Computer-aid Performance Evaluation System for the on-Board Data Compression System in HIRIS

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Abstract

This paper describes a computer-aid performance evaluation system for testing and checking the on-board data compression system used in High-Resolution Imaging Spectrometer(HIRIS).The earth resources spectra from the NASA earth resources spectral information system are taken for simulative spectra of ground objects and these spectra are sampled and quantized according to the conditions and parameters of HIRIS. Then the simulative spectral data are put in a GIFOV spectral data generator through a computer·interface.In testing the spectral data stored in the generator are sent to the data compression system at the same rate of the read out clock of subdetectors in HIRIS.The data compression system compresses the input data in real-time under the contral of the clock of the input data. After compressing, the compssion results are returned to computer through a bidirection interface,and compared with the original ones. Finally computer gives out testing results. This kind of test system can exactly simulate the original data obtained by HIRIS in space, and objectively evaluate the data compression system.

1. Introduction

High-Resolusion Imaging Spectrometer (HIRIS) is a new kind of optical sensor.It works by correcting images in many narrow contiguous spectral bands simulaneously[1].Owing to an additional dimension of information for spectrum its raw data rate greatly exceeds available downlink capability.For this reason we have studied the method and system of compressing raw data on board for the purpose of reducing the raw data rate of HIRIS.So that the data rate can be reduced on board to the level which downlink devices can bear. The processing time to compress one image corresponding to one swath of ground object at each pushbrooming moment is decided by the EOS orbit parameters. In order to meet the needs of the processing time with present techniques used for compression, a scheme of "Reducing-Dimension of 2-D image and Sequencing at Spectrum (RD2DSS) is adoped, which used a series of parallel 1-D compressions of spectral data corresponding to each Ground Instantaneous Field-of View (GIFOV) in the swath ground object as a substitution for compression of 2-D image[2]. A "Two-true-value linear prediction" data compression method and a "Base-bit + over flow-bit" coding method are proposed for compressing the original spectral data after reducing-dimension and sequencing[3]. A hardware data compression system based on the proposed scheme and methods has been developed[4]. To assess the performance of the developed data compression system and look for the effect of compressing raw data in real-time, the data compression system has been tested and checked by a computer-aid performance evaluation system Figure 1 is the block diagram of the computer-aid performance evaluation system for the on-board data compression system in HIRIS. The earth resources spectra from the NASA earth resources spectral information system are taken for spectra of simulative ground objects. The spectral data are generated in terms of the conditions and parameters of the HIRIS. Then computer sends these data into a GIFOV spectral data generator at a low speed. In testing spectral data in the generator are input to the data compression system as raw data at the same rate of the read out clock of subdetectors in the HIRIS. The data compression system compresses the simulative data in real-time under the control of the input data clock. This kind of evaluation system can objectively evaluate the actual operation performance of the developed hardware system.

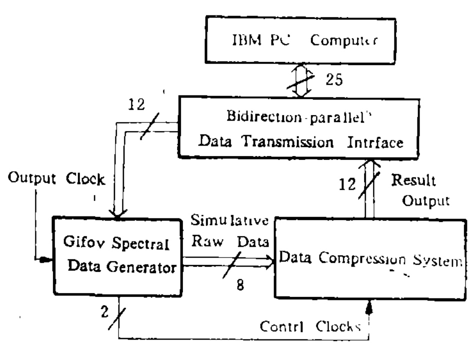

Fig.1 Block diagram of a computer-aid performance evaluation system

In following sections, first we describe the three parts constituting the evaluation system, the sampling and quantizing device, the bidirection-parallel data transmission, and the GIFOV spectral data generator, then give the experiment results obtained by the evaluation system.

2. Sampling and Quantizing Device

In the developed data compression system, which adopts the scheme of RD2DSS, in fact these are compressed by the system is the spectral data corresponding to each GIFOV. In such a kind of data compression system, the system performance evaluation only needs to check its impact of compressing spectral data corresponding to each GIFOV. So we use ground spectra from the NASA earth resources spectral information system as spectra of GIFOVs, then sample and quantize them according to the functional parameters of the HIRIS. The spectral data produced in this way can simulate that obtained by HIRIS in space with great fidelity. A constitution diagram of the device for sampling and quantizing spectral is shown in Fig.2. A tablet plotter is used for input device of spectral curves. When a spectral curve to be taken as a simulation is put underneath the transparent film of the tablet plotter, and the plotter pen draws on the transparent film along of the locus of the spectrum, computer automatically samples and quantizes the spectral curve and forms a GIFOV spectrum data file under the control of a written program. In terms of the HIRIS functional parameters, the wavelength range of simulative spectral date is 0.4~2.5μm, the spectral sample interval is 9.4nm in 0.4~1.0μm and 11.7nm in 1.0~2.5μm. Each GIFOV spectrum data file has 196 8-bit data.

