Locating Drainage Pattern for Qaraqosh Valley by Merging ETM+ with SPOT Satellite Image.

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Abstract
To perform a good interpretation and spatial analysis for remote sensing data like satellites images, it is better to enhanced these images by using Image Processing techniques. In the same time to make good interpretation for any study area it is better to collect more than one data about this study area. In this research the study area located in Qaraqosh District in Southern East of Mosul city north Iraq. Two remote sensing data are collected about this area; spectral bands of Enhanced Thematic Mapper Plus sensor (ETM+) Landsat 7 satellite, and panchromatic band of SPOT satellite. The spectral bands of Landsat 7 satellite with high spectral resolution (8 bands) with spatial resolution 28.5 meter. While panchromatic band of SPOT satellite consider as high spatial resolution (10 meter). The merging technique which applied in this search are called Brovey transformation. The side effect of this merging caused blurring in merged image. To enhance this blurring, convolution filter has been performed. Finally the enhanced merged image (with high spectral and spatial resolution image) is ready to interpretation and classification.

Keywords: image processing, convolution filter, merging image, Brovy transform, ETM+.

1.Introduction

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area, or phenomenon under investigation [1]. Tow type of remote sensing data are used in this research:

1. Four bands of Landsat 7 satellite Enhanced Thematic Mapper plus (ETM+) with spatial resolution 28.5 meter. These band labeled as: ETM_1(blue), ETM_2(green), ETM_3(red) and ETM_4(Near IR).
2. The second data are used in this search represented by panchromatic band (SPO_{PAN}) of SPOT satellite with 10 meter spatial resolution. This data are of such high geometric fidelity that they can be photo interpreted like a typical aerial photograph in many instances. Thus, SPOT panchromatic data are often registered to topographic base maps and used as orthophotomaps. Such image maps are useful in GIS databases because they contain more accurate planimetric information.

2. Image Processing Techniques

The science of remote sensing is advancing rapidly as sophisticated sensor systems obtain data with increasingly detailed spatial, spectral, temporal, and radiometric resolution. Digital image processing algorithms used to extract information from the remote sensing data continue to improve. This has resulted in an increase in our ability to extract quantitative, biophysical data (e.g., temperature, biomass, precipitation) and land-use/land-cover information from remote sensor data. Such information becoming increasingly important as input to spatially distributed models we use it to understand natural and human-modified ecosystems [2]. The following techniques are used in this search.

2.1 Band Composite

This mixing of color is depending on "Color Theory" where three primary color of red, green and blue are mixed. Additive color theory based on what happen when light is mixed , rather than when pigment are mixed using subtractive color theory. The RGB model, each color appears in its primary spectral components of red, green, and blue. For multispectral remotely sensed scenes as the ETM_+, different combinations of image bands yield different composite effects[3]. The following color combinations are commonly used to display images:

- **True or Natural Color Composite (ETM_{321}):** in which bands ETM_3, ETM_2, ETM_1, are regarded as red, green, and blue. This is what terrain would like if the analyst were on board the satellite platform looking down.
- **False Color Composite (ETM_{432}):** except true color composite, any color composite are called false color composite. For example if the bands ETM_4, ETM_3, ETM_2 were placed in red, green, and blue, respectively. This false color composite is referred as infrared color composite. By this composition, healthy vegetation appears in shades of red because photosynthesizing vegetation absorbs most of the green and red incident energy and reflects approximately half of the incident near-infrared energy. Dense urban areas reflect approximately equal portion of near-infrared, red and green energy; therefore they appear as steal gray.

2.2 Image Merging Operation

Image merging (some time referred as image fusion or image unification) is usually used to improve the lower resolution images, spatially and spectrally [4]. In this paper SPOT (10 m PAN) data are merged with Landsat 7 data. Generally, the higher spatial resolution image (i.e. the Panchromatic SPOT image) visualized the spatial information better than the lower spatial resolution images (i.e. the ETM+ bands), while the ETM+ bands involves higher degree of spectral information. In this search the merging process produce newly bands (named $ETSP_{ijk}$) with improved spatial and spectral information. This operation involves the following processes as shown in figure (3.2).

