An Approach To Spectral Merging Of Landsat TM & Spot Panchromatic Data

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Yüksek çözümlemeli, düşük spektral özellikli uydu görüntüleriyle yüksek spektral özellikli, düşük çözümlemeli uydu görüntülerinin sayısal birleştirilmesi, görüntülerin zenginleştirilmesinde kullanılmaktadır. Aynı bölgenin farklı zamanlarda, değişik çözümleme ve spektral özelliklere sahip uydu görüntülerinin sayısal birleştirme yöntemleriyle, etkin görsel yorum için detaylandırılmış melez görüntüleri elde edilir. Bu işlemin bir diğer olumlu sonucu da çalışma hızının arttırılması ve işlenen veri hacminin azaltılmasıdır. Bu çalışmada Afyon şehri ve çevresinin 23 Haziran 1993 tarihli, 28.5 metre çözümlemeli Landsat -5 TM görüntüsü ile 8 Mart 1990 tarihli, 10 metre çözümlemeli SPOT Pankromatik görüntüleri kullanılmıştır. Aritmetik toplama (arithmetic addition method) ve Ters IHS dönüşüm (reverse IHS transformation method) yöntemleriyle melez görüntüleri elde edilmiş ve sonuçları karşılaştırılmıştır.

1. INTRODUCTION

In the late 80's improvements in computer and remote sensing technology caused spectral merging methods to be used by various researchers. In 1982 Haydn proposed ***I***ntensity ***H***ue ***S***aturation transformation for merging processes. Chavez (1986) used scanned high altitude photography data and Landsat TM images to produce 1/24000 scale image maps. Welch (1987) took Spot HRV and Landsat TM images for multiresolutional merging. In 1988 Chavez used Landsat TM images sharpened by Spot Panchromatic data for agricultural, urban and geological sites. Finally Grasso (1993) produced 1/24000 scale maps from merging of digitized aerial photographs and Landsat MSS data to obtain a low cost Spot alternative.

As remote sensing data occupies large volumes, it is wise to store duplicated information once. This will also help to collect enhanced information from different sensors. The final product will be multitemporal, multiresolutional and multispectral. Hence, it is useful for visual interpretation. The aim of the study is to compare two different spectral merging methods visually and statistically.

2. METHODS

The common steps for both of the methods consist of the following:

1. Geographically registering of the two data sets:
The data set with the low spatial resolution and the high spectral resolution is called the master. The other set is the slave one and it has high spectral resolution but low spatial resolution. In our case the master image is Landsat 5 TM with bands 4 5 3 and the slave is Spot panchromatic. Ground control points are chosen throughout the study area to make a geographic registration. Then the master image is resampled to fit the spatial resolution of the slave image.

2. Spatial filtering of the two data sets:
As the spatial resolution of Landsat TM data (master) is artificially enlarged to 10 meters, a blocky structure appears. To overcome this problem a low pass filter with the dimensions equal to the digital enlargement (3x3) is applied to the master image. On the other hand a high pass filter is applied to the slave image to enhance the high frequency/spatial

information. This will also provide to suppress the spectral information coming from the slave image.

2.1. Additive Method

Additive method is based on pixel by pixel simple arithmetic addition of master and slave images:

$$XA = (XM+XS)/2$$

where;

XA: Digital number of additive product, XM: Digital number of master, XS: Digital number of slave

Factor 2 is used to rescale the reflectance values to 0-255 range. With this method the spectral and spatial characteristics of both images are equally represented in the hybrid image.

2.2. IHS Transformation Method

The two elements of the IHS data sets hue and saturation contain spectral information. On the contrary intensity reflects spatial information. Therefore, if the Spot panchromatic image is substituted with the intensity channel and the reverse IHS transformation is performed, the product image will have the spatial characteristics of slave image and spectral characteristics of the master image.

The IHS representation is based on the color sphere (figure 1) in which the vertical axis represents intensity, the radius represents saturation and the circumference represents hue (Sabins 1987). Brightness variations are symbolized by the intensity ranging from 0 to 255. Hue represents the dominant wavelength of the reflectance value. It has values from 0 to 255 around the circumference of the color sphere. Saturation value shows the purity of the color. High levels of saturation correspond to pure colors, middle values correspond to pastel tones, low levels of saturation correspond to impure colors.

