A STUDY ON PERFORMANCE IMPROVEMENT OF RESIDUAL NUC ALGORITHM BY ANALYZING SIDE-SLITHER IMAGES OF KOMPSAT-3A

You-Kyung Seo, JaeHeon Jeong, DaeSoon Park, DooChun Seo, DongHan Lee, and HyoSuk Lim

Korea Aerospace Research Institute, 169-84 Gwahak-ro, Yuseong-gu, Daejeon, 34133, Korea
Email: ykseo@kari.re.kr

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ABSTRACT: This study focuses on improving the algorithm for the RNUC (Residual Non-Uniformity Correction) of KOMPSAT images, and proposes a method for generating RNUC tables using side-slither images compared to using normal images using existing methods. The images corrected by the new RNUC algorithm can be seen to be improved in linearity and uniformity compared to the existing calibration methods.

1. INTRODUCTION

Each pixel of the satellite image sensor should ideally be a uniform output, but the actual output is not. Non-uniformity occurs according to the characteristics of pixels and the transmission characteristics of optical modules such as mirrors, structures and lenses. The non-uniformity characteristics of a sensor directly affect image quality, and if a line-scanning type image sensor or a Time Delay Integration (TDI) sensor is used, it is seen as a striped type noise fixed to the image. This noise is fixed and can be removed using correction coefficient obtained by a calibration algorithm called non-uniformity correction (NUC). However, according to the non-linearity characteristic, there is a noise component in the specific area in the image data that must be removed separately after NUC, and a correction method to reduce this component is called RNUC. In order to obtain coefficients for RNUC, Image data taken from relatively dark, uniform areas such as lakes, seas, and rivers are used. In order to obtain coefficients for RNUC, video data taken from relatively dark, uniform areas such as lakes, seas, and rivers are used. However, it takes a lot of time to acquire images with uniform areas for the entire column. As an alternative to this, side-slither images allow rapid sampling of various Digital Number (DN) ranges. Therefore, in this study, a new RNUC algorithm is developed using side-slither images of KOMPSAT-3A.

2. STUDY AREA AND DATA

Data to generate the RNUC Table are 100 Side-Slither images acquired with the KOMPSAT-3A from November 2017 to July 2018. The data used in the RNUC-applied tests are 27 images of deserts, seas, forests and urban areas acquired by the KOMPSAT-3A from November 2015 to July 2018.

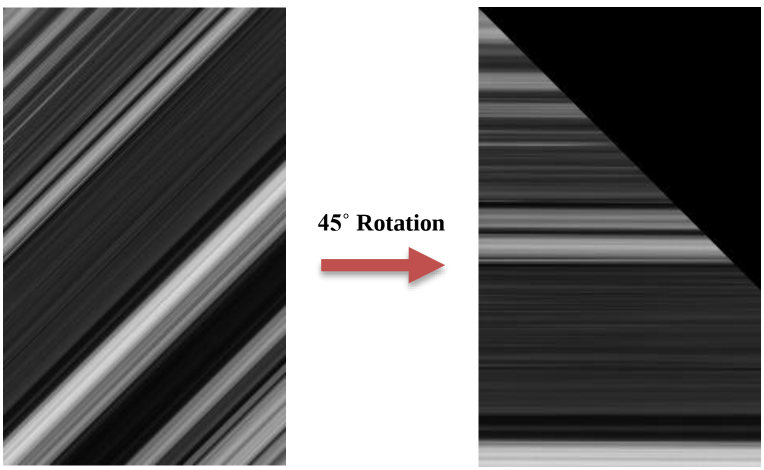

Figure 1. Rotation of Side-Slither Image

3. EXPERIMENTAL METHODS

NUC of the KOMPSAT satellite can be divided into the normal NUC, which is performed first on the satellite, and RNUC, which is performed second. In the image generated through normal NUC, there is noise that is not removed by the nonlinearity characteristic, and it is removed separately through RNUC. In order to perform RNUC, the linearity check must be preceded. Check the linearity of the image data of PAN, MS1, MS2, MS3, and MS4 band and create the RNUC table for linearity correction. Finally, a calibrated image can be obtained by applying the generated RNUC table to the KOMPSAT image.