2.3 The Spatial Interpolation Process

The spatial interpolation is used to convert ETM+ image bands (28.5m spatial resolution) to a new spatial resolution equivalent to $SPOT_{Pan}$ (10m spatial resolution), using the following first order polynomial equations

$$x = a_\circ + a_1 x' + a_2 y'$$
$$y = b_\circ + b_1 x' + b_2 y' \qquad (1)$$

Where x & y, represent the new coordinate for the new ETM_+ (which have the same coordinate of $SPOT_{pan}$) and x'& y' represent the old (original) coordinates of ETM_+. At least six points are required to determine the coefficient's values ($a_\circ, a_1, a_2, b_\circ, b_1, \text{and} b_2$).

2.4 The Intensity Interpolation

This step involves extract brightness value from x′ and y′ locations, relocating them on x, y points. Three commonly used methods of intensity interpolation are usually faced in the literature; 1) Nearest Neighbor. 2) Bilinear Interpolation. 3) Cubic convolution Method. In this project, the bilinear interpolation has been chosen. The interpolated brightness value ($BV_{Bilinear}$) by the Bilinear method is determined using:

$$BV_{Bilinear} = \frac{\sum_{k=1}^{4} \frac{Z_k}{D_k^2}}{\sum_{k=1}^{4} \frac{1}{D_k^2}} \qquad (2)$$

Where Z_k are the surrounded four neighbor point's values, and D_k are the distances from the point (x′, y′), given by:

$$D_K = \sqrt{(x_K - x')^2 + (y_K - y')^2} \ .$$

2.5 Brovey Transformation

The Brovey transform method is a recommended merging technique, which is preferred when ETM+ multispectral images want to be merged with SPOT panchromatic. The output multispectral pixel's values of the lower resolution image are given by, [52]

$$\left.\begin{aligned} NewDN_1 &= \frac{DN_1}{DN_1 + DN_2 + DN_3} \times DN_{\text{High Resolution}} \\ NewDN_2 &= \frac{DN_2}{DN_1 + DN_2 + DN_3} \times DN_{\text{High.Resol ution}} \\ NewDN_3 &= \frac{DN_3}{DN_1 + DN_2 + DN_3} \times DN_{\text{High.Resol ution}} \end{aligned}\right\} \quad (3)$$

Where DN_i , (i=1,2,3) represent the digital numbers (gray values) for the lower resolution images (ETM+).

In fact, the Brovey transform was developed to visually increase contrast in the lower and higher ends of an images histogram (i.e. providing contrast in shadows, water and high reflectance areas such as urban features). Consequently, the Brovey Transform should not be used if preserving the original scene radiometry was important. However, it is good for producing RGB images (such as true color bands, or false color bands from a Landsat TM or ETM+) [4].

2.6 Edge Enhancement (Sharpening) Methods

As a side effect of the merging resolution process, the resulted image $ETSP_{321}$ and $ETSP_{432}$ are blurred, thus to overcome this problem it often better to improve the image appearance by sharpening filter. The principal objective of sharpening is to highlight fine detail in an image or to enhance detail that has been blurred, either in error or as a natural effect of a particular method of image acquisition. It is well known that; image blurring could be accomplished in the spatial domain by pixel averaging in a neighborhood. Since averaging is analogous to integration, it is logical to conclude that sharpening could be accomplished by spatial differentiation. Thus, in this study the mask that used in edge enhancement as convolution filter is given in Figure 1. It is important to note that the relatively lower values become lower, and the higher values become higher, thus increasing the spatial frequency of the image.

-1	-1	-1
-1	16	-1
-1	-1	-1

Figure 1. Digital gradient mask for edge enhancement.

It is important to note that the relatively low values become lower, and the high values become higher, thus increasing the spatial frequency of the image according to the following formula which is used to derive an output data file value for the pixel being convolved (in the center):

$$V = \left[\frac{\sum_{i=1}^{q} \left(\sum_{j=1}^{q} f_{ij} d_{ij} \right)}{F} \right] \qquad (4)$$

where:

f_{ij} = the coefficient of a convolution kernel at position i,j (in the kernel)

d_{ij} = the data value of the pixel that corresponds to f_{ij}.

q = the dimension of the kernel, assuming a square kernel (if q=3, the kernel is3 ×3)

F = sum of the coefficients of the kernel

V = the output pixel value (in cases where V is less than 0, V is clipped to 0).

When this kernel is used on a set of pixels, the side effect of resampling technique have been removed and get an enhanced image with high spectral and spatial resolution. This image is ready now to the next remote sensing process, which is image interpretation.

