

## **MODULE – 4 LECTURE NOTES – 4**

### **DENSITY SLICING, THRESHOLDING, IHS, TIME COMPOSITE AND SYNERGIC IMAGES**

#### **1. Introduction**

Digital image processing involves manipulation and interpretation of the digital images so as to extract maximum information from the image. Image enhancement is used to enhance the image display such that different features can be easily differentiated. In addition to the contrast stretching and edge enhancement mentioned in the previous lectures, processes used for image enhancement include the color manipulation and the use of other data sets. This lecture covers a few of such methods used for image enhancement. These are

- Density slicing
- Thresholding
- Intensity-Hue-Saturation (IHS) images
- Time composite images
- Synergic images

#### **2. Density slicing**

Density slicing is the process in which the pixel values are sliced into different ranges and for each range a single value or color is assigned in the output image. It is also known as level slicing.

For example, Fig.1(a) shows the ASTER GDEM for a small watershed in the Krishna River Basin. Elevation values in the DEM range from 591-770 m above mean sea level. However, the contrast in the image is not sufficient to clearly identify the variations.

The pixel values are sliced into 14 ranges as shown in Fig. 1 (b) and the colors are assigned to each range. The resulting image is shown in Fig 1(b).

Density slicing may be thus used to introduce color to a single band image. Density slicing is useful in enhancing images, particularly if the pixel values are within a narrow range. It enhances the contrast between different ranges of the pixel values.

However, a disadvantage of the density slicing is the subtle information loss as a single color is assigned to each range. The variations in the pixel values within the range cannot be identified from the density sliced image.

