Quality of SAR Image Processed by Fixed Point Digital Operation (Commission II)

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1. INTRODUCTION

In the digital processing of satellite borne synthetic aperture radar (SAR) data, a vast amount of data should be processed in very high speed. It is very advantageous if these amount of data is reduced in order to minimize data storage area in the processor and to achieve high speed fixed point operation utilizing this redueed size word length.
This paper describes the result on image quality assessment in the data amount reduction by data quantization.

2. METHOD OF IMAGE QUALITY EVALUATION

To reduce data amount in the SAR data processing, quantization of intermadiate data file is very effective. In the quantization, limit of bit number reduction should be assessed by the evaluation of image quality. Since both the dynamic range of processed image and the radiometric resolution degrade due to the quantization, they are the good measure to evaluate the degradation.
Dynamic range of the image can be calculated by the ratio of the level of the brightest point to the level of the darkest point in the processed image data when the scene is ground including urban area. Radiometric resolution can be measured by the quantity δ where

$$\delta = 10 \log_{10}\left(1+\frac{\text{Std.dev}}{\text{mean}}\right)$$

from the mean and standard deviation of smooth area. This definition of radiometric resolution is based on Brooks and Miller (1979).

3. SAR DATA PROCESSING

SAR images to be evaluated have been generated from the Seasat-1 SAR raw data which is 5bit digital raw data.
To provide good understanding of evaluated image, the processing block sequence depicting each processing stage is shown in Fig.1.
The software has been developed by ourselves and modified for intermadiate quantization. Range compressed complex data has been quantized as follows

$$Ic=\begin{cases} Imax\ , & (Ain>Imax/2) \\ IFIX(Ain/(C*Std)*Ima/2+Imax/2)\ , & (-Imax/2\leq Ain\leq Imax/2) \\ 0\ , & (Ain<-Imax/2) \end{cases}$$

where Ain, C and Std are the input floating point number, normalize constant and standard deviation of range compressed first range line data, respectively. The normalize constant has been set 2.0 or 0.05 depending on the quantization bit number. Imax is expressed as

$$Imax = 2^{M-1}$$

where M is quantization bit number.

4. PROCESSED IMAGE AND DATA EVALUATION

4.1 Processed Image

Several images has been produced where floating point operation and quantezation from 16bit to 1bit has been achieved. Fig.2 is the output scene of floating point operation. This image is the reference image to the images produced by intermadiate quantization. Fig.3 to Fig.9 are examples of quantized operation. In the inspection by human eye, no degradation can be observed from 16bit to 3bit. In the 1bit quantizedoperation, image quality is very poor. This quality is improved by reducing normalizing constant.

4.2 Dynamic Range

Dynamic Range in the scene has been measured using processed images. Table 1 shows the image levels of the same target in the different images. For distributed target, average level of 21 by 21 pixells of smooth area is shown. From the result, very large level such as 50dB higher than average distributed target level degrade 6dB from floating point operation. This degradation is not severe because most of high level return is by artificial coherent target and is not important for SAR Image data applications.
For distributed target, relative image value does not degrade exeeding $\pm$0.3dB even 3dB quantization.

4.3 Radiometric Resulution

Radiometric resolution has also been evaluated. Like dynamic range evaluation, same target in the different images has been measured. Table 2 shows the radiometric resolution. From the tabulated data, it can be coucluded that radiometric resolution changes very few and almost negligible.

5. CONCLUSION

From the numeric evaluation it is concluded that data reduction by quantization in the intermediate processing does not affect for destributed target of SAR scene. Degradation of dynamic range affects only very large level and it does not restrict the SAR data aplications.

Since data amount can be reduced significantly by the proposed quantization processing, large area can be processed at a time and data I/O time is saved. From the result it can also be supposed that on-board range compression and quantization by small bit number is effective to reduce data transfer rate.

REFERENCE

Brooks, S,R, and Miller P.F.M., " The Influence of Radiometric Resolution on Synthetic Aperture Radar Design Parameters ", SEASAT SAR Processor Workshop, Frascati, December 1979, ESA SP-154.

