JPEG COMPRESSION PERFORMANCE ANALYSIS OF MTSAT-1R HRIT_LRIT

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ABSTRACT: This paper analyzed the JPEG compression performance of MTSAT-1R(Multi-functional Transport Satellite - 1 Replacement), which is offering the LRIT/HRIT(Low Rate Information Transmissio / High Rate Information Transmission) service now, in order to design the system regarding LRIT/HRIT of COMS(Communication, Ocean and Meteorological Satellite). To do so, we analysed Lossy and Lossless JPEG compression performance regarding the MTSAT-1R LRIT/HRIT data for 10 days, and made comparison to the image characteristics, and understood the JPEG compression characteristics regarding JPEG compression of geostationary meteorological satellite. This result of compression performance analysis is expected to be a reference not only to the system design and realization of COMS LRIT/HRIT but also to those who develop other meteorological satellite receiving systems.

KEY WORDS: COMS, MTSAT-1R, LRIT, HRIT, JPEG

1. INTRODUCTION

COMS(Communication, Ocean and Meteorological Satellite), a geostationary meteorological satellite, scheduled to launch in 2008, observes the recommendations of CGMS (Coordinate Group for Meteorological Satellites) and distributes meteorological images observed in LRIT /HRIT (Low Rate Information Transmission /High Rate Information Transmission)[1] format. In order to enhance the efficiency in data transmission, the compression baseline of COMS LRIT/HRIT uses JPEG as the compression baseline that is recommend by CGMS and described in the ISO(International Organization for Standardization) standard 10918 'Digital compression and coding of continuous-tone still images' [2]. In order to design and realize the LRIT/HRIT processing system, the performance analysis of JPEG must be preceded.

The geostationary meteorological satellite image (hereinafter image) has characteristics according to band, sunshine condition of the sun and weather conditions. This paper aims to analyse how such characteristics influence the Lossy and Lossless JPEG compression performance.

2. RESEARCH DATA AND METHODOLOGY

2.1 Research Data

LRIT/HRIT data of COMS can be achieved 2008. This paper therefore used the LRIT/HRIT[3][4] data of MTSAT-1R (Multi-functional Transport Satellite - 1 Replacement) as substitute, among those geostationary meteorological satellites that are now offering LRIT/HRIT service, because it is similar to COMS in observing location and band constitution. Then we used the data for 10 days from May 10, 2006 to May 19, 2006, among the MTSAT-1R LRIT/HRIT data received to the GlobeShot™ system[5].

The image data of MTSAT-1R is observed by the JAMI (Japanese Advanced Meteorological Imager) sensor, and as in Table 1, it is composed of VIS, IR1, IR2, IR3 and IR4 bands. VIS band observes the strength and weakness of the sun's rays that are reflected by the clouds and the Earth's surface, and in the visualized image, the stronger the reflected light, the brighter it looks. The IR1 band and the IR2 band observe the infrared energy quantity emitted by objects, and in the visualized images, the higher the temperature it looks darker, and the lower the temperature, it looks brighter. The IR3 band observes energy that is absorbed by the vapour in the air among the infrared energy. The IR4 band is Near Infrared band, and it observes the Earth's radiation and the sun's radiation together[6].

Table1. Wavelength range in each band

Band	Wavelength range (μm)
Visible(VIS)	0.55-0.80
Infrared (IR1)	10.3-11.3
Infrared(IR2)	11.5-12.5
Water Vapour(IR3)	6.5-7.0
Near Infrared(IR4)	3.5-4.0

The VIS band image size of MTSAT-1R HRIT is 11000*11000(Pixel), and the image size of IR band is 2750*2750(Pixel). Spectral resolution of all band images is 10bits. For HRIT transmission, all images are divided into 10 segments as in Figure 1.

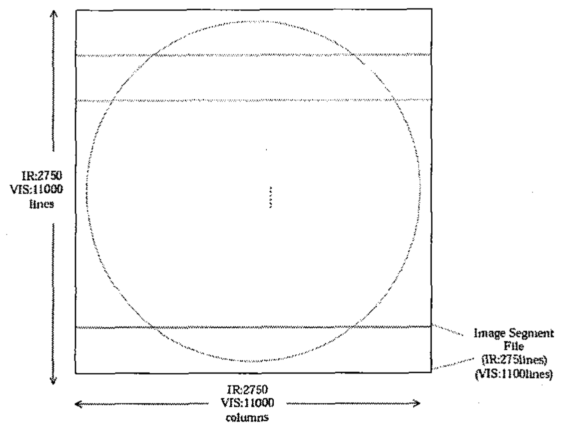

Figure 1. HRIT image data file structure

The Full-disk image size of MTSAT-1R LRIT is 2200*2200(Pixel) and spectral resolution is 8bits, and for LRIT transmission, all images are divided into 10 segments. Regional image sizes in East Asia, Northeast of Japan, Southwest of Japan is 800*800(Pixel) and spectral resolution is 8bits.

