ECE 637: Lab 3

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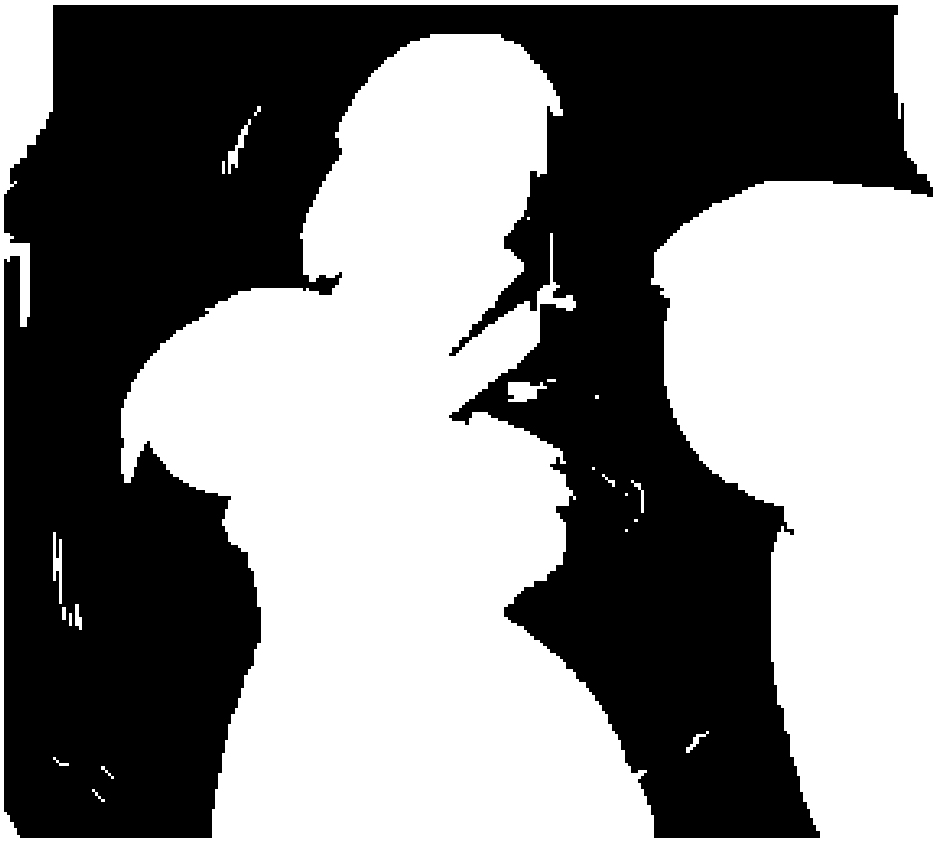
Section 1 Report

