NIIRS ESTIMATION USING THE GENERAL IMAGE-QUALITY EQUATION FOR MONITORING IMAGE DEGRADATION

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ABSTRACT:

Generally, the quality of satellite images is expressed by GSD (Ground Sample Distance), MTF (Modulation Transfer Function) and SNR (Signal to Noise Ratio). However, these factors are technology-oriented and do not explain interpretability of satellite images. We need a standardized index which shows standard of interpretability. In this study, we estimated NIIRS (National Imagery Interpretability Rating Scale) through the GIQE (General Image Quality Equation) which is able to judge image interpretability with the standardized index. Traditionally, NIIRS has been determined manually by specialized image analysts. We used the GIQE in order to reduce inefficiency and high costs cause by manual interpretation and to produce accurate NIIRS. For monitoring image degradation, we estimated GIQE physical parameters from image analysis and carried out time series analysis about the quality of the KOMPSAT-1 images. On all of the tests, we were able to identify the image degradation due to the changing time. This indicates that NIIRS derived from GIQE will be used for image degradation indicator.

KEY WORDS: GSD, MTF, SNR, NIIRS, GIQE, KOMPSAT-1

1. INTRODUCTION

The Quality of satellite images has increased along with development of science & technology. The users who are using the satellite images have to know accurate information about the quality of satellite images. Because of this reason, satellite image providers provide information about the quality of satellite images to the users until the time when the life of the satellites becomes extinguished.

As time goes by, the quality of satellite images is degraded. This degradation of image quality affects users who are using the satellite images. So satellite image providers have to meet the requirements of users. Because of that reason, notifying the degradation of the quality of images to the users is very important. However, only a few image providers offer quality information that degradation has been taken into account.

Numbers of experiments have progressed in order to grasp the quality of satellite images and the provider of satellite images have been providing information about the quality of images using the those results. For example, there is experiment for the quality of satellite images by the Earth Science Application Directorate John C. stennis space center in NASA (National Aeronautics and Space Administration) (Zanoni et al., 2003). In this place, the experiment about the quality of images has been executed in geospatial accuracy aspect, image quality accuracy aspect and radiometric accuracy aspect and they provide the information of the quality of images about IKONOS and QUICKBIRD satellite using this experiment results. And image processing laboratory in South Dakota state university electrical engineering and computer science department measured parameters such as PSF (Point Spread Function), MTF and SNR which affects quality of satellite images and represented information about quality of IKONOS and QUICKBIRD satellite images (Helder et al 2006). However, previous studies focused on how to estimate and represent the immediate image qualities. In this paper, few discussed how to evaluate degradation and how to express the degradation for users.

To measure degradation of quality of satellite images, we need standardized index which is able to judge interpretability of satellite images. In this paper, we used NIIRS as a parameter to judge degradation of image quality.

In this experiment, to observe change of interpretability along time, we used KOMPSAT-1 images which were acquired from different dates. Using GIQE, we executed time series analysis.

1.1 NIIRS

We used NIIRS which represent the interpretability of images with standardized index. NIIRS was developed for representing objective standard about quality of images. NIIRS is composed of 10 graduated levels. Objectively each level was characterized by features which appeared from satellite images. So the objects were detected from NIIRS level 3 images are not visible in the level 2 and 1 images.

Currently NIIRS used for this experiment is the civil NIIRS (IRARS Committee. 1996). Early NIIRS is used to

classify military structures and equipments but civil NIIRS was characterized for civil remote sensing community and developed with various categories under IRARS (Imagery Resolution Assessments and Reporting Standards) committee. Civil NIIRS has an own criteria, agricultural criteria, cultural criteria and natural criteria. Besides, NIIRS for panchromatic image interpretation is extended to multispectral satellite images and infrared satellite images, so current civil NIIRS is extensively used for standard of image interpretation (IRARS Committee, 1996).

