ECE 637 Lab 8 Report
Image Halftoning

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Section3 – Thresholding and Random Noise Binarization

3.1 The original image and the result of thresholding

Fig 3-1-1 The original image *house.tif*

Fig 3-1-2 The image after applying the sample thresholding T = 127

3.2 The computed RMSE and fidelity values

The RMSE value is 87.3933.

The fidelity value is 77.3371.

3.3 The code for my *fidelity* function

```
function [fid] = fidelity(f, b)

fid = 0;
[m,n] = size(f);

fl = 255*(f/255).^(2.2);
bl = 255*(b/255).^(2.2);

sigma2 = 2;
h = zeros(7,7);
for i=1:7
    for j=1:7
        h(i,j)=exp(-((i-4)^2+(j-4)^2)/(2*sigma2));
    end
end
h = h/(sum(sum(h)));
flp = conv2(fl, h, 'same');
blp = conv2(b, h, 'same');

ff = 255*(flp/255).^(1/3);
bb = 255*(blp/255).^(1/3);

for i = 1:m
    for j = 1:n
        fid = fid+ (ff(i,j)-bb(i,j))^2;
    end
end
fid = sqrt(fid/(m*n));
```

Additional matlab code:

```
img = imread('house.tif');
[m, n] = size(img);
T = 127;
img = double(img);
b = zeros(m,n);
b((img>127)) = 255;
% colormap(gray(255));
% image(b);

RMSE = 0;
for i = 1:m
    for j = 1:n
        RMSE = RMSE+ (img(i,j)-b(i,j))^2;
    end
end
RMSE = sqrt(RMSE/(m*n))

fid = fidelity(img, b)
```

Section4 – Ordered Dithering

4.2.1 The three Bayer index matrices of sizes 2 x 2, 4 x 4, and 8 x 8

$$I_2 = \begin{bmatrix} 1 & 2 \\ 3 & 0 \end{bmatrix}$$

$$I_4 = \begin{bmatrix} 5 & 9 & 6 & 10 \\ 13 & 1 & 14 & 2 \\ 7 & 11 & 4 & 8 \\ 15 & 3 & 12 & 0 \end{bmatrix}$$

$$I_8 = \begin{bmatrix} 21 & 37 & 25 & 41 & 22 & 38 & 26 & 42 \\ 53 & 5 & 57 & 9 & 54 & 6 & 58 & 10 \\ 29 & 45 & 17 & 33 & 30 & 46 & 18 & 34 \\ 61 & 13 & 49 & 1 & 62 & 14 & 50 & 2 \\ 23 & 39 & 27 & 43 & 20 & 36 & 24 & 40 \\ 55 & 7 & 59 & 11 & 52 & 4 & 58 & 8 \\ 31 & 47 & 19 & 35 & 28 & 44 & 16 & 32 \\ 63 & 15 & 51 & 3 & 60 & 12 & 48 & 0 \end{bmatrix}$$

