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Space - Qualified Hardware Design for 16 bit Image Compression

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Abstract: This paper presents a state-of-the-art implementation of lossless image compression algorithm LOCO-R, which is based on the LOCO-I (low complexity lossless compression for images) algorithm developed by weinberger, Seroussi and Sapiro, with modifications and betterment, the algorithm reduces obviously the implementation complexity. Experiments illustrate that this algorithm is better than Rice Compression typically by around 15 percent.

Keywords: Image Compression, Video Compression, EZW, Compression Ratio.

I. INTRODUCTION

Lossless image compression is well-established as a means of reducing the volume of image data without compromising the data quality. Missions often desire hardware to perfonn such compression, the aim is to reduce the demand on processors and to increase the speed at which images can be compressed. Currently, the available space-qualified hardware designed for lossless compression is based on the Rice Compression algorithm[l]. Rice Compression has limitations, however, and there are other algorithms that achieve better lossless image compression. An algorithm known as LOCO-I (low complexity lossless compression for images i 2 ,] is an appealing choice. LOCO-I is at the core of JPEG-LS, the algorithm selected by the Joint Photographic ExpertsGroup as the International Standards Organization/International Telecommunications Union (lSOIITU) standard for lossless and near-Iossless compression of continuous-tone images[4]. The paper have improved LOCO-I to reduce the complexity of implementation, regarded as LOCO-R. For natural images, the compression achieved by LOCO-R exceeds Rice Compression in compression rate LOCO-R ALGORITHM The LOCO-R algorithm described in this section is based on the LOCO-I algorithm[5] , it takes as input a rectangular image with 8-bit pixel values (the pixel values are within the range ° to 255). The compressed image produced is a sequence of bits from which the original image can be reconstructed. Let wd be the image width and ht be the image height. Pixels are identified by coordinates (x, y) with x in the range [O, wd-l] and y in the range [O, ht-l]. This paper supposes: (0,0) corresponds to the upper left comer of the image. The LOCO-R algorithm is based on predictive compression [6]. During compression, the pixels of the image are processed in raster scan order. Specifically, y is incremented through the range [O, ht-l], and for each y value, x is incremented through the range[O, wd-l]. (Thus, the y dimensions, the slowly varying dimension.)The first two pixels, with coordinates (0,0) and (1,0), are simply put into the output bit stream uncoded. For all other pixels of the image, the processing that occurs can be conceptually divided into four steps: (1) Classify the pixel into one of several contexts according to the values of (usually 5) previously encoded pixels. (2) Estimate the pixel value from (usually 3) previously encoded pixels, and add a correction(called the bias), which depends on the context. (3) Map the difference between the estimate and the actual pixel value to a non-negative integer, and encode this integer using Golomb's variable length codes [7]. (4) Update the statistics for the context based on the new pixel value. These steps are explained in detail below.

II. RELATED WORK

LOCO-I (LOw COmplexity LOssless COmpression for Images) is the algorithm at the core of the new ISO/ITU standard for lossless and near-lossless compression of continuous-tone images, JPEG-LS. The algorithm was introduced in an abridged format in [1]. The standard evolved after successive refinements [2, 3, 4, 5, 6], and a complete specification can be found in [7]. However, the latter reference is quite obscure, and it omits the theoretical background that explains the success of the algorithm. In this paper, we discuss the theoretical foundations of LOCO-I and present a full description of the main algorithmic components of JPEG-LS. Lossless data compression schemes often consist of two distinct and independent components: modelling and coding. The modelling part can be formulated as an inductive inference problem, in which the data (e.g., an image) is observed sample by sample in some pre-defined order (e.g., raster-scan, which will be the assumed order for images in the sequel). At each time instant t, and after having scanned past data xt = x1x2 ⋯ xt, one wishes to make inferences on the next sample value xt+1 by assigning a