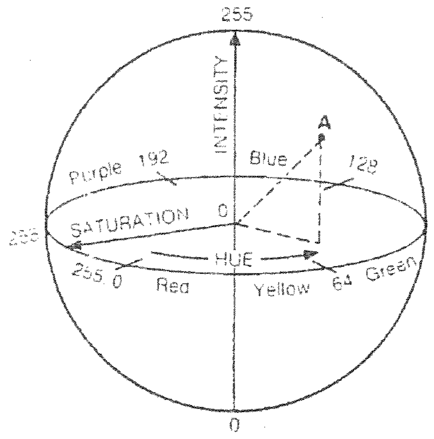

Figure 1 Color sphere representing Intensity, Hue and Saturation

Transformations between RGB and IHS color systems are possible (figure 2). The following Equations are used for the transformations:

$$I = R + G + B$$
$$H = (G - B) / (I - 3B)$$
$$S = (I - 3B) / I$$

where;

I : Intensity value, H: Hue value, S: Saturation value,

R : Red channel value, G: Green channel value, B: Blue channel value

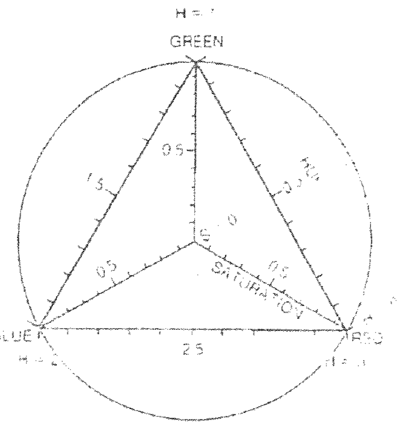

Figure 2 Relation between RGB and IHS systems

The RGB to IHS transformation is used to convert the master image -in our case Landsat TM- to the IHS components. Intensity component contains spatial information corresponding the surface morphology, while hue and saturation components represent spectral information (Grasso, 1993). The intensity channel is replaced with the sharpened Spot panchromatic slave image that has the higher spatial resolution. The spatial characteristics of the slave image are passed to the hybrid image with the IHS to RGB transformation. Also the spectral characteristics of the master image are transferred to the product.

Other than the ones mentioned above there are several more methods to digitally merge remote sensing data. Some of these are subtraction, multiplication, ratioing and selective principal component analysis.

3. APPLICATION

In this study we processed Landsat 5 TM image dated 23.June.1993 and Spot panchromatic image dated 03.August.1990 of Afyon city and its vicinity. The characteristics of both images are given in the table 1.

Table 1 Characteristics of source images

	Landsat TM 3	4	5	Spot Panchromatic
Date	23.Jun.1993	23.Jun.1993	23.Jun.1993	03.Aug.1990
Spatial resolution (m)	28.5	28.5	28.5	10
Wave length (mm)	0.60 - 0.69	0.76 - 0.90	1.55 - 1.75	0.51 - 0.73
Column x Row	600x600	600x600	600x600	1800x1800
Size (km)	18x18	18x18	18x18	18x18

Digital image processing of the study is done by using software Erdas 7.5 and Imagine 8.0.1. configured on Hewlett Packard workstation Apollo 715.

4. ANALYSIS AND RESULTS

The results of the analysis are derived from the products of both methods statistically, using correlation matrix and qualitative, by visual interpretation. A covariance matrix is calculated by the principal component analysis between all the source and product channels. Then correlation values are computed from the covariance matrix (table 2).

Table 2 Correlation values of input and output images

	TM 4	TM 5	TM 3	Spot P.	IHS 1	IHS 2	IHS 3	ADD 1	ADD 2	ADD 3
TM 4	1	0.01986	0.05309	0.18950	0.32604	0.03741	0.05665	0.44084	0.08582	0.10378
TM 5	0.01986	1	0.81758	0.41431	-0.13862	0.29225	0.25558	0.20588	0.66919	0.48840
TM 3	0.05309	0.81758	1	0.54266	-0.05815	0.29732	0.38552	0.27592	0.63049	0.60396
Spot P.	0.18950	0.41431	0.54266	1	0.60818	0.75072	0.77066	0.76251	0.79734	0.84508
IHS 1	0.32604	-0.13862	-0.05815	0.60818	1	0.82907	0.80710	0.91112	0.59101	0.70476
IHS 2	0.03741	0.29225	0.29732	0.75072	0.82907	1	0.92253	0.89263	0.88782	0.92067
IHS 3	0.05665	0.25558	0.38552	0.77066	0.80710	0.92253	1	0.88558	0.85738	0.94075
ADD 1	0.44084	0.20588	0.27592	0.76251	0.91112	0.89263	0.88558	1	0.80980	0.87586
ADD 2	0.08582	0.66919	0.63049	0.79734	0.59101	0.88782	0.85738	0.80980	1	0.95612
ADD 3	0.10378	0.48840	0.60396	0.84508	0.70476	0.92067	0.94075	0.87586	0.95612	1

