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Comparison between Lossless Compression of the Dithered Image Using Pseudo-Distance Transform and Modified Pseudo-Distance Transform

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Abstract— When high-bit resolution images is to be displayed in low bit resolution display devices, the total number of bits in an image is need to be reduced especially for low cost or small (mobile) devices. To solve the bit reduction problem, a color quantization technique is used called dithering. This dithering technique is employed on high bit resolution images. The dithering process is used to reduce number of colors but it cannot be used efficiently for storage and transmission . For the storage and transmission of images, several compression techniques have been proposed in past decades. To improve the compression ratio, compression techniques that takes data structure into account must be developed. In this paper, the pseudo-distance transform is used for dithered images, it yields better compression ratio results than in GIF and PNG.

Index Terms— compression ratio, dithering, low bit resolution, pseudo-distance transform.

1 INTRODUCTION

The data compression is the process of reducing the amount of data required to represent a digital image removing the redundant data. For this purpose, the data has to be stored and transmitted. In case of long term storage and transmission of data, the data compression will be critical. When a file type is known, the prediction models can be designed which will attain better compression results. Since low-cost display device has limited ability, a color image quantization technique called dithering would be essential for such low-cost display devices. For example, there are 16.8 million (2^24) possible color combinations in an RGB color image. Since an RGB color image consists of three bytes for each pixel; one byte for each color (red, blue, and green), a color image quantization is applied to map 24 bits to 16, 8, or 4 bits per pixel. The compression of an image using dithered images is a threestep process: the first step is designing a suitable palette to reduce the number of colors, the second step is coding, and the final step is decoding . For each RGB image, by generating a set of representative colors a palette is formed. Later, the palette is used in image encoding and decoding. In the encoding process, each color pixel in the RGB image is replaced with the index of the closest color in the palette. In effect, each RGB color pixel is represented by an index, which is mapped to the color palette. If the palette size is 256 or less, each index can be represented with a byte. Hence, effectively, image size is reduced from 3 bytes per color to one byte per index value by applying the quantization. In quantization process, we may have quantization errors, e.g., distortion. To overcome quantization errors, dithering algorithms are used. In World Wide Web, many Web pages use quantized images. They are stored and transmitted after they are compressed losslessly with the standard Graphics Interchange Format (GIF) or Portable Network Graphics (PNG). Better compression gain than other techniques can be obtained when pseudo-distance technique (PDT) is applied to color mapped images. For efficient storage and transmission several lossless compression techniques were designed such as GIF, PNG, JPEG-LS. Since GIF was patented, the PNG format was designed to replace GIF as an improved and patent-free alternative. The PNG file for an image is usually 10% – 35% smaller than the GIF file for the same image. These algorithms fail to obtain good compression gain, e.g., GIF standard uses Lempel–Ziv compression, which treats the image as a 1-D sequence of index values, ignoring the 2-D nature. Besides GIF and PNG, several researchers proposed different methods for quantized images. The re-indexing scheme yields the best compression gain when JPEGLS or JPEG-2000 is used after the re-indexing method. These methods show that reordering and re-indexing help 2-D compression schemes.But PNG yields better compression than JPEG-based techniques on reindexed color-mapped images.Tree structured color palettes greatly reduce the computational requirements of the palette design and pixel mapping tasks, while allowing colors to be properly allocated to densely pop-

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ulated areas of the color space. The algorithms produce higher quality displayed images and require less computations than previously proposed methods. Error diffusion techniques are commonly used for displaying images which have been quantized to very few levels.The proposed algorithms attempt to produce color palettes which minimized an objective error criteria[1]. Dithering techniques consist of adding a dither signal to the input image in order to reduce the disturbance introduced atthe quantizer stage due to noise as far as a human observer is concerned. In fact, human vision has been shown to be less sensitive to high frequencies and dithering methods aim to take advantage of this property. These methods aim to try to shift the quantization noise to the higher frequencies and to introduce at low frequencies as little disturbance as possible to the result of the quantization. To quantize an image by the mean of a dithering method can be seen in a first approach as disturbing the input image *X* by a dither signal *D* before operating the proper quantization process. This signal is added to the image to quantize in order to give a better-looking result after the quantization[2].Palette reordering is a class of preprocessing methods aiming at finding a permutation of the color palette, such that the resulting image of indexes is more amenable for compression. These preprocessing techniques have the advantage of not requiring post-processing and of being costless in terms of side information[3].The prediction error is not a index number difference between an original color and its predicted color, but a value called as “pseudo distance” which is related to the Euclidian distance between these two colors in the 3-D color space. since the pseudo distance is small when the predicted color is close to the original color, the distribution of the pseudo distance results in low entropy. Preliminary computer simulation results show that the proposed approach outperforms the index based linear prediction[4].