Figure 2. Residual NUC Algorithm

3.1 Uniform Block Sampling

To extract the uniform samples, side-slither images were rotated at 45 degrees diagonally, as shown in Figure 1. Side-Slither images, theoretically, should be completely horizontal when rotated 45 degrees, and pixels taken with the same CCD should have the same brightness, but sometimes they are not completely horizontal and the brightness are different due to various factors, such as satellite motion, satellite imaging environment, and so on. Therefore, it should be preceded by the selection of a valid uniform sample for RNUC calibration within the side-slither image.

In this paper, the smaller the standard deviation of the image, the more uniform the image is considered. However, in exceptional cases, if the standard deviation of the samples is too low, these samples were excluded because they were judged to be of no value for RNUC purposes.

Across the entire line of the side-slither image, blocks were created in 20 lines per block. These blocks are subject to the conditions in Step 3, and the samples conforming to the conditions are classified as valid. The number of samples obtained in this study is 219. Ten lines are extracted from the middle of each sample and are finally used for RNUC calibration.

Figure 3 shows one of the constraints for selecting uniform samples. Currently, monthly uniformity is measured using side-slither images in KARI (Korea Aerospace Research Institute). Based on the results of this measurement, the effective sample is selected. If it comes within a level similar (±10 DN) to the uniformity trend, it is considered a valid sample.

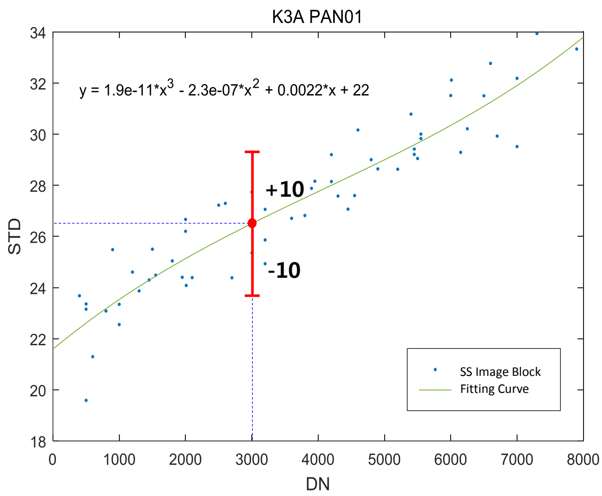

Figure 3. Constraints for Selecting Uniform Samples

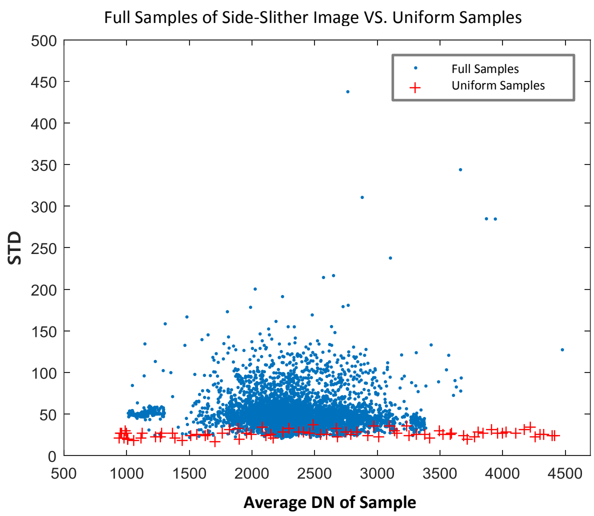

Figure 4. Uniform Sample Validation Process

3.2 RNUC Table Creation

After sampling the various DN, mean DNs of the entire pixel are obtained for all samples. And then, the gain and offset between this mean DN and the mean DN of one column are obtained. This is repeated for the entire column, and the last calculated coefficients are used to generate the RNUC table.