For the transmission efficiency, MTSAT-1R LRIT/ HRIT uses JPEG as the compression baseline that is described in the ISO standard 10918 'Digital compression and coding of continuous-tone still images'[2]. MTSAT-1R LRIT uses both Lossless JPEG and Lossy JPEG, while MTSAT-1R HRIT uses only Lossless JPEG.

2.2 Research Methodology

Lossy and Lossless JPEG compression was undone for the 10-day MTSAT-1R LRIT/HRIT image data and the compression ratio for each image data were calculated. Image data then were divided by segment, band, time zone and weather conditions, and the calculated compression ratio's average was calculated, and it was analysed how each characteristics influences JPEG performance. The definition of compression ratio used in this paper is as follows.

Compression ratio

Compression ratio presents the ratio of compressed image size for the original image size, and it is used as an important decisive factor in data transmission.

$$CR = 100 - \frac{CI}{OI} * 100 \qquad (1)$$

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

3. JPEG PERFORMANCE ANALYSIS OF MTSAT-1R LRIT/HRIT

3.1 Compression Ratio by Segment

In case of Full-disk image of MTSAT-1R LRIT/HRIT, all images are divided into 10 segments and compressed to Lossless JPEG for transmission. As in Figure 1, the difference between the location and dimensions of Earth area observed by segment images influences compression ratio. The Lossy JPEG compression was not analysed, as it is pertinent only to regional images without segment.

To analyse the relation between segment and the Lossless JPEG compression ratio, average compression ratio was calculated of MTSAT-1R LRIT for IR3 band. In case of MTSAT-1R HRIT, average compression ratio was calculated for all bands. Figure 2 compares the average compression ratio by segments. In case of MTSAT-1R LRIT, No. 10 Segment was the highest in average compression ratio as 79.0%, and the No. 5 Segment was the lowest as 56.4%. In case of MTSAT-1R HRIT, No. 10 Segment was the highest in average compression ratio as 84.6% and No. 4 Segment was the lowest as 68.7%.

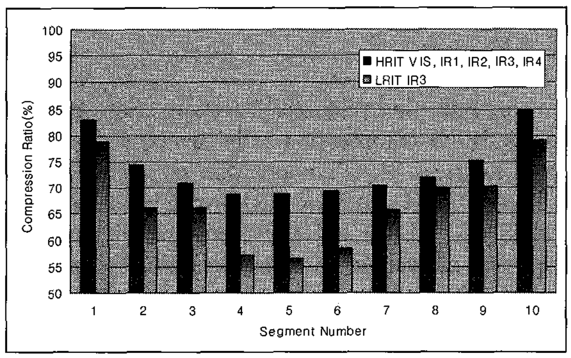

Figure 2. Compression ratio by Segments

With all images as standard, segments in the upper and lower portion shows high average compression ratio and the middle segments show low average compression ratio. Segments in upper and lower portion has wider dimension outside of the Earth, than that of the middle segment, so it is considered why their Lossless JPEG compression ratio is found high.

The difference in average compression ratio by each segment is different by the LRIT/HRIT band, but it was found to be between 11.74% and 22.55% at the maximum.

3.2 Compression Ratio by Channels

As the observation objects differ according to each band's wavelength range, the images in each band are different and it also influences the compression ratio, even when observation is made for the same time zone and the same area.

3.2.1 Lossy

To analyse the relations between each band and Lossy JPEG compression ratio, average JPEG compression ratios of Lossy JPEG for 10 days were calculated for VIS, IR1, IR3, IR4 bands in MTSAT-1R LRIT. Figure 3 shows comparison of average compression ratios by bands. The order of high average compression ratios is VIS, IR3, IR1 and IR4 band images, and the average compression ratio of VIS band was the highest as 83.7% and the average compression ratio of IR4 band was the lowest as 64.8%. The difference between average compression ratios in each band was the maximum 18.9%.

