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A survey of still image compression

Anitha. S
Govindammal Aditanar College for women, Tiruchendur.

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ABSTRACT
In this paper we describe some recent developments that have taken place in still image compression. We addresses about different compression techniques and also give a performance comparison. Functionality and principles of compression algorithms are discussed in a unified manner. This survey reviews more recent articles on image compression and discuss their role in current research directions. There are several image compression algorithms some of them are lossy and some of them are lossless. Thus medical image, pre press industry, art work, remote sensing images for lossless image compression.

Introduction

Image compression is important when it comes to storing or transmitting images. The image is an artifact that depicts or records visual perception. The idea behind image compression is to represent the image in the smallest number of bits while maintaining the essential information of the image. Compression is more or less it depends on our aim of the application . Some application require lossless reconstruction like for some medical image or satellite image application.

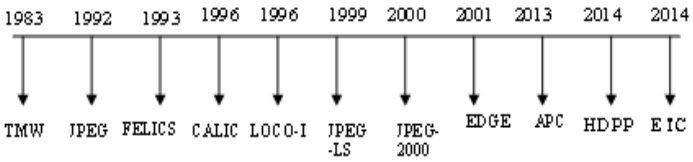
History

Morse code, invented in 1838 for use in telegraphy, is an early example of data compression based on using shorter codewords for letters such as "e" and "t" that are more common in English. Modern work on data compression began in the late 1940s with the development of information theory. In 1949 Claude Shannon and Robert Fano devised a systematic way to assign codewords based on probabilities of blocks. An optimal method for doing this was then found by David Huffman in 1951.In 1980's a joint committee , known as joint photographic experts group (**JPEG**) developed [1] first international compression standard for continous tone images. JPEG algorithm included several modes of operations. Steps in JPEG

1. Color image converted from RGB to YCbCr
2. The resolution of chromo components is reduced by a factor of 2 or 3. This reflects that the eye is less sensitive to fine color details than to brightness details
3. Image is converted into 8X8 matrix
4. DCT, Quantization is applied and finally compressed
5. Decoding is reversible process except quantization is irreversible.

FELICS (fast, Efficient lossless Image compression) was proposed [2] by Paul G.howard & Jeffrey s.vilter in 1993. It is based on context and arithmetic coding. Golomb codes are used here.CALIC (Context based adaptive lossless image codec)[3] is proposed in 1993.unique feature of CALIC is large number of modeling contexts are used. It is divided into two different modes that is binary and continuous mode. In binary mode two distinct intensity values are used 0/1. **GAP**(Gradient Adjustment Predictor) [4] is used in continuous mode for weight the neighboring pixel. It require more memory spaces. It is 26% better than Huffman coded JPEG and 12% better than arithmetic coded JPEG. **JPEG-LS** proposed in 1999. It provide low complexity lossless compression. Better than JPEG and faster than JPEG2000.

Literature Survey



TMW (Two way mixing Model)[5] it presented by Meyar in 1983. TMW uses two stage encoding process.

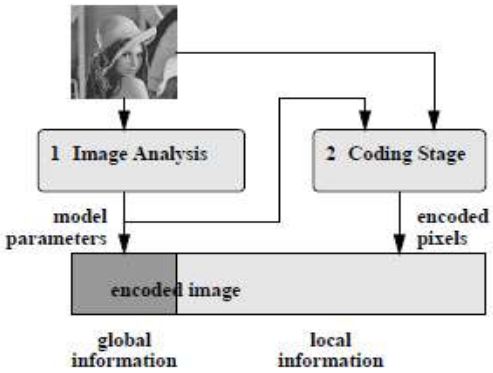


Fig 1. Flow Diagram of TMW

In this figure 1 Analysis stage consists of linear predictors, parameter which is suitable for image and also passed this information to the coding stage like side information. Coding stage consists of local information about the image. TMW uses multiple probability distribution techniques. Then the probability distributions are blended together, resulting final probability distribution which is then used to encode the pixel. It provides better result than CALIC and History based blending predictors.

History based blending predictor: It uses linear predictor and process pixel-by-pixel manner . Main demerits of History based blending predictor is explicitly detect the edge and edge orientation. CALIC address the problem by choosing from a set of fixed predictor or chooses only one predictor for a whole image. This is unsuitable for certain set of images like shapes test image.TMW provide better result for shapes text image set and also it used for image segmentation.