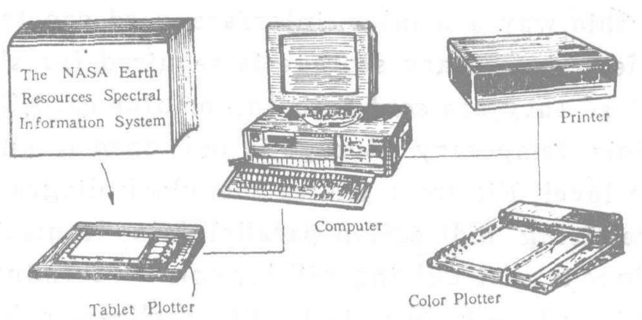

Fig.2 Constitution of spectrum sampling and quantizing device

3. Bidirection-parallel Data Transmission Interface

The bidirection-parallel data transmission interface has two tasks. The first one is to send simulative spectral data from computer to a

GIFOV spectral data generator.The second one is to send back the compressed results to computer from the data compression system. For sake of convenience a PC/XT printer interface card with appropriately amended is used as the interface for bidiection-parallel data transmission. Below we will describe how an amended printer card realizes bidirection-parallel data transmission.

1. Amendment of printer card

A printer interface card is designed for connecting a printer equipped with a parallel adapter.It has 12 output lines with latches,8 of them are data lines ($P_{2\sim9}$), 4 of them are control lines ($P_1, P_{14}, P_{16}, P_{17}$).In addition there are 5 input status lines ($P_{10\sim13}$, P_{15}).Computer understands the operation status of the printer through reading 5 status lines. Figure 3 shows the logical block diagam of a printer interface card.Data in computer are first sent into the transceiver of the card thruogh the computer data bus $D_0 \sim D_7$, then the data are sent into the data latch of the card from the transceiver through the interface data bus. Owing to the control terminal OE of the data latch being a fixed low level,the output three-state gate is open constantly,the data are connected to $P_2 \sim P_9$ of the D-shell connector as soon as they enter the data latch. Since the data latch occupies the 8 data lines ($P_{2\sim9}$) from beginning to end,input data can not get in the printer card through these 8 data lines. So this kind of printer card can transmit data only from inside to outside.In order to transmit data in bidirection with this card we change the fixed low level of the control terminal OE into a selected level.When the control terminal OE is connected to high level the output three-state gate of the data latch is in high impedance (Hi-Z),input data can get in the printer card through 8 data lines.In this way a printer interface card can transmit data from outside to inside.A temporary storage is required for storing input data temporarily before they are sent into the printer card.The output three-state gate of this temporary storage is not opened until the OE is connected to high level. Figure 4 shows the block diagram of the amended printer card realizing bidirection-parallel data transmission. The amendment to be done is just cutting off the control terminal OE in the card and connecting it with a band switch. The realization of bidirection data transmission is made by computer through the 4 control lines under the control of the written program.

2. Compressed data return to computer

It is a data input operation to send back compressed results into computer. In this operation mode the band switch in Fig.4 should be tured to "input" side. The terminal OE is set high level to turn off the output three-tate gate of the data latch in printer card. The 4 control linos are switched to data input contral circuit. Details of operation procedure are followings. First, computer gives out a control signal to send a compressed data (8 bit) into the input data temporary storage from present address unit of temporary memory of the data compression system. Then the output three-state gate of the input temporary storage is opened, so that the compressed data can be put in data lines $P_{2\sim 9}$. At this moment the compressed data in the data lines is read into computer from the transceiver through the bus buffer under the control of the progrem for input data. Afterward, computer generates a pulse to increase the address pointer

