Scalable Color Image Coding With Cellular Automata

Lilly Raffy Cheerotha
P.G.Scolar
Department Of Computer Science And Engineering
Coimbatore Institute Of Engineering And Technology,Coimbatore,Tamilnadu,India.

P.Vasanthi Kumari
ASSISTANT PROFESSOR -III
Department Of Computer Science And Engineering
Coimbatore Institute Of Engineering And Technology,Coimbatore,Tamilnadu,India.

Abstract- A scalable colour image coding algorithm is a multi resolution representation of the data. It can be often obtained using a linear filter bank. Reversible cellular automata have been proposed recently as simpler, nonlinear filter banks that produce a similar representation. The original image is decomposed into four sub bands, such that one of them retains most of the features of the original image at a reduced scale. The project discusses the utilization of reversible cellular automata and arithmetic coding for scalable compression of colour images. In the binary case, the proposed algorithm that uses simple local rules compares well with the JBIG compression standard, in particular for images where the foreground is made of a simple connected region. For complex images, more efficient local rules based upon the lifting principle have been designed. They provide compression performances very close to or even better than JBIG, depending upon the image characteristics. In the gray scale case, and in particular for smooth images such as depth maps, the proposed algorithm outperforms both the JBIG standards under most coding conditions. In colour images after sampling equally optimal transform per component could be computed. Cellular automata transform is a new scheme to enhance resolution in terms of compression ratio.

Keywords – Arithmetic coding, cellular automata (CA), scalable image coding, RCA

I. INTRODUCTION

Focusing on the compression of bi-level images, a first scalable solution for binary images, i.e., images made of black or white pixels, was proposed within the JBIG coding standard [1]. In this framework, several versions of the same input image, at different spatial resolutions, are formed and encoded. Unfortunately, this paradigm requires coding a whole image for each resolution layer introducing a significant information redundancy in the coded bit stream. Therefore, more efficient schemes for scalable coding of binary images have been proposed in literature [2]. Recent works on this subject (see [3] and [4]) have been focusing on obtaining a high compression ratio too, but at the expense of scalability. As for multilevel images, these coding strategies proved to be ineffective and, therefore, most of the successive algorithms adopted a wavelet-based decomposition of the original signal, followed by an accurate reordering and modelization of the data to be coded. As a result of this research work, image coding experts finalized the JPEG2000.

More recently, a novel binary transform, based upon cellular automata (CA) theory, has permitted the design of effective scalable coders for binary images that inherit many properties of the wavelet-based image coders [6]. This paper presents a scalable lossless image coding algorithm based upon reversible cellular automata (RCA). In practice, appropriate reversible rules are used to transform the input image into four subimages with a lower resolution. Each of these is then converted into a bit stream using a context-based adaptive arithmetic coder whose contexts are computed from the values of (already-coded) neighboring pixels, in the same (intraimage) or in the others (interimage) subimages. The RCA approach is applied to binary images, grayscale images and color images.

The rest of the paper explains about related work in section II,proposed work in section III and in Section IV implementation details are explained.

II. RELATED WORK

ITU-T (1993) Recommendation T.82. suggested[4] the Joint Bi-level Image experts Group (JBIG) . The JBIG experts group[4] was formed in 1988 to establish a Standard for the progressive encoding of bi-level images. A progressive encoding System transmits a compressed image by first sending the compressed data for a reduced resolution version of the image and then enhancing it as needed by transmitting additional compressed data, which builds on that already transmitted. This Recommendation I International Standard defines a coding method having progressive, progressive-compatibles sequential, and Single-Progressions sequential modes and suggests method to obtain any needed low-resolution renditions. It has been found possible to effectively use[4] the defined coding and resolution-reduction algorithms for the lossless coding of greyscale and colour image a s well as bi-level images. This Specification defines a method for lossless compression encoding of a bi-level image (that is, an image that, like a black-and-white image, has only two colours). The defined method tan also be used for coding greyscale and colour images. being adaptive o image characteristics, it is robust over image type. On scanned matches printed characters, observed compression ratios have been from 1,l to 1,5 times as great as those achieved by the MMR encoding algorithm (which is less complex) described in Recommendations T.4 (G3) and T.6 (G4). On Computer generated images of printed characters, observed compression ratios have been as much as 5 times as great. On images with greyscale rendered by half toning or dithering, observed compression ratios have been from 2 to 30 times as great. The method is bit-preserving high meanest hat it, like Recommendations .4 and T.6, is distortion less and that the final decoded image is identical to the original. The method also has “progressive” capability. When decoding a progressively coded image, a low-resolution rendition of the original image is made available first with subsequent doublings of resolution as more data is decoded.