We have selected additive method among the other arithmetic methods because the correlation coefficients between the source images were always positive. In the case of negative correlation values between source images, ratio and difference methods are suggested to preserve the color information in the hybrid sets (Chavez et al. 1986). Correlation value between Spot Panchromatic and Landsat TM3 is higher than the correlation coefficients between Spot Pan and Landsat TM 4 and TM5. This is because the spectral range of Spot Panchromatic corresponds to that of Landsat TM3 (table 1). As it can be seen from the table 2, Spot Panchromatic is more represented in the hybrid set of IHS transformation than the TM bands. This is because Spot Panchromatic image is directly included in the transformation as the intensity channel that represents the spatial character of the site. The correlation coefficients between Landsat TM bands and IHS hybrid sets have low values because, the spectral information is not well preserved with the IHS transformation method.

Correlation coefficient values between Landsat TM and additive product bands are high since TM bands are directly processed in this method. Hence spectral character of the site is preserved better than IHS transformation method. Finally hybrid sets are highly correlated with each other.

From the visual analysis it is concluded that the spectral characteristics are more preserved in the additive hybrid set compared with the IHS transformation product. The stadium is a good example that is more clear in the hybrid sets than the originals. In the additive product, the geometry of the stadium is not so sharp but from a spectral point of view the grass of the stadium is more visible than the one seen in the IHS transformation product. In the two resultant images, the urban blocks are more visible than the original TM set. Similarly the road network of the site is enhanced in the products.

In the hybrid sets, agricultural field borders are distinct but it is hard to guess the crop type because of the seasonal difference between the acquisition dates of the source images. On the other hand areas covered by bushes can be easily distinguished from the additive product because of the spectral characteristics carried from the TM data.

In the hybrid products the drainage network is significant both spectrally and spatially. The geological formations can better be separated in the TM image than the Spot panchromatic image, because of the rich spectral resolution. In the resultant images geological formations can be distinguished better than the source sets because of the combined spectral and spatial characteristics carried from the source images.

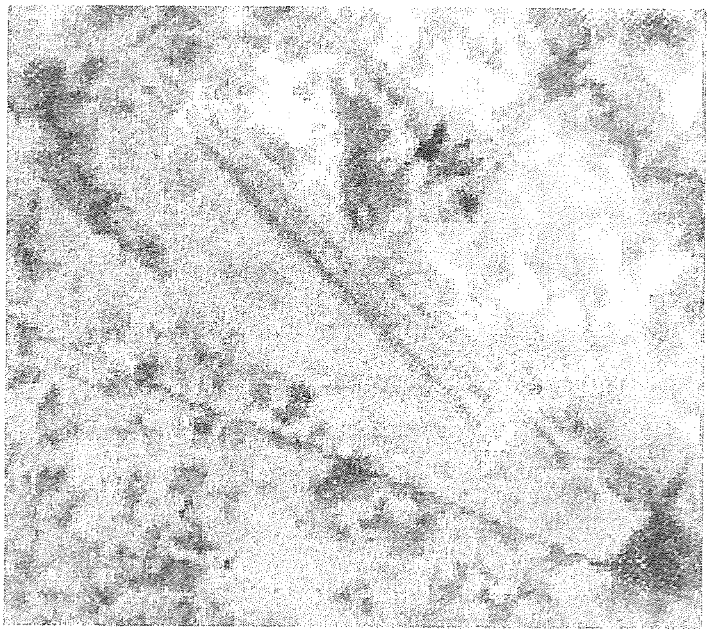

Figure 5a - Lansat TM view of airport in the south-east of Afyon. False color combination, bands 4 5 3 respectively RGB.

