PANSHARPENING OF RASAT AND GÖKTÜRK-2 IMAGES VIA HIGH PASS FILTER

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ABSTRACT:

Pan-sharpened images of RASAT and GÖKTÜRK-2 satellites were generated using High Pass Filter (HPF) in this paper. GÖKTÜRK-2 satellite has 11 bits radiometric resolution, 2.5 m GSD in panchromatic band and 5 m GSD in VNIR bands whereas RASAT has 8 bits radiometric resolution, 7.5 m GSD in panchromatic band and 15 m GSD in visible bands. Quantitative analysis was carried out by spatial metric while the while the products were qualitatively analysed with visual interpretation by an expert group. The values for spatial metric were estimated as 0.9678 and 0.9542 for RASAT and GÖKTÜRK-2, respectively. It can be concluded that the success of HPF is almost satisfactory considering the optimal value of spatial metric is 1. The visual analysis shows the performance of GÖKTÜRK-2 is higher than RASAT since the higher radiometric and geometric resolution of GÖKTÜRK-2. All operations were run in SharpQ derived by the authors in Matlab environment.

1. INTRODUCTION

Thanks to the technological developments in remote sensing, various radiometric, geometric, spectral and temporal resolutions can be gained at the present time. Various types of image fusion technics are run for the images acquired from different type of sensors, for the purpose of increasing the potential of image-usage in different applications. One of these technics is pan-sharpening fusing the higher geometric resolution of panchromatic band and the higher spectral resolution of multispectral bands. By the way, a pan-sharpened image might reflect the best characteristics of geometric and spectral resolution of images. Many pan-sharpening methods and metrics for quantitative evaluation are available in the literature (Stathaki, 2011; Özendi et al., 2016). Each method has pros and cons characteristics since some of them highlights the geometric characteristics where some emphasis the spectral feature.

Pan-sharpening performance of RASAT images were subjected using various fusion methods and quantitative evaluation by statistical metrics (Özendi et al., 2016; Teke, 2016; Abdikan, 2016). GÖKTÜRK-2 images were also evaluated by Özendi et al. (2016). Özendi et al. (2016) were handled the kinds of pan-sharpening methods such as Principle Component Analysis (PCA), Intensity Hue Saturation (IHS), and Brovey. The image products were quantitatively evaluated by the statistical metrics such as Correlation Coefficient (CC), Root Mean Square Error (RMSE), Relative Average Spectral Error (RASE), Spectral Angle Mapper (SAM) and Erreur Relative Globale Adimensionnelle de Synthése (ERGAS). In addition to the previous studies, RASAT and GÖKTÜRK-2 images were evaluated by the HPF method and spatial metric. Both HPF and spatila metric stand out its geometric characteristics. The products were also visually analysed by an expert group.

2. METHOD

Among various type of pan-sharpening methods, HPS products the closest results to the original images with respect to the geometrical characteristics (Teke, 2016). The principle of HPF is to apply a filter to the panchromatic band, which is formed as follow:

$$filter = \begin{bmatrix} -1 & \cdots & -1 \\ \vdots & (2r+1)^2 - 1 & \vdots \\ -1 & \cdots & -1 \end{bmatrix}_{(2r+1),(2r+1)} \quad (1)$$

The sum of this filter is 0 (zero). The *r* value is the ratio of ground sampling distance (GSD) of multispectral and panchromatic bands $r = GSD_{MS}/GSD_{Pan}$. In our case, it set to 2. Following the applying this filter to the panchromatic band, the new product can be calculated as:

$$F_{i,j} = MS_{i,j} + Pan_{i,j(w,h)} \quad (2)$$

where, $F_{i,j}$ is pan-sharpened image, $MS_{i,j}$, is the multispectral bands, $Pan_{i,j}$, denotes the panchromatic band, and $Pan_{i,j(w,h)}$ means the filtered panchromatic band. *i, j* is the row and column coordinates of filter with window size in *w* (width) and *h* (height) (Yusuf et al., 2013). The filtered band is convoluted by a weighting value suggested as 0.24 by Teke (2016).

For the statistical evaluation using spatial metric, both the original panchromatic and pan-sharpened image generated by HPF are re-filtered by the mask $[-1 -1 -1; -1\ 8 -1; -1 -1 -1]$ at first. Then the average CC derived by individual CCs between this new products (i.e. panchromatic and RGB bands of pan-sharpened image convoluted by the mask) is calculated (Palsson et al., 2012).

3. APPLICATION

3.1 Image and test field

RASAT and GÖKTÜRK-2 are the operational remote sensing satellites of Turkey. Their main characteristics are presented in Table 1. RASAT images can be downloaded from GEZGIN portal free-of-charge for Turkish citizens, whereas the GÖKTÜRK-2 images can be obtained free-of-charge for the non-commercial usage of governmental agencies and research/education institutions within Turkey. GÖKTÜRK-1 is

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the newest satellite with 70 cm GSD in panchromatic band, and 2.8 m GSD in VNIR band.

Launching date	17 August 2011	18 December 2012
Altitude	~ 700 km	~ 700 km
GSD	Pan 7.5 m RGB 15 m	Pan 2.5 m VNIR 5 m
Swath Width	30km	20 km
Radiometric Resolution	8 bit	11 bit
Temporal Resolution	4 days	2-3 days
Designer	TUBITAK Space Technologies Research Institute	TUBITAK Space Technologies Research Institute, Turkish Aerospace Industries, Inc.
Operator	TUBITAK Space Technologies Research Institute	Turkish Air Force

Table 1. Technical specifications of RASAT and GÖKTÜRK-2.

