LOSSY JPEG CHARACTERISTIC ANALYSIS OF METEOROLOGICAL SATELLITE IMAGE

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ABSTRACT: This paper analyzed the characteristics of the Lossy JPEG of the meteorological satellite image, and analyzed the quality of the Lossy JPEG compression, which is proper for the LRIT(Low Rate Information Transmission) to be serviced to the SDUS(Small-scale Data Utilization Station) system of the COMS(Communication, Oceans, Meteorological Satellite).
Since COMS is to start running after 2008, we collected the data of the MTSAT-1R(Multi-functional Transport Satellite -1R) for analysis, and after forming the original image to be used to LRIT by each channel and time zone of the satellite image data, we set the different quality with the Lossy JPEG compression, and compressed the original data. For the characteristic analysis of the Lossy JPEG, we measured PSNR(Peak Signal to Noise Rate), compression rate and the time spent in compression following each quality of Lossy JPEG compression. As a result of the analysis of the satellite image data of the MTSAT-1R, the ideal quality of the Lossy JPEG compression was found to be 90% in the VIS Channel, 85% in the IR1 Channel, 80% in the IR2 Channel, 90% in the IR3 Channel and 90% in the IR4 Channel.

KEY WORDS: Lossy JPEG, Quality, PSNR, Compression ratio, Compression processing time

1. INTRODUCTION

The digital format of LRIT is recently replacing the analogue format of WEFEX(Weather Facsimile) in the data format for the users of the SDUS of the meteorological satellite.

The LRIT format[1] is a data transmission method for users of the SDUS, recommended by the CGMS(Coordinate Group for Meteorological Satellites), which has the Lossy JPEG compression system in order to transmit large mount of image in a limited bandwidth. The Lossy JPEG compression way using the limit of human visual system has high quality of compression, although its some part of the original image can be distorted.

The COMS, which is scheduled to run after 2008, is to disseminate the data in LRIT format for the SDUS users. The LRIT format provides the Lossy and Lossless JPEG compression method.

The geostationary orbit satellite COMS observed the recommendations of the CGMS, and it is scheduled to transmit the data in LRIT format for the SDUS users. LRIT format provides Lossy and Loseless JPEG compression method. The Lossy JPEG compression method shows difference in the image's quality, compression ratio and compression speed, according to the quality of Lossy JPEG compression set up. Therefore, the Lossy JPEG compression quality of the LRIT to be used for COMS must be decided in consideration for the image quality, compression ratio and compression processing time.

Therefore, in order to decide the quality of the Lossy JPEG compression, this paper gave a PSNR analysis that can objectively analyse the image quality and analysed the compression size and compression speed for the LRIT data transmission rate. Also, for a precise analysis, we used MTSAT-1R image data, which provide the most similar image to the COMS, which is scheduled to run after 2008.

2. RESEARCH DATA AND METHODOLOGY

2.1 Research Data

In order to analyse the Lossy JPEG characteristics, the MTSAT-1R HRIT Full Disk image data from May 11, 2006 to May 19, 2006 were used. The HRIT image data[2], in case of the Full Disk, the depth is 16bit and the image size is 11000*11000(Pixel) in the VIS Channel, 2750*2750(Pixel) in the IR Channel. However, the LRIT image data of the COMS[3], in case of the Full Disk, is 8bit in depth and the image size is scheduled to use 2200*2200(Pixel) in all channels. Therefore, we made a sub-sampling of the MTSAT-1R HRIT image data into 8bit in depth and 2200*2200(Pixel) in size, and formed the original data for the Lossy JPEG characteristic analysis.

2.2 Research Methodology

1. Lossy JPEG compression quality was changed from 10 to 100% by 10% intervals to compress the original data and then measured the time spent for processing.
2. The compression ratio was measured by comparing the original data size and the compressed data size.
3. After undoing the compression of the data, the PSNR was measured in comparison with the original data size.
4. The quality of the Lossy JPEG compression whose PSNR was over 40dB was found.
5. In the quality of the Lossy JPEG whose PSNR was over 40dB, the proper quality of the Lossy JPEG compression was decided, in consideration of the compression ratio and the compression processing time.

PSNR, the compression ratio and the compression processing time for this paper were measured as follows.