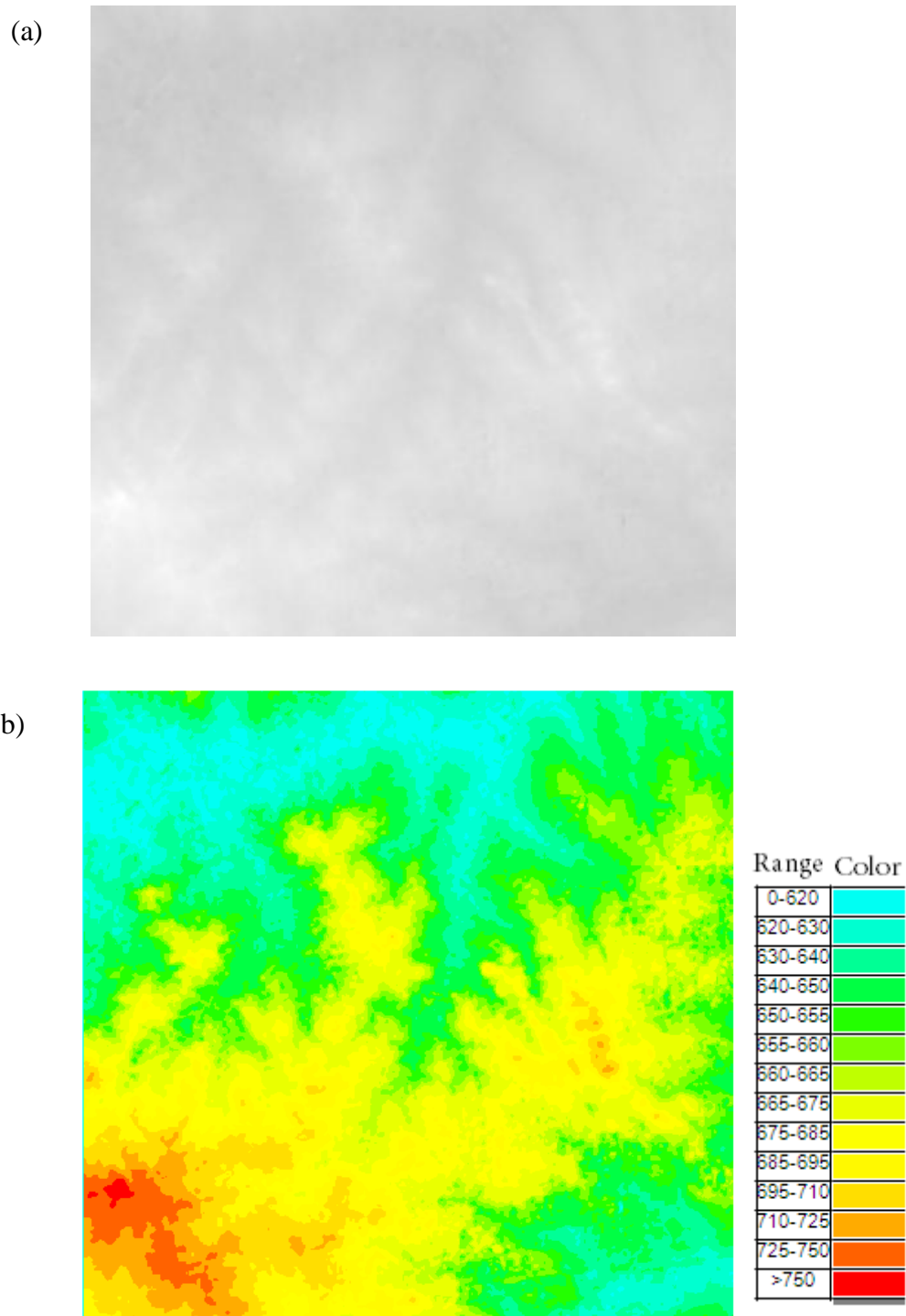


Fig. 1 (a) ASTER GDEM and (b) Density sliced image showing 14 levels of elevation

### 3. Thresholding

Thresholding is used to divide the input image into two classes: pixels having values less than the threshold and more than the threshold. The output image may be used for detailed analysis of each of these classes separately.

For example, calculate total area of lakes in the Landsat band-4 image given in Fig 2(a). This can be better estimated if the non-water pixels are deemphasized and the water pixels are emphasized. In the image highest DN for water is 35. Therefore, a threshold of 35 is used here to mask out the water bodies. All pixels with DN greater than 35 are assigned 255 (saturated to white) and those with DN less than or equal to 35 are assigned zero (black). The output image is shown in Fig. 2(b). In the output, the lakes are highlighted, whereas the other features are suppressed. From the output, area of the water bodies can be easily estimated.

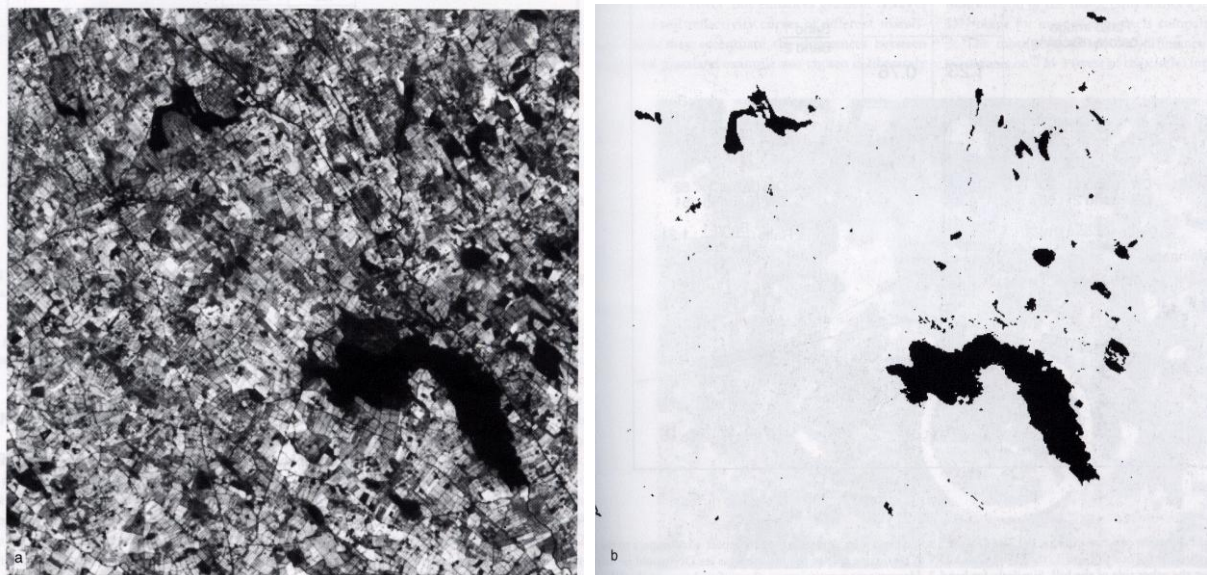
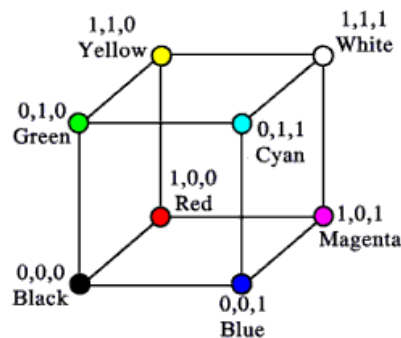


Fig. 2 (a) Landsat TM Band-4 image and (b) Output images after using a threshold DN value of 35 to mask out the water bodies

#### 4. Intensity-Hue-Saturation (IHS) images

An image is generally the color composite of the three basic colors red, blue and green. Any color in the image is obtained through a combination of the three basic colors at varying intensities.

