The Distortion in the HIS Methods to Fuse Satellite Images

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Abstract

In this research three different HIS color modules had been studies as fusion methods to fuse high special resolution monochromatic satellite image with low special resolution colored satellite image for the same place to obtain high special resolution colored satellite image, the color distortion and the intensity variation in the resultant image had been studies and the solution to override them are presented.

التشوه في دمج الصور الفضائية بوساطة طرق الـ HIS

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الخلاصة

في هذا البحث تم دراسة ثلاثة موديلات لفضائيات الألوان من نوع HIS كطرق لدمج صور فضائية عادية ذات قدرة تحليل مكانية عالية مع صور فضائية ملونة ذات قدرة تحليل مكانية واطئة أخذت لموقع واحد للحصول على صور فضائية ملونة ذات قدرة تحليل مكانية عالية. التشويش الحاصل في الألوان والتباين في الإضاءة للصور المستحصلة قد تم دراستها مع اقتراح الحلول للتخلص منها.

Introduction

The capturing techniques that used in the satellite platforms give the ability to capture images in one of two features, either high resolution panchromatic (monospectral) image or low resolution multispectral (colored) image. To combine these two features in single image, different fusion techniques are utilizes, one of the popular methods are using HIS color spaces to fuse two satellite images to produce high resolution multispectral image. The use of the HIS color space in the fusing process is due to their ability to separate the achromatic information into the intensity component (I) while the chromatic information kept in the other two components (i.e. hue H and saturation S), in contrast to the RGB color pace where the achromatic and chromatic information are distributed on all its three components (i.e. red R, green G, and blue B).

HIS Fusion Algorithms

All fusion methods that utilize HIS color spaces have the same fusion algorithm which is illustrated in figure 1, which can be described by the following steps: [1]

1- Resample the multispectral image to fit the panchromatic one.
2- Transform the multispectral image to one of the HIS color spaces.
3- Replace the intensity (I) component of the colored image by the panchromatic image.
4- Transform the colored image back to the RGB space.

According to this fusion algorithm the fusion results should convey both the high resolution feature from the panchromatic image and the color feature from the multispectral image since the HIS color space separate the achromatic information (intensity) from the chromatic (hue and saturation), therefore any altering in any part of them should have no effect on the other,

but many researchers had been addressed that the two part of the image information in the fusion results suffered from some kind of distortion comparing to the original image's features[2][3]. Where the color suffers from distortion and the intensity of the final product is differ from the original panchromatic image.

Color Distortion Analysis

The reason for the correlation between the achromatic and chromatic parts of the HIS color spaces that encountered by many researchers are due to the geometry of the perceptual color space which plays a major rule in the distortion of the fused image. In all HIS color spaces the color points are merge and split along the saturation component when the intensity component is altered producing color points position away from their original location, with probability of having an over saturation color points artifacts, as illustrated in figure (1).

Filtering step is necessary to ensure that the new color point don't suffer from that artifact by putting a threshold value for saturation component for the color point in the following form:

$$S' = \begin{cases} \alpha & if\ S > \beta \\ S & otherwise \end{cases} \quad \ldots (1)$$

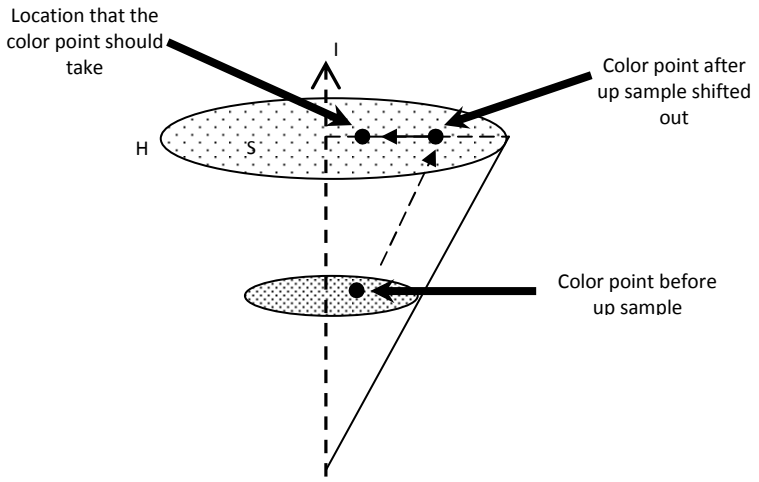

Figure 1- The Distortion In The Chromatic Information In The HIS Color Space Due To The Change In The Brightness