1.2 GIQE

Originally NIIRS has been extracted manually by specialized image analysts or researchers who are engaged in the image processing fields. However, in this experiment, we used NIIRS derived from GIQE (Leachtenauer et al., 1997) in order to reduce inefficient waste of time and cost due to the manual work. GIQE was developed by IRARS. Early GIQE was developed for parameters which affect interpretability of images but current GIQE was used for extraction of NIIRS from the images. GIQE consists of various parameters which determine the interpretability of images. NIIRS can calculate with following equation (Leachtenauer et al., 1997).

$$NIIRS = 10.251 - a\log_{10} GSD_{GM} + b\log_{10} RER_{GM} - (0.656 \times H_{GM}) - (\frac{0.344 \times G}{SNR}) \quad (1)$$

where GSD_{GM} = the geometric mean of the GSD

RER_{GM} = the geometric mean of the relative edge response

H_{GM} = the geometric mean-height overshoot caused by MTFC (Modulation Transfer Function Compensation (Leachtenauer et al., 1997)

G = the noise gain associated with MTFC

SNR = estimated for differential radiance levels from lambertian scenes with reflectance of 7% and 15 % with the noise estimated from photon, detector, and uniformly noise terms

In this equation, if the RER exceeds 0.9, then a is 3.32 and b is 1.559 and RER less than 0.9, then a is 3.16 and b is 2.817 (Leachtenauer et al., 2000).

Previously the GIQE which was used for analysis of high resolution images to check whether this equation can be used for interpretability of such images (Kim, 2008).

2. TEST DATA

2.1 Test image

Tested images were in total 6 over the same area, Daejoen taken by KOMPSAT-1. Each image was acquired by the period of activity of KOMPSAT-1 at different times. Table 1 summarizes the details of images used for time series analysis. To acquire NIIRS values from the GIQE over same area, all of the images include the Daejeon area. Fig 1 shows one image used (acquisition time: 5 May. 2001).

Table 1. Characteristics about images used for experiments

ID	Acquisition Date	Acquisition Area	GSD(m)
1	05/12/2001/01:58:27	Daejeon	6.6
2	10/07/2003/01:53:02	Daejeon	6.6
3	01/07/2005/01:45:59	Daejeon	6.7
4	06/13/2005/01:40:58	Daejeon	6.7
5	01/19/2006/01:31:13	Daejeon	6.7
6	05/30/2006/01:24:34	Daejeon	6.7

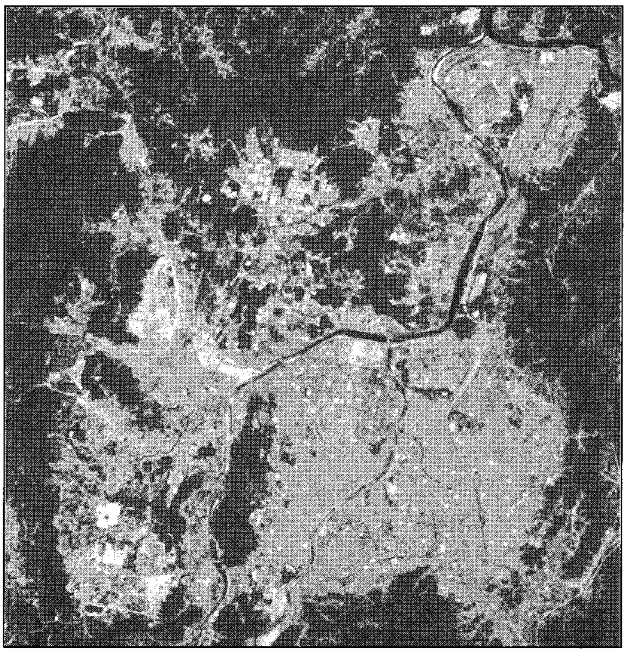

Fig 1. KOMPSAT-1 image acquire by 5 May. 2001

3. EXPERIMENTAL RESULTS

The purpose of this experiment is calculating the NIIRS using the GIQE, and using the NIIRS, to execute the time series analysis about KOMPSAT-1 satellite images. To validate the NIIRS values of KOMPSAT-1 images, we have compared NIIRS values calculated with GIQE to the published NIIRS about KOMPSAT-1 satellite images.

3.1 Time series analysis

Time series analysis was executed to using KOMPSAT-1 images which were acquired from 2001 to 2006. In this experiment, tarp images which are usually used for calibration and validation of satellite images were not available. We only used general commercial satellite images. Because of that reason, we are not able to estimate accurate GIQE parameters such as G and SNR values. So we used general constant value for G value and the published value for SNR. We directly calculated RER and H values on the image points where clearly expressed edges. RER and H are related to edge response. For that reason, after selecting the edge pixels, we calculated RER and H values. Fig 2 shows edge points for RER and H calculation.

