THE ADVANTAGE OF ON ORBIT NON-UNIFORMITY CORRECTION FOR MULTI SPECTRAL CAMERA (MSC)

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ABSTRACT:

The MSC (Multi Spectral Camera) system is a remote sensing payload to obtain high resolution ground image. This system uses lossy image compression method for "Direct mission" that transmit whole image during one contact. But some image degradation occurred especially at high compression ratio. To reduce this degradation, the MSC uses NUC (Non-uniformity Correction) Unit. This unit correct CCD (Charge Coupled Device)'s high-frequency non-uniformity. So high frequency contents of image can be minimized and whole system SNR can be maximized. But NUC has some disadvantage either. It decreases entire system reliability by adding one electronic system. Adding NUC also led to difficulty of electronic design, assembly and testability. In this paper, the comparison is performed between on-orbit non-uniform correction and on ground correction. by evaluating NUC advantage for the point of view of image quality. Using real MSC parameter and proper model, considerable reference point for the system design came to possible.

KEY WORDS: MSC, image compression, PRNU, CCD

1. INTRODUCTION

The MSC, a payload of KOMPSAT2, has data compression and storage unit (DCSU) to retain and transfer image data efficiently. To maximize data storage and data transmission efficiency, the MSC uses lossy compression method (JPEG like). So high frequency component of image is weakened and it cannot be restored on the ground station. In most case the image has not so much high frequency components that does not remarkably affect on image quality. But when each detector pixel or output channel has different gain and offset, even if target has uniform radiance, output image data may have a vast amount of high frequency component. And if high frequency component weakened, it appears as a form of pattern noise. On orbit non-uniformity correction (NUC) is needed to minimize this effect.

2. SYSTEM MODEL

2.1 Compression

8x8 block DCT forms the basis of MSC DCSU compression. In the encoding process the input component's samples are grouped into 8x8 blocks and each block is transformed by the DCT into a set of 64 values referred to as DCT coefficients. One of these values is referred to as the DC coefficient and the other 63 as the AC coefficients. Each of the 64 coefficients is then quantized using one of 64 corresponding values from a quantization table (DCSU uses uniform quantization table for the default). After quantization, the DC coefficient and the 63 AC coefficients are prepared for entropy encoding, the previous quantized DC coefficient is used to predict the current quantized DC coefficient, and the difference is encoded. The 63 quantized AC coefficients undergo no such differential encoding, but are converted into a one dimensional zig-zag sequence, the quantized coefficients are then passed to an entropy encoding procedure which compresses the data further. In whole compression procedure, only lossy part of compression is DCT coefficient quantization process. So we can focus to this block to see the degradation of image.

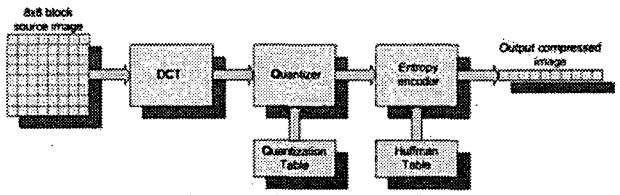

Figure 1. DCT compression

2.2 Input image

In contrast with normal DCT basis compression, DCSU performs 'rate regulation' which makes output data rate constant. This function is performed by feedback output data rate to DCT coefficient quantization level. If image has a lot of high frequency component, assignment less bits for the low frequency. This adaptation led to image degrading. So influence caused by non-uniformity through lossy compression varies to the image contents. Fallowing Figure 2 shows test image that used for this simulation. 'Image 1' is synthetic image has vast amount of high frequency component (gradually 'Image 5' has only low frequency component). This is

not real but selected to see the relationship of image frequency and non-uniformity. 'Image 6' and 'Image 7' are real aerial photography selected for the satellite image simulation.