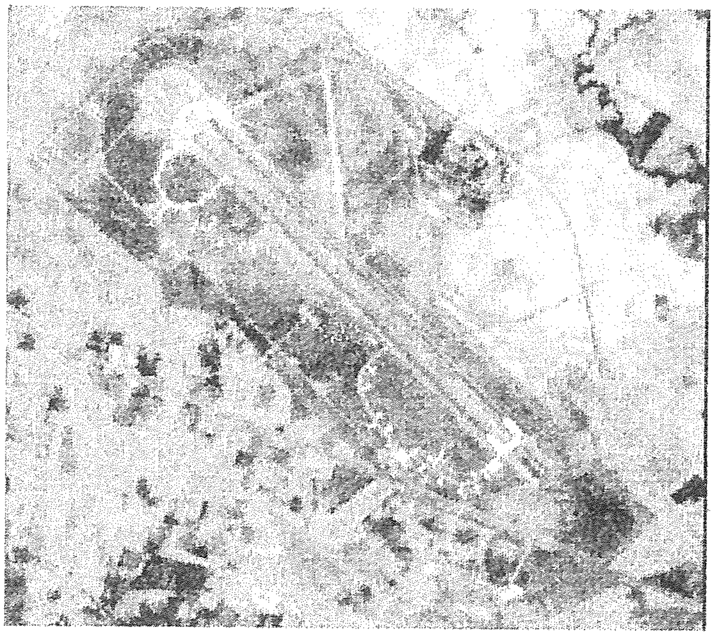

Figure 5b - Spot Panchromatic view of airport in the south-east of Afyon.

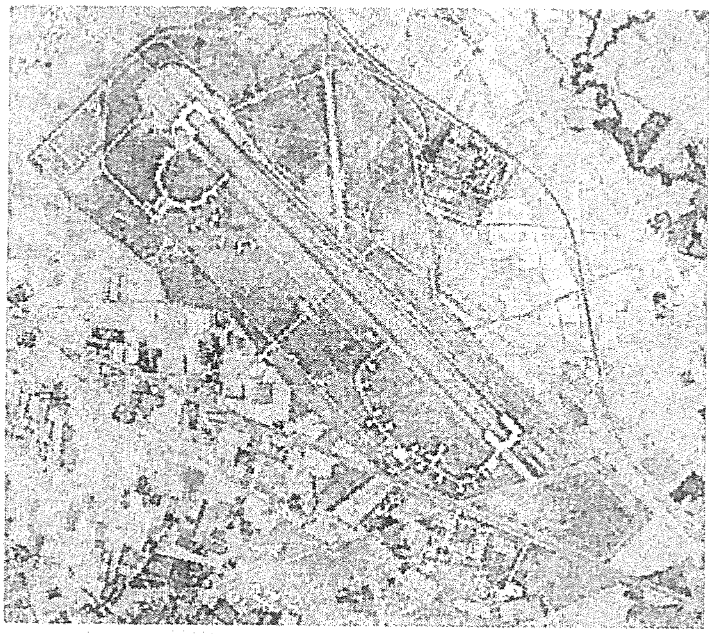

Figure 5c - IHS transformation product view of airport in the south-east of Afyon. False color combination, bands 4 5 3 respectively RGB.

Figure 5d - Addative product view of airport in the south-east of Afyon. False color combination, bands 4 5 3 respectively RGB.

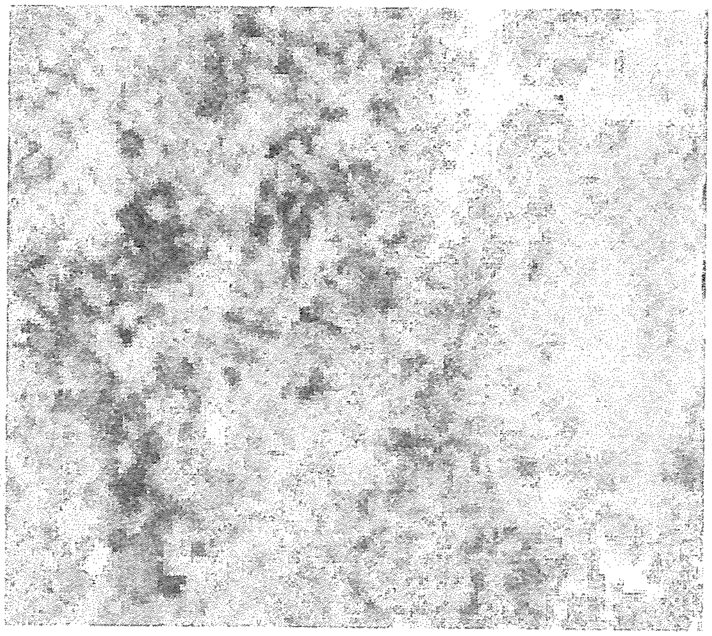

Figure 5a - Lansat TM view of agricultural sites situated in the north of Afyon. False color combination, bands 4 5 3 respectively RGB.