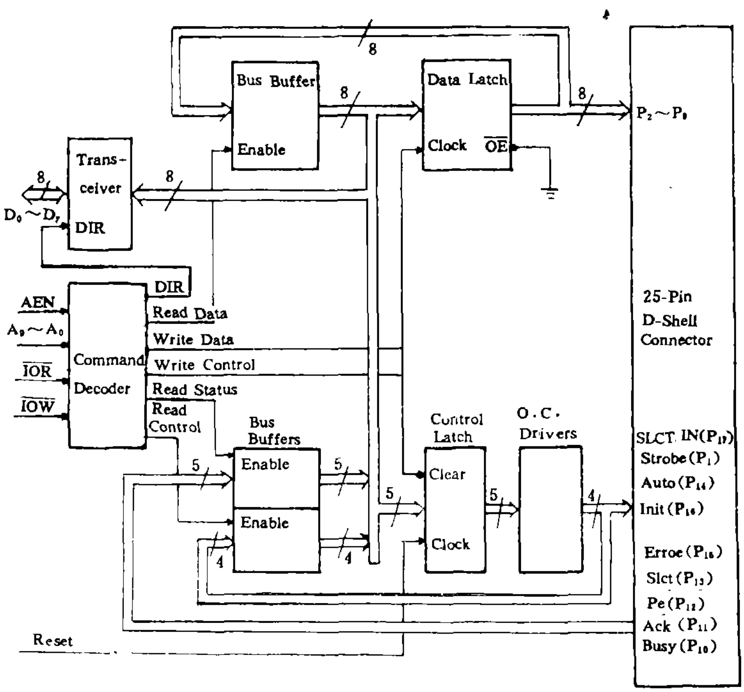

Fig.3 Block diagram of PC/XT printer card

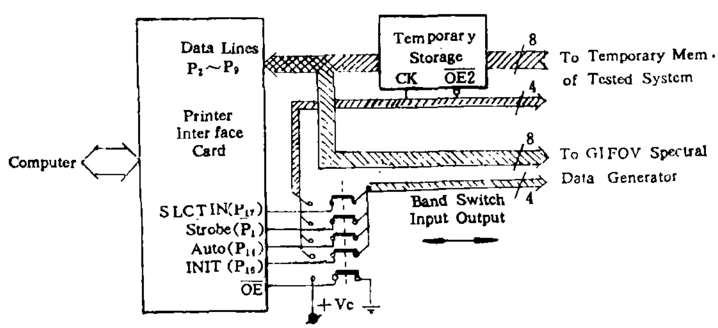

Fig.4 Block diagrm of bidirection-parallel data transmission interface

of the temporary memory for reading next compressed data. By now the operation for input one compressed data has been completed. The data input operation timing controlled by computer is shown in Fig.5. For the convenience of programming, 4 low bits of the control word which generates control pulses is given in the figure.

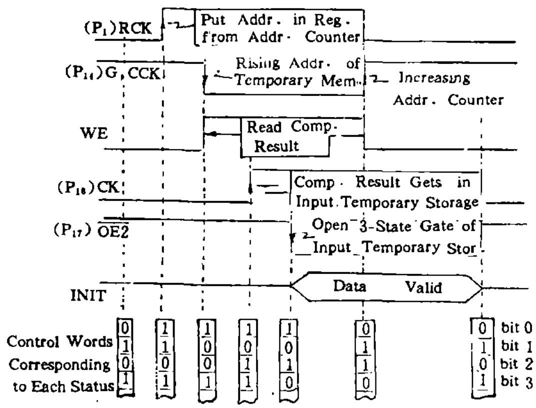

Fig.5 A timing of data input operation

4. GIFOV Spectral Data Generator

The function of a GIFOV spectral data generator is to store the simulative spectral data "slow" getting in from computer through the interface card, and "farst" get each GIFOV spectral data out at the same read out clock at which subdetectors constituting focal plane detector array read signal out. Figure 6 shows the circuit diagram of the generator. The part on left side of the dotted line is storage circuit, and the part on the right side is output control circuit.

1. Putting in simulative spectral data

The band switch of the interface card shown in Fig.4 is turned to "output"side to let the interface work in data output mode. The operation procedure to send simulative spectral data into the generator from computer is as following. First, a byte 8-bit spectral data to be output is sent into the data latch of the printer card through the computer data bus $D_0 \sim D_7$. Due to the $\overline{OE}$ of the data latch being low level the output three-state gate is open, this byte of spectral data is connected with 8 data lines of the interface card as soon as it is sent into the data latch. Next, computer gives out control pulses to put the spectral data in the generator. Figure 7 shows the timing of this operation. As each GIFOV spectral data consisting of 196 samples, a chip of RAM with 8k capacity can at most store 41 sets of GIFOV spectral data. Because of only one chip of RAM, the two chip selection terminals are connected to fixed level to keep the chip on duty all the time. Once the WE and address meet the conditions, the input spectral data is put in the present address memory unit.

