Computer vision
Homework7
Thinning

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Description

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

The program is based on homework6

(a) Binarizing and downsampling Lena from 512x512 to 64x64

Using the method used in homework6. (Source Code 12~33)

(b) Process Yokoi Operator.

Using the method used in homework6. (Source Code 34~119)

(c) Scan the pixels in the downsampled image. Delete the current pixel if it is satisfied all of the conditions below. Repeat the thinning operator until there is no change.

i. Check if the current pixel is the edge by yokoi connectivity number.

ii. Check if the current pixel is 'p' in 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:
  - $y = \begin{cases} q, if\ \sum_{n=1}^{4} h(x_n, m) < 1\ or\ x_0 \neq m \\ p, if\ \sum_{n=1}^{4} h(x_n, m) \geq 1\ and\ x_0 = m \end{cases}$

```
199 char pair_op(int i, int j) {
200     int u = 0, d = 0, r = 0, l = 0;
201
202     if (i != 0) {
203         u = yokoi_m[i - 1][j];
204     }
205     if (i != 63) {
206         d = yokoi_m[i + 1][j];
207     }
208     if (j != 0) {
209         l = yokoi_m[i][j - 1];
210     }
211     if (j != 63) {
212         r = yokoi_m[i][j + 1];
213     }
214     if (u == 1 || d == 1 || l == 1 || r == 1) {
215         return 'p';
216     }
217     else {
218         return 'q';
219     }
220
221 }
```

iii. Check if the current pixel is ‘g’ in 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:
  - $f(a_1,a_2,a_3,a_4,x) = \begin{cases} g, if\ exactly\ one\ of\ a_n = 1, n = 1\sim4 \\ x, otherwise \end{cases}$

```
121 int h_shrink(int b, int c, int d, int e) {
122     if (b == c) {
123         if (d != b || e != b) {
124             return 1;
125         }
126         else {
127             return 0;
128         }
129     }
130     return 0;
131 }
132
```

```
133 char f_shrink(int a1, int a2, int a3, int a4, int x0) {
134     if (a1 == 1 || a2 == 1 || a3 == 1 || a4 == 1) {
135         int count = 0;
136         if (a1 == 1) {
137             count++;
138         }
139         if (a2 == 1) {
140             count++;
141         }
142         if (a3 == 1) {
143             count++;
144         }
145         if (a4 == 1) {
146             count++;
147         }
148
149         if (count == 1) {
150             return 'g';
151         }
152         else {
153             return x0;
154         }
155     }
156     else {
157         return x0;
158     }
159 }
```

```
161 char shrink(int i, int j , Mat down) {
162     //i. Obtain the value of x0~x8.
163     int x[9] = { 0,0,0,0,0,0,0,0,0 };
164     x[0] = down.at<uchar>(i, j);
165     if (j != 63) {
166         x[1] = down.at<uchar>(i, j + 1);
167     }
168     if (j != 0) {
169         x[3] = down.at<uchar>(i, j - 1);
170     }
171     if (i != 0) {
172         x[2] = down.at<uchar>(i - 1, j);
173     }
174     if (i != 63) {
175         x[4] = down.at<uchar>(i + 1, j);
176     }
177     if (i != 63 && j != 63) {
178         x[5] = down.at<uchar>(i + 1, j + 1);
179     }
180     if (i != 0 && j != 0) {
181         x[7] = down.at<uchar>(i - 1, j - 1);
182     }
183     if (i != 0 && j != 63) {
184         x[6] = down.at<uchar>(i - 1, j + 1);
185     }
186     if (i != 63 && j != 0) {
187         x[8] = down.at<uchar>(i + 1, j - 1);
188     }
189     //ii. Calculate the value of a1~a4
190     char a[4];
191     a[0] = h_shrink(x[0], x[1], x[6], x[2]);
192     a[1] = h_shrink(x[0], x[2], x[7], x[3]);
193     a[2] = h_shrink(x[0], x[3], x[8], x[4]);
194     a[3] = h_shrink(x[0], x[4], x[5], x[1]);
195
196     return f_shrink(a[0], a[1], a[2], a[3], x[0]);
197 }
```

Main

```
236     //thinning
237     int time = 1;
238     while (time <= 1000) {
239         int change = 0;
240         string name = to_string(time) + ".jpg";
241 
242         //yokoi
243         yokoi(down);
244 
245         //process
246         for (int i = 0; i < 64; i++) {
247             for (int j = 0; j < 64; j++) {
248                 if (yokoi_m[i][j] == 1 && pair_op(i,j) == 'p' &&  shrink(i, j, down) == 'g') {
249                     down.at<uchar>(i, j) = 0;
250                     change++;
251                 }
252                 else if (down.at<uchar>(i, j) == 0) {
253                     down.at<uchar>(i, j) = 0;
254                 }
255                 else{
256                     down.at<uchar>(i, j) = 255;
257                 }
258 
259             }
260         }
261         imwrite(name, down);
262         if (change == 0) {
263             cout << "Iterations: " << time << endl;
264             break;
265         }
266         time++;
267     }
```

Result

Iteration:

0.

1.

2.

3.

4.

5.

6.

7. (Final result)

Reference:

1. *Pdf in homework7*
   http://cv2.csie.ntu.edu.tw/CV/_material/CV1_CH6_2018_thinning-operator.pdf
2. *lecture slide*