Tele:
E-mail addresses: anithajayakodi@gmail.com

EDP(Edge directed Prediction) It was outlined and evaluated by xin Li in 2001.LS(Least Square) based optimization is used in EDP [6][7]. It improves the prediction in the region of edge areas. It provides better result than CALIC. Instead of performing pixel by pixel basis, EDP perform Edge-by-Edge basis. In GAP, MED detecting edge & estimating the edge orientation explicitly but in EDP LS based approach locally optimized the prediction coefficients inside the casual window. It consists of 12 nearest neighboring pixels. Complexity of LS optimization is computation of covariance matrix. One of the main drawback of EDP, it is performed only for a fraction of pixel in the image EDP performance is based on the input image. If your image contains many edges then it performs well.

MED(H=4.56 bpp) GAP(H=4.39bpp) EDP(H=4.22bpp)

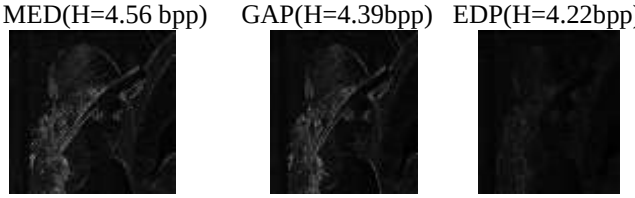


Fig 2 : Residue images of lennagrey after different prediction schemes

Hierarchical decomposition and pixel prediction: It experimented by seyun kim & Nam Ik Cho [8] in 2014. Input color image is first converted by RCT(reversible color transform) because of their invertible version.RCT [15] produce yCbCr, Y is compress by default compression like JPEG and the chrominance channel(Cb,Cr) is compressed by hierarchical prediction concepts. Signal variation still large in near the edges.

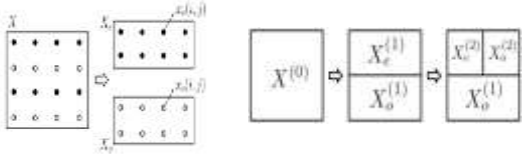


Fig 3: decomposition of input Image

Like in Fig 2 the chrominance image is decomposed into two sub images even number of rows (Xe) and a set of odd n umber of rows (X0). Xe is encoded by using the pixel in Xo,Xo is encoded by using Xe. Directional prediction is employed to avoid large prediction errors around the edges.If the horizontal edge is strong means horizontal prediction is used otherwise vertical prediction is used. It provides better result than JPEG 2000.

Bayesian Predictor

APC(Adaptive predictor combination) was proposed by Andrew martchenko in 2013 . It is a frame work for combining multiple predictors for lossless image compression [9]. It consists of two different stages. One is Predictors another one is entropy stage. Predictors stage is used to remove the spatial redundancy and produces prediction errors which are encoded by an entropy coder. Entropy stage requires an estimate of the error probability distribution. In APC there are two parameter (mean & variance) are predicted by each predictor. Computational calculation of APC is memory requirement and calculation of the sample mean and averaging the sample mean and variance.

Variable block size coding: It was presented and evaluated by Ichiro matsuda in 2002 .It is used to remove spatial redundancy [10]. Prediction error is encoded by context adaptive arithmetic coding. Quad tree based variable block size partitioning is introduced.

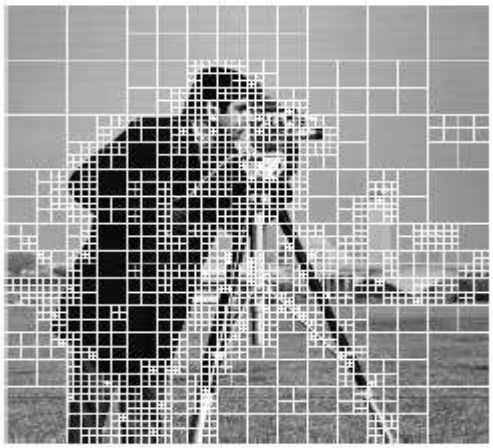


Fig 4. Block size partitioning

Like Fig 3 an image is partitions into square blocks & classifies them into several classes. Each and every class has an individual predictor which is optimized for blocks of the same class. Quad tree is built by recursive partitioning of a square block into four sub blocks. Each node of the tree, except in the lowest level, has a flag which indicates whether the corresponding blocks is further partitioned '1' or not '0'. It can process block-by-block manner. It provides better result than TMW.