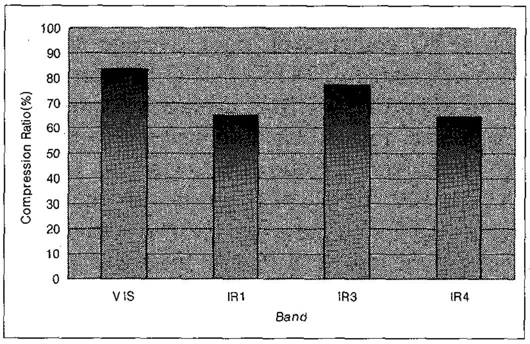

Figure 3. Average compression ratios of Lossy JPEG by bands in LRIT

3.2.2 Lossless

To analyse the relations between each band and Lossless JPEG compression ratio, average compression ratio of Lossless JPEG compression ratio was calculated for 10 days in MTSAT-1R HRIT's all band images and the MTSAT-1R LRIT's IR3 band images. Figure 4 shows comparison in average compression ratios by bands. The order of high average compression ratios in HRIT is VIS, IR3, IR2, IR1 and IR4 band images, and the average compression ratio of VIS band is the highest as 82.8% and the average compression ratio of IR4 band was the lowest as 65.7%. The difference between average compression ratios in each band was the maximum 17.13%.

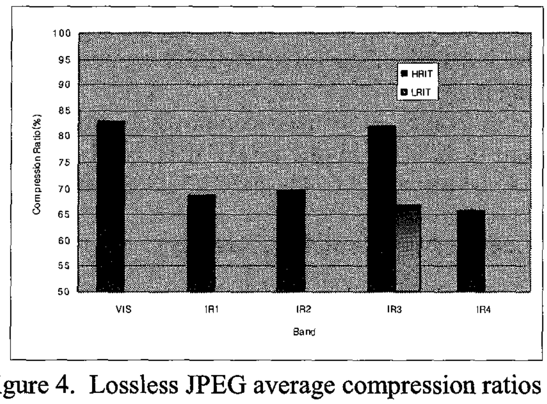

Figure 4. Lossless JPEG average compression ratios by bands

Both Lossy JPEG and Lossless JPEG were the highest in the VIS band and the lowest in the IR3 band. In case of VIS band, there are many cases when the compression ratios are high according to weather conditions or the sunshine quantity, but, in case of IR4 band images, they sensitively reacts to the vapour even in the air without cloud, regardless of the sunshine quantity, and this is considered the reason why the compression ratio is low.

3.3 Compression Ratio by Time Zones

MTSAT-1R uses passive sensor that extracts strength and weakness of energies emitted by the reflected energy of the sun's rays or by the emitted energies of the objects themselves. Therefore, their images by bands are mutually different according to the sunshine condition and it also influences the compression ratio. Except for special cases such as solar eclipse, satellite eclipse or sun interference, the time presents the sunshine condition of the sun, so the compression ratios by time zones were calculated.

3.3.1 Lossy

To analyse the relation between each time zone and Lossy JPEG compression ratio, compression ratios for 6 days from May 10, 2006 to May 15, 2006 were calculated in MTSAT-1R LRIT's East Asia regional images. As in Figure 5, the compression ratios showed difference by bands, but it showed periodicity in time.

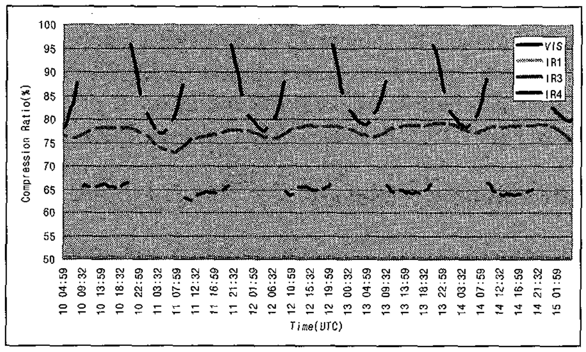

Figure 5. Lossy JPEG compression ratio by time zones

3.3.2 Lossless

To analyse the relations between each time zone and Lossless JPEG compression ratio, compression ratios in 6 days from May 10, 2006 to May 15, 2006, was calculated in all MTSAT-1R HRIT bands. As in Figure 6, the compression ratios showed difference in the ranges of change, but it showed periodicity in time.