Intensity Variation Analysis

One of the main artifacts in the field of fusing a multispectral image with the panchromatic one using HIS color spaces is the variation in brightness of the final product. This may happen when the replacement is done by using panchromatic information that differs in the mean brightness from the achromatic information in the HIS space. The result will be either ultra-bright or too dark fused image, which will produce a low SNR even if the fused image contains richer spatial information. Therefore, adjusting the mean brightness of the panchromatic image to be equal to the achromatic part of the perceptual color space is necessary to avoid the brightness variation artifact. The equation used in this study to adjust the mean brightness of the panchromatic image to be equal to the achromatic part of the perceptual color space is:

$$P' = \frac{M_a}{M_p} \times P \quad \ldots (2)$$

Where P is the panchromatic image, P' is the adjusted panchromatic brightness that will be replaced by the achromatic information, M_a is the mean of the achromatic information value for the multispectral image which calculated using the average technique, and M_p is the mean of the panchromatic information value.

Results and Discussion

Two images that cover the area of Mausoleums of the Chinese Tang-Dynasty in Shaanxi province in the PR China [BH] are used as test images, which collected using two satellite sensors the first using IRC-1C satellite to capture panchromatic image, and LANDSAT satellite to capture the multispectral image as shown in figure (2). The general HIS color space fusion algorithm combines with the proposed filters is illustrated in figure (3), where the two

additional filtering steps for the intensity and saturation components are added.

To test the proposed fusion algorithm, three different geometries are utilized, which are the triangle HIS color space (T-HIS) [4], the hexagonal HIS color space (H-HIS) [5], and the double hexagonal HIS (DH-HIS) [4]. Equation (1) is used to filter the chromatic information with two restrictions: (1) $\beta<0.5$ and (2) $\alpha<\beta$, where the values of the variables α and β were taken in the ranges $\beta = [0.37\text{-}0.4]$, and $\alpha = [0.17\text{-}0.2]$.