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conditional probability distribution P(·|xt) to it. Ideally, the code length contributed by xt+1 is − log P(xt+1|xt) bits (hereafter, logarithms are taken to the base 2), which averages to the entropy of the probabilistic model. In a sequential formulation, the distribution P(·|xt) is learned from the past and is available to the decoder as it decodes the past string sequentially. Alternatively, in a two-pass scheme the conditional distribution can be learned from the whole image in a first pass and must be sent to the decoder as header information.1 The conceptual separation between the modeling and coding operations [9] was made possible by the invention of the arithmetic codes [10], which can realize any probability assignment P(·|·), dictated by the model, to a preset precision. These two milestones in the development of lossless data compression allowed researchers to view the problem merely as one of probability assignment, concentrating on the design of imaginative models for specific applications (e.g., image compression) with the goal of improving on compression ratios. Optimization of the sequential probability assignment process for images, inspired on the ideas of universal modeling, is analyzed in [11], where a relatively high complexity scheme is presented as a way to demonstrate these ideas. Rather than pursuing this optimization, the main objective driving the design of LOCO-I is to systematically "project" the image modeling principles outlined in [11] and further developed in [12], into a low complexity plane, both from a modeling and coding perspective.

A key challenge in this process is that the above separation between modeling and coding becomes less clean under the low complexity coding constraint. This is because the use of a generic arithmetic coder, which enables the most general models, is ruled out in many low complexity applications, especially for software implementations. Image compression models customarily consisted of a fixed structure, for which parameter values were adaptively learned. The model in [11], instead, is adaptive not only in terms of the parameter values, but also in structure. While [11] represented the best published compression results at the time (at the cost of high complexity), it could be argued that the improvement over the fixed model structure paradigm, best represented by the Sunset family of algorithms [13, 14, 15, 16], was scant. The research leading to the CALIC algorithm [17], conducted in parallel to the development of LOCO-I, seems to confirm a pattern of diminishing returns. CALIC avoids some of the optimizations performed in [11], but by tuning the model more carefully to the image compression application, some compression gains are obtained. Yet, the improvement is not dramatic, even for the most complex version of the algorithm [18]. More recently, the same observation applies to the TMW algorithm [19], which adopts a multiple-pass modeling approach. Actually, in many applications, a drastic complexity reduction can have more practical impact than a modest increase in compression.

This observation suggested that judicious modeling, which seemed to be reaching a point of diminishing returns in terms of compression ratios, should rather be applied to obtain competitive compression at significantly lower complexity levels. On the other hand, simplicity-driven schemes (e.g., the most popular version of the lossless JPEG standard [20]) propose minor variations of traditional DPCM techniques [21], which include Huffman coding [22] of prediction residuals obtained with some fixed predictor. These simpler techniques are fundamentally limited in their compression performance by the first order entropy of the prediction residuals, which in general cannot achieve total decorrelation of the data [23]. The compression gap between these simple schemes and the more complex ones is significant, although the FELICS algorithm [24] can be considered a first step in bridging this gap, as it incorporates adaptivity in a low complexity framework. While maintaining the complexity level of FELICS, LOCO-I attains significantly better compression ratios, similar or superior to those obtained with state-of-the art schemes based on arithmetic coding, but at a fraction of the complexity. In fact, as shown in Section 6, when tested over a benchmark set of images of a wide variety of types, LOCO-I performed within a few per- centage points of the best available compression ratios (given, in practice, by CALIC), at a much lower complexity level. Here, complexity was estimated by measuring running times of software implementations made widely available by the authors of the respective algorithms. In the sequel, our discussions will generally be confined to gray-scale images. For multicomponent (color) images, the JPEG-LS syntax supports both interleaved and non-interleaved (i.e., component by component) modes. In interleaved modes, possible correlation between color planes is used in a limited way, as described in the Appendix. For some color spaces (e.g., an RGB representation), good decorrelation can be obtained through simple lossless color transforms as a pre-processing step to JPEG-LS. Similar performance is attained by more elaborate schemes which do not assume prior knowledge of the color space (see, e.g., [25] and [26]). JPEG-LS offers a lossy mode of operation, termed "near-lossless," in which every sample value in a reconstructed image component is guaranteed to differ from the corresponding value in the original image by up to a preset (small) amount, δ. In fact, in the specification [7], the lossless mode is just a special case of near-lossless compression, with $\delta = 0$. This paper will focus mainly on the lossless mode, with the near-lossless case presented as an extension in Section 4. The remainder of this paper is organized as follows. Section 2 reviews the principles that guide the choice of model in lossless image compression, and introduces the basic components of LOCO-I as low complexity projections of these guiding principles. Section 3 presents a detailed description of the basic algorithm behind JPEG-LS culminating with a summary of all the steps of the algorithm. Section 4 discusses the near-lossless mode, while Section 5 discusses variations to the basic configuration, including one based on arithmetic coding, which has been adopted for a prospective extension of the baseline JPEG-LS standard. In Section 6, compression results are reported for standard image sets. Finally, an appendix lists various additional features in the standard, including the treatment of color images. While modeling principles will

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generally be discussed in reference to LOCO-I as the algorithm behind JPEG-LS, specific descriptions will generally refer to LOCO-I/JPEG-LS, unless applicable to only one of the schemes.

