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Satellite Image Compression using RICE Algorithm

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Abstract*: *Processing of satellite images is time-intensive owing to the large surface of the earth and the necessity for high resolution. Compression algorithms are an active research topic since there is no single algorithm which can achieve the best compression at the highest speed. Different compression algorithms need to be explored to enhance the speed of the analysis. Here, a lossless compression scheme using RICE algorithm is implemented using Matlab and Verilog on a satellite image according to the CCSDS (Consultative Committee for Space Data Systems) recommendation. The RICE algorithm uses a set of variable length codes. The architecture comprises of a Pre-processor, Adaptive entropy coder, Postprocessor and an Inverse mapper. The design has been implemented using Xilinx.

***Index Terms*: Adaptive entropy coder, Consultative Committee for Space data systems, Inverse mapper, Lossless compression, Split sample option.**

I. INTRODUCTION

Image compression is the process of creating an encoded, compact representation of the image without loss of significant information. Compression reduces the size of the image by employing minimum number of bits to encode redundant information thereby enabling the faster and more efficient transmission of data. Two types of compression techniques are lossy and lossless compression. In lossy compression, an approximate of the original image can be reconstructed. It is often accompanied by loss of data. In lossless compression, the original image can be reconstructed without data loss.

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For remote sensing and scientific satellite missions, lossless data compression is often preferred as any loss of data reduces the usability significantly. There are many lossless compression algorithms like Huffman coding, Arithmetic coding, Lempel-Ziv coding [1] However, for space applications, algorithms which can reduce the on-board memory requirements and station contact time are preferred [8].

RICE algorithm is one such lossless compression algorithm which is used for various space applications. This scheme offers better performance than other techniques on scientific data according to the Consultative Committee for Space Data Systems (CCSDS) which is a multinational forum, composed of the world's major space agencies. The RICE algorithm uses variable length coding where shorter codewords are assigned to data that are expected to occur with higher frequency. The algorithm is very simple (additions, subtractions, shifts), which can result in computational efficiency and facile implementation. An implementation of a lossless compression technique known as the RICE algorithm is presented in this paper. The design is an original implementation according to the CCSDS recommendation. The algorithm has been designed using MATLAB. Also, the simulation of the algorithm has been performed using the Xilinx tool with the code written in Verilog.

II. LITERATURE SURVEY

A survey on the various image compression algorithms was carried out. Lossless compression algorithms such as Huffman coding, arithmetic coding, Lempel Ziv coding were explored. Mridul Kumar Mathur and Seema Loonker in the paper "Lossless Huffman coding technique for image compression and reconstruction" [2] have found that Huffman coding requires the knowledge of the probabilities of the symbols in the compressed files and compressing the file requires the frequency of each symbol and construction of Huffman tree. IAN H. Willen, Radford M. Neal, and John G. Cleary proposed a "Lossless image Compression scheme using Arithmetic coding" [3]. An elaborate study of the performance parameters such as compression efficiency and the time taken for execution of the programs, considering the effect of different arithmetic word lengths on compression efficiency has been presented but the coding technique was sensitive to channel errors. Valentina D" Arrigo, Domenico Giunta proposed paperwork on “Rice based lossless data compression system for space applications” [4]. The work described that the performance of the Rice compressor is based on the features of the image considered. In May 1997, CCSDS published a recommended standard for lossless data compression with two low-entropy coding options. This recommendation addresses only lossless source coding.

III. RICE ALGORITHM

The RICE algorithm performs compression by splitting the data samples into a block size(J) samples. The algorithm is performed independently on each of the J blocks. The fig 3.1 shows the RICE algorithm architecture. It consists of the Pre-processor,Adaptive Entropy Coder and Postprocessor. The redundancy in the samples are reduced by decorrelation using the preprocessor module.The input data sample and the previous data sample are subtracted to reduce the redundancy. Adaptive entropy coder consists of a set of options.The coding option that yields the least number of bits in the data is chosen as the compressed data. The post processor is used for reconstruction of the data.