3.Method of Work

The method of this work are shown in the Figure 2. below:

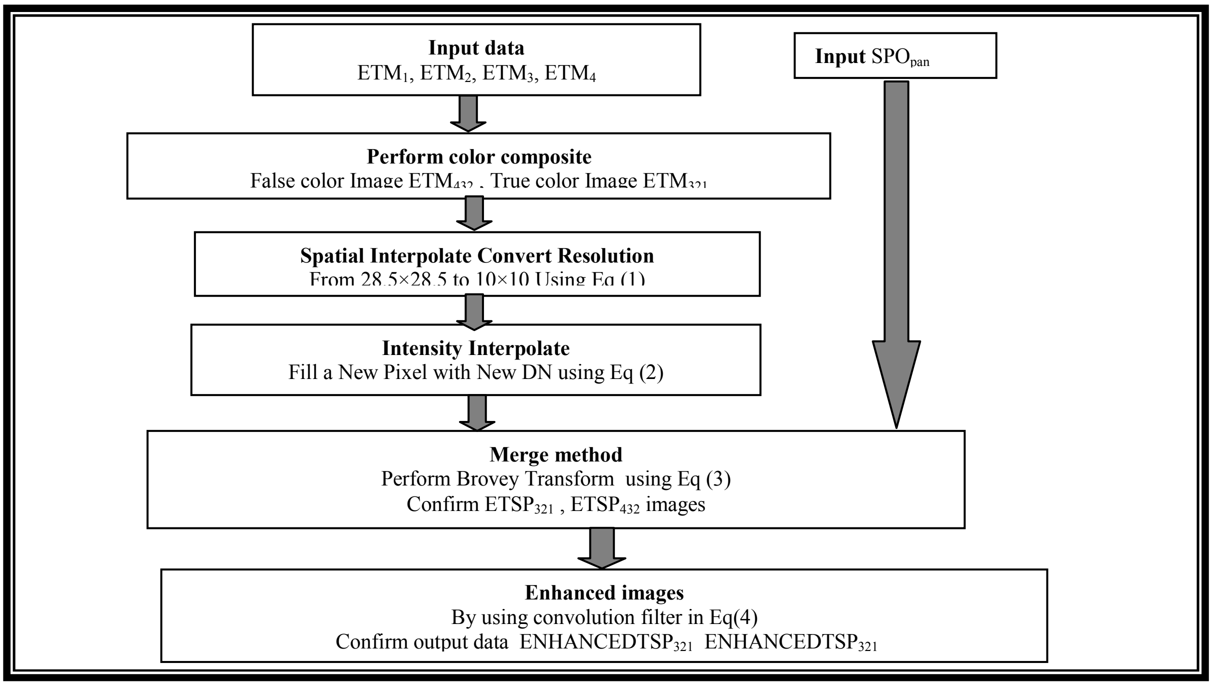

Figure 2- Image Merge Procedures.

4. Work Reviewing

Band Combination performed on Landsat 7 ETM+ bands to confirm True color image ETM_{321} and False color image ETM_{432} as shown in Figure.3 below:

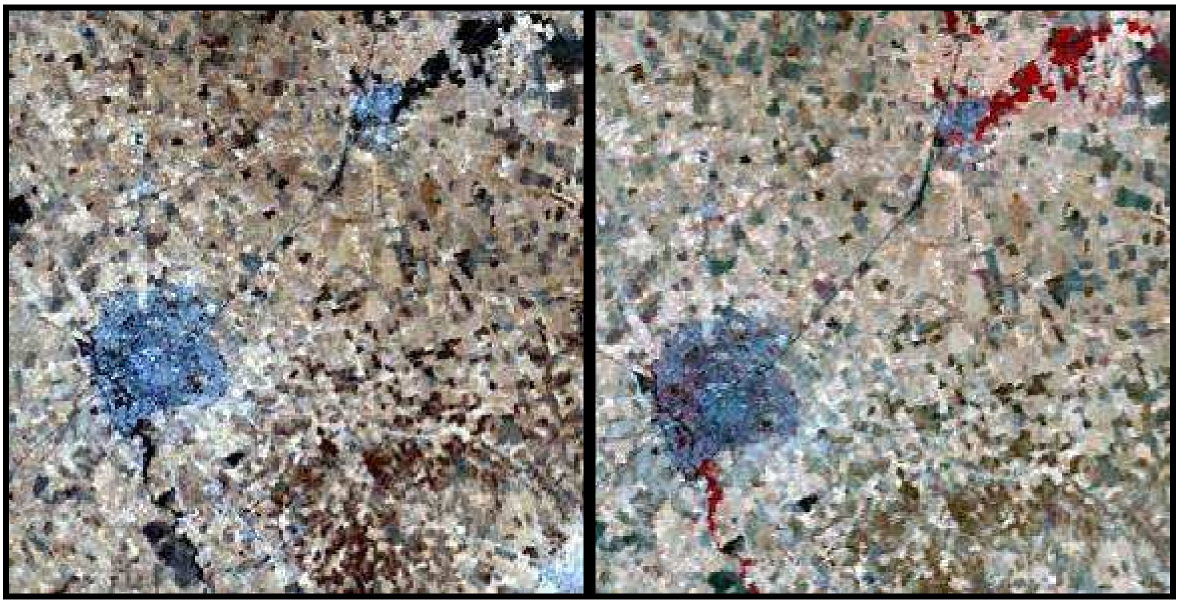

Figure 3- True Color ETM_{321} and False Color ETM_{432} scene of Qaraqosh region.

In the next step merging method is performed to unify the higher resolution $SPOT_{Pan}$ with the lower resolution images (i.e. ETM_{321} and ETM_{432}), using Brovy Transformation Method producing $ETSP_{321}$ and $ETSP4_{312}$ respectively as shown Figure .4.

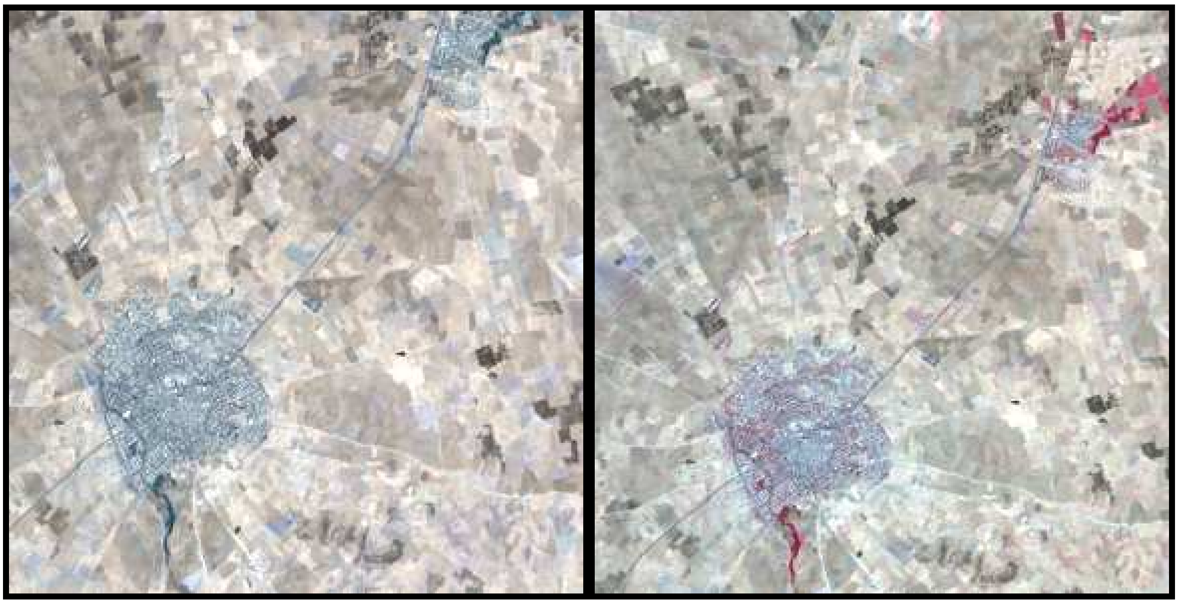

Figure 4- Merged True Color $ETSP_{321}$ and Merged False Color $ETSP_{432}$ scene of Qaraqosh region.

To enhance $ETSP_{321}$, $ETSP_{432}$ from blurring effect; convolution filter have been performed to produce final output image labeled as $ENHANCEDETSP_{432}$ and $ENHANCEDETSP_{321}$ as shown in Figure .5.