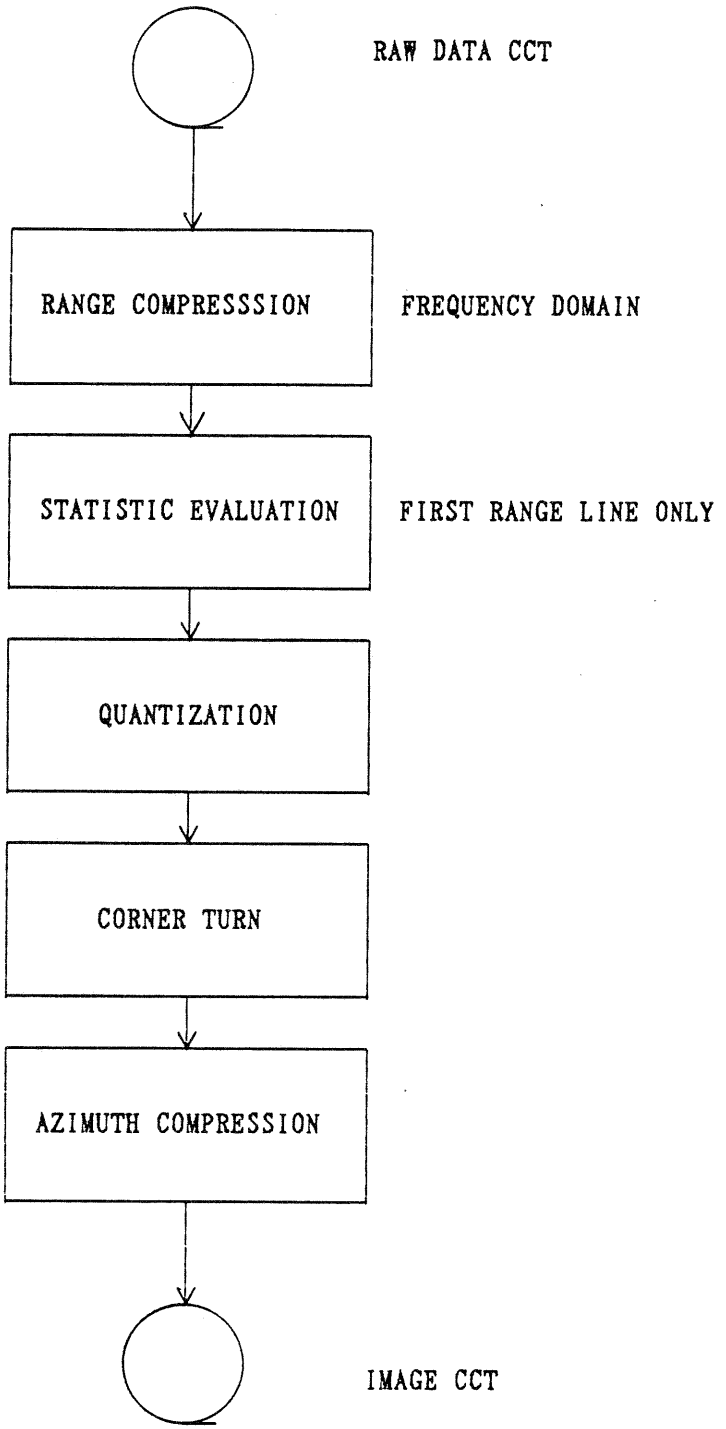

Fig. 1 Processing Block Sequence

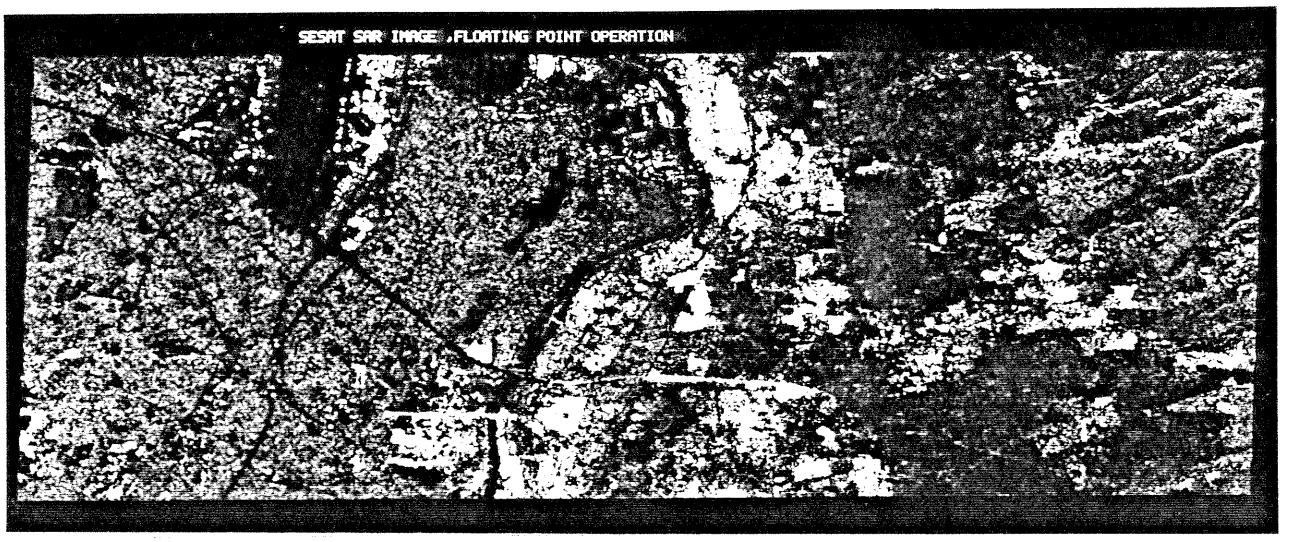

Fig.2 SAR image by floating point operation.

Fig.3 SAR image by 16BIT quantization.

Fig.4 SAR image by 12BIT quantization.

Fig.5 SAR image by 5BIT quantization.

Fig.6 SAR image by 3BIT quantization.

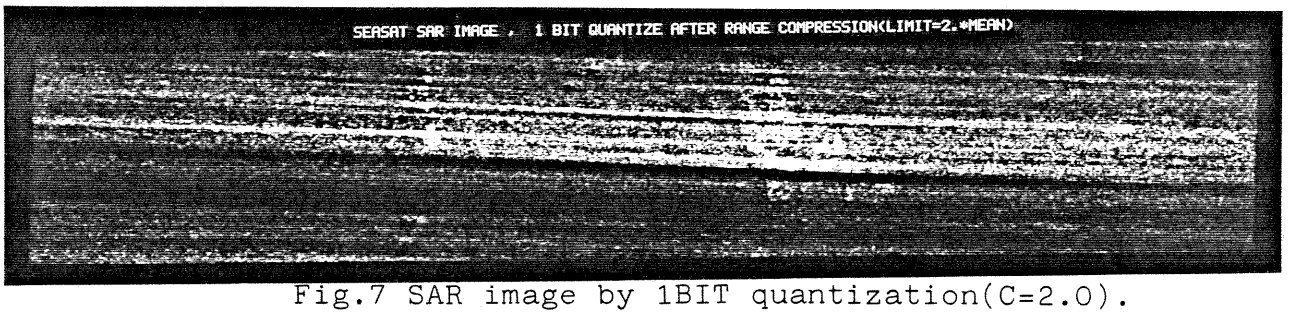

Fig.7 SAR image by 1BIT quantization(C=2.0).

Fig.8 SAR image by 1BIT quantization(C=1.0).

Fig.9 SAR image by 1BIT quantization(C=.05).

Table 1 Dynamic Range (Relative Amplitude)

Target	FLORTING	16BIT	8BIT	5BIT	3BIT	1BIT
WOODS 1	4. 947	4. 994	5. 185	5. 066	4. 498	2. 737
WOODS 2	5. 105	5. 130	5. 383	5. 277	4. 7097	2. 836