Five Modulus Method: It was developed by Firas A.Jassim in 2013. This algorithm was called FJPEG [11] (Five JPEG). The compression ratio of JPEG could be increased by embedding the Five Modulus Method into the JPEG algorithm. The main concept of this method is to convert the value of each pixel into multiples of five. This conversion used to reduce the signal variation. Divide the image into 8X8 blocks. After that each pixel in every block can be converted into a number divisible by 5. This transformation will not be noticed by HVS (Human Visual System). To complete the FFM method, the 8X8 block divided by 5 to reduce the pixel values into lesser values.FMM used to reduce the pixel variation.

Discrete Anamorphic Transform: It was introduced by H.Asghari at 2014. Physics based Transformed Technique is used here [12]. It reduces data size by using space bandwidth compression. After the anamorphic transform with proper phase profile the brightness bandwidth is compressed. It is also combined with vector quantization & entropy encoding to further reduce the image data size. The resampled image can be compressed further by using a secondary compression like JPEg,JPEG 2000. It produce more than twice compression factor.

Hyper Spectral Images: It was introduced by Huber-leener at 2014. In this method all pixels are processed identically, with no unique treatment for pixels [13]. After that the background information is extracted from the original image. Decoding process is inverse of the encoding process. This compression process consists of two stages PCA (Principal Component Analysis) & DCT. The PCA process is utilized to capture background information of the HSI. The background information is subtracted from the original image, producing the original image. The DCT is then applied to the residual image with irreversible quantization. This technique is used mainly spatially busy (noisy) images. Computational calculation of this technique is covariance calculation.

Encryption Then Compression: It was introduced by Jiantao Zhou in 2014. In this technique image encryption is conducted prior to image compression [14].

Table 1. Result analysis for still image compression

S.No	Method	Functionality	Complexity	Result Analysis
1	TMW(Two Way Mixing Model)	Blending predictors are used. Implicit Segmentation	-	Better than CALIC For shapes test Image it provide better result.
2	Hierarchical Prediction & context Adaptive Coding	RGB->YCbCr Image can be decomposed into 2 sub images.Horizontal & vertical predictors are used.	-	Better than JPEG ,JPEG 2000 (except classic image test set)
3	History based Blending	Linear predictors used. Pixel-by-pixel	Detect the edge first and then predict the edge orientation	Better than JPEG
4	Edge Based	LS(Least square based) Edge-by-edge basis No need to predict edge Orientation	Covariance Matrix. EDP is image dependent. Compression is performing only a fraction of pixels.	Better than CALIC
5	Bayesian predictor combination for lossless compression.	APL(Adaptive predictor combination) Linear predictor is used.	Memory Calculation of the sample mean and averaging the mean variance.	Better than CALIC
6	Five modulus method	(8X8) image pixel is converted to multiple of 5 Divide by 5 to reduce the pixel values DCT technique is used	-	Memory reduced. Eg : lena Image JPEG : 36.9 FJPEG : 13.5
7	Compression of Hyper spectral Images	Principal Component Analysis-DCT	Covariance Matrix	Better than JPEG
8	Encryption then compression	GAP (Gradient Adjustment predictor) Predictor error are cluster into 16 groups Columns are adjusted by cyclical shift for getting key value.	Consider may be lossy or lossless	Nearer to CALIC
9	Discrete Anamorphic Transform	Physics based transform by reducing the bandwidth and spatial intensity without increase in image size Vector quantization is used Secondary compression JPEG,JPEG2000 is used	-	Better than JPEG,JPEG 2000
10	CALIC(context based adaptive lossless image coding)	GAP is used Horizontal & vertical predictor is used to predict the best one Non-linear predictor Error feedback mechanism is used to correct itself	Memory	CALIC is better in smooth region but not suited for compound region Better than JPEG
11	JPEG	DCT,Quantization,Zig-Zag,Entropy	-	-
12	LOCO-I(Low complexity lossless coder)	MED(median edge detection) is used		
13	ALCM	Adaptive predictor that used a weighted combination of five neighbor hood pixel in order to predict the current pixels	Higer computational complexity Faces poorly with compound images	Better than MED & GAP
14	Variable block size adaptive prediction optimized for each image	Quad tree based variable block-by-block	-	Better than TMW