Resolution reduction is performed from the higher to lower resolution layers, while decoding is performed from the lower to higher resolution layers. The lowest resolution image sent in a progressives sequences a sequentially coded image. In a Single-Progression quintal coding application his is the only image sent. Progressive encodings have two distinct benefits. One is that with them it is possible to design an application with one common databases at tan efficiently serve output devices with widely different resolution capabilities. Only that Portion of the compressed age file required or reconstruction o the resolution capability of the particular output device has to be sent and decoded. Also, if additional resolution enhancements desired or say, a Paper copy of an image already on a CRT Screen only the needed resolution-enhancinging formation hast o be sent. The other benefit of progressive encodings is that they can provide subjectively superior image browsing (on a CRT) for an application using low-rate and medium-rate communication links. A low-resolution rendition is transmitted and displayed rapidly, and then followed by as much resolution enhancement as desired. Each Stage of resolution enhancement builds on the image already available. Progressive encoding tan make it easier for a user to quickly recognize the image as it is being built up, which in turn allows the user to interrupt the transmission of the image.

JBIG image compression is typically be Chosen so that the lowest resolution is roughly 10 to 25 dpi. Typical bi-level images when reduced to such a resolution are not legible, but nonetheless much low-resolution renditions are still quite useful and function as automatically generated ones. Page layout is usually apparent and recognition of particular pages that have been seen before at higher resolution is often possible.

As mentioned above, this Specification does not restrict the number D of resolution doublings. It can be set to 0 if progressive coding is of no Utility, as is the case, for example, in hardcopy facsimile. Doing so retains JBIG’s compression advantage over MMR (and in fact usually increases it somewhat), while eliminating the need for any buffering and simplifying the algorithm. Single-Progressions sequential JBIG coding has potential applications identical to those of MMR coding. Images compressed y a single-progressions sequentially encoder will be readable by decoders capable of progressive decoding, although only the lowest resolution version of a progressively encoded image will be decidable y a Single-Progression quintal encoder. It is possible to use this Specification for the lossless coding of grayscale and color images by coding bit-Planes independently as though each were itself a bi-level image. This approach to the encoding of greyscale and colour images can be used as an alternative to the photographic encodings specification .It in its lossless mode. Preliminary experimental results have shown that J IG has a compression advantage over JPEG in its lossless mode for greyscale mages up to 6 bits-per-pixel. For 6 to bits-over—pixel the compression results have been IG and JPEG. This Specification makes provision for images ~4th more than one bit plane, but makes no recommendation how to map greyscale or colour Intensities .Greyscale images a mapping via Gray-coding of intensity is superior to simple weighted-binary coding of intensity.

Arithmetic coding is superior in most respects to the better-known Huffman [lo] method. It represents information[12] at least as compactly-sometimes considerably more so. Its performance is optimal without the need for blocking of input data. It encourages a clear separation between the model for representing data and the encoding of information with respect to that model. It accommodates adaptive models easily and is computationally efficient. Yet many authors and practitioners seem unaware of the technique. Indeed there is a widespread belief that Huffman coding cannot be improved upon. We aim[12] to rectify this situation by presenting an accessible implementation of arithmetic coding and by detailing its performance characteristics. We start by briefly reviewing basic concepts of data compression and introducing the model-based approach that underlies most modern techniques. We then outline the idea of arithmetic coding using a simple example, before presenting programs for both encoding and decoding. In these programs the model occupies a separate module so that different models can easily be used. Next we discuss the construction of fixed and adaptive models and detail the compression efficiency and execution time of the programs, including the effect of different arithmetic word lengths on compression efficiency. Finally, we outline a few applications where arithmetic coding is appropriate.

III. Proposed Work

Cellular Automata are mathematical idealizations of physical systems in which space and time are discrete, and physical quantities take on a finite set of discrete values.A cellular automata consists of a regular uniform lattice with discrete variables at each site(“cell”).The state of a cellular automata completely specified by the values of the variables at each site. A CA evolves in the discrete time steps,with the value of the variable at one site be affected by the values of the variables in its neighbourhood on the previous step.

The term cellular automata is plural. To simplify our lives, we’ll also refer to cellular automata as “CA.” A cellular automaton is a model of a system of “cell” objects with the following characteristics. The cells live on a grid. Each cell has a state. The number of state possibilities is typically finite. The simplest example has the two possibilities of 1 and 0 (otherwise referred to as “on” and “off” or “alive” and “dead”). Each cell has a neighbourhood. This can be defined in any number of ways, but it is typically a list of adjacent cells.

In proposed system the existing work can be extended by introducing encoding to colour images. A scalable colour image coding algorithm is a multi resolution representation of the data. It can be often obtained using a linear filter bank. Reversible cellular automata have been proposed recently as simpler, nonlinear filter banks that produce a similar representation. In colour images after sampling equally optimal transform per component could be computed. Cellular automata transform is a new scheme to enhance resolution in terms of compression ratio.