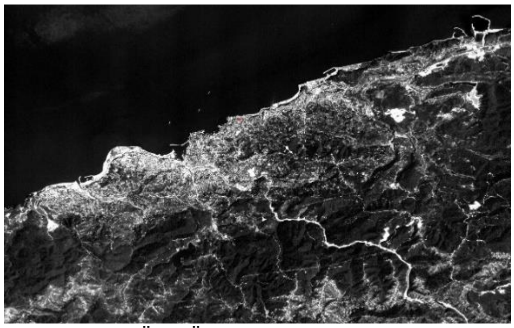
The images were acquired over Zonguldak city centre and its close surrounds. Zonguldak is a test site for evaluating the remotely sensed images since 2000s (Bayık, et al., 2016). The main characteristics of this test site is its roughness topography consisting of dense forest and urban areas and various kinds of land covers such as agricultural and industrial areas etc. Zonguldak is the major hard coal mining area of Turkey, which is still active in underground. Figure 1 shows the oblique view of the dominant topography and also the city centre.

Zonguldak city centre and its inland

A scene from Zonguldak city centre

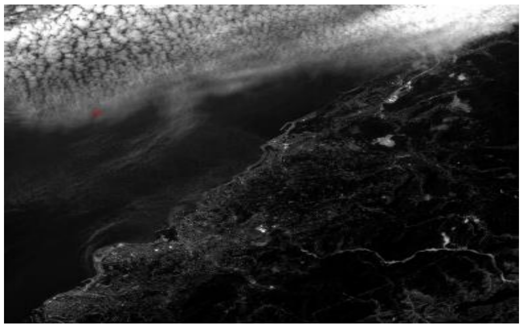
Figure 1. Zonguldak test site (Turkey).

The images in Level 1 format used in this research are shown in Figure 2. It is obvious that the GÖKTÜRK-2 has an effect of inter-detector responses. This radiometric effects were corrected by the radiometric calibration phase reported by Teke et al. (2016). Nevertheless, this radiometric distortion remained in the current images since GÖKTÜRK-2 images were dated 2014 in this study.



GÖKTÜRK-2 panchromatic

GÖKTÜRK-2 MS



RASAT panchromatic

RASAT MS

Figure 2. GÖKTÜRK-2 and RASAT images in Level 1.

The pan-sharpening images were generated by SharpQ derived by the authors in Matlab environment. Figure 3 shows the pan-sharpened images generated. Results of GÖKTÜRK-2 reach more success since its sensor has more radiometric and geometric resolution than of RASAT. Correlation coefficients for RASAT image was 0.9678 and GÖKTÜRK-2 image was 0.9542, which both are close the optimal value (1) of this metric. This means the pan-sharpening of both images has a satisfactory success with respect to spatial metric.

Not only the quantitative analysis, but also a visual comparison was carried out for the qualitative analysis.

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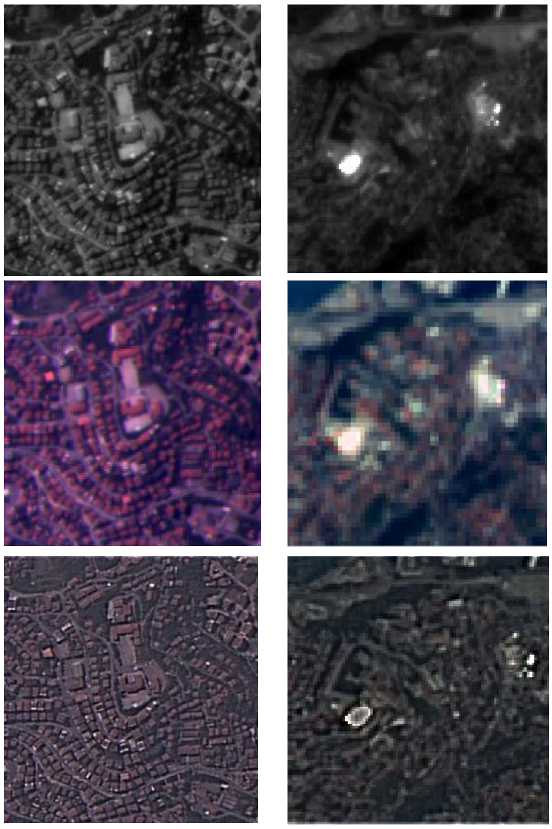

Figure 3. Pansharpened images of RASAT and GÖKTÜRK-2.

3.2 VISUAL ANALYSIS

Generally speaking, since GÖKTÜRK-2 has more geometric and radiometric resolution than RASAT, the visual quality of GÖKTÜRK-2 pan-sharpened images are higher than RASAT. The visual comparison was made for the urban and forest areas. As expected by the characteristics of HPF, this methods does not keep the colour, so its success on forest areas is poor than in urban areas.

Figure 4. Viusal comparison in urban and forest areas.

4. CONCLUSION

In this study, the pan-sharpening performance of RASAT and GÖKTÜRK-2, two of three in-operation satellites of Turkey, were investigated. HPF is preferred for the pan-sharpening method, and the images were investigated using the spatial metric for quantitative analysis. The findings for correlation coefficients were 0.9678 for RASAT and 0.9542 for GÖKTÜRK-2, which both were close the optimal value (1) of this metric. Since HPF does not keep the colour information, the success of this method is relatively poor than in urban areas in the visual comparison.

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