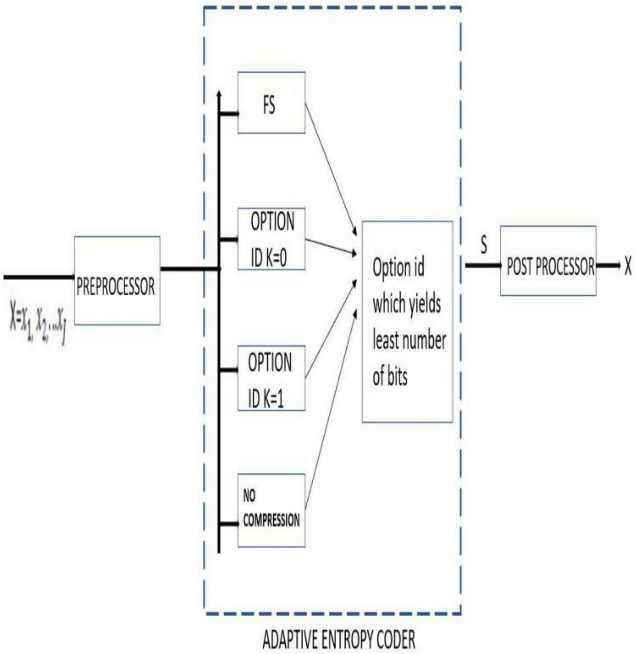

Fig 3.1 RICE algorithm architecture

A. Pre-processor

The preprocessor consists of the Unit Delay Predictor and a Mapper. The delayed sample from the predictor provides the initial reference sample. The mapper is used to convert an n-bit non-negative integer to a positive integer. The fig 3.2 shows the preprocessor module.

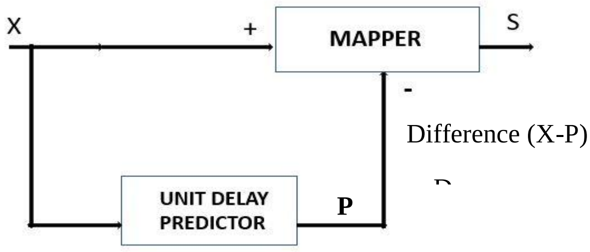

Fig 3.2 Preprocessor

The mapping is done according to the following conditions.

S = 2D for 0<=D<=T

2|D|-1 for -T<=D<=0

T+|D| otherwise

Where T= minimum (P-xmin, xmax-P)

and P is the output of the unit delay predictor

B. Adaptive Entropy Coder

The adaptive entropy coder yields encoded sequences formed from the preprocessed samples. This module consists of a number of option IDs(K). The output of the encoder is preceded by an ID pattern.

The different options available are:

- Fundamental sequence encoding
- Split sample option (split K) [8]

Fundamental sequence encoding uses the unary coding technique which is depicted as ‘R’ zeroes followed by symbol ‘1’ for the Rth preprocessed sample. The split K option is the most common option used. This option discards the K least significant bits and encodes the remaining bits with its FS code [8] The output of the entropy coder is transported in the form of packets. Fig 3.2 shows the coded data set format where J is the block size of the samples and K is the option ID.

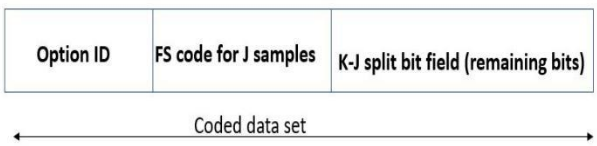

Fig 3.2 Coded data set format

C. Post Processor

Post processor reverses the mapper operation given the unit delayed input sample (P). Fig 3.3 shows the post processor block.

