Computer Vision I (922 U0610) - Homework 7

Author: alanhc

ID: r10944007

Date: 10/27

README

0. create env: `conda env create -f environment.yml`
1. enter env: `conda activate ntu-cv`
2. run jupyter `jupyter notebook`

Write a program which does thinning on a downsampled image (lena.bmp).

- Downsampling Lena from 512x512 to 64x64:
  - Binarize the benchmark image lena as in HW2, then using 8x8 blocks as a unit, take the topmost-left pixel as the downsampled data.
- You have to use 4-connected neighborhood detection.
- You can use any programing language to implement homework, however, you'll get zero point if you just call existing library.
- More detail about this homework. Download here-->PPT|PDF

Thinning Operator

- Create marked image
  1. Yokoi Operator
  2. Pair Relationship Operator
- Connected Shrink Operator
- Compare the shrink result with marked image

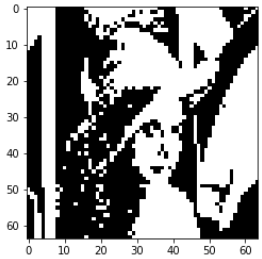
In [1]:
```
from PIL import Image
import numpy as np

# Todo: 讀檔，確定影像大小
img = Image.open("input/lena.bmp")
img = np.array(img)

h, w = img.shape

print("image shape:", img.shape)
show = Image.fromarray(img).resize((256,256))
show
```

```
image shape: (512, 512)
```

Out[1]:

In [2]:
```
# Todo: sampling
## Hint: topmost-left: 左上角點可用//8求
# Algorithm:
## 1. 根據hint，先算出一個row/col有幾個sampling點，再用*8來還原sampling點在原本的位置
## 2. >127 來產生threshold 128的影像

## 512->64.  512/64=8
# 1.
ans = np.zeros((h//8,w//8))
for y in range(h//8):
    for x in range(w//8):
        # 1.
        if (img[y*8][x*8]>127):# 2.
            ans[y][x] = 255

import matplotlib.pyplot as plt
print(ans.shape)
plt.imshow(ans, cmap="gray")
img_downSampling = ans
```

```
(64, 64)
```



In [3]:
```
"""
index pixels
7 2 6
3 0 1
8 4 5
"""
# Todo: Yokoi connectivity numbe
# Algorithm:
## 1. 計算 h(a,b,c,d)，*程式為f_h* ，藉由三個coner點判斷類型 q,r,s，其中b,c,d,e為帶入的kernel點xi
## 2. 計算 connectivity operator f(a1,a2,a3,a4)，其中a1,a2,a3,a4是由 h(x0,x1,x6,x2), h(x0,x2,x7,x3),
##                                                                    h(x0,x3,x8,x4), h(x0,x4,x5,x1)
## 3. 根據課本式子參考上圖，計算5或n

def Yokoi(img):
    s_h, s_w = img.shape

    def index_values(img, y, x, n):
        # shift is a convert table reelated to index  textbook:x0,x1,x2...
        shift = {
            7:[-1,-1],
            2:[-1,0],
            6:[-1,1],
            3:[0,-1],
            0:[0,0],
            1:[0,1],
            8:[1,-1],
            4:[1,0],
            5:[1,1]
        }
        now_y = y+shift[n][0]
        now_x = x+shift[n][1]

        if (now_y>=0 and now_x>=0 and now_y<s_h and now_x<s_w):
            return img[ now_y ][ now_x ]
        else:
            return 0

    # 1.
    def f_h(img, pos,b,c,d,e):
        y, x = pos

        b = index_values(img, y, x, b)
        c = index_values(img, y, x, c)
        d = index_values(img, y, x, d)
        e = index_values(img, y, x, e)

        if (b==c and (d!=b or e!=b)):
            return "q"
        ## (b==c and (d==b and e==b)):
            return "r"
        if (b!=c):
            return "s"
        else:
            print("=", b,c,d,e)

    def f(a1,a2,a3,a4):
        if (a1==a2 and a2==a3 and a3==a4 and a4=="r"):
            return 5
        s = str(a1+a2+a3+a4)
        ## 找{a1,a2,a3,a4}有幾個q
        ct=0
        for i in range(len(s)):
            if s[i]=="q":
                ct+=1
        return ct
    src = img
    ans = np.zeros((s_h, s_w))
    for y in range(s_h):
        for x in range(s_w):
            ## 2.
            a1 = f_h(src, (y,x),0,1,6,2)
            a2 = f_h(src, (y,x),0,2,7,3)
            a3 = f_h(src, (y,x),0,3,8,4)
            a4 = f_h(src, (y,x),0,4,5,1)
            if (src[y][x]==0):
                continue
            ## 3.
            ans[y][x] = f(a1,a2,a3,a4)
    return ans
```

