Journal of Mining and Earth Sciences Vol.56 (2016) 78-83

Journal of Mining and Earth Sciences

Website: http://tapchi.humg.edu.vn

The integration of radar and optical imagery by applying IHS technique

Ha Thanh Tran[1,*], Tri Dinh Tran[1], Hai Minh Nguyen[1]

[1] *Faculty of Geomatics and Land Administration, Hanoi University of Mining and Geology, Vietnam*

ARTICLE INFO

Article history:
Received 13 Oct. 2016
Accepted 28 Oct. 2016
Available online 20 Nov. 2016

Keywords:
Radar
Landsat images
HIS
Transformation

ABSTRACT

This paper presents theoretical basis, and practical experiment of Intensity-Hue-Saturation (IHS) transformation technique in integrating Radar images, and optical satellite images. This procedure helps enhancing interpretation processes of objects on Radar images in term of visualization discipline. A flowchart of this procedure is shown in the theory section. For approaching the final results, two types of images are selected, a Radar image- the ALOS PALSAR, and an optical image- the Landsat 7 ETM captured an urban area in the center of Hanoi, Vietnam. Although, spatial resolution of the ALOS PALSAR is higher than the Landsat, it is hard to clarify objects on the PALSAR due to the fact of its color visualization (black and white in particular). Thus, by applying IHS for fusing the PALSAR and the Landsat, we can not only keep the PALSAR spatial resolution, but also utilize the ability of band combination of Landsat data to enhance the readability of the Radar image for identifying specific objects on the surface. For example, some of land types are clearly obvious characterizing by color on the fused image, such as trying with the 4-3-radar combination, the urban area appears in blue color, while the vegetation is in red color. Generally, the IHS method can help to decipher objects more precisely, which is one of the most important steps in mapping.

1. Introduction

Optical images, such as Aster, Landsat, or SPOT are acquired mainly in visible and infrared spectral region (James, 2011). Thus, information on those images appears closely to the nature of human perception. That is the reason why it is easy for interpreters to work on optical imagery based on typical objects' characteristics, such as: color, shape. However, because optical imagery are acquired by passive remote sensing systems, which depend on solar radiation, their qualities are influenced by the weather, and atmospheric elements (such as cloud, water vapor density, or fog) (James, 2011). These disadvantages of passive remote sensing systems often occur on images

---

*Corresponding author
E-mail: ha.davt@gmail.com

that captured tropical countries and region where receiving the large amount of solar radiation, and moisture. Vietnam is one of examples.

Another disadvantage of optical remote sensing is that it records radian energy reflected or emitted by objects on the ground in the visible and infrared region. As a result, information about structure, roughness of the surface is not sufficient.

Radar imagery (Radio Detection and Ranging) can overcome those disadvantages of optical data. Radar is a system using the radio bands for distance measurement. Owing to be taken by an active remote sensing system, quality of radar data does not depend on the solar radiation. Thus, independence on atmospheric elements, the weather, or day or night time is one of the advantages of radar imagery. Therefore, this type of remote sensing data can be applied to study on remote areas where there is lack of cloud-free resources. Otherwise, using longer wavelengths than visible light (from 0.75 to 100cm) (Chan, 2008), radar imagery are sensitive to surface roughness, structure, and surface moisture which are not available on optical images in general. Nevertheless, radar has its own disadvantages, for example speckle, and relief replacement. Furthermore, the appearance of objects on radar images are not similar to the nature of human perception, so application and interpretation of radar imagery have not been used widespread.

In order to utilize the benefits of optical and radar data, this paper attempted to integrate two types of data by applying one of the mixed image techniques. Currently, though there are a lot of techniques approaching this part, most of them centralize color or feature enhancement for radar interpretation procedure, for example RGB transformation, HSV (Hue-Saturation-Value), HLS (Hue-Lightness-Saturation), or Intensity-Hue-Saturation (IHS) transformation (Gang, 2009), (Grasso, 1993), (Liao, 1998), (Jeff, 1990), (Klonus, 2008). Each of technique is constructed based on different color transformation model depending on the quality of final results, and study areas. The IHS transformation is a common technique for approaching. Therefore, this study investigated IHS method in integrating an ALOS PALSAR and a Landsat image to figure out the possibility, and ability of applying this method on radar data of Vietnam. Research area is a small part of Hanoi capital, where both types of imagers are available.

