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Loseless Compression of Dithered Images Using Pseudo Distance Technique (PDT)

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Abstract: **In order to display high-bit resolution images on low-bit resolution displays, bit resolution needs to be reduced. This problem is vital especially for low-cost or small (mobile) devices. To untangle the bit reduction problem, special color quantization algorithms, called dithering, are employed on high-bit resolution images. The dithering process helps to provide solution the problem, but it does not help much in terms of storage and transmission of images. Several compression techniques such as PNG,GIF, JPEG have been employed for compression of dithered images. To improve the compression gain, special compression techniques that take into account structure of image data and transmission must be developed. We propose to implement the Pseudo-Distance Technique (PDT) for dithered images The compression result of this approach will be compared with result of graphic interchange format (GIF) ,a portable network format (PNG),JPEG formats.**

Keywords: **PDT,COLOR QUANTIZATION,DITHERING, PNG,GIF ,JPEG.**

I. INTRODUCTION

In order to display high-bit resolution images on low-bit resolution displays, bit resolution needs to be reduced. This problem is vital especially for low-cost or small (mobile) devices. To untangle the bit reduction problem, special color quantization algorithms, called dithering, are employed on high-bit resolution images. Dither is an intentionally applied form of noise, used to randomize quantization error, preventing large-scale patterns such as color banding in images.

The dithering process reduces the quantization error but it does not help much in terms of storage. Several compression techniques such PNG, GIF, JPEG have been employed for compression of dithered images. To improve the compression gain, special compression techniques that take into account structure of image data and transmission must be developed. Here the pseudo-distance technique (PDT) is used for dithered images. The compression result of this approach is much better when compared to the GIF, PNG, JPEG formats.

PNG-Portable Network Graphics is a raster graphics file format that supports lossless data compression. PNG supports palette-based images, gray scale images, and full-color non-palette-based RGB images.
GIF could not provide good compression results, so 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.

Both the GIF and PNG fail to obtain good compression results. Even though JPEG achieve better compression results than GIF and PNG; however, most of these techniques need two passes on the images data, while others do not run in linear time.

II. DITHERING

Dither is an intentionally applied form of noise, used to randomize quantization error, preventing large-scale patterns such as color banding in images. In quantization process, we may have quantization errors, e.g., distortion. To overcome quantization errors, dithering algorithms are used. In a dithered image, colors not available in the palette are approximated by a diffusion of colored pixels from within the available palette.
There are several dithering algorithms such as Floyd Steinberg dithering, Color Banding, Anti-aliasing, Ordered dithering. Here the Floyd Steinberg Dithering is used.
Floyd Steinberg dithering uses error-diffusion algorithms instead of basic dithering algorithms, such as average, ordered, or random, and produces images which look closer to original form. Error diffusion techniques are commonly used for displaying images which have been quantized to very few levels.

$$\begin{bmatrix} & & * & \frac{7}{16} & \cdots \\ \cdots & \frac{3}{16} & \frac{5}{16} & \frac{1}{16} & \cdots \end{bmatrix}$$

The pixel indicated with a star (*) indicates the pixel currently being scanned, and the blank pixels are the previously-scanned pixels. The algorithm scans the image from left to right, top to bottom, quantizing pixel values one by one. Each time the quantization error is transferred to the neighboring pixels, while not affecting the pixels that already have been quantized. Hence, if a number of pixels have been rounded downwards, it becomes more likely that the next pixel is rounded upwards, such that on average, the quantization error is close to zero.

In pseudocode:

```
for each y from top to bottom
  for each x from left to
    right oldpixel  :=
    pixel[x][y]
    newpixel  := find_closest_palette_color(oldpixel)
    pixel[x][y]  := newpixel
    quant_error  := oldpixel -
    newpixel
    pixel[x+1][y  ] := pixel[x+1][y  ] + quant_error * 7/16
    pixel[x-1][y+1] := pixel[x-1][y+1] + quant_error * 3/16
    pixel[x  ][y+1] := pixel[x  ][y+1] + quant_error * 5/16
    pixel[x+1][y+1] := pixel[x+1][y+1] + quant_error *
    1/16
```

When converting 16 bit grayscale to 8 bit, find_closest_pallette_color() may perform just a simple rounding, for example:

```
find_closest_palette_color(oldpixel) = floor(oldpixel / 256)
```

Fig A: Original Image

Fig B: Dithered Image

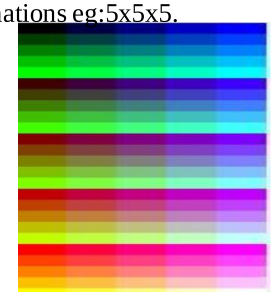
III. PSEUDO DISTANCE TECHNIQUE AND EUCLIDEAN DISTANCE MATRIX

Here we are using PDT for compression of dithered images.PDT gives better compression gain than GIF, PNG, JPEG formats. Most of the techniques need two passes on the images data, while others do not **runs** in linear time. The pseudo distance technique runs in linear time and requires only one pass.