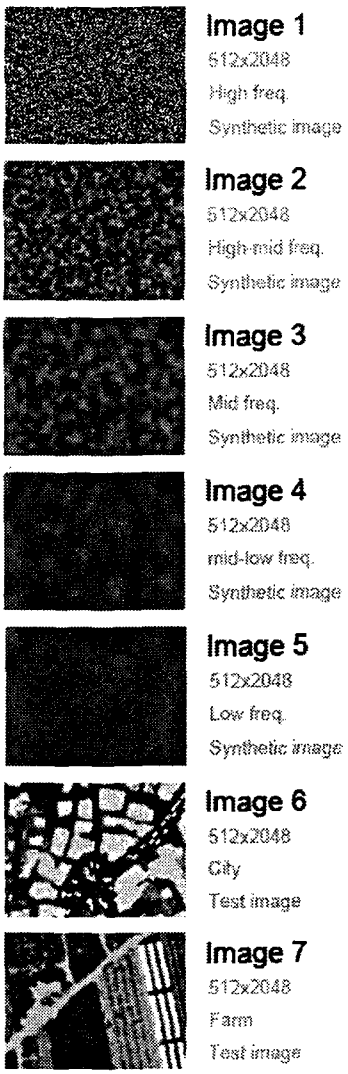

Figure 2. Input test image

2.3 Non-uniformity

Because of the limitation of practical semiconductor fabrication technology, CCD non-uniformity appeared with various form. First of all, due to the lithograph error, each pixel response for the light is not same. This led to gaussian distribution of CCD output characteristic. Also It is difficult to have uniform characteristic form one end to the other end for big CCD. After photon convert to the electron, this electron transferred to output capacitor. Generally, high speed CCD have different channel for even and odd pixel. So even and odd pixel have different output channel and this make some non-uniformity.

Our aim is identification of image degradation by the image compression. So we can concentrate on to the non-uniform component which affect by compression. 8x8 block DCT forms the basis of MSC DCSU compression. So we can ignore low frequency non-uniformity which exceeds one compression block. Following Figure 2 shows non-uniformity profile for the simulation. Aligned four box means one compression block.

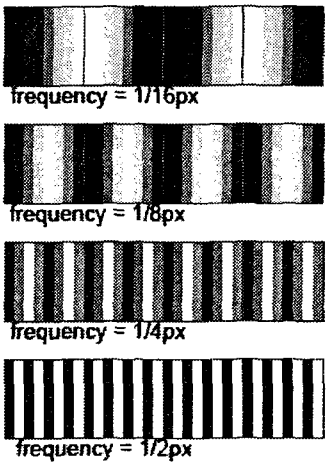

Figure 3. non-uniformity

3. SIMULATION RESULT

Usirfg DCSU compression/decompression simulator image transfer channel model is constructed. Following figure 4 - figure 10 show each simulation results for the input image. For the indication of image quality, PSNR is used. Small circles on the graph mean each data point. Background curves are interpolated from this point.

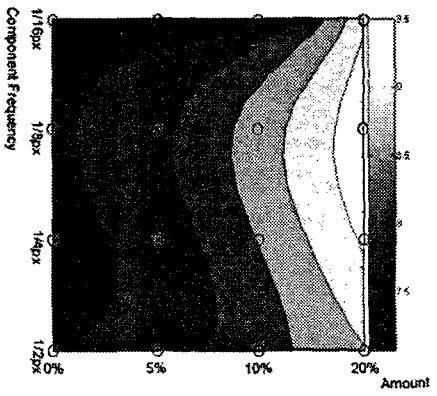

Figure 4. PSNR result for Image 1.

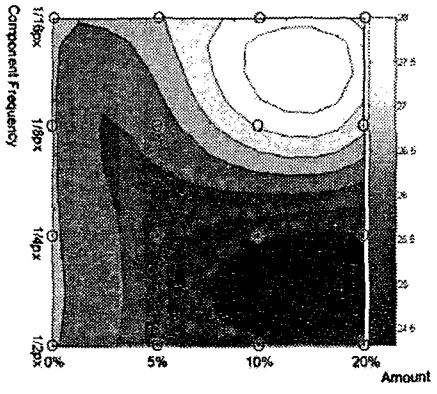

Figure 5. PSNR result for Image 2.