For example, each basic color can vary from 0-255 in an 8-bit display system. Thus several combinations of the three colors are possible. A color cube (Fig. 3), with red, blue and green as its axes, is one way of representing the color composite obtained by adding the three basic colors. This is called RGB color scheme. More details are given in lecture 1.



Source: <http://viz.aset.psu.edu>

Fig. 3. A color cube used to represent the RGB color scheme

An alternate way of describing the colors is by using intensity-hue-saturation (IHS) system. The following are the components of the IHS system.

**Intensity:** Intensity represents the brightness of the color. It varies from black (corresponding to 0) to white (corresponding to 255 in an 8-bit system).

**Hue:** Hue represents the dominant wavelength of light contributing to the color. It varies from 0 to 255 corresponding to various ranges of red, blue and green.

**Saturation:** Saturation represents the purity of the color. A value 0 represents completely impure color with all wavelengths equally represented in it (grey tones). The maximum value (255 in an 8-bit system) represents the completely pure color (red, blue or green).

Any color is described using a combination of the intensity (I), hue (H) and saturation (S) components as shown in Fig. 4.

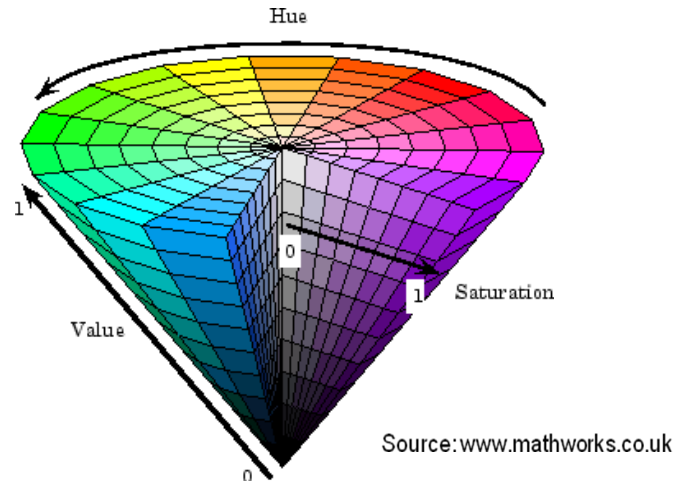


Fig. 4 Representation of color in the IHS scheme

#### 4.1 Transformation from RGB scheme into IHS scheme

The RGB color components may be transformed into the corresponding IHS components by projecting the RGB color cube into a plane perpendicular to the gray line of the color cube, and tangent to the cube at the corner farthest from the origin as shown in Fig. 5(a).

This gives a hexagon. If the plane of projection is moved from black to white, the size of the hexagon increases. The size of the projected hexagon is the minimum at black, which gives only a point, and maximum at white.

The series of hexagons developed by moving the plane of projection from black to white are combined to form the hexacone, which is shown in Fig. 5(b).

In this projection, size of the hexagon at any point along the cone is determined by the intensity. Within each hexagon, the representation of hue and saturation are shown in Fig. 5(c). Hue increases counterclockwise from the axis corresponding to red. Saturation is the length of the vector from the origin.

