Self-Evaluation of Band Matching Quality in KOMPSAT-3A Data Processing procedure

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ABSTRACT: Each band of KOMPSAT-3A (KOrean Multi-Purpose SATellite - 3A) sensor projects the ground to the constant interval. Therefore, when each band observes the same position, attitude angle difference of satellite and difference of imaging time occurs and distortion is generated geometrically. To correct this distortion, KARI developed a matching technique specialized in KOMPSAT-3A and is currently operating in the processing system. However, this matching technique is not complete, so mismatch occurs. In this case, there is a problem that the image quality should be analyzed in operation to determine the matching quality. To improve this, we developed a technique that can quantitatively report the mismatching ratio by self-determining the accuracy in the matching process between KOMPSAT-3A bands. Consequently, this technique has a significant effect on evaluating the matching quality by determining the relative variation by matching for each band at the same point and determining the mismatch rate by analyzing the variation of all bands in the form of color map.

1. INTRODUCTION

After KOMPSAT-3A launched at March 25 2015, the Cal/Val team in KARI has been managing satellite image quality for KOMPSAT-3A. As shown in Figure 1, KOMPSAT-3A data processing process is composed, and algorithms for improving satellite image quality are developed and operated at each category. Each processing step is related to the main parameters that determine the satellite image quality and has been developed specifically for the KOMPSAT-3A to satisfy both system and user requirements. The representative quality parameters managed are Modulation Transfer Function (MTF), Signal to Noise Ratio (SNR), matching accuracy and location accuracy. Among these, matching accuracy is an important quality that determines satellite image quality. In the case of KOMPSAT-3A, the angle of view of the same area is interpreted differently for each band according to the ground elevation due to the structure of the sensor. Each band of KOMPSAT-3A sensor projects the ground to the constant interval. Therefore, when each band observes the same position, attitude angle difference of satellite and difference of imaging time occurs and distortion is generated geometrically. To correct this distortion, the Cal/Val team in KARI developed a matching technique specialized in KOMPSAT-3A and is currently operating in the processing system.

Table 1. System Requirements for KOMPSAT-3A

Category	System Attributes	Requirements
Spatial	MTF	PAN 08%, MS 12%
	MTF Compensation	PAN 13%, MS 18%
Radiometric	SNR	> 100
	Radiometric Resolution	14 bit
Geometric	GSD	PAN 0.55m, MS 2.2m
	Swath width	> 12 km
	Location Accuracy	POD/PAD 70m, OD/AD 285m
	Registration(Matching) Accuracy	< 0.5 pixel (MS)

Figure 1. Overview of KOMPSAT-3A Data Processing procedure

2. BAND TO BAND MATCHING

2.1 Feature based matching

The feature-based matching technique is a technique commonly used in image processing and can maintain high accuracy. In particular, in the case of satellite image, a large number of feature points can be extracted according to the imaging area, and a highly accurate matching can be performed based on this. In KOMPSAT-3A, based on the satellite camera model, initial matching considering relative LOD (Line-Of-Detector) / LOS (Line-Of-Sight) is performed as shown in Figure 2, and the location of feature extraction is determined by filtering. After the feature point extraction is performed, the relative variation between the reference point and the candidate point is calculated, filtered and corrected, and finally, the optimal candidate point is selected by calculating the correlation coefficients of the two points.