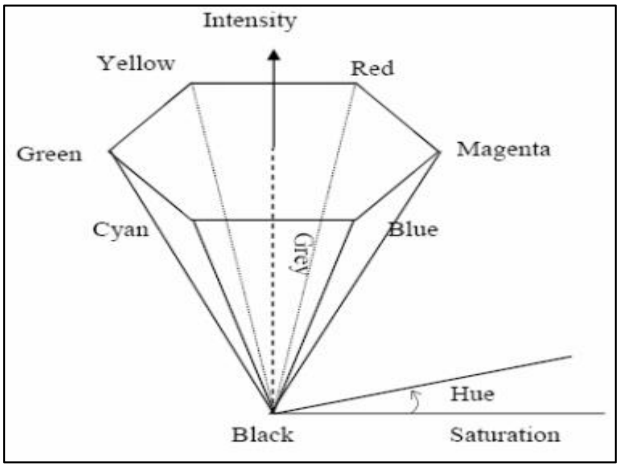

Figure 1. Model of the transformation from RGB to IHS

2. Methodology

2.1. Theoretical basis of IHS transformation

IHS is one of imagery fusion techniques for feature enhancement and sharpening, so it can be considered as one of standard techniques to enhance color visualization and spatial resolution of an image when fusing it with other image (Pohl and Van Genderen, 1998). IHS transformation combines a high spatial-resolution panchromatic image with a multi-spectral image at coarser spatial resolution. As a result, the R,G,B bands of the multispectral image will become, and replace parts of IHS panchromatic, and establish a reverse transformation to obtain a new multispectral one with high spatial resolution (Gang, 2009). Thus, the IHS enhances the details for multispectral images, and improves the structure characteristics of the combined images (Hui and Cheng, 2008).

IHS transformation is an effective technique to integrate Radar data with other types of data, like geophysics, optical data (Lamyaa Gamal, 2010), (Yang, 2001). One of the most important steps combining images by IHS is to assign color values which highlights spatial characteristic of objects on images.

IHS technique is based on the model of a hexacone in Figure 1. Proposed by (Kruse and Raines, 1984), and on the method of PCI Geomatica. In the procedure, Intensity parameter (I) in the IHS space is replaced by the grey scale of the panchromatic image at higher resolution (Pan), then transformed back to the RBG space at the same origin with other parameters hue (H), and saturation (S). Finally, a new IHS is established. The model transformation is depicted by the following formula in (Hui and Cheng, 2008).

$$\begin{bmatrix} 1 \\ v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} \\ \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{6}} & \frac{2}{\sqrt{6}} \\ \frac{-1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} H = \tan^{-1}\left(\frac{v_2}{v_1}\right)$$

Where,

$$S = \sqrt{v_1^2 + v_2^2}$$

And $v_1 = S\cos(H)$ & $v_2 = S\sin(H)$ are intermediate values

New values are derived from the corresponding inverse transformation below:

$$\begin{bmatrix} R^{'} \\ G^{'} \\ B^{'} \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{3}} & \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \frac{-1}{\sqrt{6}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{3}} & \frac{2}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} 1 \\ v_1 \\ v_2 \end{bmatrix}$$

IHS transformation is a cubic equation because a matrix of 3x3size. This proposed matrix can be not only quickly implemented, but also applied to manually transform, then increase the likelihood of change in the order tertiary arbitrary.

The IHS allows making different types of maps corresponding to different forms of spectral information, and the context, which are combined into a homogenous data for analysis (Grasso, 1993). In order to decrease the effects of color distortion, the panchromatic is integrated with firstly the intensive parameter, or the hue, and saturation will be extended in space before transforming.