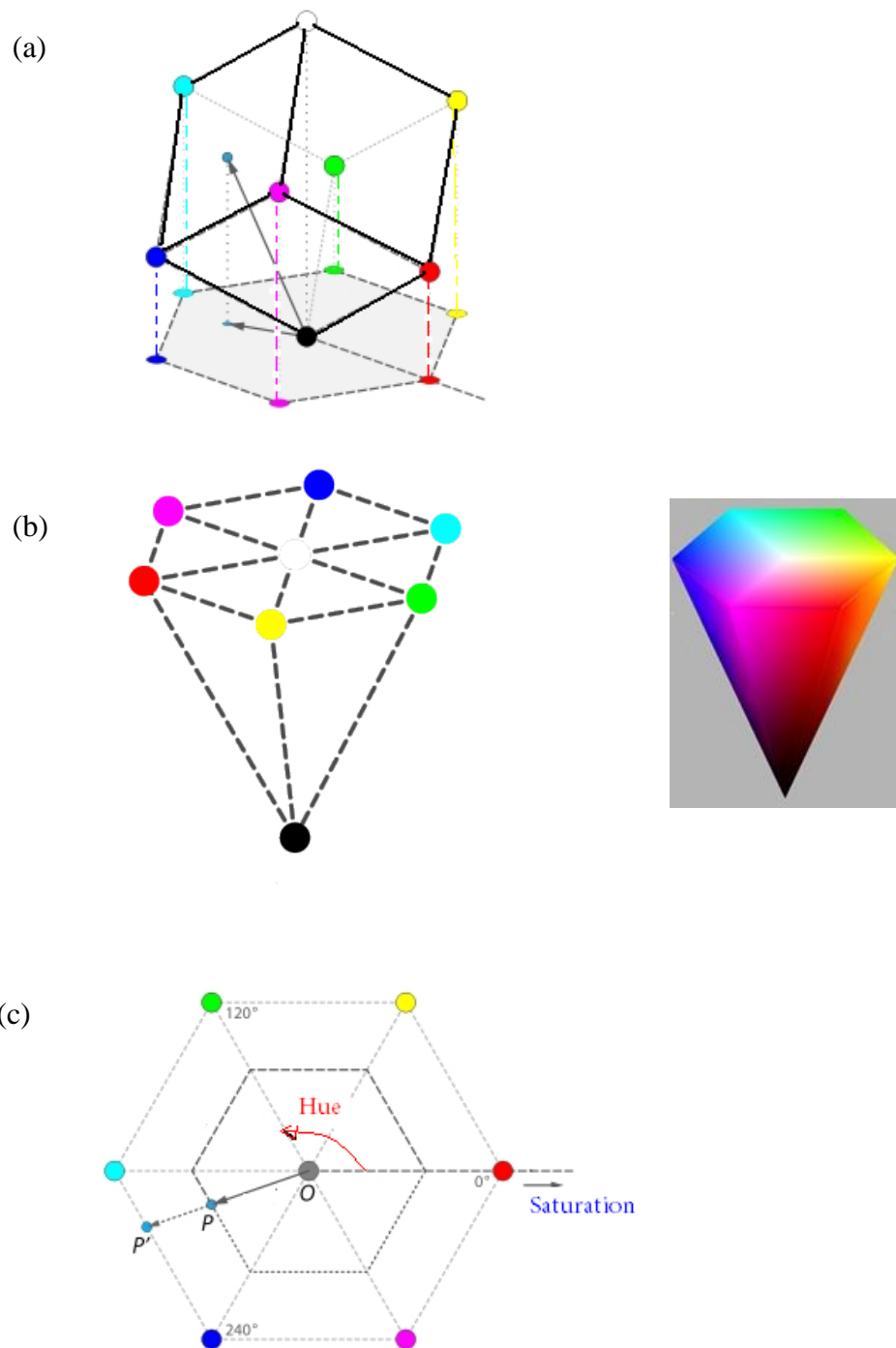


Fig. 5 (a) Projection of a color cube in to a plane through black (b) Hexacone representing the IHS color scheme (c) Hexagon showing the intensity, hue and saturation components in the IHS representation

(Source: [http://en.wikipedia.org/wiki/HSL\\_and\\_HSV](http://en.wikipedia.org/wiki/HSL_and_HSV))

Instead of the hexagonal plane, circular planes are also used to represent the IHS transformations, which are called IHS cones (Fig. 6)

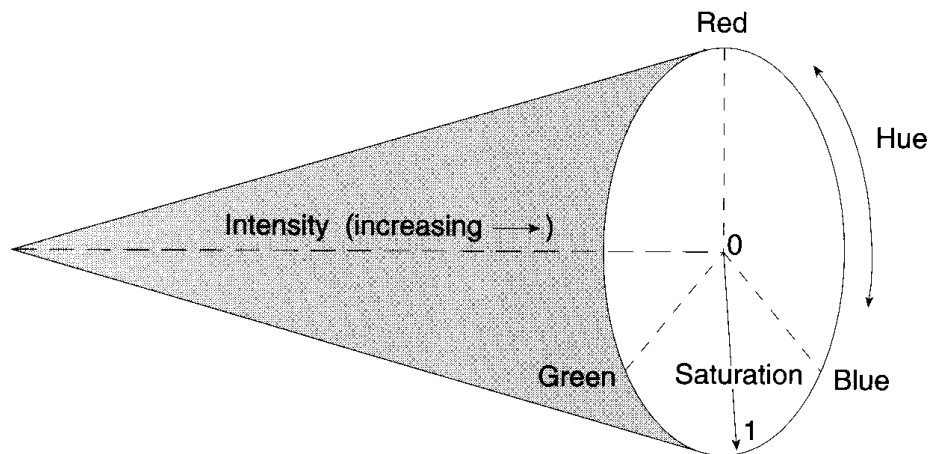


Fig. 6. IHS cone representing the color scheme

In the IHS color scheme the relationship between the IHS components with the corresponding RGB components is established as shown in Fig. 7. Consider an equilateral triangle in the circular plane with its corners located at the position of the red, green, and blue hue. Hue changes in a counterclockwise direction around the triangle, from red ( $H=0$ ), to green ( $H=1$ ) to blue ( $H=2$ ) and again to red ( $H=3$ ). Values of saturation are 0 at the center of the triangle and increase to maximum of 1 at the corners.