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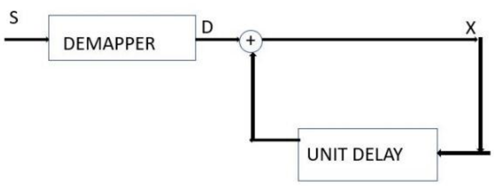

Fig 3.3 Post processor block

The inverse mapper functions are given below:

If S<= 2T

D = S/2 when S is even

= -(S+1)/2 when S is odd

If S > 2T

D = S-T when T=P-xmin

T-S when T=xmax-P

IV RESULTS AND DISCUSSIONS

The RICE algorithm is simulated using MATLAB R2018.To illustrate the implementation in software, a satellite image of LISS-3, Resourcesat-2 (172 X 169) of the Bangalore Urban district has been considered. Fig 4.1 shows the input satellite image

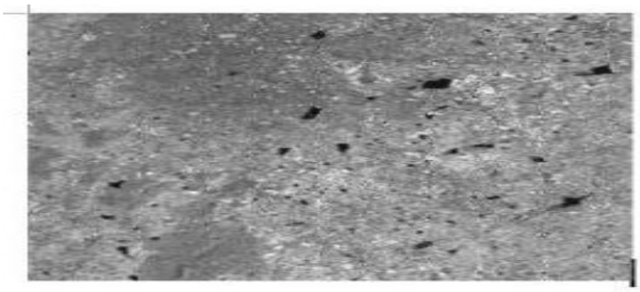

Fig 4.1: Input satellite image of LISS-3, Resourcesat-2.

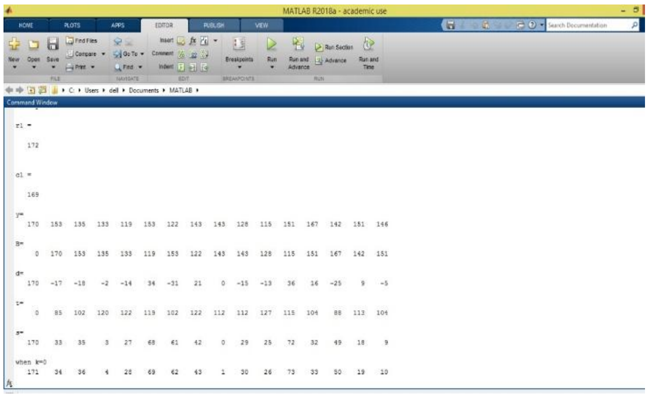

Fig 4.2: Output of preprocessor block

The fig 4.2 shows the output of the preprocessor block

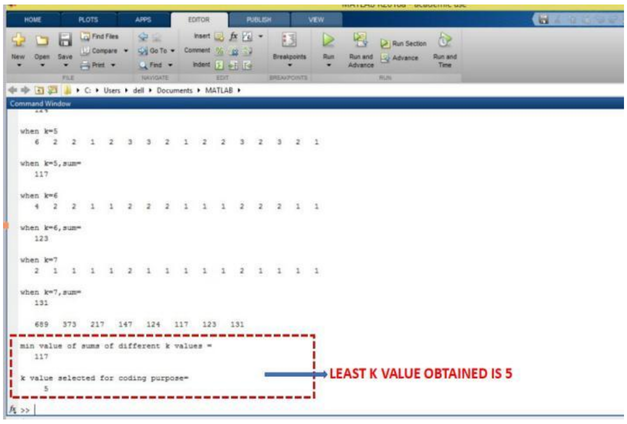

Fig 4.3 Split sample option

The fig 4.3 shows the split sample option for the block size of 16 bits where in, the sample option ID of 5 has been obtained to give the compressed data.

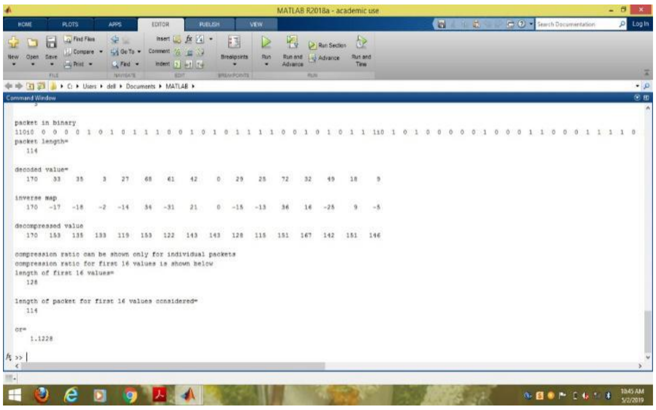

Fig 4.4 Postprocessor

Fig 4.4 shows the post processor operation after the formation of packets.