4.2.2 The three halftoned images produced by the three dither patterns

Fig 4-2-2-1 Halftoned Image Produced by I2

Fig 4-2-2-2 Halftoned Image Produced by I4

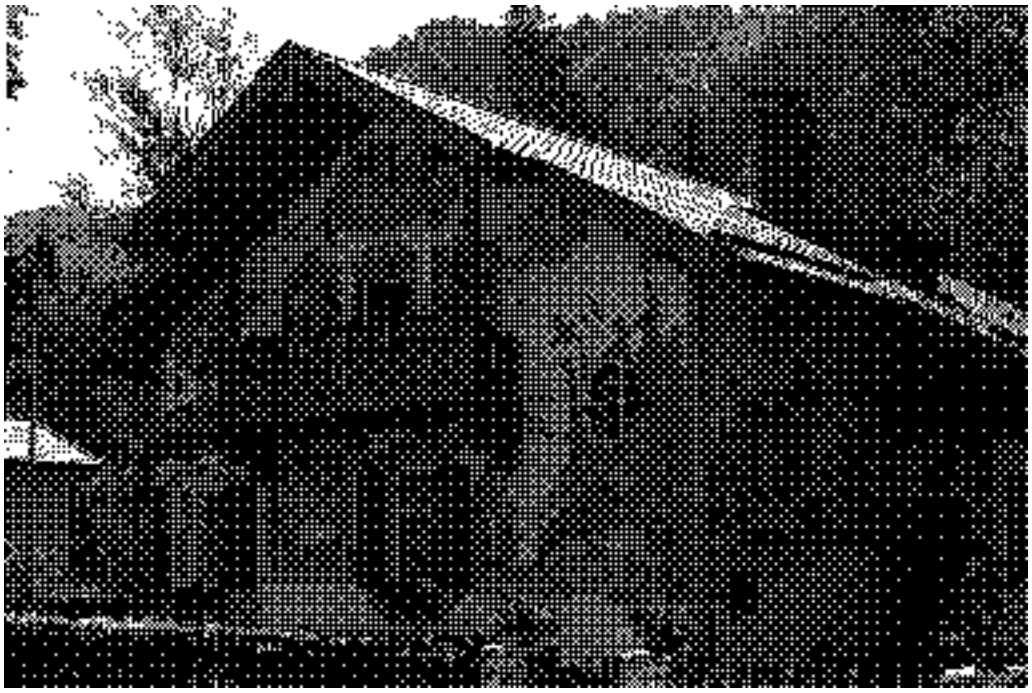

Fig 4-2-2-3 Halftoned Image Produced by I8

4.2.3 The RMSE and fidelity for each of the three halftoned images.

	RMSE	Fidelity
I2	97.6690	50.0569
I4	101.0069	16.5583
I8	100.9145	14.6918

Section5 – Error Diffusion

5.1 The error diffusion Matlab Code

```
img = imread('house.tif');
[m, n] = size(img);
T = 127;
img = double(img);

f = 255 * (img / 255).^2.2;
e = zeros(m,n);
b = zeros(m,n);

for i=1:m-1
    for j=1:n
        b(i,j) = (f(i,j)>127)*255;
        e = f(i,j) - b(i,j);
        if(j<n)
            f(i,j+1) = f(i,j+1) + e*7/16;
            f(i+1,j+1) = f(i+1,j+1) + e*1/16;
        end
        if(j>1)
            f(i+1,j-1) = f(i+1,j-1) + e*3/16;
        end
        f(i+1,j) = f(i+1,j) + e*5/16;
    end
end

colormap(gray(256));
image(b);
truesize
imwrite(b,'errordiffusion.tiff')

RMSE = 0;
for i = 1:m
    for j = 1:n
        RMSE = RMSE+ (img(i,j)-b(i,j))^2;
    end
end
RMSE = sqrt(RMSE/(m*n))

fid = fidelity(img, b)
```

5.2 The error diffusion result

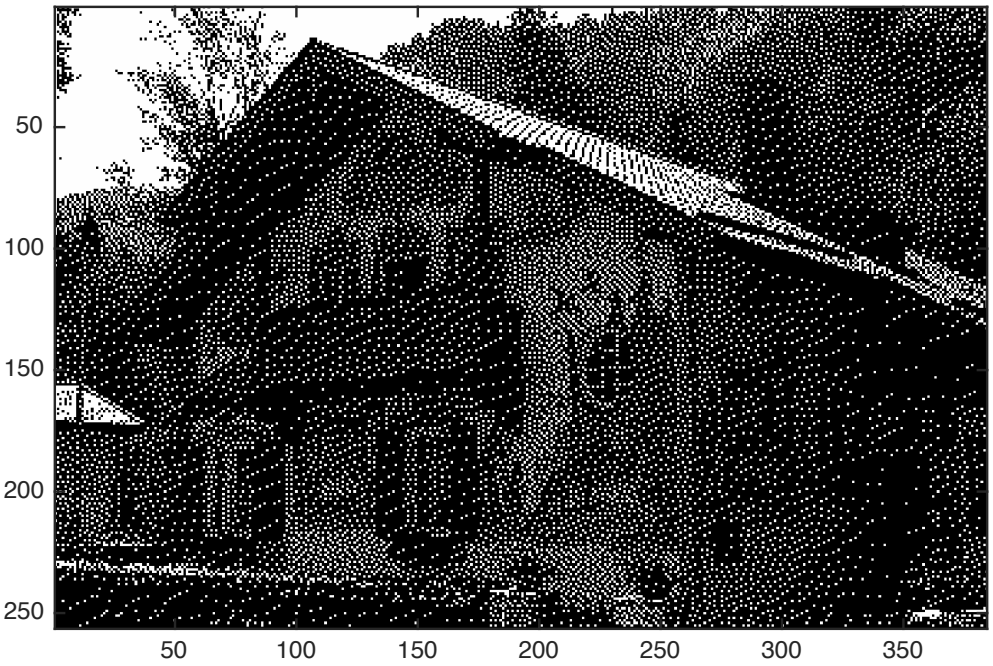

Fig 5-2 The Error Diffusion Result

5.3 The RMSE and fidelity of the error diffusion result

RMSE = 98.8489

Fidelity = 13.7005

5.4 Tabulate the RMSE and fidelity for the simple thresholding, ordered dithering, and error diffusion results.

	RMSE	Fidelity
Simple Thresholding	87.3933	77.3371
2^{nd} ordered Dithering	97.6690	50.0569
4^{th} ordered Dithering	101.0069	16.5583
8^{th} ordered Dithering	100.9145	14.6918
Error Diffusion	98.8489	13.7005

The *RMSEs* are similar for each method, comparing to *Fidelity*, and the simple thresholding result has the smallest root mean square error. The *Fidelity* is decreasing from simple thresholding method to dithering method to error diffusion method. As shown in the result

images, the larger the *Fidelity*, the worse the image quality.
By comparing *RMSE* values and *Fidelity* values for each method, it seems like the Fidelity will gives us more information about the image quality.