2. Output control circuit

The output control circuit is used to control the operation of output spectral data from the generator to the tested system. The simulative spectral data with two clocks C_D and $\overline{SY}_{GIFOV}$ are input the tested data compression system. $\overline{SY}_{GIFOV}$ a synchronous pulse with a $2C_D$ width is generated after output 196 spectral data, that is, one set of GIFOV spectral data. In HIRIS the period of read out clock for each mosaic subdetector is reckoned to be 1μs if the focal plane detector array is contituted by 64×64 pixel detectors, While the period of read out clock of each mosaic subdetector is 0.25μs if the focal plane detector array is constituted by 128×128 pixel detectors. The period of compressing one byte of input spectral data in the developed data compression system is designed with 0.5μs in experiment phase. Therefore the frequency of output clock is set to 2^{MHZ} in testing.

The part on right side of dotted line in Fig.6 is output control circuit. When in output mode the band switch is turned to "output" side. The output operation is started by a hand pulse. The hand pulse does

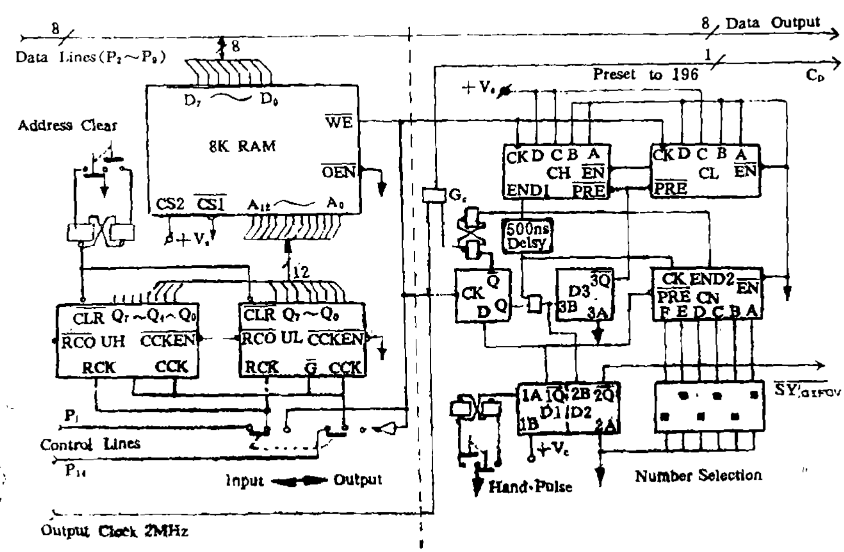

Fig.6 Circuit diagram of a GIFOV spectral data generator

not open the clock gate G_C until a rising edge of the input square waveform reaches. So that the falling edge of a start pulse can align with the rising edge of clock C_D. The counters CL and CH in the figure are used for producing $\overline{SY}_{GIFOV}$. Figure 8 shows the timing of the data output operation.

