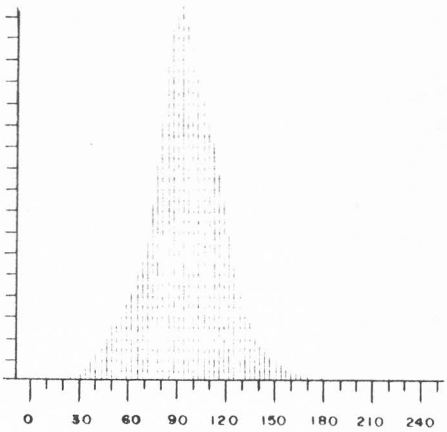
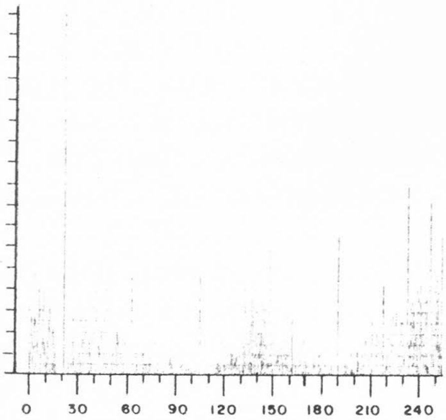


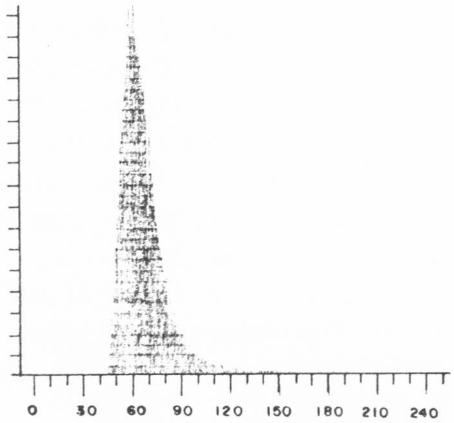
Fig. 4 - Schematic diagram of hue rotation in the IHS domain.
a) rotation of +30°, and b) rotation of -30°.



a) "I" Component

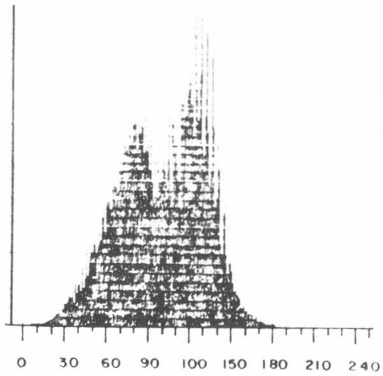


b) "H" Component

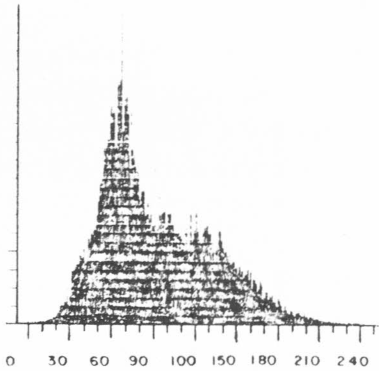


c) "S" Component

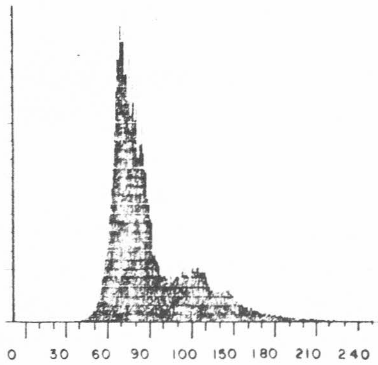
Fig. 5 - Histogram of processed IHS (approach "2").



a) "R" Component



b) "G" Component



c) "B" Component

Fig. 6 - Histogram of enhanced bands (approach "2").