SCSV3213

FUNDAMENTAL OF IMAGE PROCESSING

IMAGE ENHANCEMENT IN SPATIAL DOMAIN
HALFTONING

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Acknowledgements

Most of the slide are taken and modified from other resources including books and slides from lectures from others universities. It is rearranged to suit the syllabus of the course.

SYNOPSIS

In this lecture, image enhancement operations in spatial domain topic is halftoning. It will cover the followings halftoning methods

1. Patterning
2. Dithering

Introduction

- What can we do when the printing/ display device only accept binary input?
- We need to convert the greyscale image to binary image BUT what effect will it give?
- Can we preserve the visual display of the greyscale image through the binary display?
- Images below shows the result images of greyscale converted to binary display using constant threshold value and using halftoning.

GrayScale

Threshold

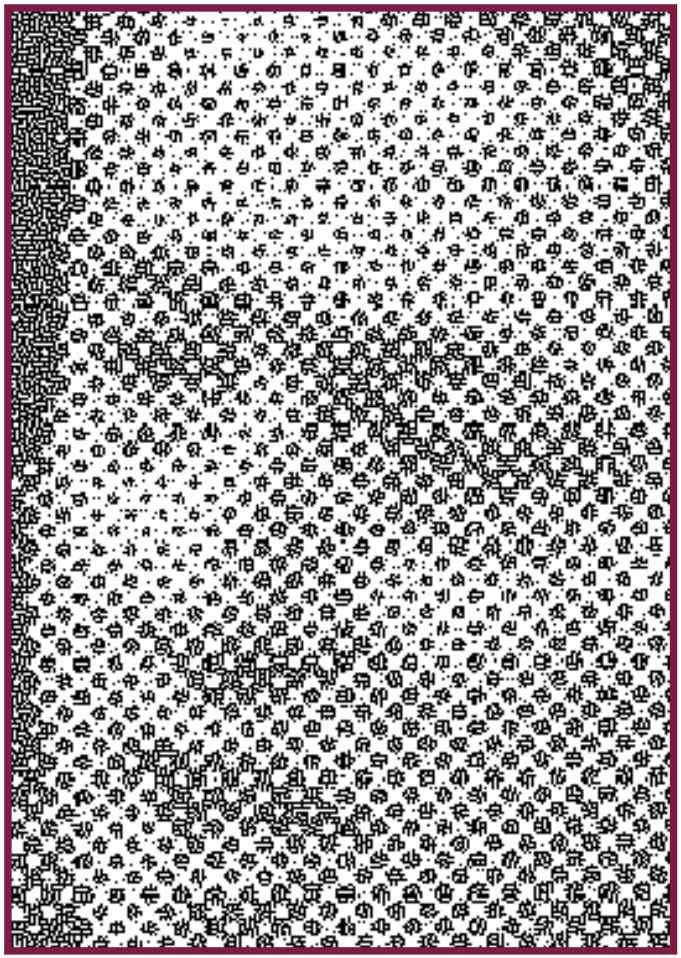
Halftone

Intro: continue

- One of the industries that used to display binary input is the newspaper industry.
- Newspaper photographs simulate a greyscale, despite the fact that they have been printed using only black ink.
- A newspaper picture is, in fact, made up of a pattern of tiny black dots of varying size.
- The human visual system has a tendency to average brightness over small areas, so the black dots and their white background merge and are perceived as an intermediate shade of grey.