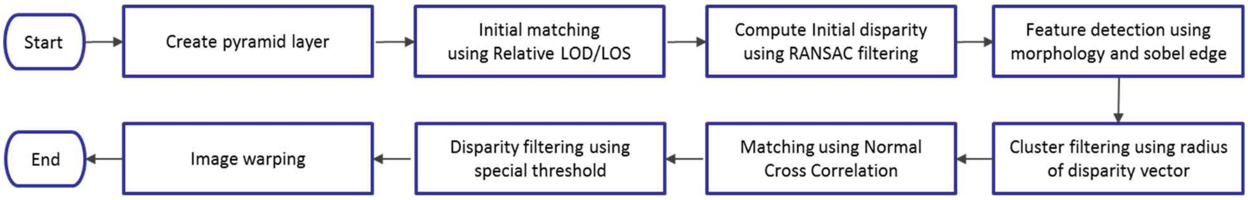
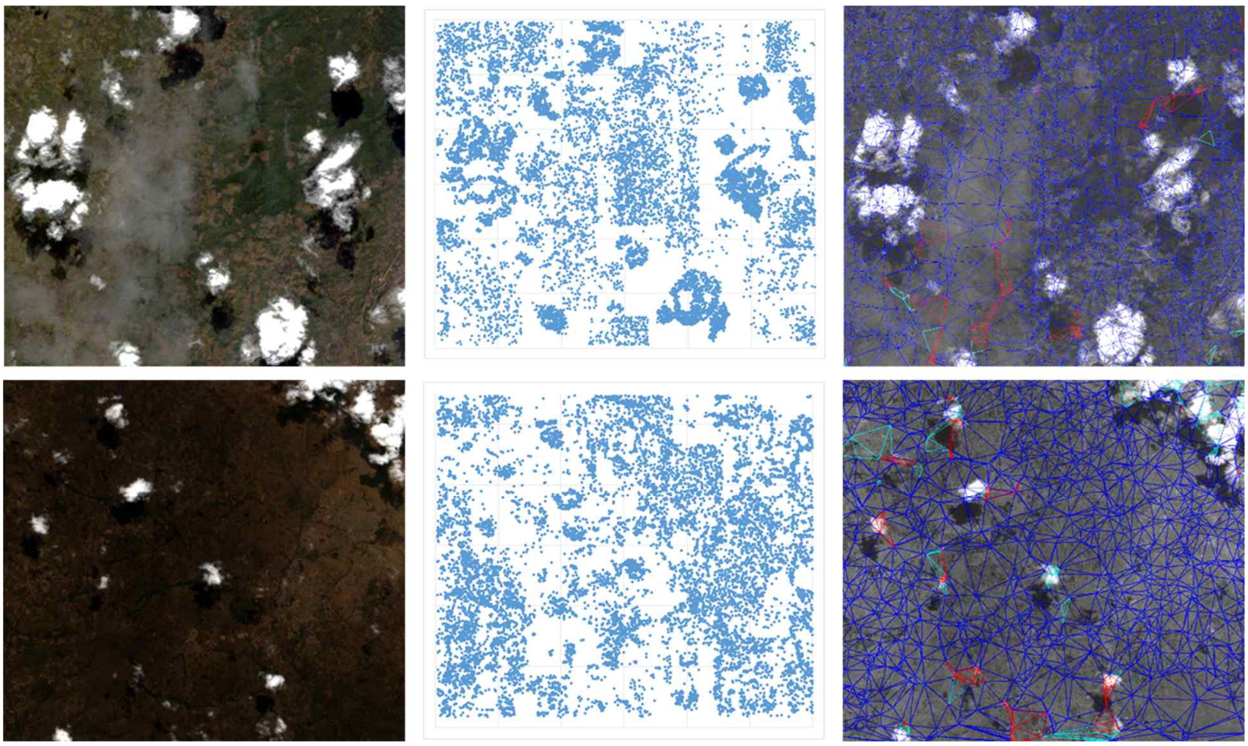


Figure 2. Band to band matching procedure of KOMPSAT-3A

2.2 Warping using disparity of tie points

Finally, the distortion of the two images is corrected by using the final pair of candidate points selected. However, as mentioned earlier, it is impossible to correct simply using affine or polynomial because the amount of distortion is complicated by the angle of view of each band and the altitude of the ground. Therefore, KOMPSAT-3A was developed to correct distortion by performing local warping type resampling using the final selected candidate points. As shown in Figure 3, after selecting many candidate points in the whole image, each candidate point is composed of bundles that can be warped by each region, and all affine coefficients are calculated for each region and calculated as variation. Afterwards, the shift amount was calculated for all the pixels by smoothing the total shift amount to prevent each region from being disconnected.