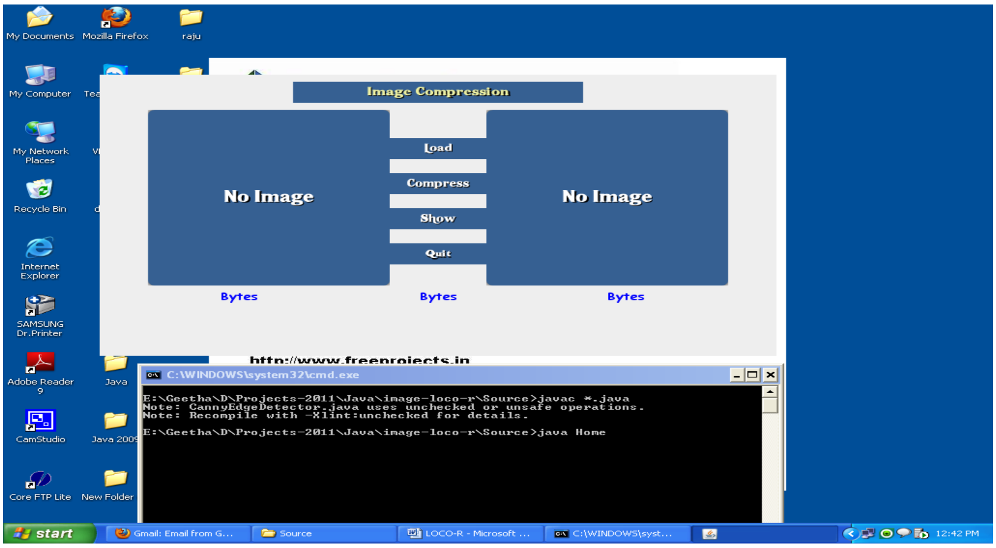
III. EXISTING SYSTEM

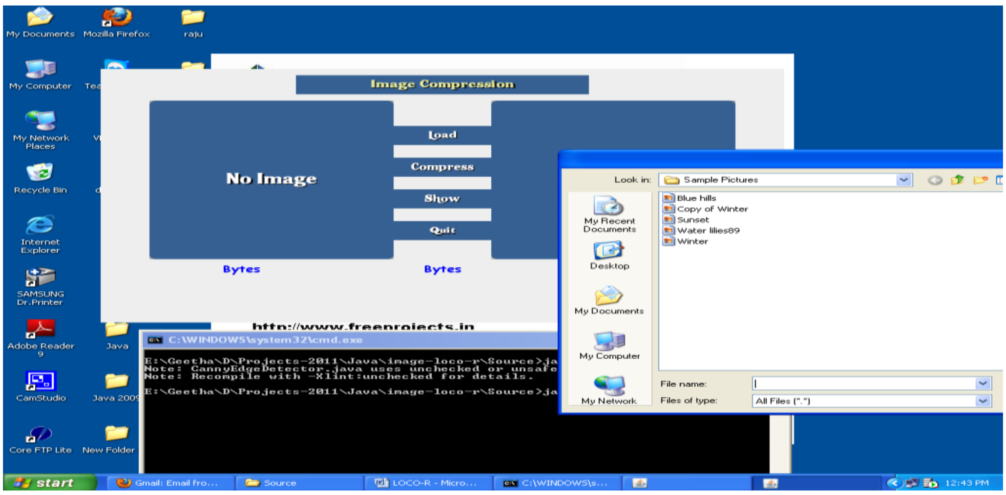
The Lossy compression is a data encoding method which discards (loses) some of the data, in order to achieve its goal, with the result that decompressing the data yields content that is different from the original, though similar enough to be useful in some way. It is possible to compress many types of digital data in a way which reduces the size of a computer file needed to store it or the bandwidth needed to stream it, with no loss of the full information contained in the original file.