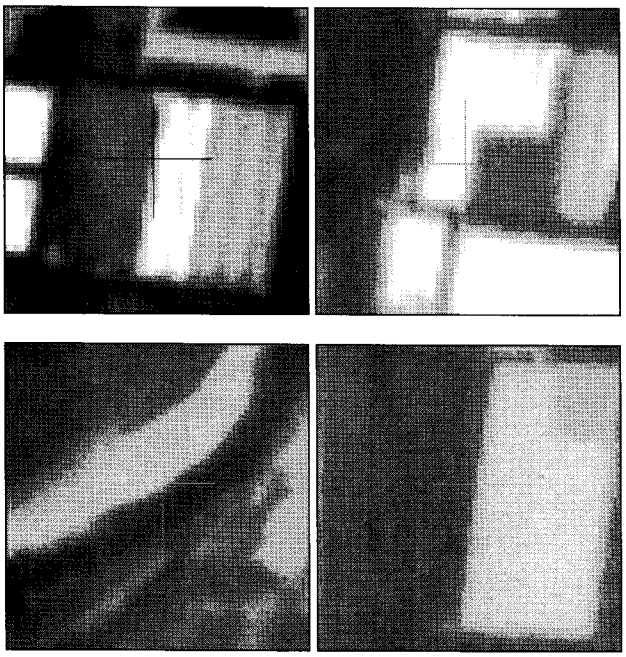

Fig 2. Edge points

After determined edge points, we calculated RER and H values. The validation of selected edge points was executed using normalized edge response graph against whole edge points. The reason for validation of edge points is because NIIRS values are highly related to the edge response parameters, RER and H.

The edge response graph about whole edge points showed good results. Fig 3 shows edge response graph about the whole edge points from image-1.

In this experiment, we applied each parameter to the GIQE and estimate NIIRS about all of the images. The experimental result represented that the NIIRS values are decreased as time goes by. This result indicated that NIIRS which was calculated with GIQE can be used for image degradation indicator. Fig 4 and Table 2 clearly show results of NIIRS degradation due to the changing time.

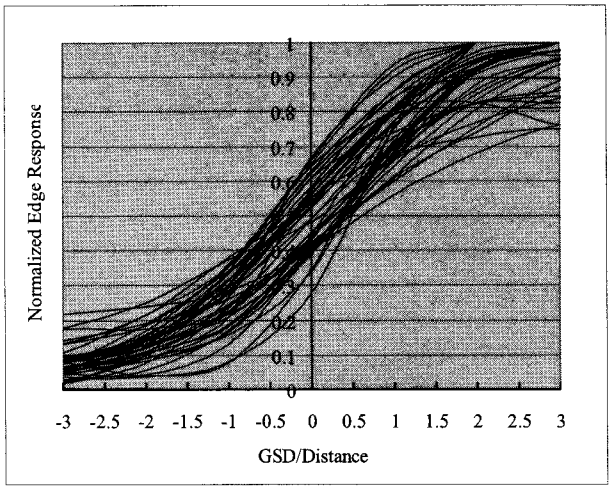

Fig. 3 Normalized Edge Response graph about whole points from image-1

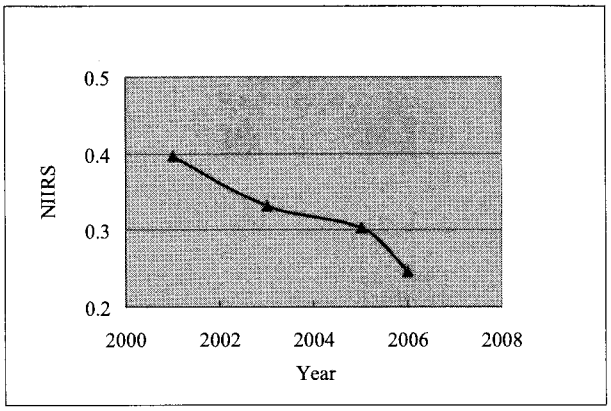

Fig. 4 the graph of time series

Table. 2 the result of NIIRS about KOMPSAT-1 images

Acquisition Date	NIIRS
05/12/2001/01:58:27	0.397113
10/07/2003/01:53:02	0.332254
01/07/2005/01:45:59	0.266784
06/13/2005/01:40:58	0.339202
01/19/2006/01:31:13	0.290194
05/30/2006/01:24:34	0.203088

4. CONCLUSION

Results of time series analysis showed image degradation as time goes by. This result represent that NIIRS which was derived from GIQE indicate the image degradation and that NIIRS derived from GIQE can be used for image degradation indicator. For further research, there are few things for improvements. Firstly, accurate

SNR value must be used for NIIRS calculation. Secondly, Because NIIRS derived from GIQE was sensitive against edge points, effects edge selection have to be carefully considered.

5. REFERENCES

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6. ACKNOWLEDGEMENT

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