(a) Ground image (b) Selected tie points (c) Warping area using tie points

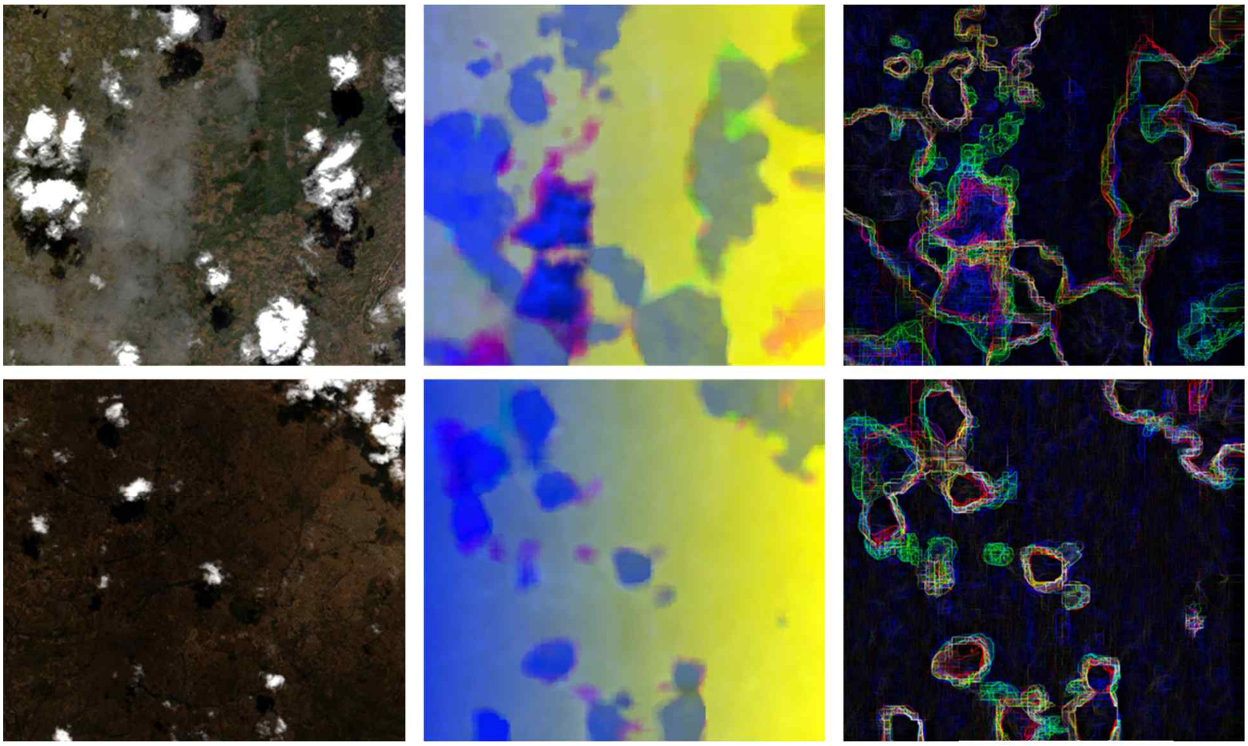
Figure 3. Warping process of matching procedure

3. SELF EVALUATION

The foregoing has described the process of matching in the process of KOMPSAT-3A. Based on this, in this paper, we propose a technique for evaluating the quality of matching itself after matching is performed before the process is completed. The feature-based matching algorithm generally guarantees a high accuracy, but in some cases, a low accuracy result may be obtained. In particular, considering the sensor structure of KOMPSAT-3A, there is a good possibility that low-accuracy results are obtained for terrains with high ground altitudes or clouds that exist at high altitudes. Since this can be a significant problem in terms of managing the quality of satellite images, it is important to evaluate and report this within the processing of KOMPSAT-3A. For this purpose, we devised a method to evaluate the matching quality by fusing the amount of variation calculated for each band in the matching process of KOMPSAT-3A.

3.1 Gradient of disparity map

Disparity map of Figure 4 is a variation of candidate points calculated during the warping process in Section 2.2. Since only a single-band variation could not be used to identify low-accuracy matching quality, the disparity vector calculated from each band was shaped into a three-dimensional color map. This means that there is a possibility that the amount of variation in a certain region is significantly higher than that in other regions, but it is possible to have a lower accuracy. It is intended to analyze its characteristics by expressing it in spatial domain. If there is a large variation in all bands in the same region of all the bands where the matching is performed, the variation of variance and continuity in the surrounding region is likely to be low. The gradient map was generated as shown in gradient map of Figure 4. Gradient maps allow us to calculate regions of regions where a certain level of variation occurs in all bands, and segment them by connecting them to closed curves.