4. RESULT AND DISCUSSION

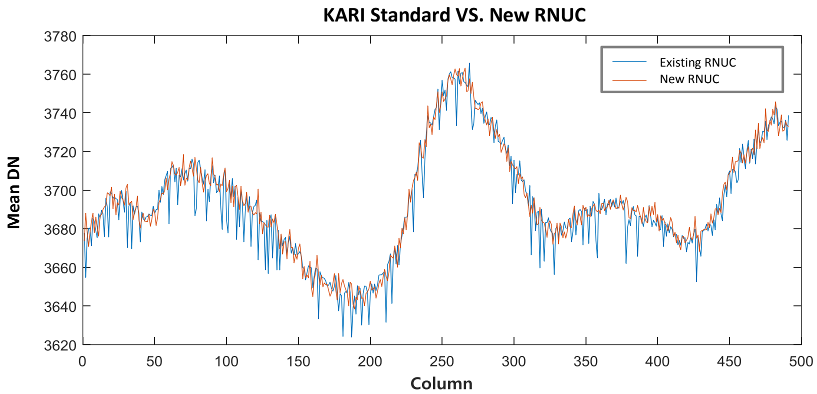

Figure 5. Comparison of Result of Existing RNUC and New RNUC

As a result of applying the new RNUC algorithm to 27 general images, it was found that linearity and uniformity were improved compared to the existing KARI standard method. As shown in Figure 5, the profile for a portion of the test image shows that the new RNUC application results in a smaller deviation from the DN between adjacent columns than the existing method. The following figure shows the RNUC off, existing RNUC, and new RNUC results for the same image. As can be seen in Figure 6 to 8, it is possible to see that the vertical noise has improved significantly in the application of the new RNUC. The brightness and contrast of images were adjusted for a clear comparison between the following figures.

However, some of the 27 test images (especially sea images) had problems with the detector Uniformity Differential performance. This should be improved in the next study considering the characteristics of the KOMPSAT camera system.

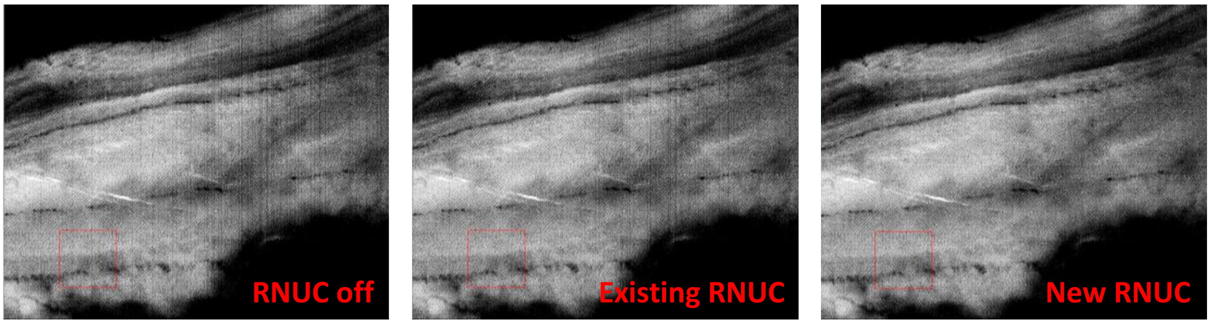

Figure 6. Comparison of Result of RNUC Application (KOMPSAT-3A PAN Image, 10 December 2017)

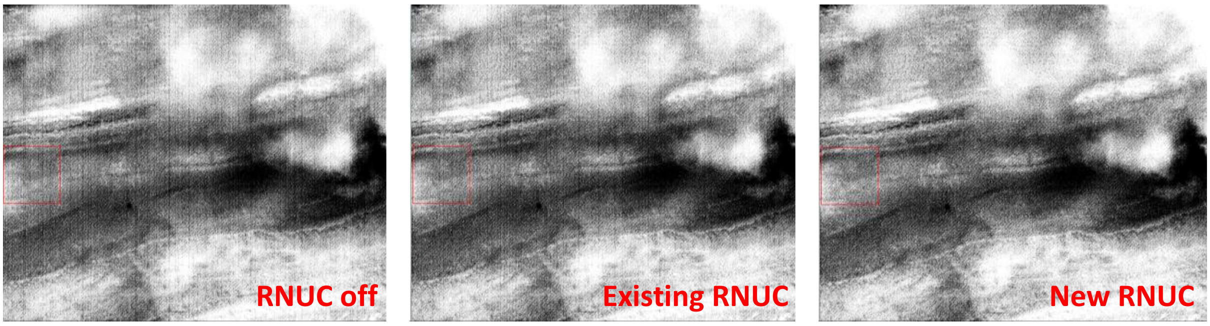

Figure 7. Comparison of Result of RNUC Application (KOMPSAT-3A PAN Image, 11 March 2018)