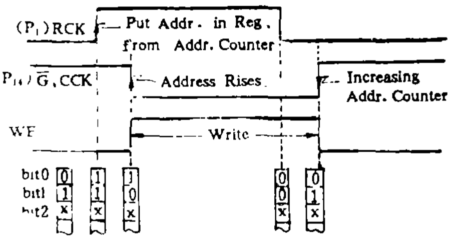

Fig.7 A timing of spectral data putting in

Table 1 Experiment results

Types	Spectrum name	Comp.R	E_{rms}(%)	Comp.R	E_{rms}(%)
SOIL	Organic-dominated	4.88	1.35	7.24	2.15
	Minimally altered	4.29	1.29	6.00	2.23
	Iron-affected	4.27	1.37	5.12	2.10
	Organic-affected	4.77	1.38	7.78	2.81
	Iron-dominated	6.36	1.35	9.55	2.11
ROCK	Calcitic carbonatite	4.67	1.41	5.12	2.41
	Dolomitic carbonatite	2.41	1.00	2.92	1.71
	Kaolinite	2.80	1.09	4.12	1.86
	Sericite	2.59	1.24	3.39	2.17
	Alunite	2.02	1.00	2.53	1.52
PLANT	Blue grass	2.96	1.15	4.12	1.63
	Grass mixture	2.76	1.16	3.89	2.08
	Beans	3.13	1.06	3.75	1.68
	wheat	2.88	1.11	4.12	1.98
	Corn	2.66	1.05	3.23	1.64
FOREST	Birch	3.39	1.16	5.00	2.07
	Red pine	3.09	1.10	3.44	1.60
	Red maple	3.00	1.17	3.50	1.83
WATER	Water	5.38	1.52	6.67	2.33
	Ice	6.56	1.55	8.40	2.44
	Snow	3.23	1.25	3.89	1.78
Each item's average:		3.71	1.22	4.95	1.99

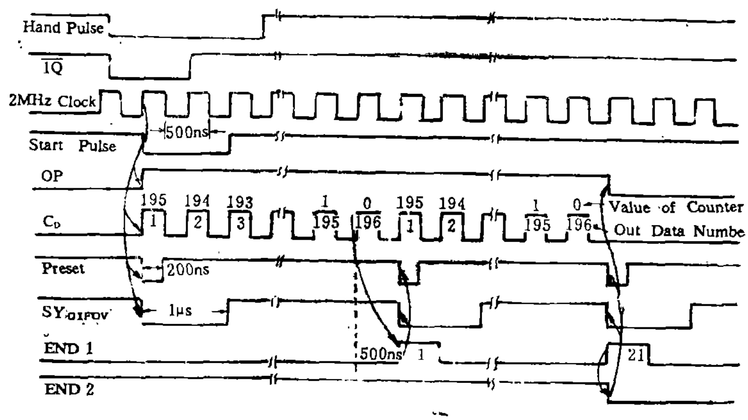

Fig.8 A timing of data output from the generator

5. Experiment Results

Twenty one kinds of typical earth resources spectra are selected from the NASA earth resources spectral information system as spectra of simulative ground objects, and generated simulative spectral data as discussed above. These twenty one kinds of spectra can be divided to five groups. The first group is soil spectrum, using five representative reflectance spectra of surface samples by Stoner[5]. The second group is rock spectrum, five rock of spectra are selected, two carbonatites: calcitic and dolomitic, and three altered rocks: kaolinte, sericite and alunite. The third group is plant spectrum, five plant spectra are selected, two grasses: blue grass and mixture grass, three crops: beans, wheat and corn. The fourth group is forest spectrum, they are birch, red maple and red red pine. The last group is water, snow and ice spectra.

First the data compression system compresses the input simulative spectral data under the control of the two input clocks. Second the compressed results are returned to computer. Third computer decompresses the compressed data and compares them with the original ones to evaluate the performance of the tested system. Table 1 lists out the experimental resulfs of compressing/decompressing under two reconstruction errors 1%, 2%. The test result shows that the data compression system works well under the designed parameters. The maximum input rate of the data compression system can reach 20 Mbits/sec. For these twenty one typical spectra of group objects, an average compression ratio 3.71 : 1 can be obtained under 1% reconstruction error; and an average conpssion ratio

4.95 : 1 can be obtained under 2% reconstruction error.

References

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用于HIRIS机上实时数据压缩系统的计算机辅助性能评价系统

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摘要：介绍的是用于对高分辨率成像光谱仪机上实时数据压缩系统进行测试和考查的计算机辅助性能系统。以美国NASA地球资源信息库提供的地物光谱作为模拟地面目标光谱，按照HIRIS实际测量的条件、参数将这些光谱数据经计算机送入到一个专门的 GIFOV 光谱数据发生器中。考核测试时存放在发生器中的光谱数据以 HIRIS 在空间测量时各镶嵌子探测器的读出时钟相同的速率送待测压缩系统，压缩系统在这个输入数据时钟控制下，对模拟原始输入数据进行实时压缩。压缩完毕后用双向数据传输接口将压缩结果送计算机进行恢复，再与原始数据进行比较。最后由计算输出测试结果。这种测试系统可很好地模拟HIRIS在空间测量时产生的原始数据的实际压缩情况，可客观、准确地评价压缩系统的性能。