2.2. The procedure for practical experiment of IHS transformation

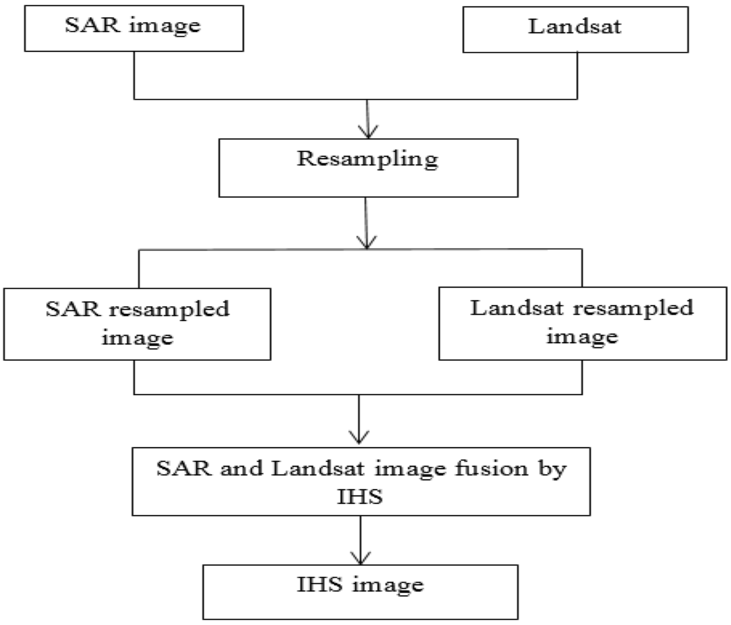

Figure 2. The flowchart of the procedure applying IHS transformation

Figure 2 shows the main procedure to integrate SAR image and Landsat image applying IHS transformation. Because two studied images, the PALSAR and Landsat 7, were acquired by different sensors, and at different spatial resolutions (23m for the PALSAR, and 30m for the Landsat 7 respectively), it is necessary to resample the images to the same spatial resolution (23m according to the PALSAR). Other important step is to fuse two resampled images by the IHS transformation. There are some available softwares designed to work with RADAR imagery, and support the IHS, such as ENVI, PCI Gematica, or ERDAS IMAGINE. In this study, we used ENVI 5.2 software, with its special tool - ENVI SARscape to perform our final result. The final result is a fused image with different bands, which allow to interpret different band combination to detect different objects in the image.

3. Results and discussion

3.1. Study area, and materials

Our study area is an urban area in Hanoi, capital city of Vietnam.

This area has a high population density with variety of objects on the surface, such as: residential buildings, roads and streets, urban vegetation, hydrology (rivers or ponds). Because of the surface variety, the ground surveying may cost a lot of labors, time, and budgets. Thus, using remotely sensed images for interpretation process is one of the most saving options.

In this experiment, ALOS PALSAR and Landsat 7 ETM products were investigated (see Figure 3). The PALSAR was acquired by an active microwave sensor using L-band frequency, while the cloud-free Landsat 7 image was acquired by an optical passive sensor. Table 1 shows more details about these two images.

Table 1. Information for studied images.

Type of Images	Time acquisition	Spatial resolution	Center coordinates
ALOS PALSAR	2001	23m	104^{0}21′51.83″E 22^{0}37′45.20″N
LANDSAT 7 ETM	2003	30m	104^{0}21′52.83″E 22^{0}37′44.95″N.

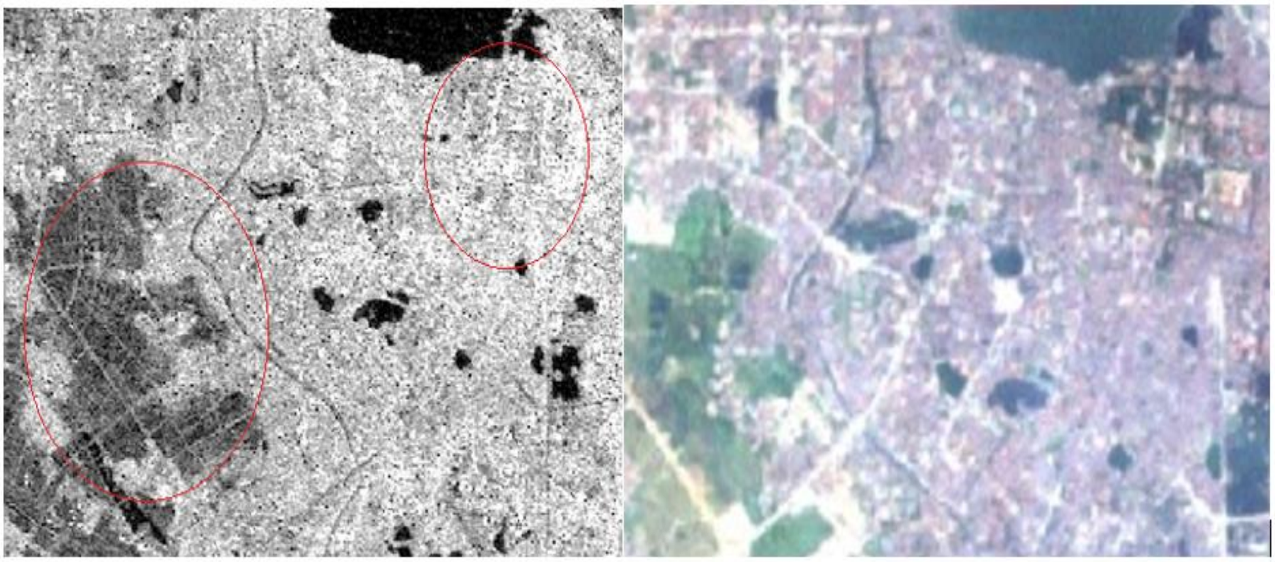

Figure 3. Cropped ALOS PALSAR (left), and cropped Landsat 7 natural look (right). Two red circles on the PALSAR image show the vegetation (left), and the urban-water mixing (right) of Hanoi areas.