2 IMAGE DITHERING

Dithering is the process to represent an image by using afewer number of colors . Instead of using (256X256X256) different RGB shades, dithering converts the image to fewernumber of shades. The process is done by comparing each pixel in an image with a color palette having a fixed number of shades (24 for example). For every pixels RGB value the closest of the 24color values in the palette is chosen as its representative color. In a dithered image, colors not available in the palette are approximated by a diffusion of colored pixels from within the available palette. The human eye accepts the diffusion as a mixture of the colors within it.f the colors within it. In recent years, several dithering algorithms were proposed. The most well-known algorithm was developed by Floyd– Steinberg, which is known as the Floyd–Steinberg dithering technique. It uses error-diffusion algorithms instead of basic dithering algorithms , such as average, ordered, or random, and produces images which look closer to original form.The Floyd- Steinberg dithering algorithm is based on error dispersion. The error dispersion technique describes each point in the image, first step is to find the closest color available, then calculate the difference between the value in the image and the color it have. Then divide up these error values and distribute them over the neighboring pixels that is not visited yet. When these later pixels is received, just add the errors distributed from the earlier ones, let the values to the allowed range if it is needed, then continue the process till all pixels is reached

3 PSEUDO –DISTANCE TRANSFORM

A distance matrixD is formed by calculating Euclidean distance between every pair of indices from a color palette (colormap table). In each row of D, there may be similar values. To overcome the problem of non-uniqueness of the entries inrows of D, we compute a corresponding pseudodistance matrix P, where each row element P (a,b) gets a unique value c (0 < c < 255)based on the rank of D (a,b) in the sorted row a of matrix D . The Euclidean distance between two colours colour1 (Represented by R1G1B1) and colour2 (R2G2B2) is calculated as follows,

$$E(a,b) = \sqrt{(R_a - R_b)^2 + (G_a - G_b)^2 + (B_a - B_b)^2}^{\,2} \qquad (1)$$

Where,
E [a, b] : Distance between index a and index b.
(Ra-Rb) : Difference between the R values of a and b.
(Ga-Gb) : Difference between the G values of a and b.
(Ba-Bb) : Difference between the B values of a and b.

TABLE 1
COLOUR PALETTESS

INDEX	R	G	B
0	115	82	68
1	194	150	130
2	98	122	157
3	87	108	67
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22	122	122	121
23	85	85	85
24	52	52	52

By calculating the Euclidian distance between every pair of indices, a distance matrix can be constructed, as illustrated in Table 1.

TABLE 2
DISTANCE MATRIX D

	0	1	2	. . . .	24
0	0	121.28	99.04	. . .	71.58
1	121.28	0	103.58	. . .	189.34
...	...	...	...	...	...
24	71.58	189.34	134.31	. . .	0

A pseudo-distance matrix P is formed, where each row element P (a, b) gets a unique value c (0≤ c ≤ 255) based on the rank of D (a, b) in the sorted row a of matrix D.

TABLE 3
PSEUDO DISTANCE MATRIX

	0	1	. . .	24
0	0	16	. . .	6
1	14	0	. . .	13
...	...	...	...	...
23	2	17	. . .	4
24	4	19	. . .	0

3.1 Prediction Algorithm

The main purpose of prediction algorithms is to forecast the elements of a given data set with high accuracy. If an algorithm can estimate underlying data elements close to100%, to form the original data, information that will be needed to transmit would be negligible. Unfortunately, in real life, it is hard to achieve prediction with very high accuracy. However, if the data type is known and special characteristics of the data can be determined, then data specific predictor algorithms can be developed that achieve high accuracy. Currently used prediction-based image compression techniques usually predict the current pixel x by using some neighbors of x. the pixel a (reference) and x to determine a prediction error e from the pseudo-distance matrix. The goal of a predictor algorithm is to predict x with the minimum possible error.