Sample newspaper image

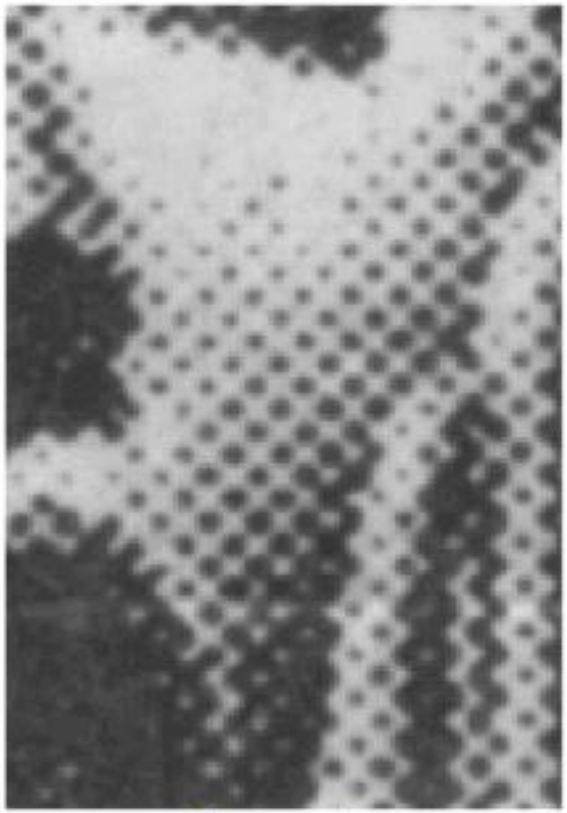
Newspaper image



From New York Times 9/21/99

Sample Newpaper Image

Original



Zoom-in

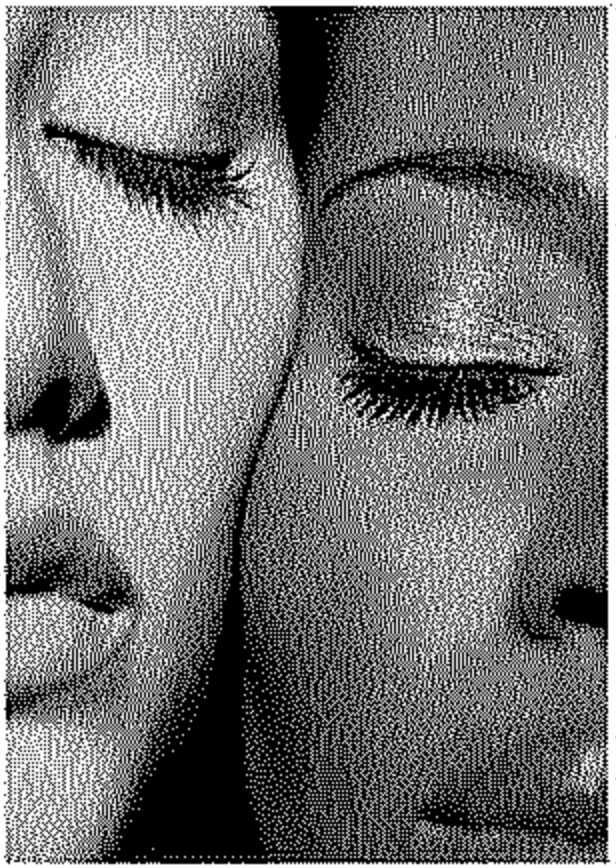
Intro: continue

- The process of generating a binary pattern of black and white dots from an image is termed **halftoning.**
- In traditional newspaper and magazine production, this process is carried out photographically by projection of a transparency through a 'halftone screen' onto film.
- The screen is a glass plate with a grid etched into it.
- Different screens can be used to control the size and shape of the dots in the halftoned image.

Intro: continue

- A fine grid, with a 'screen frequency' of 200-300 lines per inch, gives the image quality necessary for magazine production.
- A screen frequency of 85 lines per inch is deemed acceptable for newspapers.