PSNR

PSNR is objective analysis data, comparing original data to the decompressed data after compressed to the Lossy JPEG. Generally, over 40dB, it is considered that it has almost no change in image quality compared with that of the data of the original image, and if it's under 30dB, the difference can be stated to be large in image quality.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|X(i,j)-Y(i,j)\right| \qquad (1)$$

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

where MSE = Mean squared error
M = Image width
N = Image height
X = Original image
Y = Restored image

Compression ratio

Compression ratio shows the ratio of compressed size compared with the original image size, and it is used as an important decisive factor in the LRIT data transmission.

$$CR = 100 - \frac{CI}{OI} * 100 \qquad (2)$$

where CR = Compression ratio
CI = Size of compressed image
OI = Size of original image

Compression processing time

Compression processing time is a measured for processing the original image compressed to the Lossy JPEG, and this will be used as necessary data when forming the LRIT data in the COMS. The equipment used for measuring the compression processing time is as follows.

- CPU: Intel Pentium4 3.2GHz
- Memory: 1GB
- Operation System: Windows NT

3. PSNR CHANGE ACCORDING TO QUALITY

Using the original data from May 11, 2006 to May 19, 2006, the PSNR change was analysed following the quality of the Lossy JPEG compression by each channel.

3.1 VIS Channel

PSNR in the VIS Channel shows a big difference between daytime and night time, as shown in Figure 1. In the nighttime, PSNR and the compression ratio are found big, whereas the compression processing time is found small. The daytime, the other way, finds PSNR and compression ratio small whereas the compression processing time is found big. The image data of the nighttime in the VIS Channel are mostly filled with 0 values, and therefore, there is little change in brightness and thus the compression ratio is found big.

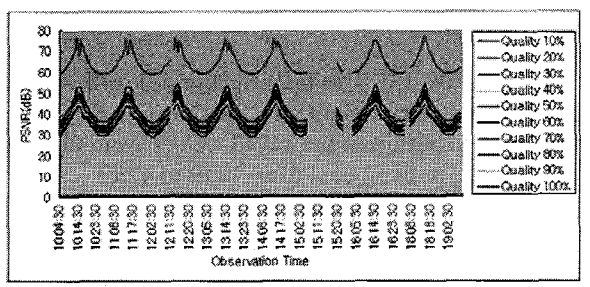

Figure 1. PSNR change following quality

Table 1 presented the maximum, minimum and average values. In the VIS Channel, the quality of the Lossy JPEG compression must be set up to be over 80% in order to see the average PSNR value to be over 40dB. However, in order to find PSNR over 40dB in all time zones, the quality of the Lossy JPEG compression must be set up to be over 90%.

Table 1 Max., Min. and Average values of PSNR

Quality(%)	Max.(dB)	Min.(dB)	Ave.(dB)
60	51.348	33.348	39.706
70	47.096	34.196	39.601
80	54.263	35.817	42.137
90	58.209	39.643	45.697
100	77.012	59.526	64.400

3.2 IR1 Channel

PSNR in the IR1 Channel is presented to be the same in both daytime and night time, as shown in Figure 2, and we can check that the PSNR values from quality 10% to 90% is distributed between 30dB to 42dB.

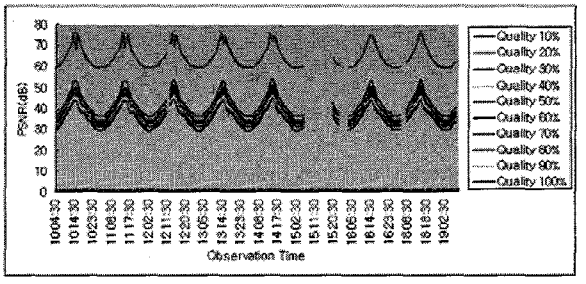

Figure 2 PSNR change according to quality

In the IR1 Channel, the quality of Lossy JPEG compression must be set up to be over 80%, to see the average PSNR values over 40dB. However, in order to enhance the quality to have all PSNR over 40dB, the quality of the Lossy JPEG compression must be set up over about 85%.