IV. Implementation Detail

A.SUB BAND CODING WITH CELLULAR AUTOMATA

Cellular Automata (CA) are dynamical systems and models of massively parallel computation that share many properties of the physical world . A cellular automaton consists of an infinite lattice of identical cells arranged regularly, with a natural notion of neighbourhood. Each cell is provided with a state from a finite number of possible states. The CA evolves to a new global state, or configuration, by updating the states of the cells synchronously, in discrete time steps, according to a local update rule, which takes into account the current state of each cell and its neighbours. More precisely, let us consider a d-dimensional CA, with a finite state set Q. The cells are positioned at the integer lattice points of the d-dimensional Euclidean space, indexed by Zd. The configuration of the system at any given time is a function c : Zd → Q that provides the states of all cells. Let Cd Q denote the set of all d-dimensional configurations over the state set Q. The neighbourhood vector N = ($\bar{v}$1, $\bar{v}$2, . . . , $\bar{v}$n) of the CA specifies the relative locations of the neighbours of the cells: each cell $\bar{x}$ $\in$ Zd has neighbours, in positions $\bar{x}$ + $\bar{v}$i for i = 1, 2, . . . , n. The local rule f : Qn → Q determines the global dynamics F : Cd Q → Cd as stated in (1),Q as follows: for every c E Cd Q and $\bar{x}$ E Zd we have

$$\mathbf{F(c)(\bar{x}) = f[c(\bar{x} + \bar{v}1), c(\bar{x} + \bar{v}2), \ldots, c(\bar{x} + \bar{v}n)]} \quad (1)$$

Function F maps configurations into configurations and is called a (global) CA function. Reversible cellular automata (RCA), also known as invertible cellular automata, are cellular automata that fully preserve information, i.e. for every current configuration there is exactly one past configuration , that can be reached by the inverse automaton. We can think to a digital image as the cellular space where a CA evolves, associating pixels and their intensity values with cells and their states, respectively. This is the basic idea behind the use of CA to perform transformations on images. Moreover, reversible CA satisfies the perfect reconstruction property needed for lossless compression. This idea is exploited in by defining a special class of RCA, called reversible multiband cellular automata (Rm-bandCA) which are used as non-linear FIR filter banks for sub band coding of bi-level images. Rm-bandCA apply different local rules on different positions, allowing cells to store a vector of m different values (sub bands) which is updated by applying m different local rules (f1, f2, ..., fm).

Let us take 2×2 blocks of the input bi-level image as cells in the initial configuration of a reversible 4-band CA, where every pixel of the block belongs to one of four sub bands (LL, HL, LH, HH). The CA is evolved to the next configuration and the same transformation is further applied to sub band LL for a new level of decomposition, obtaining a multiresolution-like representation of the image (see Figure 1(a-c)). If the local rules of the filters are properly designed (and following sub band naming conventions of JPEG2000 [1]), after R − 1 levels of decomposition LLR−1 is a representation of the image at lower resolution, and, for i = 1, 2, . . . ,R − 1, HLi contains vertical borders (equivalent to High/Low-pass filtering along rows/columns), LHi horizontal borders (Low/High-pass filtering along rows/columns), and HHi diagonal borders. Ri are the available resolutions at each level: R0 is the image at the innermost (smallest) resolution and RR−1 at the largest resolution (i.e. the original image). The characterization of reversible local rules for a CA is a difficult and widely studied problem in CA theory. If the space is at least 2-dimensional it is even undesirable whether a given local rule is reversible (the problem is instead decidable in the 1-dimensional case). There exist some basic techniques to design reversible local rules , which have been extended to Rm-bandCA in .