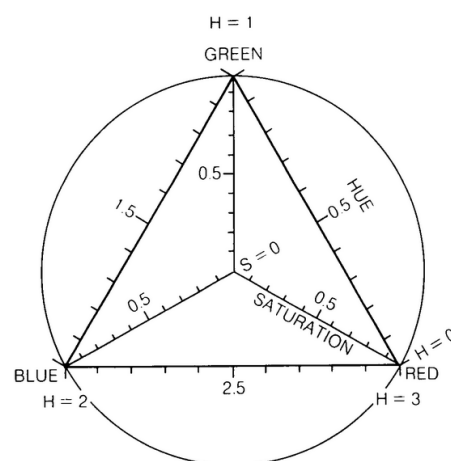


Fig.7. Relationship between RGB and IHS system

IHS values can be derived from RGB values through the following transformations (Gonzalez and Woods, 2006). Inverse of these relationships may be used for mapping IHS values into RGB values. These have been covered in Section 2.4 of module 4, lecture 1 and therefore will not be repeated here.

## **4.2 Image enhancement through IHS transformation**

When any three spectral bands of a MSS (multi-spectral scanner) data are combined in the RGB system, the resulting color image typically lacks saturation, even though the bands have been contrast-stretched. This under-saturation is due to the high degree of correlation between spectral bands. High reflectance values in the green band, for example, are accompanied by high values in the blue and red bands, and hence pure colors are not produced.

To correct this problem, a method of enhancing saturation was developed that consists of the following steps:

- Transform any three bands of data from the RGB system into the IHS system in which the three component images represent intensity, hue and saturation.
- Typically intensity image is dominated by albedo and topography. Sunlit slopes have high intensity values (bright tones), and shadowed areas have low values (dark tones)
- Saturation image will be dark because of the lack of saturation in the original data.
- Apply a linear contrast stretch to the saturation image



- Transform the intensity, hue and enhanced saturation images from the IHS system back into three images of the RGB system. These enhanced RGB images may be used to prepare the new color composite image

Schematic of the steps involved in the image enhancement through IHS transformation is shown in Fig.8. At this point, we assume that the reader is familiar with the RGB to IHS transformation. In Fig. 8 below, the original RGB components are first transformed into their corresponding IHS components (encode), then these IHS components are manipulated to enhance the desired characteristics of the image (manipulate) and finally the modified IHS components are transformed back into the RGB color system for display (decode).

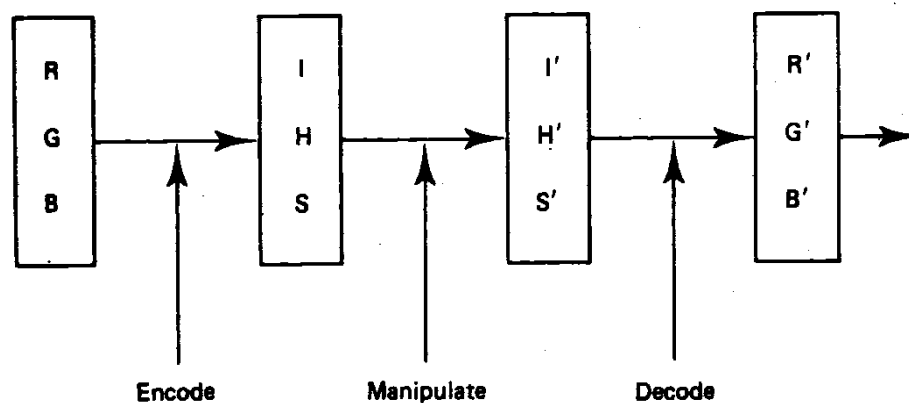


Fig.8. Schematic of the steps involved in the image enhancement through IHS transformation

The color composite output after the saturation enhancement gives better color contrast within the image.

For example, Fig.9 (a) shows the Landsat ETM<sup>+</sup> standard FCC image (bands 2, 3 and 4 are used as blue, green and red components). Color contrast between the features is not significant, which makes the feature identification difficult. The image is converted from the RGB scheme to IHS scheme. Fig 8 (b) shows the IHS transformation of the image. The saturation of the image enhanced through IHS transformation. In the display, intensity and hue are displayed through red and green, respectively. Blue is used to display the saturation. From the image, it is evident that the saturation is poor (as indicated by the poor contribution of blue in the display).

Further, the saturation component is linearly stretched. The intensity, hue and the linearly stretched saturation components are then transformed into the corresponding RGB scheme.