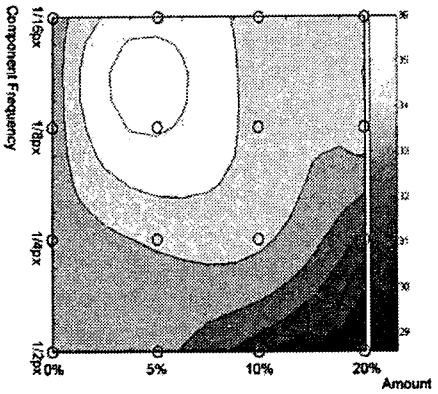

Figure 6. PSNR result for Image 3.

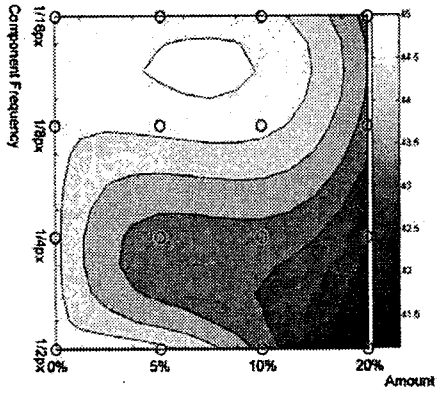

Figure 7. PSNR result for Image 4.

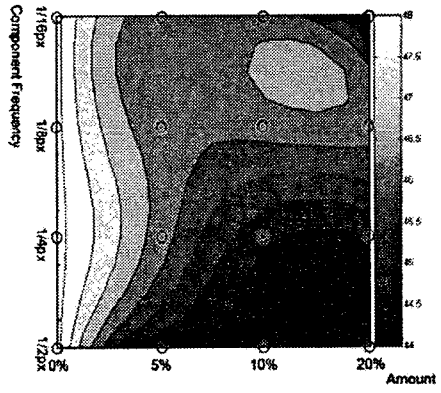

Figure 8. PSNR result for Image 5.

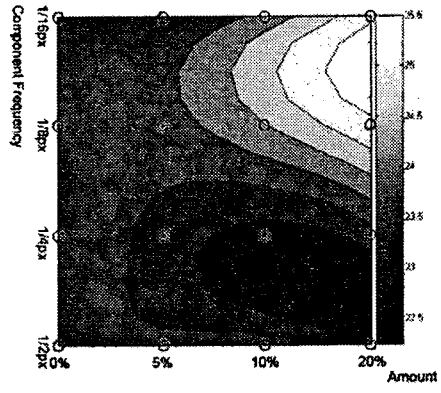

Figure 9. PSNR result for Image 6.

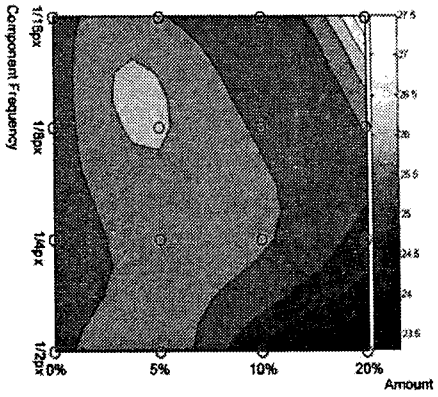

Figure 10. PSNR result for Image 7.

All results show same trend except 'Image 1' on figure 4. Because 'Image 1' has unrealistically vast amount of high frequency component, absolute PSNR is unacceptably very low. So we need not attention to the result of Image 1. Other result shows interesting characteristic. From the point of non-uniformity frequency view, it divided two distinct regions. Non uniformity frequency more than 1/4px show degradation along to the axis of non-uniformity amount. It was just as we had expected. But Non uniformity frequency less than 1/4px show PSNR improvement along to the axis of non-uniformity amount. With this result we can't say low frequency non-uniformity increase the system performance but low frequency does not contribute to the compression loss.

4. CONCLUSION

Simulation results shows high frequency non-uniformity induces image degradation by lossy compression that PSNR loss is maximum 3.5dB at 5% non-uniformity increase. This loss is apparent at low frequency block. But at high frequency block PSNR improvement is not considerably big.

5. REFERENCE

MSC EOS system requirement specification, ELOP
MSC CEU hardware specification, ELOP
MSC CCD requirement specification, ELOP
MSC NUC system requirement specification, ELOP
MSC DCSU system specification, ALCATEL