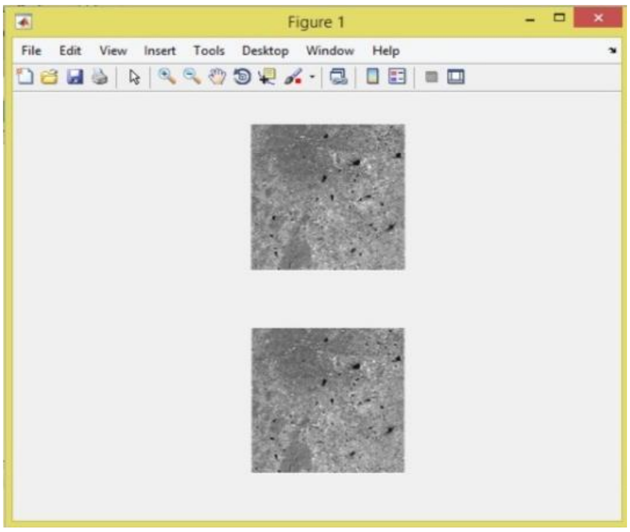

Fig 4.5 Input and output (decompressed image)

The fig 4.5 shows the output image obtained after performing RICE algorithm.

The algorithm has been simulated in Verilog using Xilinx tool. The results after simulation are as shown in fig 4.6 and fig 4.7

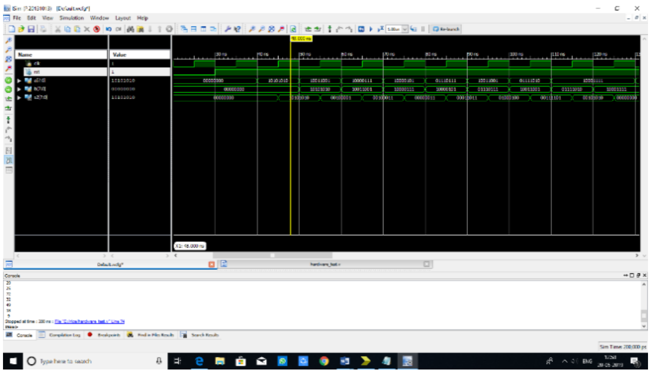

Fig 4.6 Simulation results using Xilinx

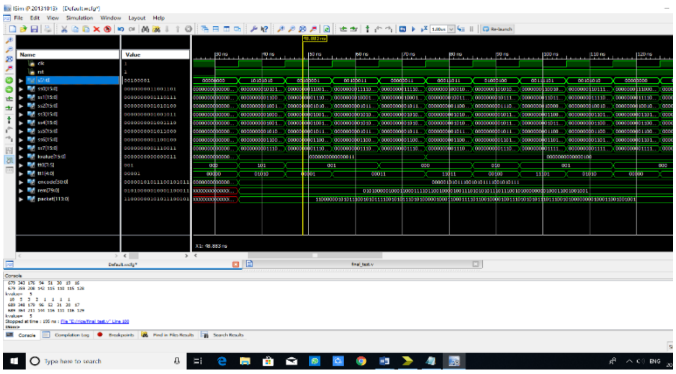

Fig 4.7 Simulation output using the Xilinx tool

V. CONCLUSIONS

In this paper, we have implemented the RICE algorithm. The main advantage is the independent packet formation based on the block size without the need for an additional lookup table as in other techniques. The RICE algorithm stores the data with fewer bits thus reducing the storage space. This algorithm is of importance in space applications as the simplicity and adaptivity allows high -speed space implementation. Also, loss of information is not tolerable and on-board storage requirement is less.

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