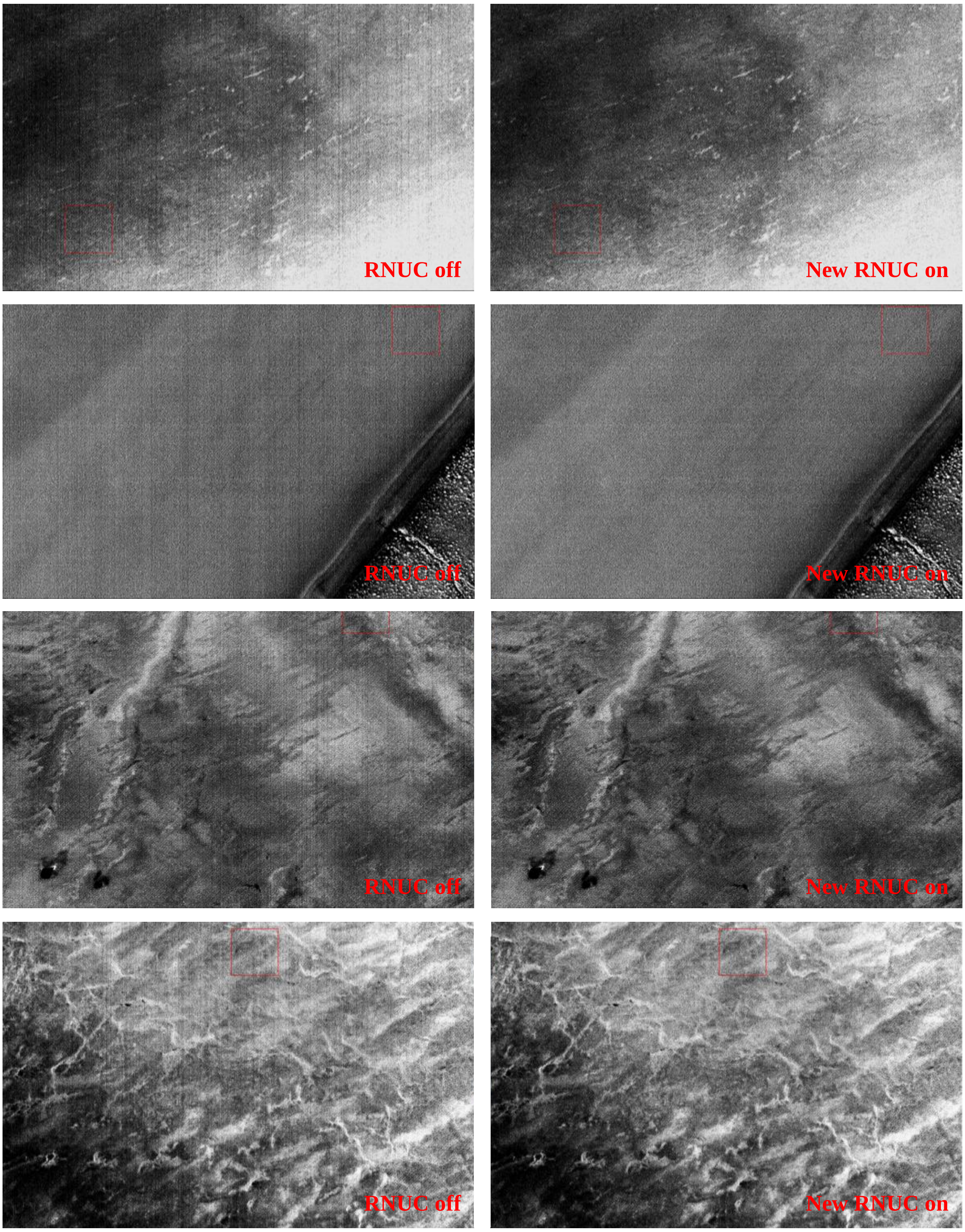

Figure 8. Comparison of Result of RNUC Application (KOMPSAT-3A PAN Image)

5. REFFERENCE

Kim, Y. S., J. P. Kong, H. P. Heo, and J. E. Park, 2007. Proposal and Verification of Image Sensor Non-uniformity Correction Algorithm, The Institute of Electronics of Korea – System and Control 44(3), 29p.