Fig. 10 shows the image displayed using the modified RGB color scheme. A comparison with the original FCC image reveals the contrast enhancement achieved through the enhancement using IHS transformation.



(a)

(b)

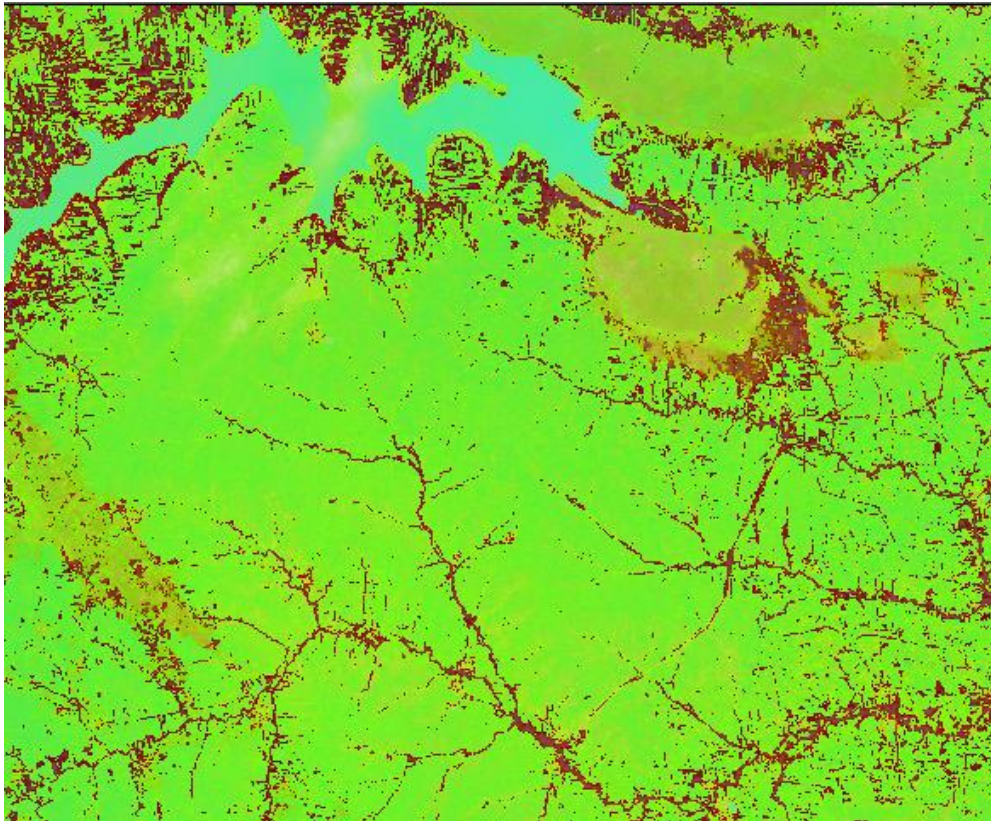


Fig. 9 (a) Standard FCC of the Landsat ETM+ image and (b) corresponding IHS transformed image



Fig.10. Landsat ETM+ image enhanced through IHS transformation

### 4.3 Advantages of IHS transfer in image enhancement

IHS system mimics the human eye system more closely in conceiving color. Following are some of the advantages of IHS transformation in image enhancement.

- IHS transformation gives more control over the color enhancement
- Transformation from RGB scheme to IHS scheme gives the flexibility to vary each component of the IHS system separately without effecting the other
- IHS transformed image can be used to generate synergic images.

Using this approach, data of different sensors, having different spatial and spectral resolution can be merged to enhance the information. High resolution data from one source may be displayed as the intensity component, and the low resolution data from some other source as the hue and saturation components.