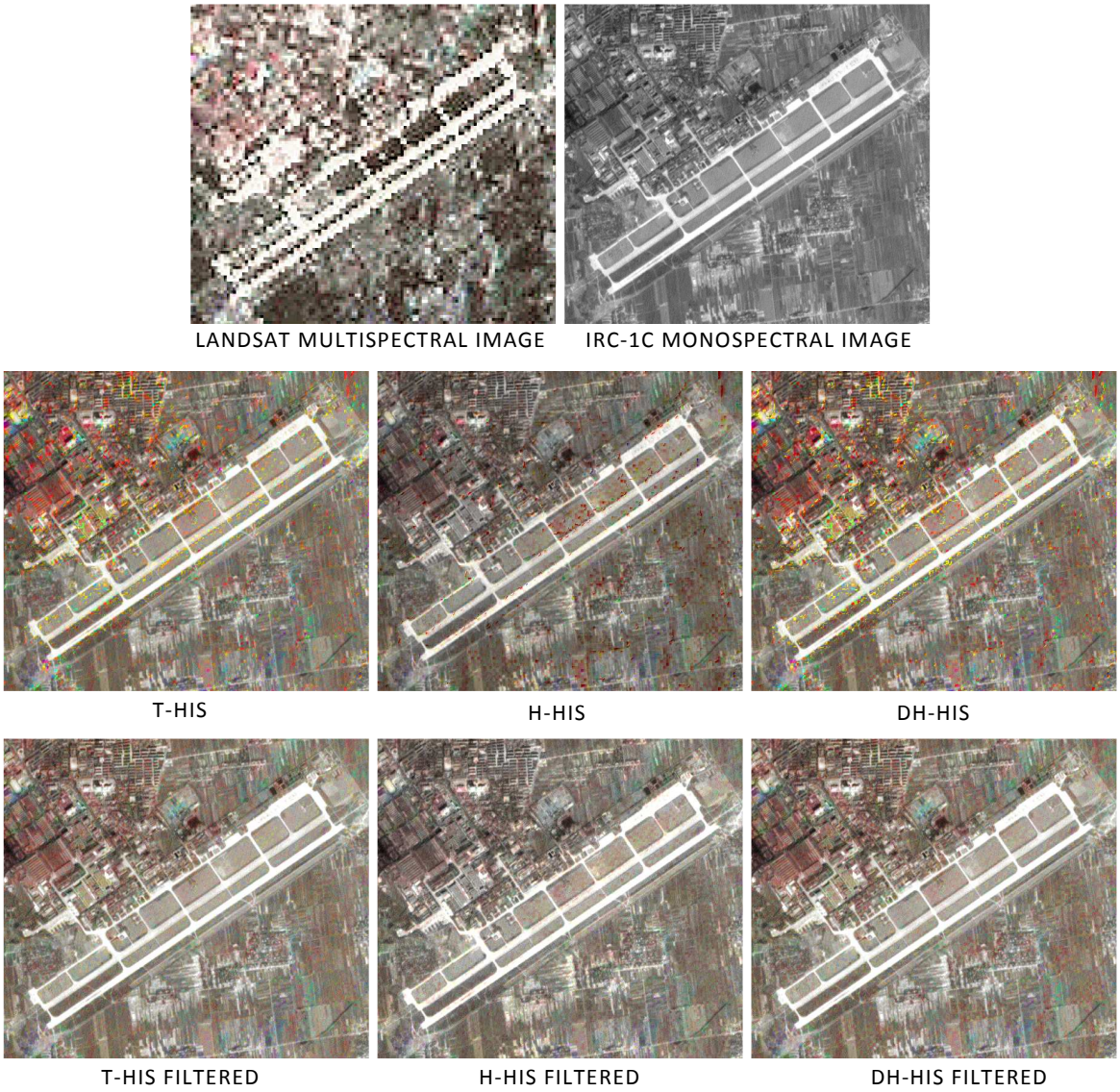

Figure 2- The Two Test Image And The Result Of The Fusion Algorithm Using The Three Different HIS Color Space Geometries.

The results of the modified algorithm compared with the general HIS fusion algorithm are illustrate in figure (2), to evaluate the result objectively, the SNR criterion after eliminating the images mean is used to measure the distortion in the achromatic information, while the mean difference angle (equation 3) is used to calculate the distortion in the chromatic information, figure (4) display the calculated zero mean SNR and the average dispersion angle for the fused image using the general and modified algorithm, in which it is clear that the images that produced using the modified fusion algorithm have in most cases less distortion in both achromatic and chromatic information when we compare it objectively, but using subjective criterion one can notice that the modified fusion algorithm eliminate the over saturation artifact that the results that obtain from the regular algorithm suffered from with intensity value similar to the panchromatic image.

$$\theta = \frac{1}{N \times M} \sum_{x}^{N} \sum_{y}^{M} \cos^{-1} \left(\frac{\sum_{c}^{3} I(x,y,c) I'(x,y,c)}{\sqrt{\sum_{c}^{3} I(x,y,c)^2 \sum_{c}^{3} I'(x,y,c)^2}} \right) \quad .. (3)$$

Where N and M the dimension of the image, I and I' are the original and fused images respectively, x and y are the location of the pixels in the images, c is the number of the bands.