STEPS FOR GENERATING PSEUDO DISTANCE MATRIX

1) COLOR PALETTE CREATION

We create a color palette by using the colors available in the dithered images. The original image contains 256 x 256 x 256 color combinations (RGB) after dithering it reduces less combinations eg:5x5x5.



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

2) CREATION OF EUCLIDIEAN DISTANCE MATRIX

A distance matrix D is formed by calculating Euclidean distance between every pair of indices from a color palette and stored in a matrix. The Euclidean distance between two colors colour1 (Represented by R1G1B1) and colour2 (R2G2B2) is calculated as follows.

EUCLIDEAN DISTANCE MATRIX

	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

In each row of D, there may be similar values. To overcome the problem of non-uniqueness of the entries in rows of D, we compute a corresponding pseudo distance matrix P

3) GENERATION OF PSEUDO DISTANCE MATRIX

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.

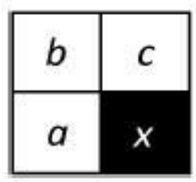
	0	1	...	24
0	0	16	...	6
1	14	0	...	13
...	...	...	...	...
23	2	17	...	4
24	4	19	...	0

IV. ENCODING

We perform the encoding operation of the image after calculating the PD matrix.

For a given pixel x we take three adjacent pixels a, b, c. The reference pixel is chosen by performing the following steps:

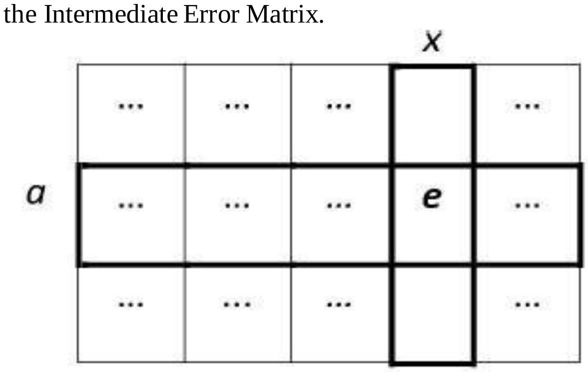
1) Calculate E (a, x), E(b, x) , E(c, x).
2) Where E (a, i): Euclidean Distance between a & i.
3) Take the reference pixel from the pair having maximum
4) Euclidean distance.



a: reference pixel

x: predicted pixel

In row a & column x, the intersecting value (e) from PD Matrix is taken as the error. The error is stored in the Intermediate Error Matrix.



INTERMEDIATE ERROR MATRIX

	0	1	2	3	..
0	3	3	3	2	
1	3	2	2	2	
2	2	2	0	0	
3	3				
..					

ERROR MATRIX

	0	1	2	3	..
0	3	0	0	1	
1	0	1	0	0	
2	1	0	2	0	
3	1				
..					

V. COMPRESSION AND DECOMPRESSION

Here we use the Run Length Encoding (RLE). The use of run length 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 sequence. RLE along with binary arithmetic coder gives compression output.

While the use of RLE improves compression gain, it also decreases the computation time of the entropy coder.

VI. DECODING

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 matrix.The original image is reconstructed as follows:

1) First, the pseudo-distance matrix is reconstructed from the index table.

2) Let r be the first value retrieved from the index table. In encoding process, r was encoded as a raw byte.

3) 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.

4) Then, in row r of the pseudo-distance matrix, we search for the error signal value e.

5) Upon determining e in row r, emit the corresponding column value x as the original index value for the image to be reconstructed. Finally, x will be r.

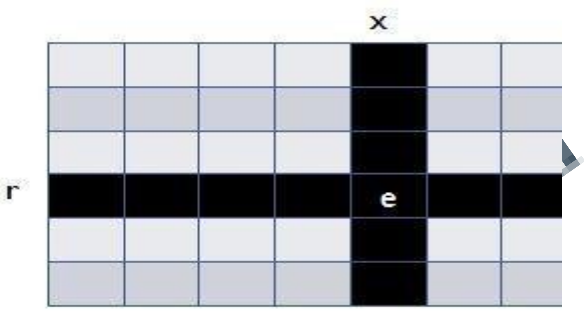
6) Based on the value of *x*, the neighbouring pixels in the first row & first column is reconstructed and the rest of the pixels

ENCODED IMAGE FILE

r	e			
f	g			

Encoded Image File

PSEUDO DISTANCE MATRIX



Pseudo Distance Matrix

CONCLUSION

The PDT is an efficient lossless image compression method for color-palette images since the PDT runs in linear time and requires only one-pass . PDT gives better compression results than the well-known image compressors such as GIF, PNG, JPEG-LS, and JPEG2000 on dithered images. PDT can give about 46.8% compression gain over GIF and 14.2% over PNG.

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