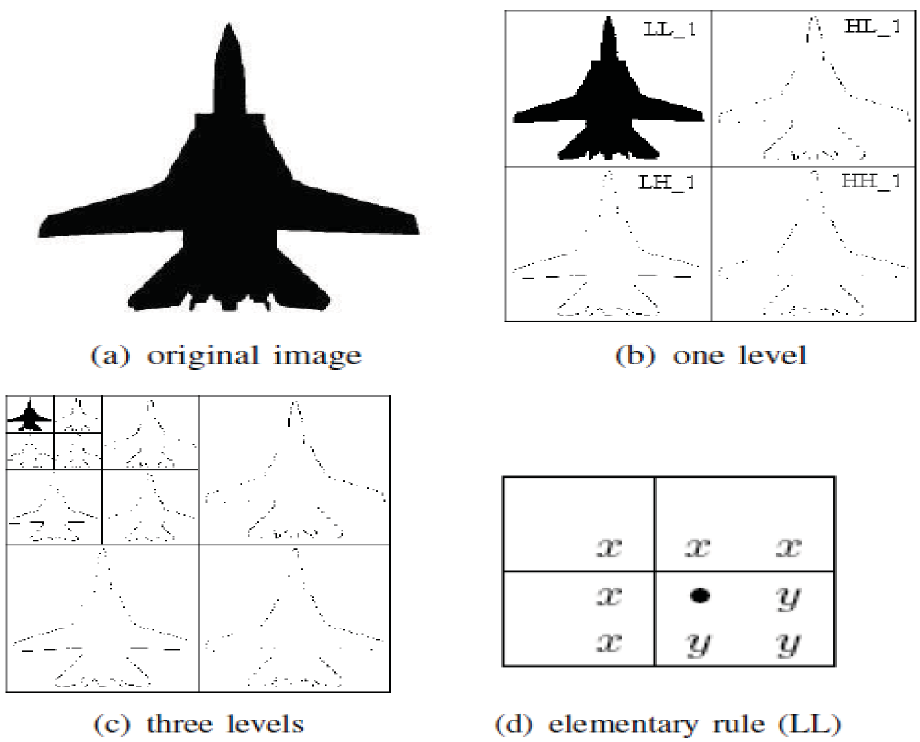

FIGURE 1: CA based transformation process(a)original image(b)one level(c)three levels(d)elementary rule(LL)

B. REVERSIBLE RM-BAND CA TRANSFORMATION

Let us consider binary images as the initial configuration of a 2-dimensional 4-bandCA with 16 states, where cells are 2 × 2 blocks with state q = (qll, qhl, qlh, qhh) Q, and qll, qhl, qlh, qhh E {0, 1} are the pixels (or components) inside the cell corresponding to sub bands LL, HL, LH and HH respectively. An elementary rule changes components values of only one subband according to some permutations defined over its domain. The permutation actually used is determined by looking at the other m – 1 subbands of neighbouring cells. This operation is invertible by the inverse permutation since the processed components are not affecting each other and the other subbands remain unchanged. The rule used for pixels in the LL subband, for example, has neighbourhood N = ((0, 0), (−1, 0), (−1,−1), (0,−1)). The pixel value is toggled if and only if the other three components in the same cell have identical colours and all five closest components in the neighbourhood have the opposite colour (i.e. x 6= y in Figure 1(d)). The same rule can be defined for components in subbands HL, LH and HH, respectively. They are then applied one after the other as a composition of four CA. The transformation step is completed by applying a trivial local rule (see Figure 2), whose neighbourhood consists of only one cell (itself), and the state of the cell changes according to a permutation_ of the state set Q. This rule is clearly invertible using the inverse permutation _−1. The resulting transformation after the composition of the previous Rm-band CA exploits the correlation in the image data and has been successfully applied for the compression of bi-level images, obtaining compression results comparable to JBIG. Elementary rules allow information to cross block boundaries helping to capture diagonal borders; the trivial rule in Figure 2 arranges the information inside blocks in order to obtain better and more compressible multi resolution-like representations. It takes advantage of non-linearity and low computational complexity of RCA transforms. Rm-band CA compression is also inherently parallel and can be implemented on parallel hardware if high throughput is necessary.

C. MULTILEVEL DIGITAL IMAGE COMPRESSION

When dealing with multi level images, we must be able to cope with a substantially more complex correlation structure in the image data.

- Non-binary RCA filter banks could be used where the initial configuration directly stores the values of the image samples. This case allows for a “true” non-linear filtering, which can be hard to design but gives optimum performance.

- Multi-level images can be seen as a collection of their bit-planes from B0 (less significant) to BP−1 (most significant), that can be thought as P bi-level images. Binary RCA filter banks that store each Bi could be used whose local rules depend also on the actual values of some samples in the “upper” planes Bi+1 to BP−1. In this case a “sub-optimal” non-linear filtering could be achieved with relaxed design difficulties.

- Independent binary RCA filter banks that store each Bi could be used and designed, with local rules transforming Bi into Bti both dependently or independently from the plane index i. The residual inter-plane correlation is then exploited in the CA-transformed domain.

- Some form of inter-plane prediction could be used for prediction of bit-plane Bi (i < P −1) from planes Bi+1 to BP−1, such that only the prediction error Ei must be actually coded (providing that the upper planes are encoded first). Then, independent *binary* RCA filter banks that store each Ei could be used (with local rules transforming Ei into Et i both dependently or independently from i).

V.CONCLUSION

In proposed system the existing work is extended by introducing encoding to colour images. A scalable colour image coding algorithm is a multi resolution representation of the data. It can be often obtained using a linear filter bank. Reversible cellular automata have been proposed recently as simpler, nonlinear filter banks that produce a similar representation. In colour images after sampling equally optimal transform per component could be computed. Cellular automata transform is a new scheme to enhance resolution in terms of compression ratio.These are number of benefits in colour image coding like less storage space and for transmission of image**.**

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