Table 2. APC is better than others

Complexity	Low							High		
Image	JPEG-LS [3]	CALIC [6]	HBB [5]	APC-7*	APC-MAP-4	APC-MAP-7	APC-MAP-10	TMW [10]	MRP [18]	APC-WLS [10]
balloon	2.90	2.83	2.80	2.74	2.76	2.74	**2.73**	2.60	**2.58**	2.60
barb	4.69	4.41	4.28	4.26	4.30	4.27	**4.21**	3.84	3.82	**3.75**
barb2	4.69	4.53	4.48	4.45	4.30	4.27	**4.45**	4.24	4.22	**4.18**
board	3.68	3.56	3.54	3.44	3.48	3.43	**3.43**	3.27	3.27	**3.27**
boats	3.93	3.83	3.80	3.74	3.76	3.72	**3.72**	3.53	3.54	**3.53**
girl	3.93	3.77	3.74	3.65	3.65	3.62	**3.62**	3.47	3.46	**3.45**
gold	4.48	4.39	4.37	**4.33**	4.36	4.34	4.34	4.22	4.21	**4.20**
hotel	4.38	4.25	4.27	4.17	4.20	4.17	**4.15**	4.01	4.03	**4.01**
zelda	3.89	3.75	3.72	3.67	3.67	3.64	**3.64**	3.50	**3.49**	3.51
average	4.04	3.92	3.89	3.83	3.85	3.82	**3.81**	3.63	3.62	**3.61**
seconds	0.08[4]	0.17[5]	1.70[6]	0.34	0.36	0.62	0.88	4200[7]	2680[8]	4200[9]

It may be consider both lossy and lossless. Instead of treating all the prediction error as a whole, we divide the error into L clusters (L=16).After that perform two key driven cyclical shift offsets, and read out the data in raster scan order. It provides high level security.GAP predictor is used to predict the surrounding pixels and also arithmetic encoding is used. When comparing the results the Performance of ETC is nearer to CALIC not better than CALIC.

Original Image Encrypted Reconstructed Image

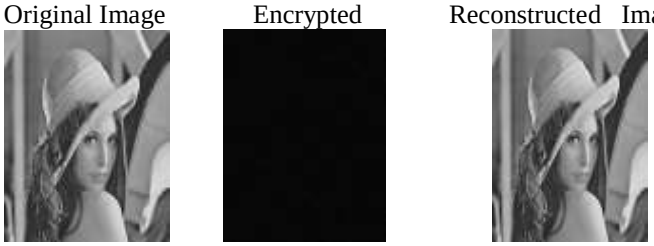


Fig 5. ETC technique

Result Analysis

In this table some of the compression algorithms are compared and the result is analysed.

Conclusion

This paper presents various techniques of image compression.. Some of these techniques are obtained good for certain applications like security technologies. After study of all techniques it is found that lossless image compression techniques are most effective over the lossy compression techniques. Lossy provides a higher compression ratio than lossless.JPEG LS better than JPEG 2000.FJPEG compression ratio increased than JPEG.TMW performance is better than EDP.APC provide better ratio than TMW.

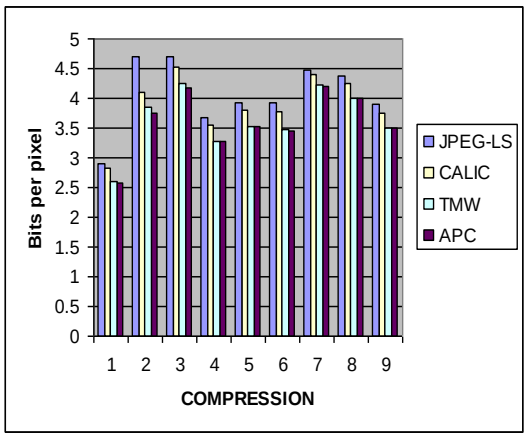


Fig 6: Compression comparison chart

After Comparison of the following algorithms APC is better than others

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Author Profile

ANITHA.S received her Bachelor's degree in Computer Science from Govindammal Aditanar College for women, Tiruchendur in 2006. She did her Master of Computer Application in Noorul Islam College of Engineering, Nagercoil.Completed her M.Phil in MS University, Tirunelveli. She has published 6 papers in International research journals. At present she is working as an Assistant Prof.in Govindammal Aditanar College for Women, Tiruchendur.