Table 2 Max., Min. and Average values of PSNR

Quality(%)	Max.(dB)	Min.(dB)	Ave.(dB)
60	38.551	37.285	38.087
70	39.386	38.155	38.928
80	40.604	39.476	40.167
90	43.181	42.312	42.817
100	60.123	59.597	59.624

3.3 IR2 Channel

PSNR in the IR2 Channel is presented to be the same in both daytime and night time, as shown in the Figure 3, and we can check that the PSNR values from the quality 10% to 90% is distributed from 30dB to 42dB.

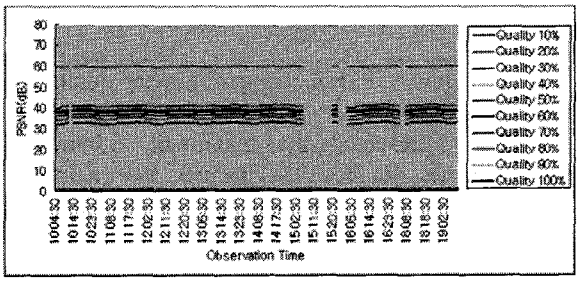

Figure 3 PSNR change according to quality

In the IR2 Channel, the quality of the Lossy JPEG compression must be over 80%, to find the average and the total PSNR over 40dB, as shown in the Table 3.

Table 3 Max., Min. and Average values of PSNR

Quality(%)	Max.(dB)	Min.(dB)	Ave.(dB)
60	39.221	37.944	38.737
70	40.059	38.808	39.580
80	41.251	40.099	40.797
90	43.753	42.851	43.367
100	60.088	59.569	59.590

3.4 IR3 Channel

The IR3 Channel has PSNR values that are in average higher than other Channels. As in Figure 4, a PSNR value from quality 20% to 90% presents values between 40dB to 50dB. IR3 Channel observes the water vapour images in the wavelength range from 6.5 to 7.0 μm, and the pixel values of the image data aggregate densely in distribution. Therefore, the PSNR values are presented to be larger than those in other Channels.

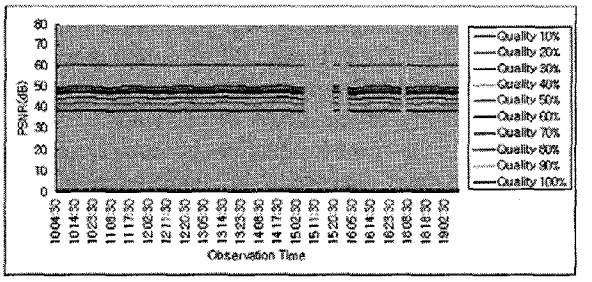

Figure 4 PSNR change according to quality

IR3 Channel shows PSNR average values over 40dB in case when the quality is 20%.

Table 4 Max., Min. and Average values of PSNR

Quality(%)	Max.(dB)	Min.(dB)	Ave.(dB)
10	38.515	38.047	38.317
20	41.692	41.157	41.450
30	44.589	43.847	44.247
40	45.848	45.051	45.482
50	46.979	46.102	46.572

3.5 IR4 Channel

We can check that PSNR values in the IR4 Channel show some difference in daytime and in night time, in Figure 5. This is because the IR4 Channel is observed in the 3.5 to 4.0 μm wavelength range, that is near infrared area, and the Pixel value distribution of the image data in day and night are different. Therefore the PSNR values are presented differently. We can see that the PSNR values from the quality 20% to 90% is distributed between 30dB to 40dB.

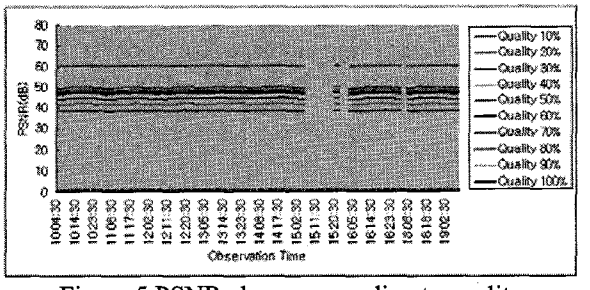

Figure 5 PSNR change according to quality

We can see that, in order to have PSNR average values over 40dB as in Table 5, the quality must be set up to be over 90% for compression.

