REMOTE SENSING IMAGE QUALITY ASSESSMENT EXPERIMENT WITH POST-PROCESSING

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ABSTRACT:

This paper briefly describes the post-processing influence assessment experiment, the experiment includes three steps: the physical simulation, image processing, and image quality assessment. The physical simulation models sampled imaging system in laboratory, the imaging system parameters are tested, the digital image serving as image processing input are produced by this imaging system with the same imaging system parameters. The gathered optical sampled images with the tested imaging parameters are processed by 3 digital image processes, including calibration pre-processing, lossy compression with different compression ratio and image post-processing with different core. Image quality assessment method used is just noticeable difference (JND) subject assessment based on ISO20462, through subject assessment of the gathered and processing images, the influence of different imaging parameters and post-processing to image quality can be found. The six JND subject assessment experimental data can be validated each other. Main conclusions include: image post-processing can improve image quality; image post-processing can improve image quality even with lossy compression, image quality with higher compression ratio improves less than lower ratio; with our image post-processing method, image quality is better, when camera MTF being within a small range.

1. INTRODUCTION

Image post-processing is often applied to improve remote sensing image quality, General Image Quality Equation (GIQE) models the influence of image post-processing with edge response and noise. (Leachtenauer and Driggers, 2001). Many high resolution optical satellite images are processed with image post-processing, such as IKONOS (Ryan, 2003) and Orbview-3 (Kohm, 2004).

The applied of image post-processing, however, should consider many factors. The noise of remote sensor and lossy compression will decrease the effect of image post-processing, so the image post-processing should involve in the image chain. In order to quantitate the influence of image post-processing, the post-processing influence assessment experiment is made out.

The validating experiment includes three steps: the physical simulation, image processing, and image quality assessment. The physical simulation experiment which includes lossy compression models the optical sampled imaging system and exactly tests the parameters of each gathered image in laboratory. The image quality assessment method is Just Noticeable Difference (JND) subject assessment based on ISO20462. (Keelan, 2004). The quantitative results about post-processing is achieved.

2. PHYSICAL SIMULATION EXPERIMENT

The physical simulation experiment is composed of CCD camera, standard optical lens, and so on, as listed in Table 1. Firstly, the imaging system parameters are tested. Secondly, the printed analogous scene is imaged by this imaging system with the same imaging system parameters. Thirdly, the gathered images with the tested imaging parameters are stored in computer serving as data source inputting into JND subject assessment experiment.

Equipments	Values
CCD	Pixel=12μm×12μm
Test Bar	Hi-contrast Nyquist frequency
Integrating Sphere	Diameter=200 mm
Optical Filter	500~800 nm
Tunable Light Source	100W，8A
Lens	Focal length=300mm
Analogous Scene	GSD=0.3m (aerial image)

Table 1. Main experimental equipment

2.1 Data Source

There are some analogous scene data sources can be used in the experiment, including computer produced images, scanned photographic film image, high-resolution aerial images. The aerial image is selected, as illustrated in Figure 1.

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Figure 1. Part of the aerial image

2.2 Schematic Diagram of Analogous Scene Imaging

The schematic diagram is illustrated in Figure 2, the ground targets are imaged by digital aerial camera and reconstructed by professional device, which can be modeled as Gaussian blur, the measured MTF at Nyquist frequency (fn) is about 0.5, approximately equaling MTF reduction factor caused by on-board and atmosphere.

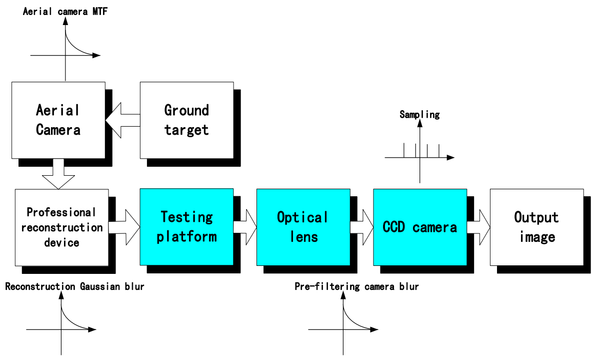

Figure 2. Diagram of analogous scene imaging

2.3 Imaging Parameters SNR and camera MTF Testing

When testing the system parameters and imaging the analogous scene, below parameters are tuned to produce the expected camera MTF (MTF_camera) and SNR, tunable imaging parameters include:

1. Lens F number: 4, 5.6, 8, 11, 16,
2. Integrating sphere luminance: continuous changeable,
3. Pixel binning: 1x, 2x, 4x,
4. Integrating time: continuous changeable,
5. Defocus step: continuous changeable,

SNR testing approach is uniform area (mean/std. deviation) method. Camera MTF testing approach is Hi-contrast target method. Testing results list as Table 2 in two group:

Group	SNR	camera MTF
Group A	47dB	0.08
	47dB	0.10
	47dB	0.12
	47dB	0.15
	47dB	0.18
Group B	42dB	0.08
	42dB	0.10
	42dB	0.12
	42dB	0.15
	42dB	0.18

Table 2. Two group testing results

2.4 Image Processing

The gathered optical sampled images with the tested imaging parameters are processed by 3 digital image processes, including calibration pre-processing, lossy compression with different compression ratio and image post-processing with different core. Firstly, image is processed with calibration method, in order to reduce the fix pattern noise of CCD. Secondly, image is processed with lossy code/decode with JPEG-2000 method. Thirdly, image is post-processed with Weiner filtering and wavelet-based MTF compensation (MTFC) method, in order to improve the contrast and sharpness. Compression and post-process are optional and reversal in sequence.

Parameters	Values
MTF after post-processing	0.23
	0.25
	0.27
Lossy compress ratio	1:1, No compress
	4:1
	8:1

Table 3. Lossy compress and post-processing parameters

3. JND SUBJECT ASSESSMENT EXPERIMENT

JND subject assessment experiment is the last and most important step. Image quality assessment method used is just noticeable difference (JND) subject assessment based on ISO20462. Through subject assessment of the gathered and processing images, the influence of different imaging parameters and post-processing to image quality can be found.

3.1 Assessment Method

JND is a psycho-physical quality, defined as stimulus difference that leads to a 75:25 proportion of responses in a paired comparison task. If 25 percent persons assure that sample A is better than sample B, and 75 percent assure that sample B is better than Sample B, then quality of sample B is 1 JND higher than sample A.

The JND subject assessment conforms to ISO20462，and is operated with rank ordering psychophysical method. The assessment data are analyzed according to ISO20462. JND values can be calculated by:

$$JND = (12/\pi) \times \sin^{-1}(\sqrt{p}) - 3 \quad (1)$$

where p = the probability of cumulative frequency n

$$p = (N + n)/(2 \times N) \quad (2)$$

where n = the cumulative frequency
N = the number of experiment, here N equals 36

3.2 Design of the JND Assessment Experiment

Six professional image analysts are invited. Thirty-six times are assessed for each image group. Four experiments are designed:

1. Influence of MTF to image quality.
2. Influence of image post-processing to image quality.

3. Influence of lossy compression and image post-processing to image quality.
4. Influence of MTF to image post-processing.

The second and third experiment are twice. Same images are in different group, in order to validate the assessment results.

4. ANALYSIS OF PROCESSING VALIDATION EXPERIMENTAL DATA

4.1 Influence of camera MTF to Image Quality

This experiment includes one group composed of five images with different camera MTF values. Each point in Figure 3 represents an image with different camera MTF. Detail data can be inspected in Figure 3.

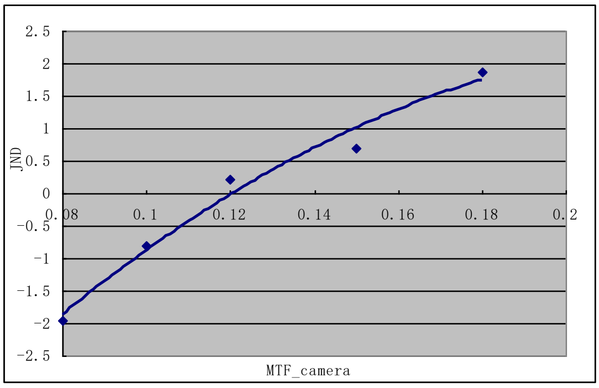

Figure 3. Relationship of camera MTF and JND

Conclusion can be drawn from Figure 3: camera MTF is higher, JND is higher, image quality is higher. This conclusion is same as the common sense. JND assessment has good agreement in this group.

4.2 Influence of Post-processing to Image Quality

This experiment includes two groups, each group is composed of a reference image without post-processing and six images with post-processing. Each point in Figure 4 and Figure 5 represents an image with different camera MTF and different MTF with post-processing. Detail data can be inspected in Figure 4 and Figure 5.