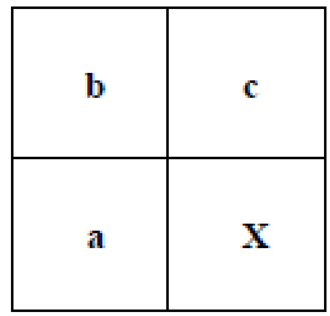

Fig. 1 Predicted Pixel X and Neighbouring Pixel

Fig. 2 Ranking With Pseudo-distance Matrix p

3.2 Reverse Pseudo-Distance Transform

The decoder part of the application uses a procedure similar to that used by the encoding algorithm. The encoded image file consists of the index table of the original image and the error signals. Hence, the decoder can easily construct the Euclidean distance and the pseudo distance matrices.The decoding process reconstructs the original image file as follows: By using the index table, first is to construct the pseudo-distance matrix P. Let r be the first value retrieved from the index table. In encoding process, r was encoded as a raw byte. To get back the first row and first column of the image, first, the error signal e of the next pixel from the encoded image is received. Then, in row r of the pseudodistance matrix, we search for the error signal value e. Upon determining e in row r, we emit the corresponding column value x as the original index value for the image to be reconstructed. Finally, x will be r .

4 Encoding and Decoding Algorithms

To compress the modified pseudo-distance transformed color mapped images further, the context - based binary arithmetic coder with a run-length encoder (RLE).The use of RLE is vital in entropy coder phase since the output of the PDT on dithered images contains a significant number of zeros. RLE detects long run sequences and regroup the repetitive sequences. It also improves the context-based arithmetic coder (AC) performance by helping the AC in determining non-zero symbol probabilities. While the use of RLE improves compression gain, it also decreases the computation time ofthe entropy coder. The zero run-length transformed data were used along with the context-based AC.The binary AC (BAC) with run-length encoding algorithm. The quantized AC coefficients usually contain runs of repeated zeros. Therefore, a coding can be obtained by using a run-length technique to improve advantage of the coding, where the upper four bits of the code symbol indicate the number of repeated zeros before the next coefficient, and the lower four bits indicates the number of significant bits in the next coefficient.Following the code symbol are the significant bits of the coefficient, the length is determined by the lower four bits of the code. The inverse run-length encoder translates the input coded stream into an output array stream of AC coefficients. It takes the current code symbol and transfer to the output array as the number of zeros corresponding to the four bits used for the zero run-length coder. The coefficient that is in the output array has the number of bits determined by the lower four bits of the run-length code and a value determined by the number of trailing bits. Binary arithmetic coders work with a limited source alphabet. This limitation overcomes some drawbacks of structured arithmetic coder because it helps to solve complexity problems on the data. In binary arithmetic coder, only 0s and 1s are used which makes the cumulative distribution task in encoding and decoding simpler. All kind of data can be represented in binary system and binary arithmetic coder can be used to encode them. A context-adaptive binary arithmetic coder is used. It has wide range of probability modes for different contexts. Basically, in the first stage, the encoder takes the input and converts the non-binary data to binary data. After that, the encoder determines which probability model is suitable by using information acquired from neighboring elements. Later, data is encoded. Context model helps the probability Estimation and is considerably beneficial in compression

5 Results

Fig. 3 Original Input Image

Fig. 4 Dithered input Image

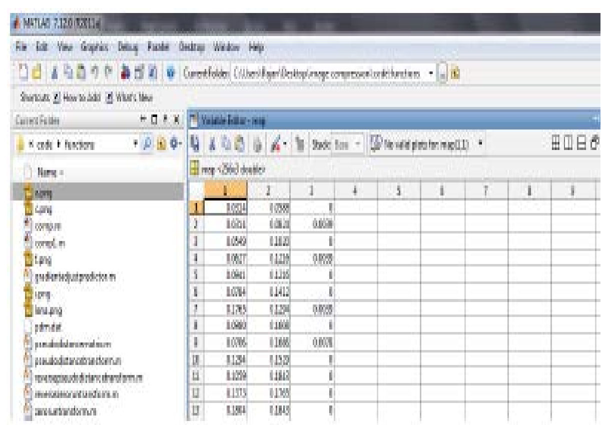

Fig. 5 General Color Map Table

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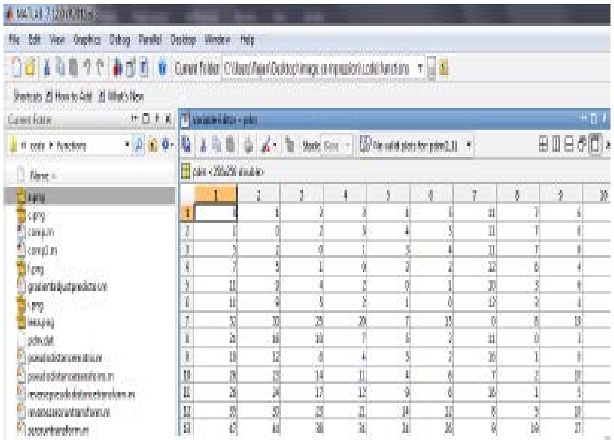