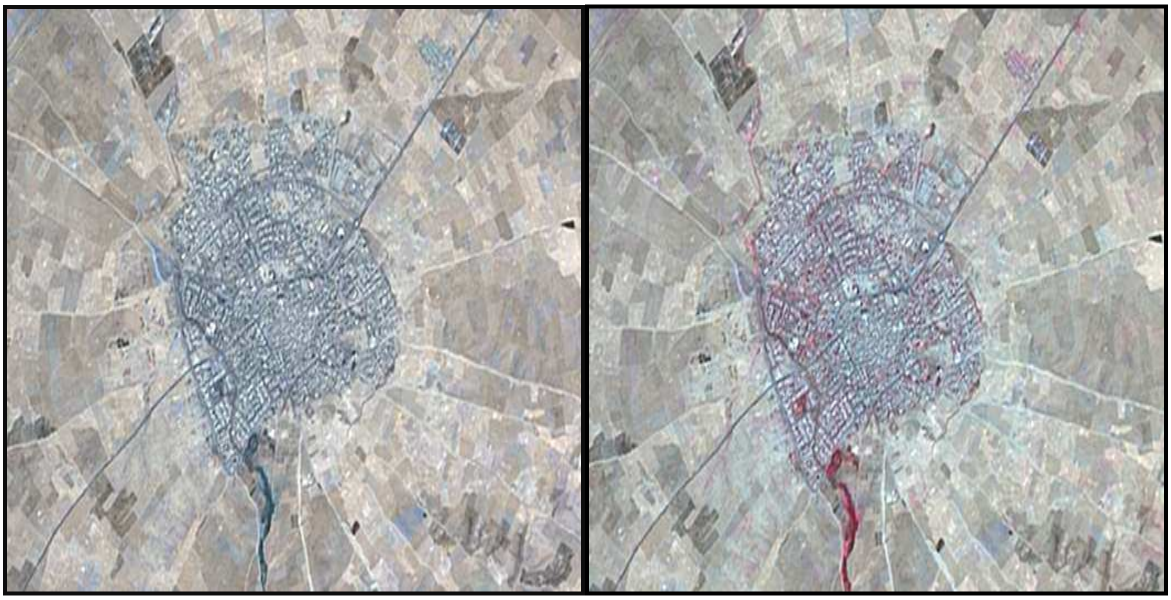

Figure 5- Enhanced Merged Image for True Color ($ENHANCEDETSP_{321}$) and False Color ($ENHANCEDETSP_{432}$).

The enhancement results are demonstrated in Figures 6 and 7 which represent the true and false coloring scenes, before and after merging and edge enhancement operations. i.e. These figures show comparison between (ETM_{432} and ETM_{321}), and the last enhanced merged images ($ENHANCEDETSP_{432}$ and $ENHANCEDETSP_{321}$)