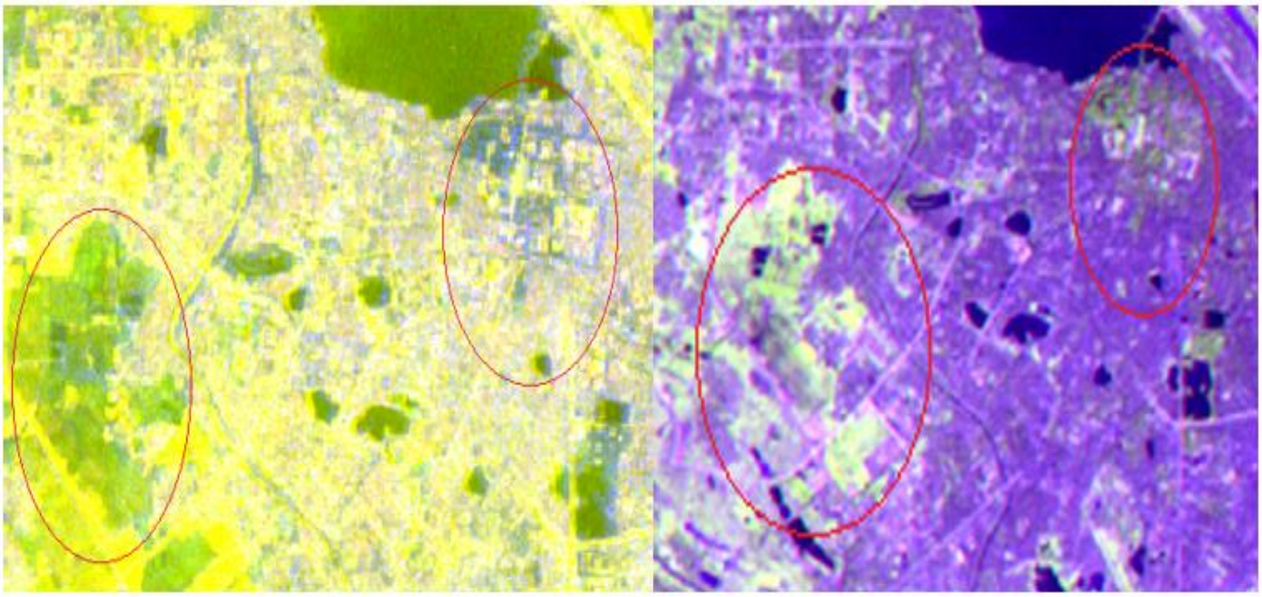

Figure 4. Two band combination images of 3-2-radar, and 7-4 radar

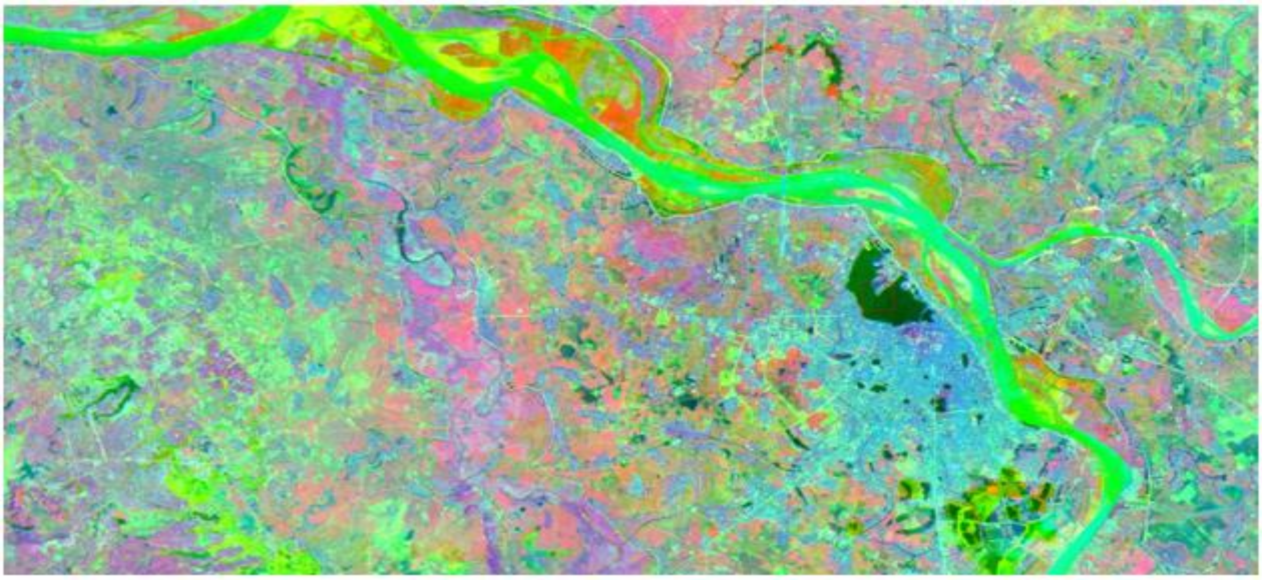

Figure 5. Integrated image with the 4-3-radar combination: the urban area is in blue color, while the vegetation is in red color

Figure 4 shows the final results after integrating PALSAR image and Landsat 7 image. By using different band combination, we can identify different objects on the PALSAR image. For example, on the combination 4-3-radar image, vegetation appears with the natural color - green, while the urban- water mixing is more obvious than on the original image, which was just in black and white color. Thus, the readability of the PALSAR image was improved. Otherwise, by trying different band combination, other objects on the Radar image can be determined (Figure 5).

4. Conclusion

By applying the IHS transformation, visual interpretation of radar image is improved significantly. Based on the experiment, we Figure out that the IHS has many advantages: firstly, quickly calculating, and generating fused images; secondly, the transformation of the image is the transformation of both distance and hue; and thirdly, homogenous images can be readable and close to the nature of color. However, there are some drawbacks of this technique, for example spectral distortions when using two different types of remotely sensed data (Wen, 2008). Nevertheless, we must admit that the IHS method can help humans to decipher objects more precisely. This is one of the most important steps in mapping procedure.

References

Campbell J.B., and Wynne, R.H., 2011. *Introduction to Remote Sensing*. Fifth Edition. The Guilford Press, New York. USA.

Chan, Y.K., Koo, V.C., 2008. An introduction to synthetic aperture radar (SAR). *Progress in Electromagnetics Research B* 2, 27-60.

Gang, H., Yun, Z., and Bryan, M., 2009. A Wavelet and IHS Integration Method to Fuse High Resolution SAR with Moderate Resolution Multispectral Images. *Photogrammetric Engineering & Remote Sensing* 75(10), 1213-1223.

