Digital Image Processing Laboratory 8

Image Halftoning
Praneet Singh

April 17, 2020

1 Thresholding & Random Noise Binarization 100/100

1.1 Original Image

1.2 Thresholded Image, T = 127

1.3 RMSE and Fidelity Values

RMSE = 87.39
Fidelity = 77.33

1.4 Fidelity function

```
function f = fidelity(f,b)

    linf = 255*((f/255).^2.2);
    linb = 255*((b/255).^2.2);
  [i j] = meshgrid(-3:1:3,-3:1:3);
  h = exp(-(i.^2 +j.^2)/4);
  h = h/sum(h(:));
  f_filtered = conv2(linf,h,'same');
  b_filtered = conv2(linb,h,'same');
  f_trans = 255*((f_filtered/255).^(1/3));
  b_trans = 255*((b_filtered/255).^(1/3));
  [m, n]  size(f_trans);
  f = sqrt((sum(sum((f_trans-b_trans).^2)))/(m*n));

end
```

2 Ordered Dithering

2.1 Bayer Index Matrices

2.1.1 2 x 2

$$I_{2x2} = \begin{bmatrix} 1 & 2 \\ 3 & 0 \end{bmatrix}$$

2.1.2 4 x 4

$$I_{4x4} = \begin{bmatrix} 5 & 9 & 6 & 10 \\ 13 & 1 & 14 & 2 \\ 7 & 11 & 4 & 8 \\ 15 & 3 & 12 & 0 \end{bmatrix}$$

2.1.3 8 x 8

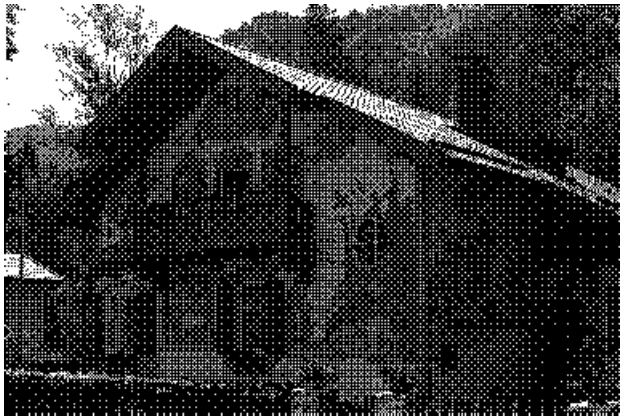
$$I_{8x8} = \begin{bmatrix} 21 & 37 & 25 & 41 & 22 & 38 & 26 & 42 \\ 53 & 5 & 57 & 9 & 54 & 6 & 58 & 10 \\ 29 & 45 & 17 & 33 & 30 & 46 & 18 & 34 \\ 61 & 13 & 49 & 1 & 62 & 14 & 50 & 2 \\ 23 & 39 & 27 & 43 & 20 & 36 & 24 & 40 \\ 55 & 7 & 59 & 11 & 52 & 4 & 56 & 8 \\ 31 & 47 & 19 & 35 & 28 & 44 & 16 & 32 \\ 63 & 15 & 51 & 3 & 60 & 12 & 48 & 0 \end{bmatrix}$$

2.2 Halftoned Images

2.2.1 Using 2 x 2 dither pattern

2.2.2 Using 4 x 4 dither pattern

2.2.3 Using 8 x 8 dither pattern



2.3 RMSE and Fidelity Values

Dithering Matrix	RMSE	Fidelity
2 x 2	97.67	50.06
4 x 4	101.01	16.56
8 x 8	100.91	14.69

3 Error Diffusion

3.1 MATLAB Code

```
clear all;
close all;

img = double(imread('house.tiff'));

img_gc = 255 * (img/255).^2.2;
[m,n] = size(img_gc);
img_out = padarray(img_gc,[1 1]);

for i = 2:size(img_out,1)-1
  for j = 2:size(out,2) - 1
    val = img_out(i,j);
    img_out(i,j) = (img_out(i,j) > 127) * 255;
    error = val - img_out(i,j);
    img_out(i,j+1) = img_out(i,j+1) + error*(7/16);
    img_out(i+1,j+1) = img_out(i+1,j+1) + error*(1/16);
    img_out(i+1,j) = img_out(i+1,j) + error*(5/16);
    img_out(i+1,j-1) = img_out(i+1,j-1) + error*(3/16);
  end
end

img_out = img_out(2:end-1,2:end-1);

graymap = [0:255,0:255,0:255]'/255;
colormap(graymap);
image(img_out);

rmse = sqrt(sum(sum(img_gc - img_out).^2)/(m*n));
fid = fidelity(img_gc , img_out);
```

3.2 Error diffusion result

3.3 RMSE and Fidelity Values

RMSE = 98.84
Fidelity = 13.42

3.4 Result Comparison

Technique	RMSE	Fidelity
Thresholding	87.39	77.33
2 x 2 Dithering	97.67	50.06
4 x 4 Dithering	101.01	16.56
8 x 8 Dithering	100.91	14.69
Error Diffusion	98.84	13.42

Observation: We can see that the RMSE values do not vary too much but the fidelity values vary quite significantly between the methods. Thresholding has the highest fidelity value but the image does not even look as good as the others.