Table 5 Max., Min. and Average values of PSNR

Quality(%)	Max.(dB)	Min.(dB)	Ave.(dB)
60	37.318	34.618	36.415
70	38.132	35.503	37.265
80	39.362	36.931	38.584
90	42.071	40.211	41.511
100	60.046	59.525	59.578

4. AVERAGE COMPRESSION RATIO AND CHANGE IN PROECSSING TIME ACCORDING TO QUALITY

Figure 6 showed the average compression ratio according to quality of the Lossy JPEG compression and Figure 7 showed the average processing time. VIS, IR1, IR2 and IR4 Channels have average compression ratio over 90% when the quality of Lossy JPEG compression is under 80%, and the IR3 Channel has over 90% average compression ratio even when the quality was under 90%. Plus, we can see that the more average compression ratio is reduced, the faster the average compression processing speed gets.

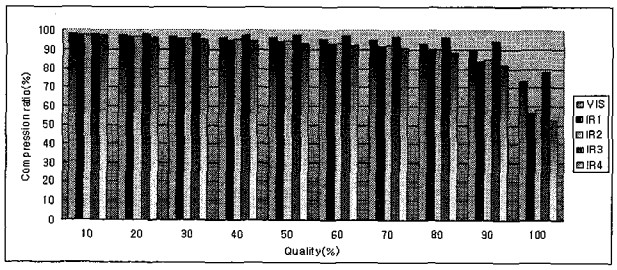

Figure 6 Average compression ratio

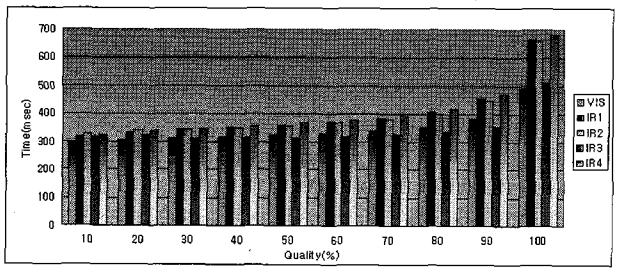

Figure 7 Average processing speed

VIS Channel could set up quality of Lossy JPEG compression over 90%, when considering the PSNR, but the average compression ratio radically dropped at the 90% quality, and the average processing time radically increased, therefore, it's good to set up the quality to be 90%.

IR1 Channel could set up quality of Lossy JPEG compression over 85%, considering the PSNR, but the average compression ratio became markedly low and the average compression processing time increased when the quality was over 80%, therefore, it's good to set up the quality at 85%.

IR2 Channel could set up quality of Lossy JPEG compression over 80%, considering the PSNR, but the average compression ratio was notably reduced and the average compression processing time increased when the quality was over 80%, therefore, it's good to set up the quality at 80%.

IR3 Channel could set up quality of Lossy JPEG compression over 20%, considering the PSNR. However, when the quality was from 20 to 90%, the average compression ratio and average processing time did not show big changes, so it does not matter if the quality is set up, up to 90%.

IR4 Channel could set up quality of Lossy JPEG compression over 90%, considering the PSNR, but the average compression ratio notably reduced and the average processing time was increased, therefore it's good to set up the quality at 90%.

5. CONCLUTION

Quality of the Lossy JPEG compression in the VIS Channel is good to be set up at about 90%. However, the characteristic of the Lossy JPEG compression in the VIS Channel shows a big difference between day and night, therefore it would also be good to coordinate the quality of day and night in the set up.

Quality of the Lossy JPEG compression in IR1 and IR2 Channel, is good to be set up at about 85%, 80%. And, when the quality of the Lossy JPEG compression quality is increased in order to enhance the image quality, it is good to be set up under 90%, considering the compression size and compression processing time.

Quality of the Lossy JPEG compression in the IR3 Channel is good to be set up at around 20%, but in case when the quality of image is hoped to be enhanced, it is good to set up at 90%, as there is no big change in compression ratio and in compression processing speed when it is set up, up to around 90%.

Quality of the Lossy JPEG compression in the IR4 Channel is good to be maintained at about 90% always, and if the quality is set up over 90% in order to enhance quality of the image, compression size and compression processing time must be considered.

As COMS is scheduled to run after 2008, we used the MTSAT-1R satellite data for analysis. The difference between the COMS satellite data and MTSAT-1R satellite date is expected to be small. Therefore, the Lossy JPEG compression characteristics will be presented similarly, and this paper is expected to help decide proper quality of the Lossy JPEG to be used in the COMS LRIT later.

6. REFERENCES

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