ECE637 Lab report 8
Image Halftoning

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Section 1 . Thresholding

1. The plot of original image and binary image.

Figure 1.1 original image

Figure 1.2 binary image

2. RMSE and fidelity values

RMSE = 87.393316543870510

fidelity = 77.337149172432460

3. Code of fidelity

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

const = 0;
for k = -3:3
    for l = -3:3
        const = const + exp(-(k^2 + l^2)/4);
    end
end
C = 1/const;

[m,n] = size(f);
fl = 255*(f/255).^2.2;
bl = 255*(b/255).^2.2;

fb = zeros(m+6,n+6);
bb = zeros(m+6,n+6);

for i = 1:m
    for j = 1:n
        fb(i+3,j+3) = fl(i,j);
        bb(i+3,j+3) = bl(i,j);
    end
end

for i = 1:m
    for j = 1:n
        sum1 = 0;
        sum2 = 0;
      for k = -3:3
          for l = -3:3
              sum1 = sum1 + fb(i+3+k,j+3+l)*C*exp(-(k^2 +
l^2)/4);
```

```
            sum2 = sum2 + bb(i+3+k,j+3+l)*C*exp(-(k^2 +
l^2)/4);
         end
      end
      fl(i,j) = 255*(sum1/255)^(1/3);
      bl(i,j) = 255*(sum2/255)^(1/3);
    end
end
fide = 0;
for i = 1:m
    for j = 1:n
        fide = fide+ ((fl(i,j)-bl(i,j))^2);
    end
end
fide = sqrt(fide/(m*n));
```

Session 2. Ordered dithering

1. Three matrices:

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

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

$$I_8 = \begin{bmatrix} 21 & 37 & 25 & 41 & 22 & 38 & 26 & 42 \\ 53 & 5 & 57 & 9 & 54 & 6 & 58 & 10 \\ 29 & 45 & 17 & 33 & 30 & 46 & 18 & 34 \\ 61 & 13 & 49 & 1 & 62 & 14 & 50 & 2 \\ 23 & 39 & 27 & 43 & 20 & 36 & 24 & 40 \\ 55 & 7 & 59 & 11 & 52 & 4 & 56 & 8 \\ 31 & 47 & 19 & 35 & 28 & 44 & 16 & 32 \\ 63 & 15 & 51 & 3 & 60 & 12 & 48 & 0 \end{bmatrix}$$

2. RMSE and fidelity values

2×2 dither pattern:

RMSE = 74.368723619209850

Fidelity = 52.012277527030150

4 ×4 dither pattern:

RMSE =81.838823772004600

Fidelity = 61.220489655455864

8 ×8 dither pattern:

RMSE = 81.447589682057970

Fidelity = 60.812270846722900

3.Image results

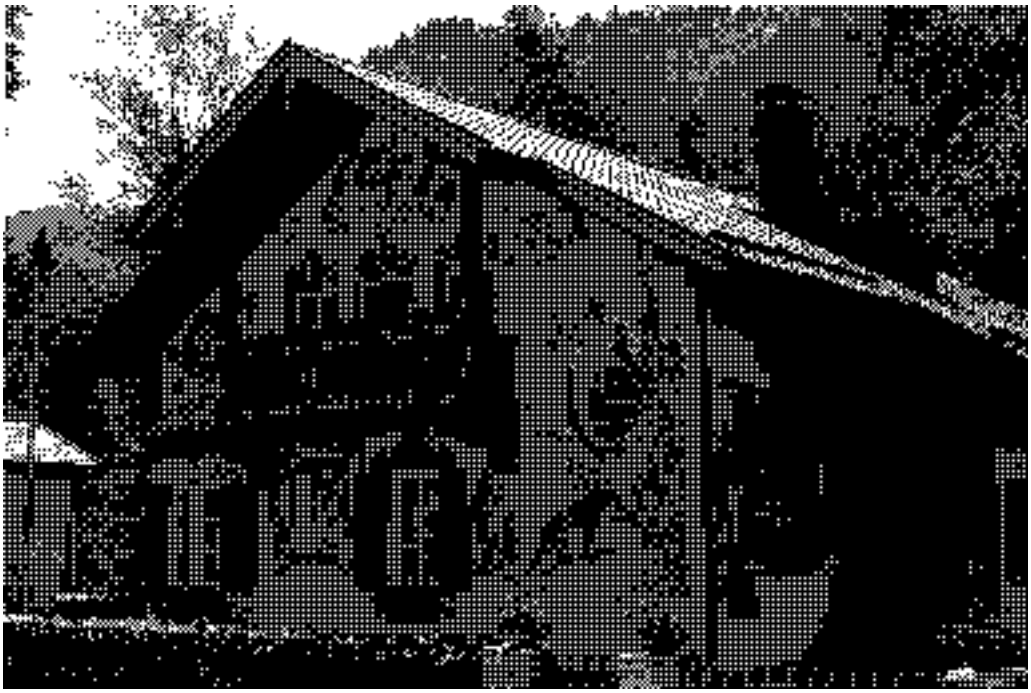

Figure 2.1 ordered dithering 2x2

Figure 2.2 ordered dithering 4x4

Figure 2.2 ordered dithering 8x8

Session 3. Error diffusion

1. error diffusion code:

```
clc;
clear;

T = 127;
H = [1/16,5/16,3/16;7/16,0,0];
f = imread('E:\2016spring\ECE637\lab8\house.tif');
f = double(f);
[m,n] = size(f);

fl = 255*(f/255).^2.2;
error = zeros(m+1,n+2);
b = zeros(m,n);

for i = 1:m
    for j =1:n
        fl(i,j) = fl(i,j) + sum(sum(error(i:i+1,j:j+2).*H));
        if(fl(i,j) > T)
            b(i,j) = 255;
        else
            b(i,j) = 0;
        end
        error(i+1,j+1) = fl(i,j) - b(i,j);
    end
end

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

fide = fidelity(fl,b);

image(b)
colormap(gray(256));

truesize
imwrite(uint8(b),'error_diffusion.tif')
```

2. Error diffusion result:

Figure 3.1 error diffusion

RMSE = 84.132962841636100

Fidelity = 28.367870007414123

Method	thresholding	2x2 dither	4x4 dither	8x8 dither	error diffusion
RMSE	87.393316543870510	74.368723619209850	81.838823772004600	81.447589682057970	84.1329
Fidelity	77.337149172432460	52.012277527030150	61.220489655455864	60.812270846722900	28.367870007414123

For RMSE value, thresholding method results in the largest value.

Meanwhile, different sizes of dither pattern are giving different results.

For error diffusion, its value is close to thresholding.

On the other hand, fidelity is giving an reasonable result. Thresholding

is the largest, followed by 8x8,4x4 and 2x2 dithering. The fidelity value for error diffusion is smallest one.

By comparing the intuitively image quality, RMSE is not providing a reliable result.

However, fidelity actually provides much more reliable results. The smaller the fidelity value, the better the image quality.