Figure 5b - Spot Panchromatic view of agricultural sites situated in the north of Afyon.

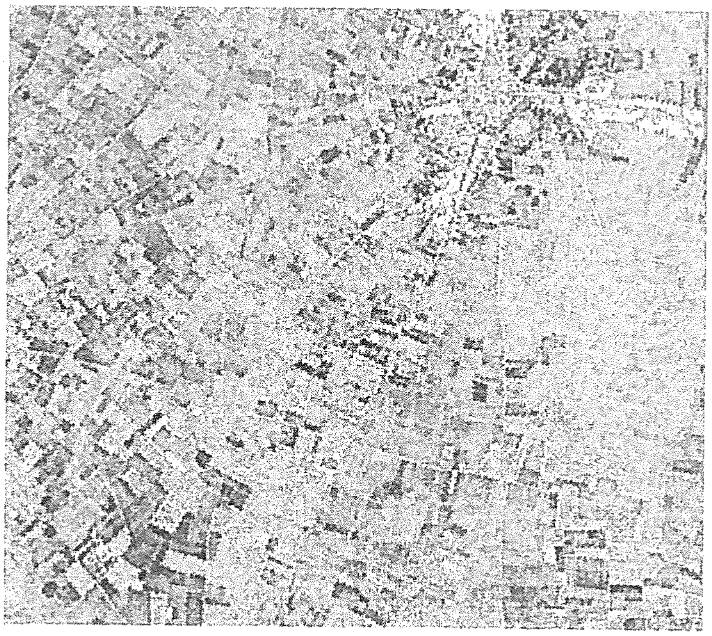

Figure 5c - IHS transformation product view of agricultural sites situated in the north of Afyon. False color combination, bands 4 5 3 respectively RGB.

Figure 5d - Addative product view of agricultural sites situated in the north of Afyon. False color combination, bands 4 5 3 respectively RGB.

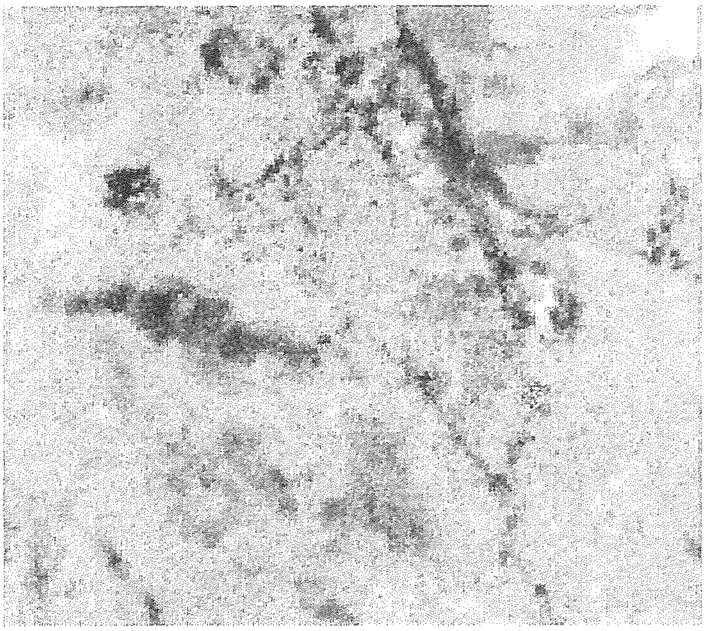

Figure 3a - Lansat Tm view of Afyon city center. False color combination, bands 4 5 3 respectively RGB.