IV. PROPOSED SYSTEM

The LOCO-R algorithm works as LOCO-I and takes rectangular image block with 8 pixel values. The compressed image produced is a sequence of bits from which the original image can be reconstructed. Let wd be the image width and ht be the image height. Pixels are identified by coordinates (x, y) with x in the range [O, wd-l] and y in the range [O, ht-l]. Lossless image compression is well-established as a means of reducing the volume of image data without compromising the data quality. LOCO-R (LOw Complexity LOssless COmpression for Images) is the algorithm at the core of the new ISO/ITU standard for lossless and near-lossless compression of continuous-tone images, JPEG-LS.The aim is to reduce to increase the speed at which images can be compressed. Currently, the available space-qualified hardware designed for lossless compression is based on the Rice Compression algorithm.

V. EXPERIMENTAL RESULTS





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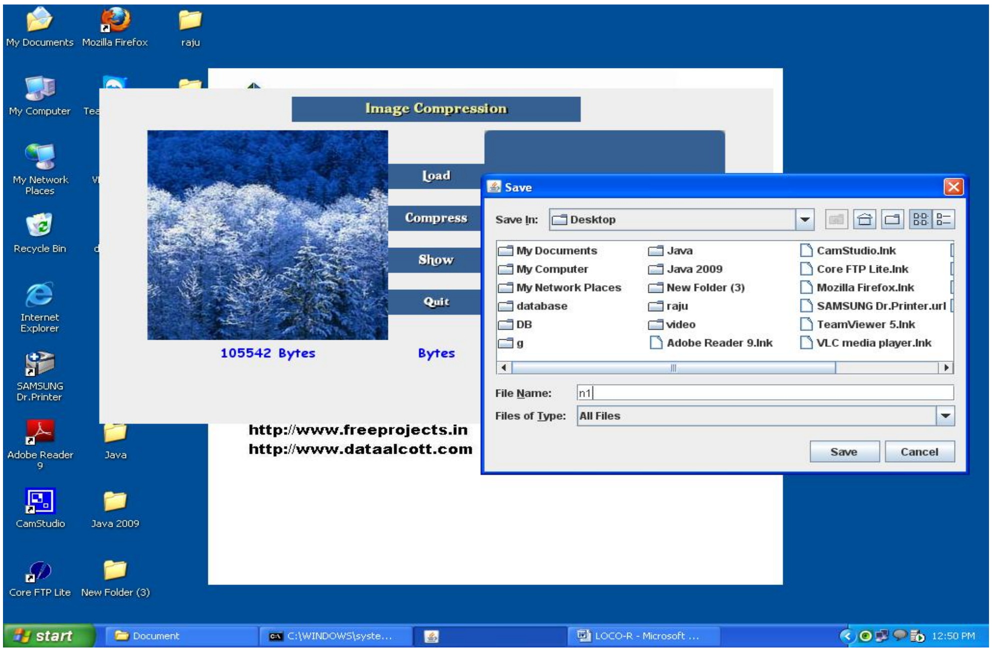