Pair Relationship Operator

- H function: (m="1", means "edge" in Yokoi)
  - $h(a,m) = \begin{cases} 1, if\ a = m \\ 0, otherwise \end{cases}$
- Output:
  - $y = \begin{cases} q, if\ \sum_{n=1}^{4} h(x_n, m) < 1\ or\ x_0 \neq m \\ p, if\ \sum_{n=1}^{4} h(x_n, m) \geq 1\ and\ x_0 = m \end{cases}$ (m=1, q=1, p=2)

In [4]:
```
# Pair Relationship Operator
## 參考上面公式
## 1. 前面算出的yokoi對應到 h(a, 1)，代表點yokoi[y][x]==1
## 2. 判斷周圍點x1,x2,x3,x4，為標記p及q
def pair_relationship(yokoi):
    h, w = yokoi.shape
    #註： y-1>=0 | y+1<h 是邊界條件
    # 1.
    def h_P4(yokoi, y, x):
        if (y-1>=0 and yokoi[y-1][x  ]==1):
            return 1
        if (x-1>=0 and yokoi[y  ][x-1]==1):
            return 1
        if (y+1<h and yokoi[y+1][x  ]==1):
            return 1
        if (x+1<w and yokoi[y  ][x+1]==1):
            return 1
        return 0
    mark = np.zeros((h,w))
    for y in range(h):
        for x in range(w):
            # p = 1
            # q = 2
            # 2.
            if (yokoi[y][x]==0):
                mark[y][x] = 0
            elif (yokoi[y][x]==1 and h_P4(yokoi, y, x)==1):
                mark[y][x] = 2
            else:
                mark[y][x] = 1

    return mark
```

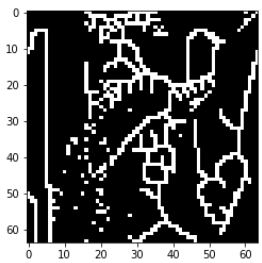
Connected Shrink Operator

- H function: (yokoi corner => "q")
  - $h(b,c,d,e) = \begin{cases} 1, if\ b = c\ and\ (d \neq b\ or\ e \neq b) \\ 0, otherwise \end{cases}$
- Output:
  - $f(a_1, a_2, a_3, a_4, x) = \begin{cases} g, if\ exactly\ one\ of\ a_n = 1, n = 1 \\ x, otherwise \end{cases}$

In [5]:
```
# Connected Shrink Operator & marked
## 參考上面公式
## 1. 根據 h(b, c, d, e)，找出yokoi corner
## 2. Connected Shrink Operator ，只有一個==1，可刪除
## 3. mark==2(p) && 是被2. 留下來的點
def marked_and_connected_shrink(img, img_mark):
    s_h, s_w = img.shape

    def index_values(img, y, x, n):
        # shift is a convert table reelated to index  textbook:x0,x1,x2...
        shift = {
            7:[-1,-1],
            2:[-1,0],
            6:[-1,1],
            3:[0,-1],
            0:[0,0],
            1:[0,1],
            8:[1,-1],
            4:[1,0],
            5:[1,1]
        }
        now_y = y+shift[n][0]
        now_x = x+shift[n][1]

        if (now_y>=0 and now_x>=0 and now_y<s_h and now_x<s_w):
            return img[ now_y ][ now_x ]
        else:
            return 0

    # 1.
    def f_h(img, pos,b,c,d,e):
        y, x = pos

        b = index_values(img, y, x, b)
        c = index_values(img, y, x, c)
        d = index_values(img, y, x, d)
        e = index_values(img, y, x, e)

        if (b==c and (b!=d or b!=e)):
            return 1
        else:
            return 0
    # Connected Shrink Operator
    def f(a1,a2,a3,a4, x0):
        if (a1+a2+a3+a4==1):
            return 0 # "g"
        return x0

    for y in range(s_h):
        for x in range(s_w):

            a1 = f_h(img, (y,x),0,1,6,2)
            a2 = f_h(img, (y,x),0,2,7,3)
            a3 = f_h(img, (y,x),0,3,8,4)
            a4 = f_h(img, (y,x),0,4,5,1)
            x0 = img[y][x]
            ## 2.
            if (img_mark[y][x]==2):
                img[y][x] = f(a1,a2,a3,a4,x0)
    return img
```

In [6]:
```
# 要做七次
for i in range(7):
    yokoi = Yokoi(img_downSampling)
    img_mark = pair_relationship(yokoi)
    img_downSampling = marked_and_connected_shrink(img_downSampling, img_mark)
plt.imshow(img_downSampling, cmap="gray")
```

Out[6]:
```
<matplotlib.image.AxesImage at 0x7fd51aae3eb0>
```



Ref

- textbook