## 5. Synergic images

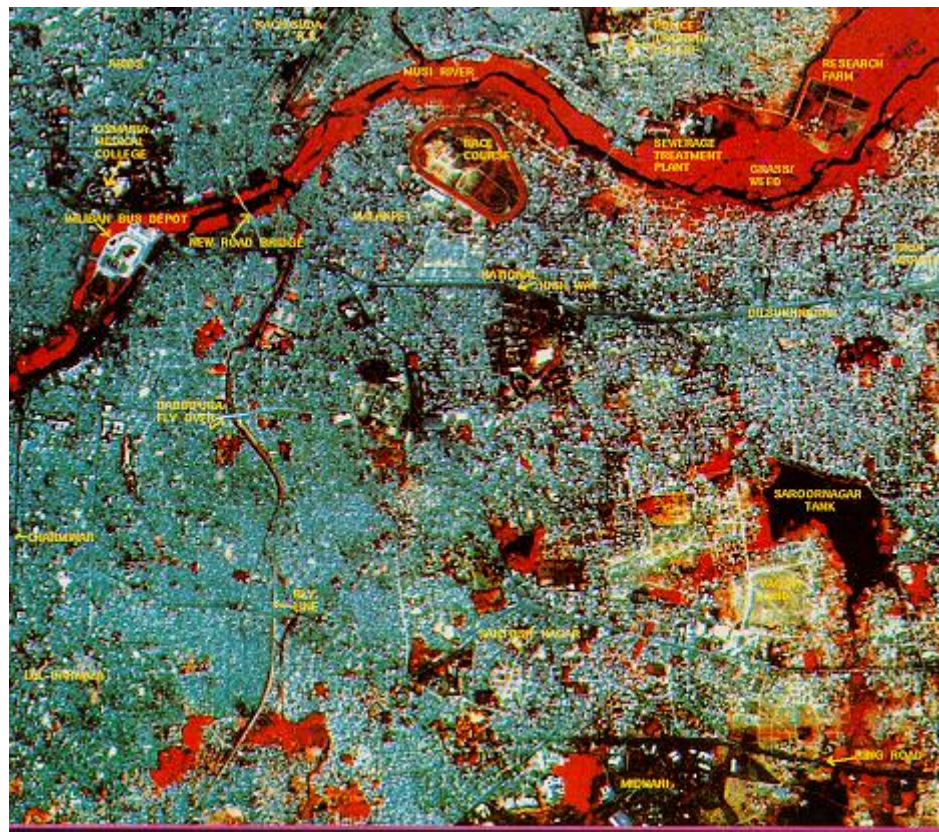
Synergic images are those generated by combining information from different data sources. Images of different spatial and spectral resolutions are merged to enhance the information contained in an image.

For synergetic image generation, it is important that separate bands are co-registered with each other and that they contain same number of rows and columns. FCC can be produced by considering any three bands (may be of different spectral or spatial resolution).

Examples: PAN data merged with LISS data (substituted for the Intensity image), TM data merged with SPOT PAN data and Radar data merged with IRS LISS data.

Fig. 11 shows the synergic image produced by combining the IRS LISS-III image with high resolution PAN image.





**IRS-1C(LISS III and PAN) digitally merged and enhanced image of Hyderabad city**

Fig. 11. IRS LISS III and PAN merged and enhanced Image of Hyderabad

IRS LISS-III image and the PAN images are of different spatial and spectral resolution. LISS-III image is of 23m spatial resolution and uses 4 narrow wavelength bands. PAN image gives coarse spectral resolution using a single band. However, PAN image gives fine spatial resolution (5.8m). Combining the benefits of both, a synergic image can be produced using the IHS transformation. The intensity component of the PAN image is replaced from the LISS-III image. The resulted synergic image is transformed back to the RGB scheme, which is shown in Fig. 10. Spectral information from the LISS-III image is merged the fine spatial resolution of the PAN data in the image.

Non-remote sensing data such as topographic data, elevation information may also be merged through DEM. Non-remote sensing data such as location names can also be merged.

Perspective view of southeast of Los Angeles produced by draping TM and radar data over a DEM and viewing from the southwest is shown in Fig. 12.