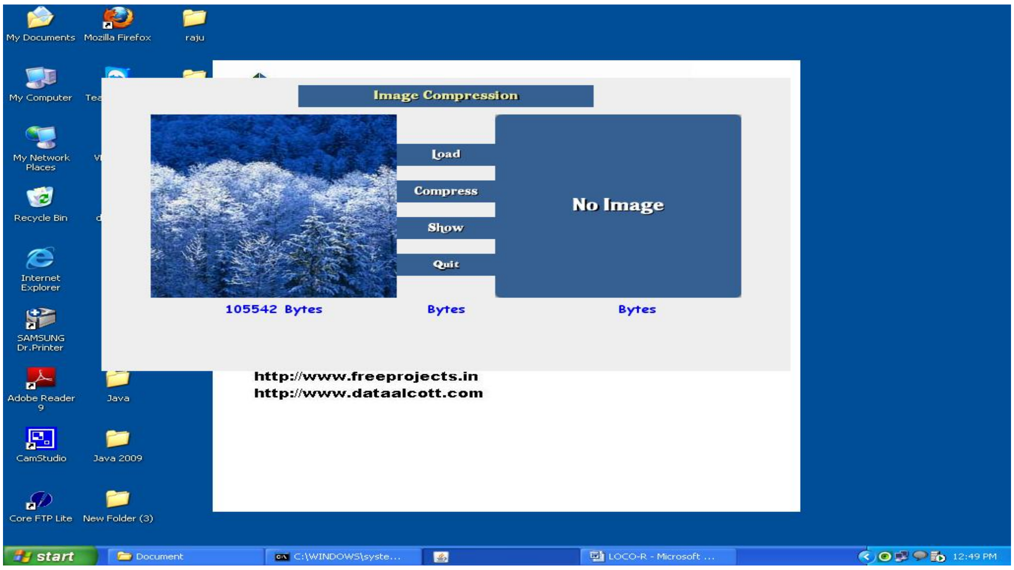

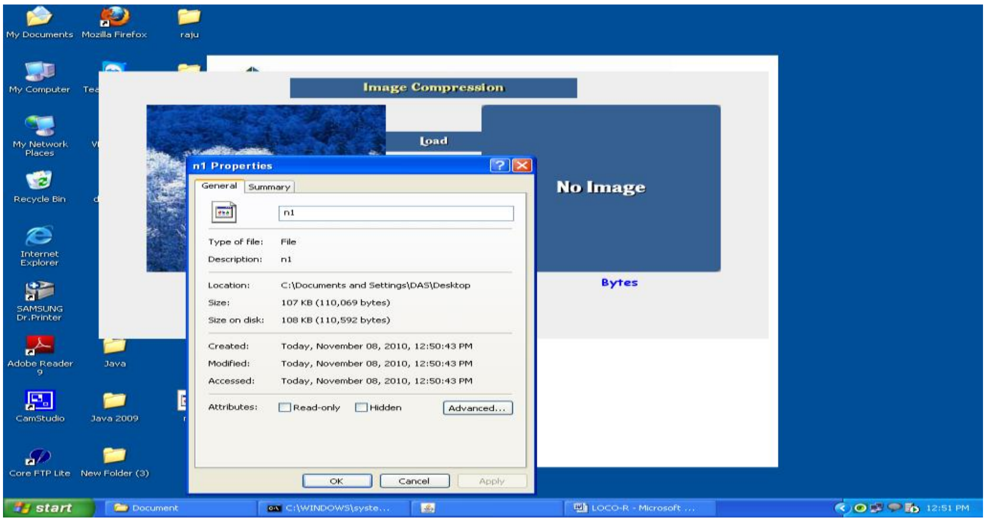

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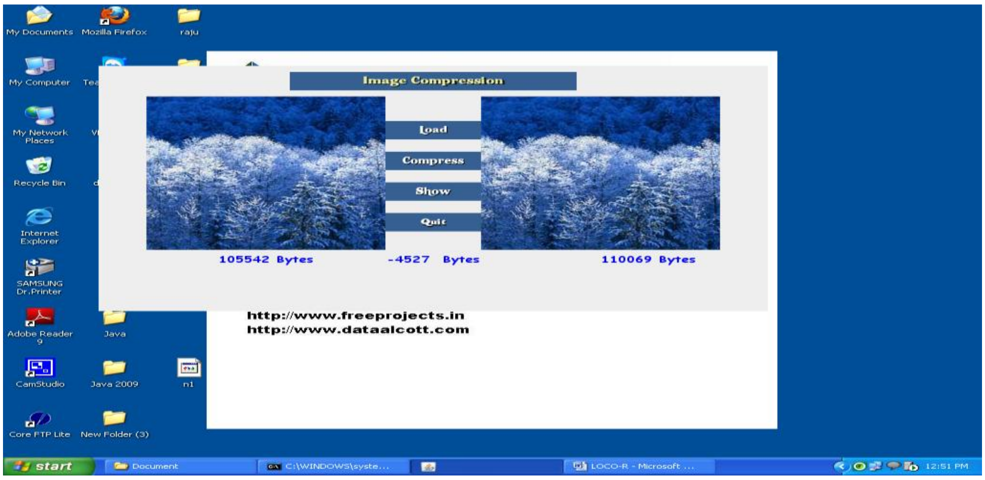

VI. CONCLUSION

LOCO-R algorithm represents significant progress toward producing lossless image-compression with improved compression performance as compared with currently available solution.

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BIOGRAPHIES

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