Fig. 6 General Pseudo Distance Matrix

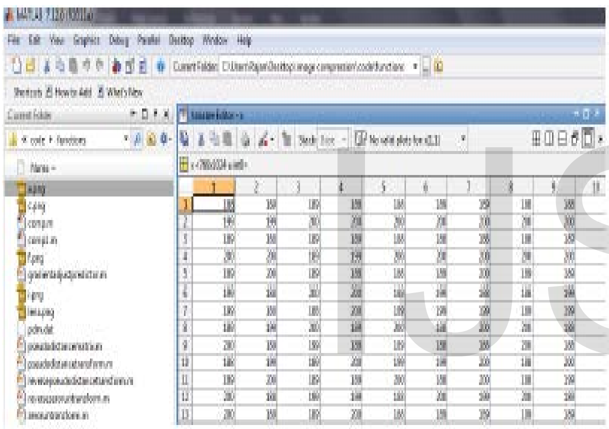

Fig. 7 Index of Normal Dithered Image

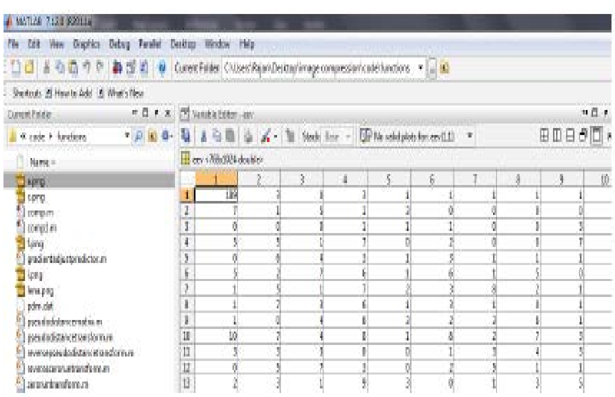

Fig. 8 Pseudo Distance Transformed Matrix Using Normal Dithered Input Image

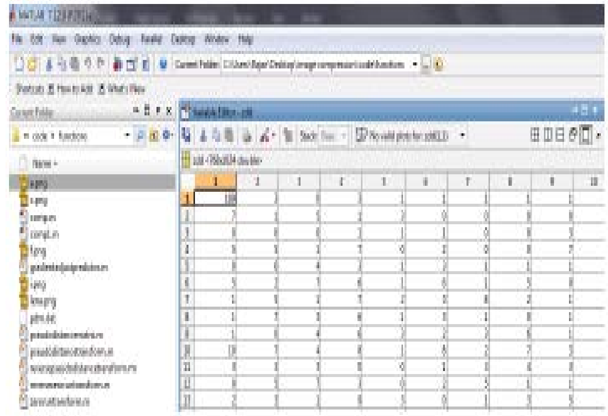

Fig. 9 Reverse Pseudo Distance Transformed MatrixUsing Normal Dithered Image

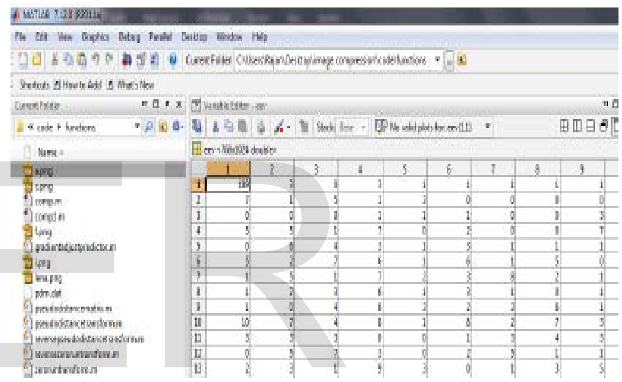

Fig. 10 Decoded Index Image of Normal Dithered Reconstructed Image

Fig. 11Reconstructed Normal Dithered Image

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