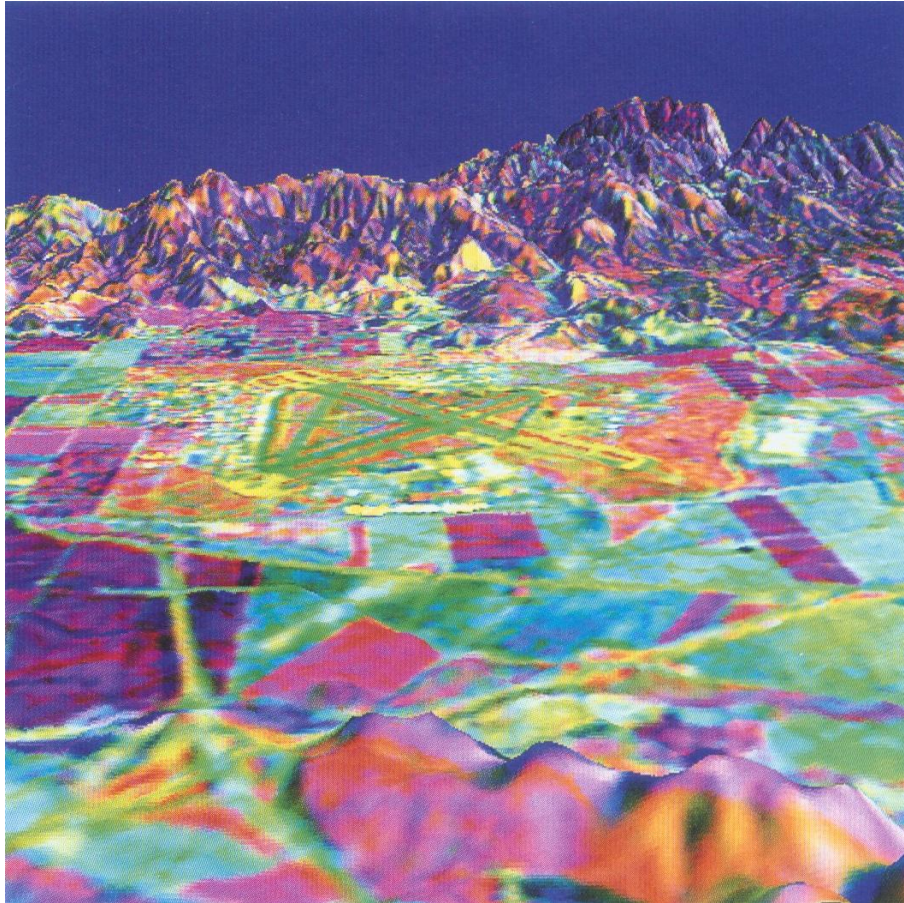


Fig. 12. Perspective view of southeast of Los Angeles produced by draping TM and radar data over a digital elevation model and viewing from the southwest

Fig 13. Shows the comparison of Landsat TM image with TM/SPOT fused data for an airport southeast of Los Angeles. The fused image is considerably sharper than the standard TM image.



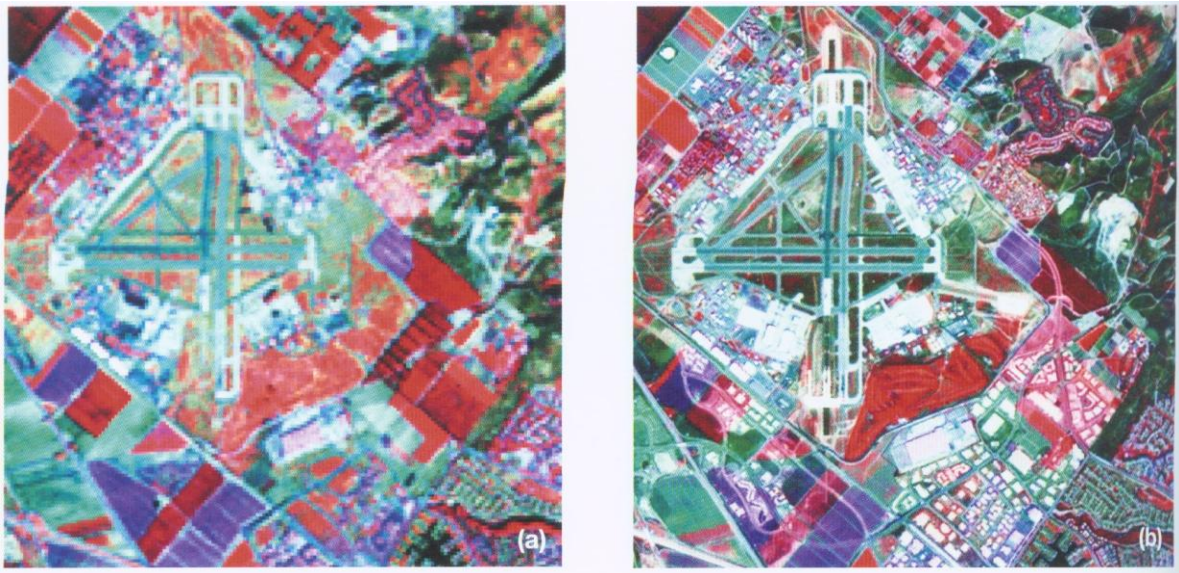


Fig 13. (a) Landsat TM image (b) TM/SPOT fused data for an airport southeast of Los Angeles

## 6. Time composite images

Cloud cover in the atmosphere often restricts the visibility of the land area in optical images. However, if an image contains cloud cover in a portion and if that imagery can be acquired everyday like in the case of NOAA AVHRR, a time composite imagery can be produced without cloud cover. For the cloud covered area, the information is extracted from the successive images. The following are the steps followed for generating time composite images.

- Co-register images acquired over number of days (say 15 days)
- Area with cloud cover is identified from the first imagery and is replaced by the next imagery of the same area.
- Cloud cover (if any) from this composite imagery is replaced with the third imagery.
- This procedure is repeated 15 times (say over 15 days imageries)

The National Remote Sensing Centre (NRSC) used such time composited imageries of NOAA AVHRR over 15 days for Agricultural drought assessment and analysis.

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