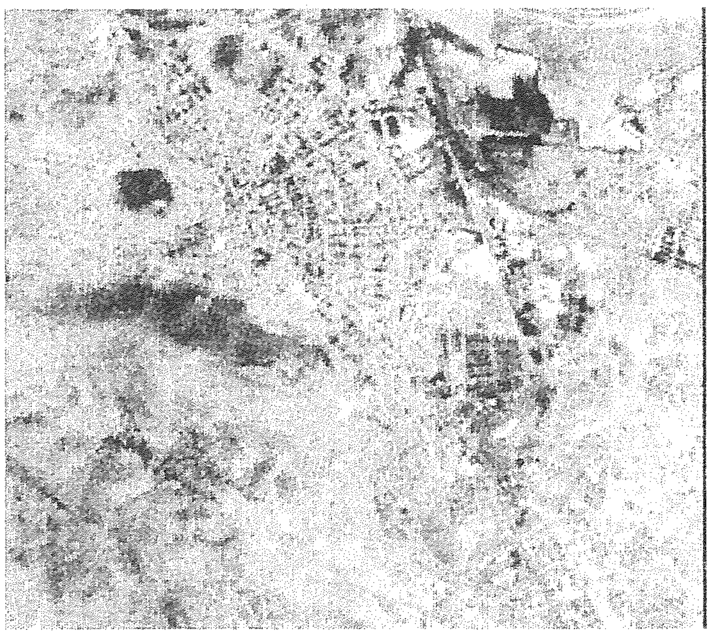

Figure 3b - Spot Panchromatic view of Afyon city center.

Figure 3c - IHS transformation product view of Afyon city center. False color combination, bands 4 5 3 respectively RGB.

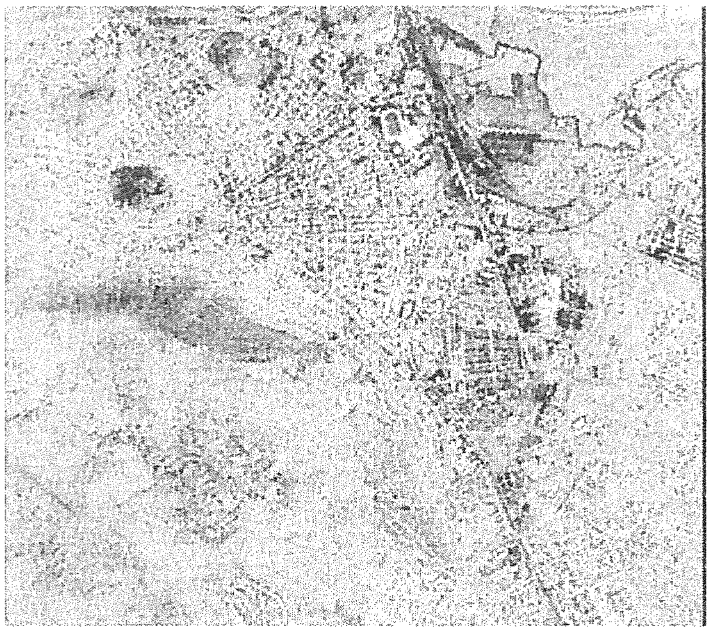

Figure 3d - Addative product view of Afyon city center. False color combination, bands 4 5 3 respectively RGB.

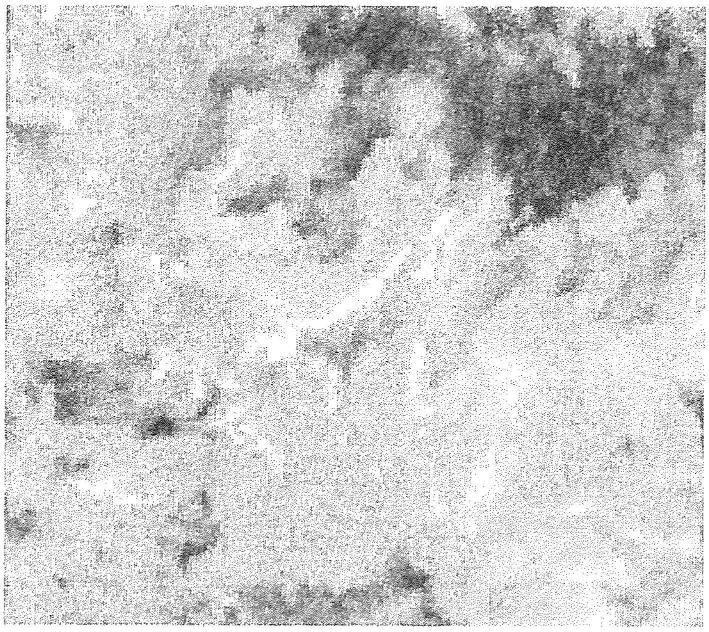

Figure 4a - Lansat TM view of Neogene sedimentary deposits situated in the east of Afyon. False color combination, bands 4 5 3 respectively RGB.