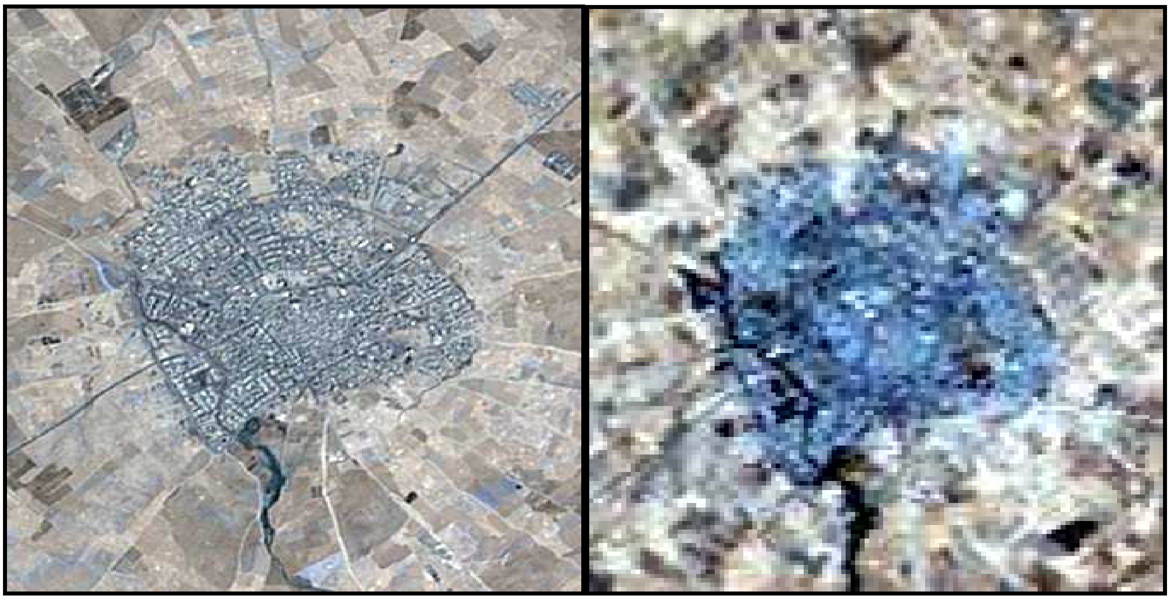

Figure 6- Comparison between extracted scenes before and after edge enhancement for true color image

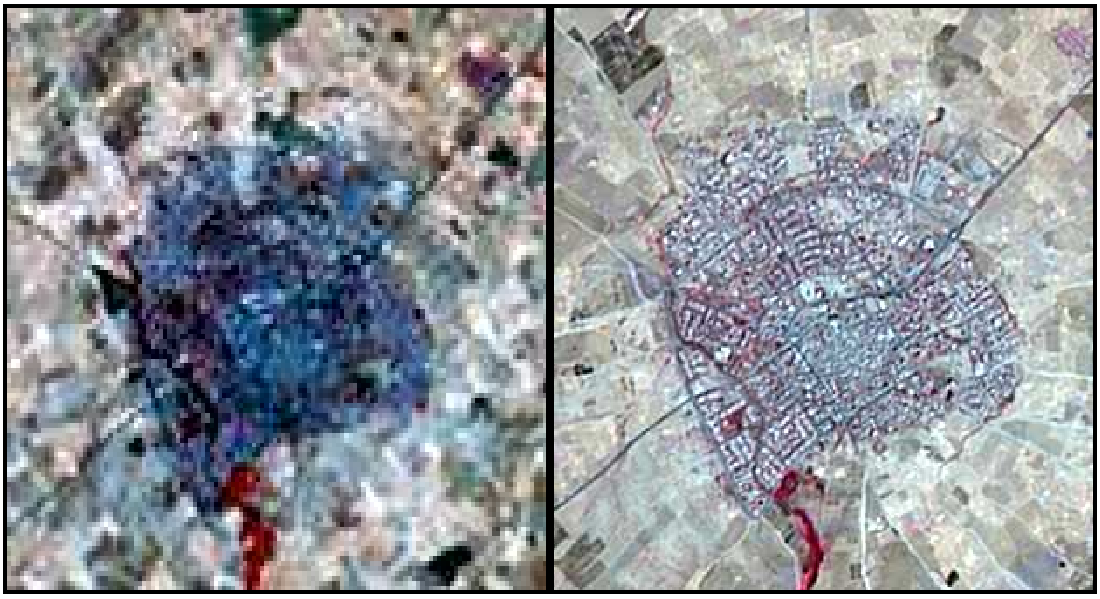

Figure 7- Comparison between extracted scenes before and after edge enhancement for true color image

4.Conclusion:

1. Figures 4 and 5 show that a noticeable enhancement in an image contrast as a result of merge resolution techniques. That is help us to make good interpretation and classification for land use and land cover for study area.

2. To confirm merge method both image satellite (Landsat and SPOT) must be georeferenced to same coordinate system and datum, in this search geographic coordinate (longitude and latitude) are adopted as coordinate system and World Georeference System (WGS84) are adopted as datum.

3. For more precise results, higher spatial resolution satellite images may be used; e.g. IKONOS, QuickBird, and/ or Aerial Photographs. For the same satellite images, the panchromatic band may be used to improve the spatial resolution of the satellite's bands.

4. The false color image is better than true image color in interpretation of biomass and vegetation area like orchard and valley.

5. It is possible to merge spectral bands with panchromatic band for the same type 0f data for example Landsat 7 bands $ETM_{1,2,3....7}$ merge with ETM_{PAN}. Also for $SPOT_{1,2,3,4}$ merge with SPO_{PAN}

6. There are another types of merge methods like principal component or multiplicative method. Also, there are another types of resampling techniques like nearest neighbor or cubic convolution. The chosen of method and technique depends on type of merged image.

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