AIRPORT	1. 000	1. 0	1. 0	1. 0	1. 0	1. 0
GRASS	1. 304	1. 314	1. 353	1. 330	1. 300	1. 083
HILL	3. 316	3. 320	3. 354	3. 263	3. 0195	1. 666
RIVER	2. 051	2. 040	1. 9921	2. 089	1. 9807	1. 276
Hard Target 1	2078. 2 (66. 46dB)	1842. 2 (65. 31dB)	1414. 4 (63. 01dB)	1388. 61 (62. 85dB)	1203. 45 (61. 61dB)	214. 0 (46. 6dB)
Hard Target 2	233. 1	234. 6	240. 6	234. 93	210. 92	70. 89

Table 2 Radiometric Resolution (in dB)

Target	FLORTING	16BIT	8BIT	5BIT	3BIT	1BIT
WOODS 1	1.635	1.645	1.607	1.611	1.568	1.629
WOODS 2	1.623	1.624	1.635	1.627	1.5947	1.732
AIRPORT	1.619	1.612	1.597	1.549	1.569	1.652
GRASS	1.891	1.891	1.940	1.939	1.829	1.729
HILL	1.937	1.932	1.900	1.920	1.861	1.687
RIVER	0.952	0.918	0.807	0.770	1.014	1.153