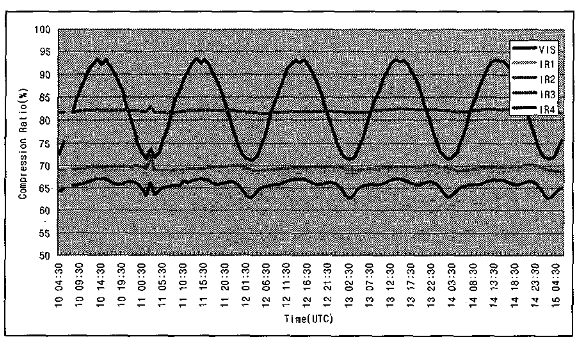

Figure 6. Lossless JPEG compression ratio by time zones

The biggest difference in Lossy and Lossless JPEG average compression ratio in each time zone is over 20% in VIS band images and under 10% in IR band images. VIS band images present the strength and weakness of the sun's rays reflected from cloud and the Earth's surface, and therefore, the less reflected light, the less changes in image brightness, and the compression ratio gets higher in night time zone than in day time zone. IR Channel image's compression ratio is considered to be not so significantly influenced by the sunshine condition.

3.4 Compression Ratio by Weather Conditions

Weather conditions such as amount of clouds, cloud distribution, cloud dimensions, vapour amount, and so on, are closely related to the image brightness change in each band, so they influence compression ratio. This paper analysed cloud cover and vapour amount only, as they are easy to discern with naked eyes. To consider weather conditions only, Lossy and Lossless JPEG compression ratio in the same band and the same time zone was compared in the 10-day images.

3.4.1 Lossy

Lossy JPEG compression ratio difference according to weather conditions is found to be under 4.05% in VIS band image, under 3.97% in IR1 band image, under 4.00% in the IR3 band image, under 2.91% in IR4 band image. Figure 9 compares Day 16 image with Day 19 image in the same area (East Asia) and the same time zone (04:59 UTC) in the IR1 band image with the biggest compression ratio difference.

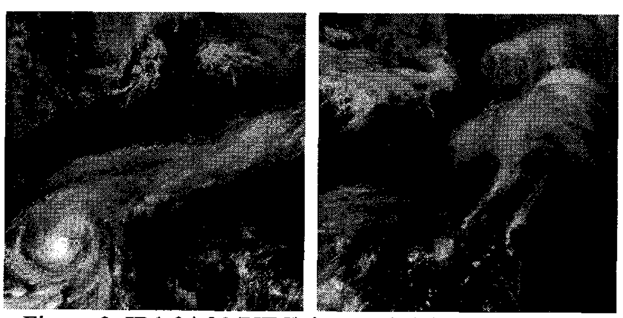

Figure 9. IR1 04:39(UTC) image, left is Day 16 image and right is Day 19 image.

The compression ratio of Day 16 is 59.50% and that of Day 19 is 63.48%. To the naked eyes, Day 19 image appears to have more cloud cover than that of Day 16 and shows bigger changes in image brightness, because of the formation of typhoon.

3.4.2 Lossless

Lossless JPEG compression ratio difference according to weather conditions was found to be under 3.75% in VIS Channel image, under 5.38% in IR1 Channel image, under 5.61% in IR2 Channel image, under 4.94% in IR3 Channel image and under 3.23% in IR4 Channel image. Figure 7 and Figure 8 compares the Day 14 image with Day 19 image in the same segment (No.2) and the same time zone (04:39), in the IR2 band with the biggest compression ratio difference.

Figure 7. IR2 2006-05-14 04:39(UTC) Segment 2 image

Figure 8. IR2 2006-05-19 04:39(UTC) Segment 2 image

The compression ratio for the Day 14 is 65.95% and that of the Day 19 is 60.0%. To the naked eyes, the Day 19 image has more cloud cover than that of the Day 14 image.

It is considered that the compression ratio is lowered because the more cloud clover and vapour amount, the bigger the changes in image brightness. However, the difference in compression ratio according to weather conditions was found to be less than 6%, which was not so significant in compression ratio difference compared with other characteristics.

4. CONCLUSIONS

This paper examined the LRIT/HRIT Lossless and Lossy JPEG compression performance according to the geostationary meteorological satellite image characteristics, by using the MTSAT-1R image data. The result is expected to make reference not only to the COMS LRIT/HRIT-related system design and realization but also to other meteorological satellite receiving system development that distributes user data in LRIT/HRIT format.

This paper found that the compression ratio according to weather conditions is low, but it is considered that 10-day data are insufficient to analyse the difference according to weather changes. In the future, this paper's results must be complemented, by designing research methodology enabling quantitative and qualitative analysis into weather conditions not by naked eyes and also by performing research on how weather conditions such as yellow dust, typhoons, monsoon season, influence the Lossless and Lossy JPEG compression performance.

5. REFERENCES

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