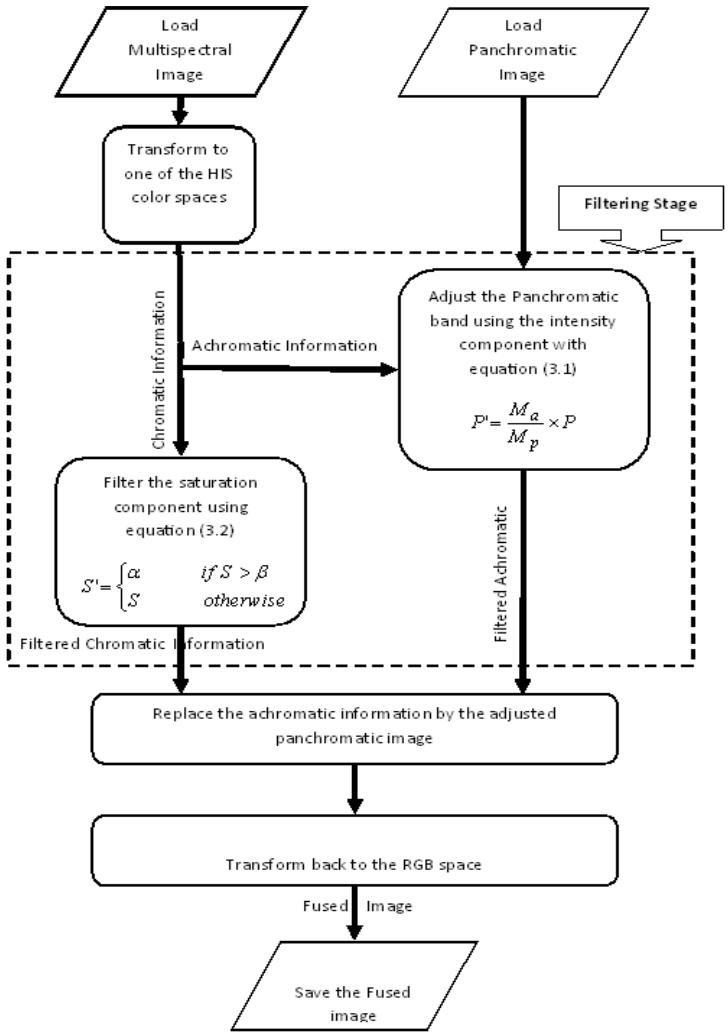

Figure 3- The HIS Color Space Fused Algorithm Combined With It The Filtering Stage

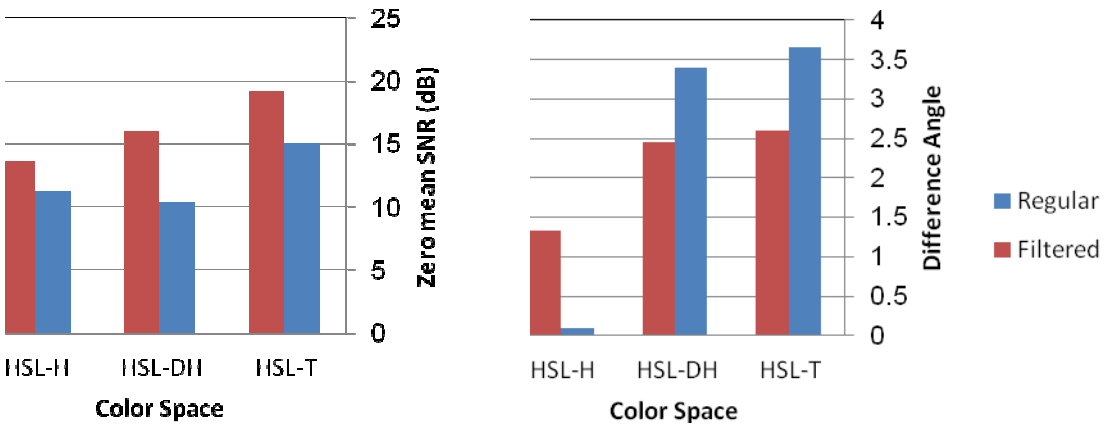

Figure4- The Effect Of The Filtering Process On The Chromatic And The Achromatic Information In The Final Fused Product

Conclusions

The results of the general HIS fusion algorithm using different HIS color space geometries suffered from alteration in the achromatic information (intensity) and distortion in the chromatic information (over saturation artifact). The proposed filters for achromatic and chromatic information succeed to produce achromatic information similar to the original achromatic information (panchromatic image) and eliminate the distortion for all geometries.

Using the objective criterion for all HIS geometries the results of the modified HIS fusion algorithm is better than the general algorithm except in case of eliminating the distortion in the chromatic information for H-HIS, where the average dispersion angle indicate that the general algorithm produce better fused image than the modified algorithm, but once the subjective criterion one can notice that modified algorithm eliminate the over saturation artifact even with low objective criterion.

References

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