Sample Images



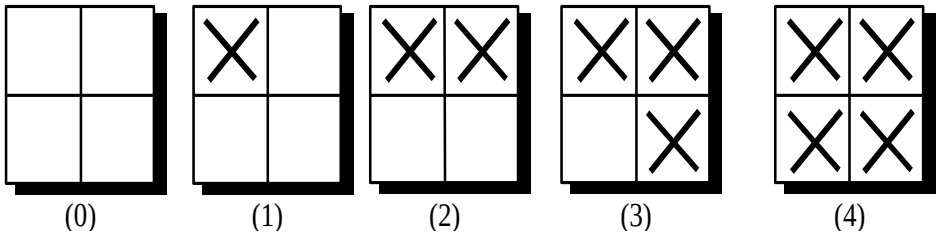
Sample Images

1. PATTERNING

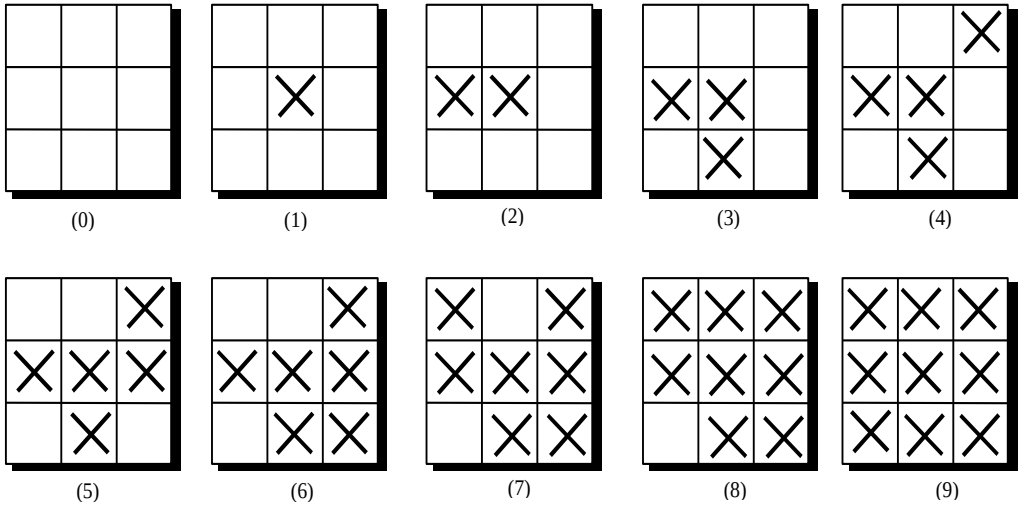
Patterning

- A simple digital halftoning technique known as **patterning** involves replacing each pixel by a pattern taken from a 'binary font'.
- Patterning can be made through 2x2 matrices or 3x3 matrices.
- A 2x2 matrices can be used up to 5 levels font. While 3x3 matrices can made up to 10 levels font.
- The 3x3 matrices can be used to print an image consisting of ten grey levels.

Level of halftoning using patterning



5 levels



10 levels

How it is done ?

- There will be a threshold imposed on the grey level value of the original image.
- If the threshold is within the first font range then the first font pattern will be replaced for the pixels.
- The process continue for all pixels in the image and replaced with the corresponding font pattern.
- Note that, since we are replacing each pixel by a 3 x 3 block of pixels, both the width and the height of the image increase by a factor of 3.

Sample algorithm (for 2x2 matrix)

1. Set all pixel of image size to 0 (indicating black)
2. Start loop based on size of row and column (I,j)
3. if image(i,j) > 50 // 50 is the threshold range
   Newimage(i*2,j*2+1) = 1;
   end
4. if image(i,j) > 101 // 101 is the threshold range
   Newimage(i*2+1 ,j*2) = 1;
   endif
5. if image(i,j) > 152 // 152 is the threshold range
   Newimage(i*2+1,j*2+1) = 1;
   endif
6. if image(i,j) > 203 // 203 is the threshold range
   Newimage(i*2,j*2) = 1;
   endif
7. Repeat until all pixels in the image are read.