Grasso D., 1993. Applications of the IHS color transformation for 1:24,000-scale geologic mapping, A low cost SPOT alternative. *Photogrammetric Engineering & Remote Sensing* 59(1), 73-80.

Hui Y.X. and Cheng J.L., 2008. Fusion Algorithm for Remote Sensing Images Based on Nonsubsampled Contourlet *Transform. Acta automatica sinica* 34(3), 274-281.

Jeff, H., Richard, M., Tom, H., 1990. IHS transform for the integration of radar imagery with other remotely sensed data. *Photogrammetric Engineering and Remote Sensing* 56(12), 1631-1641.

Kruse F.A., and Raines G.L., 1984. A Technique forEnhancing Digital Colour Images by Contrast Stretching In Munsell Colour Space. *Proceedings Of The International Symposium on Remote Sensing of Environment, 3RD Thematic Conference*, Environmental Research Institute of Michigan, Colorado Springs, Colorado.

Klonus, S., Ehlers, M., 2008. Pansharpening with TerraSAR-X and optical data. *Institute for Geoinformatics and remote Sensing*, University of Osnabrück.

Lamyaa, G., El-deen, T.S., Farouk, E., 2010. Investigation of fusion of SAR and Landsat data for shoreline super resolution mapping: the northeastern Mediterranean Sea coast in Egypt. *Applies Geomatics* 2(4), 177-186.

Liao Y.C., Wang T.Y. and Zheng W.T., 1998. Quality Analysis Of Synthesized High Resolution Multispectral Imagery. (URL Gisdevelopment.Net/AARS/ACRS1998/ *Image Processing*

Pohl C. and Van Genderen J.L., 1998. Multisensor Image Fusion In Remote Sensing: Concepts, Methods And Applications. *International Journal Of Remote Sensing* 19(5), 823-854.

Wen, D., Yunhao, C., 2008. An improved HIS image fusion method with high spectral fidelity. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* XXXVII, Part B7.

Yang, Q., and et al., 2001. Application of Radar Image in Land-Use Dynamic Monitoring in Beijing. *The 22nd Asian Conference on Remote Sensing*, Singapore.