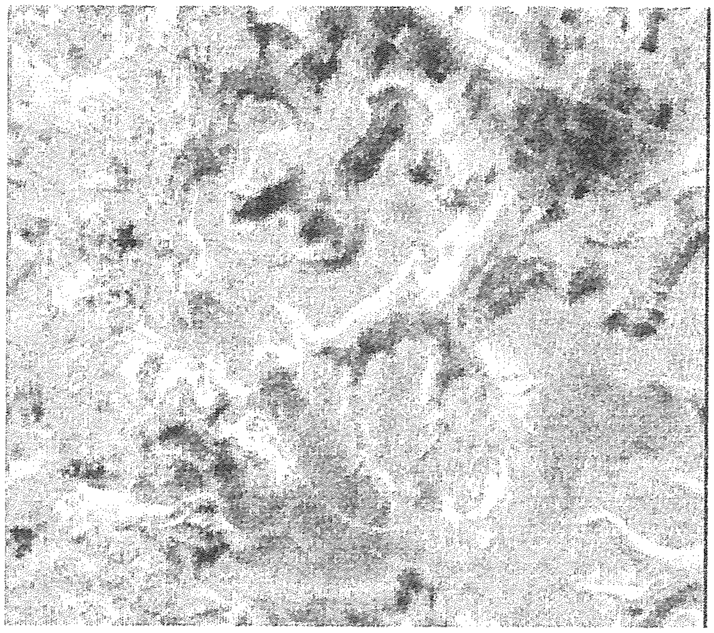

Figure 4b - Spot Panchromatic view of Neogene sedimentary deposits situated in the east of Afyon.

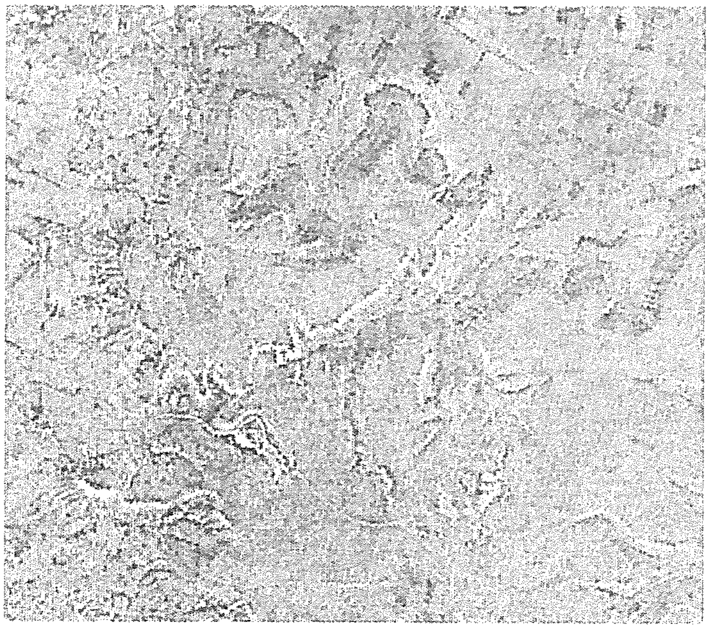

Figure 4c - IHS transformation product view of Neogene sedimentary deposits situated in the east of Afyon. False color combination, bands 4 5 3 respectively RGB.

Figure 4d - Addative product view of Neogene sedimentary deposits situated in the east of Afyon. False color combination, bands 4 5 3 respectively RGB.

5. DISCUSSION

The multitemporal, multispectral and multiresolutional characteristics of digital merging makes it adequate for a great diversity of applications.

From a geological point of view merging processes produce enhanced images to draw formation borders. Also, spatially refined images help working on surface morphology. The spectral merging of digital images having the same date of acquisition can be helpful for agricultural applications to determine the crop type and field borders sensitively. Hybrid image set of digital merging permits precise change detection in urban planning and forestry applications with the multitemporal property.

6. ACKNOWLEDGMENT

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