0	**0**
0	0

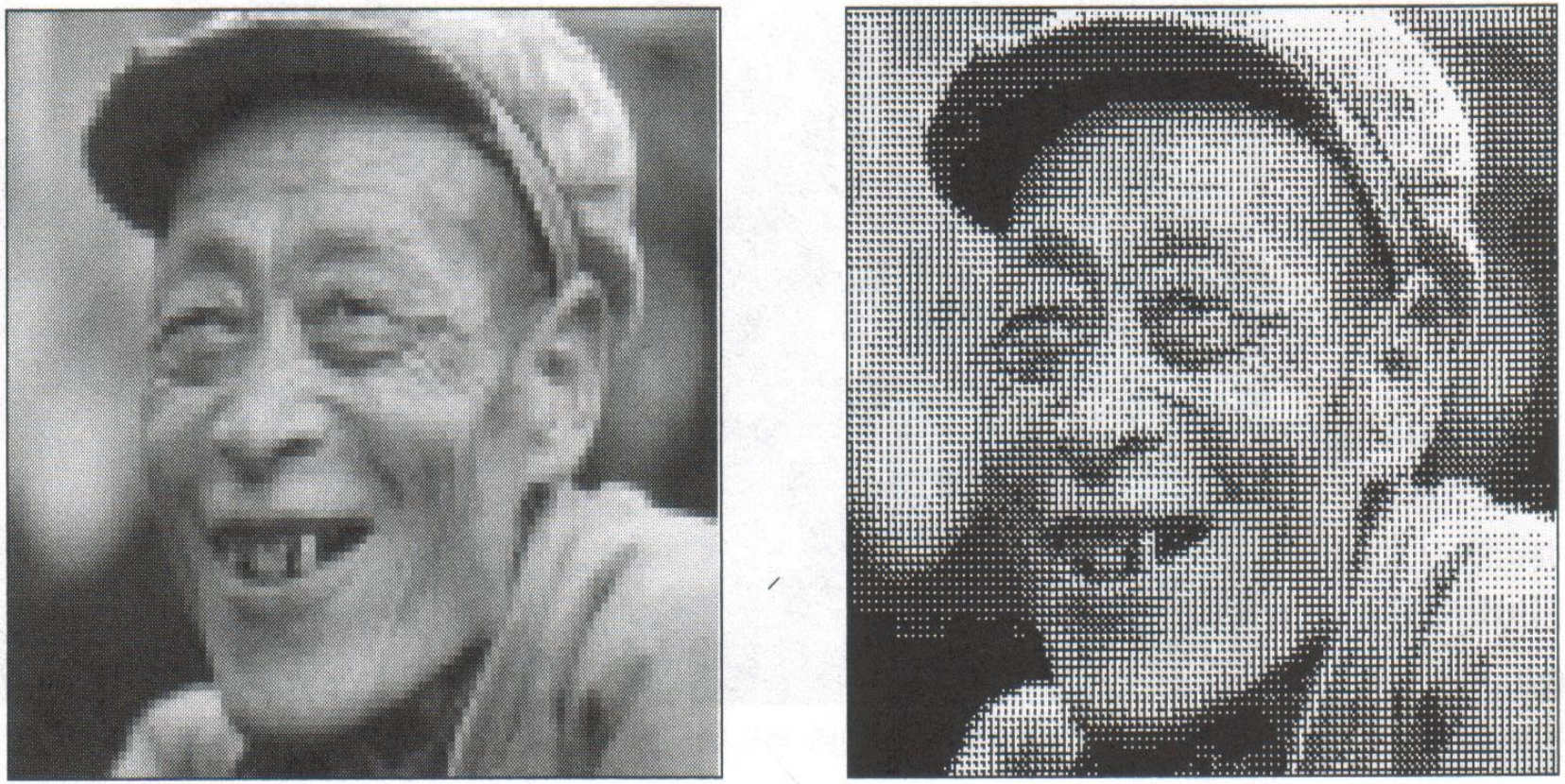
0	**1**
0	0

0	**1**
1	0

0	**1**
1	1

1	**1**
1	1

Sample Images



(a) (b)

Halftoning with a binary font. (a) 8-bit image (b) halftoned image

2. DITHERING

Dithering

- Another technique for digital halftoning is **dithering.**
- Dithering can be accomplished by thresholding the image against a **dither matrix.**
- The elements of a dither matrix are thresholds.

Dither Matrices

- The first two dither matrices, rescaled for application to 8-bit images, are

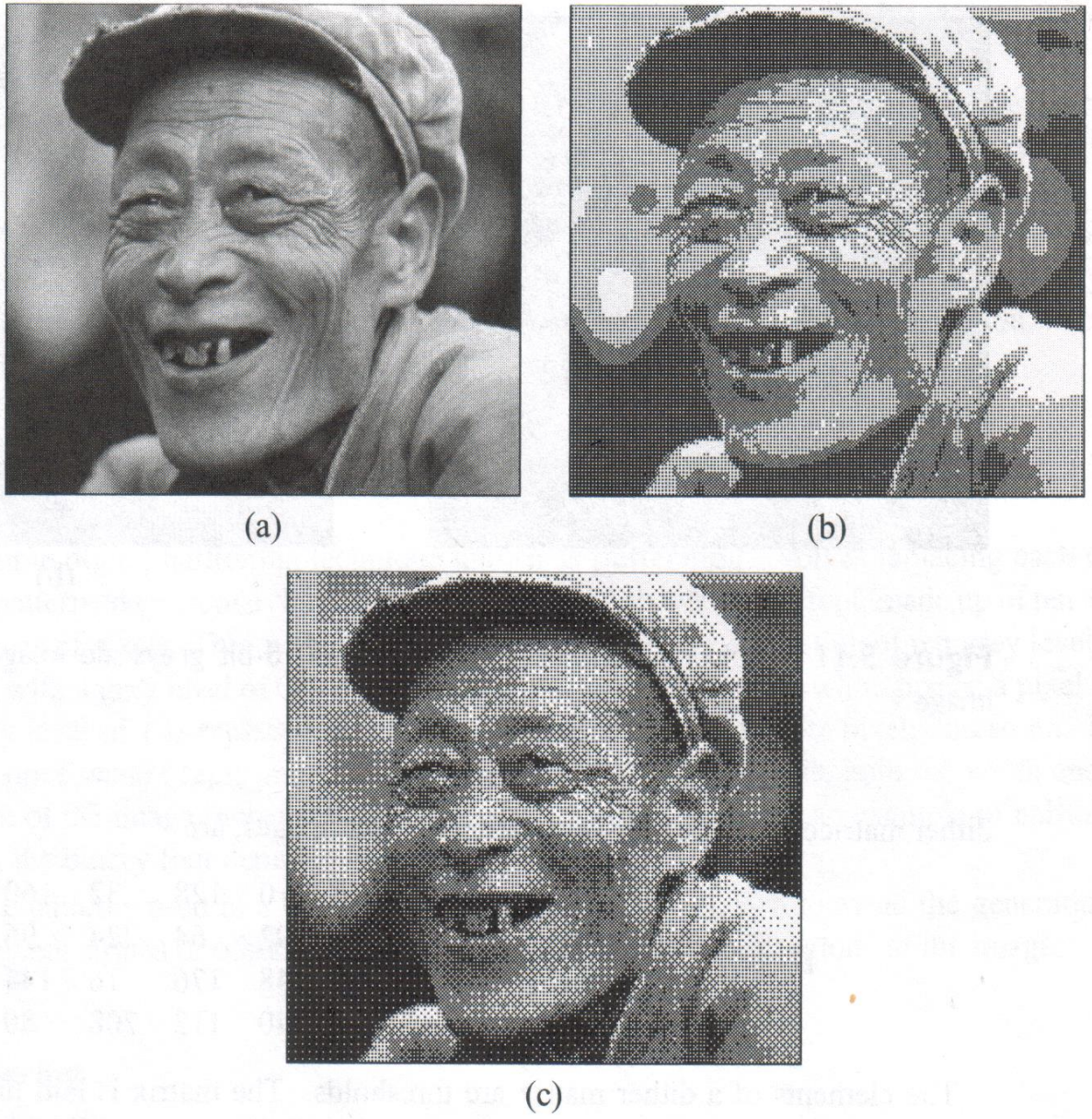
$$\mathbf{D}_1 = \begin{bmatrix} 0 & 128 \\ 192 & 64 \end{bmatrix}$$