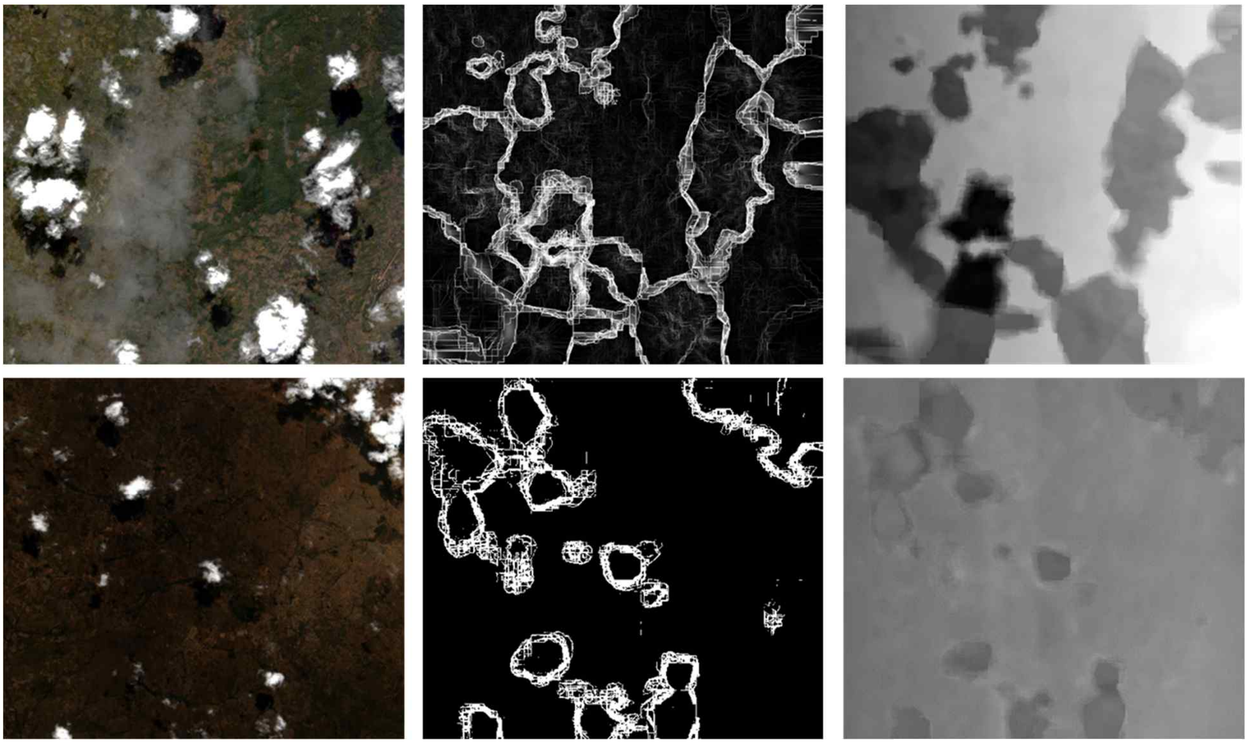


(a) Ground image (b) Disparity map (c) Gradient map

Figure 4. Analysis of disparity pairs

3.2 Determination of closed contour using gradient map

The boundary region identified by the gradient map mentioned in Section 3.1 means that the extracted candidate points have abnormal variations. This is because the variation of coherent forms did not occur in the warping of several bands, so that the relevant area may be disconnected from other areas. In other words, mismatching occurs in this disconnected region. In this paper, to evaluate the quality of matching by extracting this domain, the algorithm is constructed as follows. First, a closed curve can be generated using a gradient map, and then the contour of the portion with the high gradient can be extracted using a morphology operation. Then, the extracted contour is overlapped with the disparity map to determine the mismatching area by analyzing the area through the difference in the amount of variation inside and outside the closed curve. The matching quality of the total number of pixels is calculated using the mismatched region thus determined to evaluate the matching quality.



(a) Ground image (b) Contour of gradient map (c) Selected mismatch area

Figure 5. Calculation of mismatching ratio

4. CONCLUSION

In this paper, we propose an algorithm to reduce the risk on quality evaluation that may occur in the distribution process by evaluating matching quality in KOMPSAT-3A's data processing process. This can shorten the time it takes to distribute the data of KOMPSAT-3A, and in some cases it can be a standard to run additional improvement algorithms when the self-evaluated quality is not good. Although the accuracy of the mismatching area is still considered to be improved, it is confirmed that there is sufficient effect as a criterion for determining whether to run additional quality improvement algorithms by dichotomously evaluating whether mismatching has occurred.

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