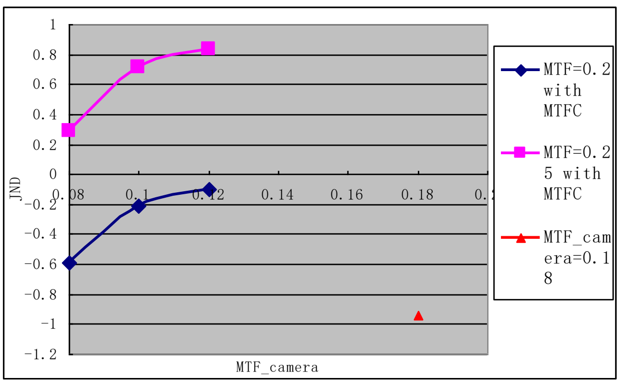

Figure 4. Group A post-processing validation

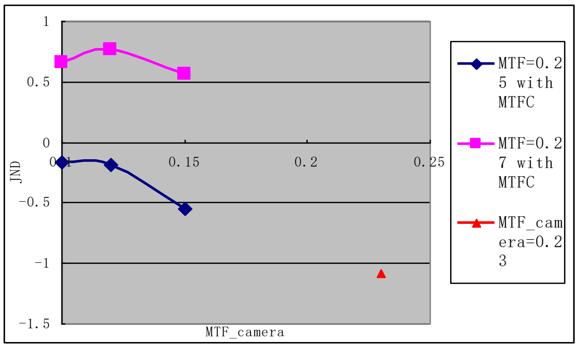

Figure 5. Group B post-processing validation

Conclusions can be validated in two groups as Figure 4 and Figure 5 illustrated:

1. Image quality with post-processing is better than without post-processing
2. Image quality is equivalent between camera MTF=0.1 and 0.12 with post-processing
3. JND assessment has good agreement in the two groups.

4.3 Influence of Lossy Compression and Post-processing to Image Quality

This experiment includes two groups, each group is composed of five compressed images with post-processing and five images without post-processing. Each point in Figure 6 and Figure 7 represents an image with or without post-processing and different compression rates. Detail data can be inspected in Figure 6 and Figure 7.

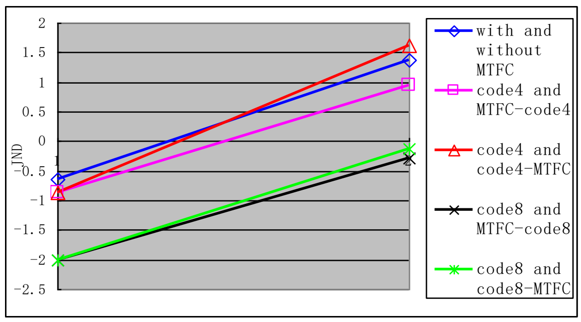

Figure 6. Group A validation of post-processing with compression

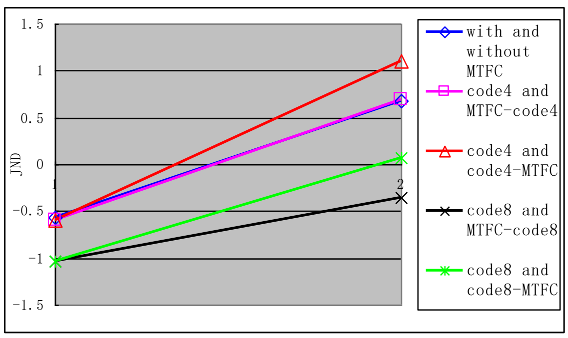

Figure 7. Group B validation of post-processing with compression

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Conclusions can be validated in two groups as Figure 6 and Figure 7 illustrated:

1. Image quality decreases with compression ratio increasing.
2. Lossy compression ratio equaling 4 can be considered as near-lossless compression, while ratio equaling 8 losses more information.
3. Image quality of ratio equaling 4 is much better than 8 with post-processing.
4. Image quality of Compression with post-processing is better than only-compression.
5. JND assessment has good agreement in the two groups.

4.4 Influence of camera MTF to Post-processing

This experiment includes one group composed of five post-processed images with different camera MTF values. Each point in Figure 8 represents a post-processed image with different camera MTF. Detail data can be inspected in Figure 8.

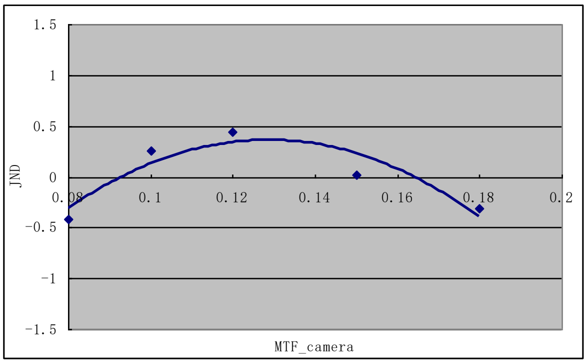

Figure 8. Influence of camera MTF to post-processing

Conclusion can be drawn from Figure 8: When camera MTF is from 0.10 to 0.15, image quality is better with post-processing.

5. CONCLUSIONS

Different from theory and computer simulation analysis, this paper generally studies post-processing of optical sampled imaging system through physical simulation experiment and JND subject assessment experiment based on ISO20462. The six JND subject assessment experimental data can be validated each other, which shows that the JND subject assessment experiment is objective, and the assessment experimental data and conclusions are reliable. Main conclusions include：image post-processing can improve image quality; image post-processing can improve image quality even with lossy compression, image quality with higher compression ratio improves less than lower ratio; with our image post-processing method, image quality is better, when camera MTF being within a small range.

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