$$\mathbf{D}_2 = \begin{bmatrix} 0 & 128 & 32 & 160 \\ 192 & 64 & 224 & 96 \\ 48 & 176 & 16 & 144 \\ 240 & 112 & 208 & 80 \end{bmatrix}.$$

- The matrix is laid like a tile over the entire image and each pixel value is compared with the corresponding threshold from the matrix.
- The pixel becomes white if its value exceeds the threshold or black otherwise.
- This approach produces an output image with the same dimensions as the input image, but with less detail visible.

Algorithm to halftone an image using a dither matrix.

```
for  all x & y do
     if f(x,y) > m(x,y) then
          g(x,y) = white
     else
          g(x,y) = black
     end if
End for
```



Halftoning with dither matrices. (a) Input image. (b) Halftoned image using D_1. (c) Halftoned image using D_2

TUTORIAL ON HAFTONING

TUTORIAL 1: Halftoning / patterning

- Halftoning function ()

```
function [ imgOut ] = half_toning( imgIn )
imgOut = zeros(size(imgIn)*2);

for i = 1 : size(imgIn, 1)
  for j = 1: size(imgIn, 2)
    if imgIn(i, j) > 50
      imgOut(i*2, j*2 + 1) = 1;
    end
    if imgIn(i, j) > 101
      imgOut(i*2 + 1, j*2) = 1;
    end
    if imgIn(i, j) > 152
      imgOut(i*2 + 1, j*2 + 1) = 1;
    end
    if imgIn(i, j) > 203
      imgOut(i*2, j*2) = 1;
    end
  end
end
end
```

TUTORIAL 1

- Call function . Make sure the image is within the same folder

```
imgIn=imread('lindsay.tif');
figure('Position', [0 0 10 10]);
title('source');
imshow(imgIn);

figure('Position', [0 400 10 10]);
title('half toned');
imgOut = half_toning(imgIn);
imshow(imgOut);
```

TUTORIAL : Halftoning /Dithering

- Task: write a function name dithering.m that will accept an image and dither matric and perform halftoning.
- Test your function

TEST YOUR UNDERSTANDING

Q1:

- What is the output image size if an image A of size 200x200 pixels is halftoning using 2x2 binary font using patterning method?
- using the same question above what is the size if using dithering method?

Q2: Patterning

Given pixels value of an image sample below. What is the new image when applying patterning of 2x2 used in algorithm slide 17.

51	**40**	**106**
245	125	255
62	170	162

Q3: Dithering

Given pixels value of an image sample below. What is the new image when applying dithering matric of size 2x2 D1 as in slide 21

51	**40**	**106**	**100**
245	125	255	50
62	170	162	23
100	210	33	150

$$\mathbf{D}_1 = \begin{bmatrix} 0 & 128 \\ 192 & 64 \end{bmatrix},$$

End:
Spatial Domain Enhancement
Haftoning
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