1. Print out of img22gd2.tif

Figure 1: Input gray scale image

2. Print out of image showing connected set for $s = (67, 45)$ and $T = 2$



3. Print out of image showing connected set for $s = (67, 45)$ and $T = 1$

4. Print out of image showing connected set for $s = (67, 45)$ and $T = 3$

5. For C-code of function *ConnectedSet_LL()* and *ConnectedNeighbors()* refer to Listing 2 at page 8.

Section 2 Report

1. Print out of randomly colored segmentation to $T = 1$, $T = 2$ and $T = 3$.

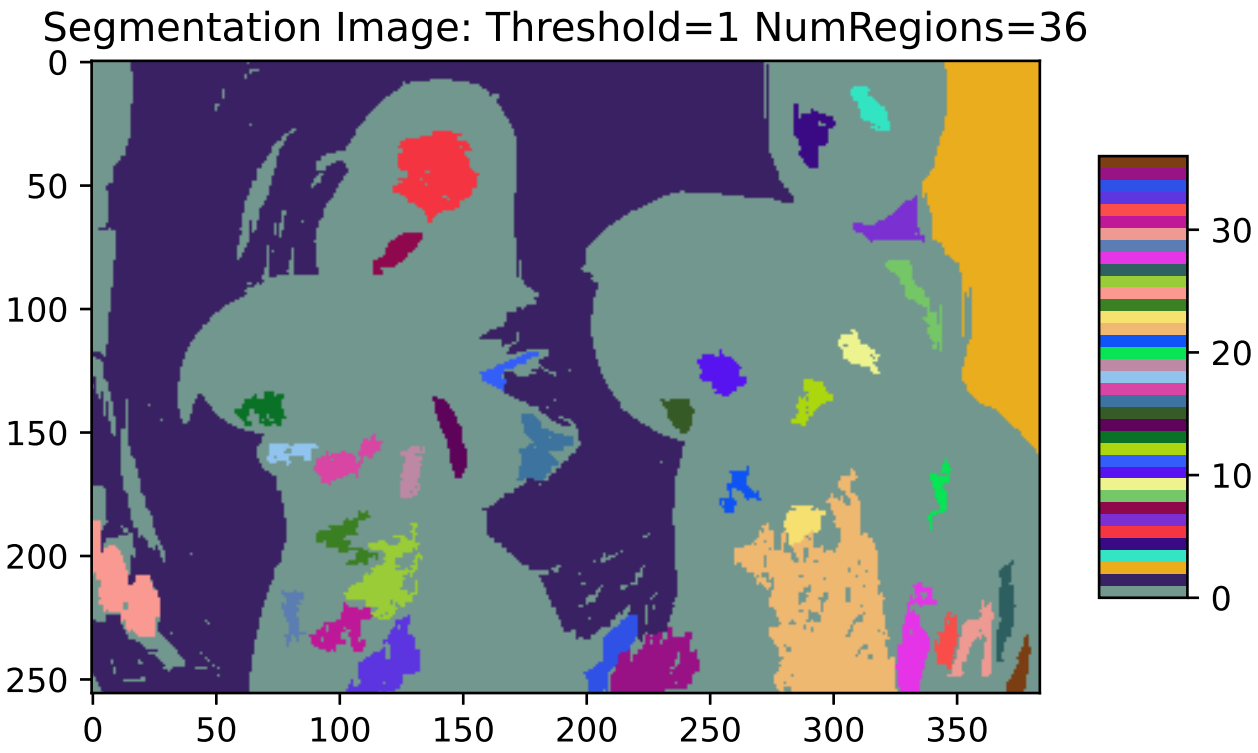


Figure 2: segmentation result for T=1

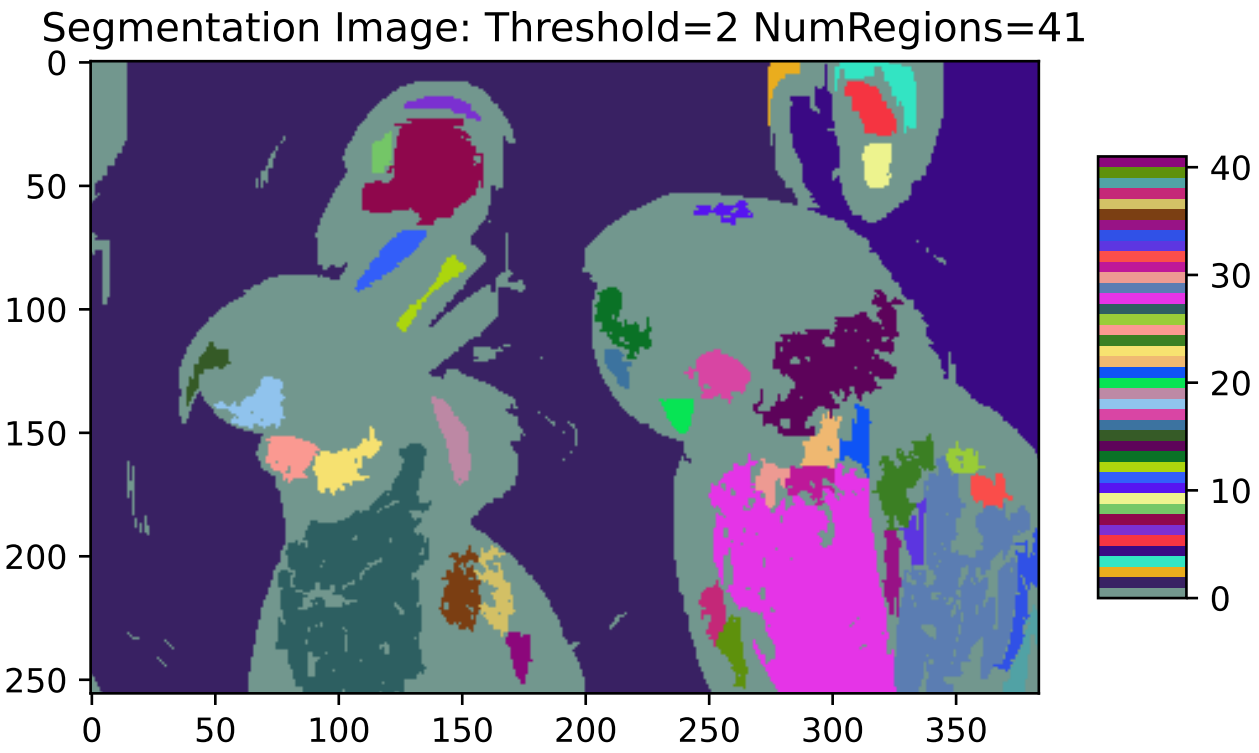


Figure 3: segmentation result for T=2

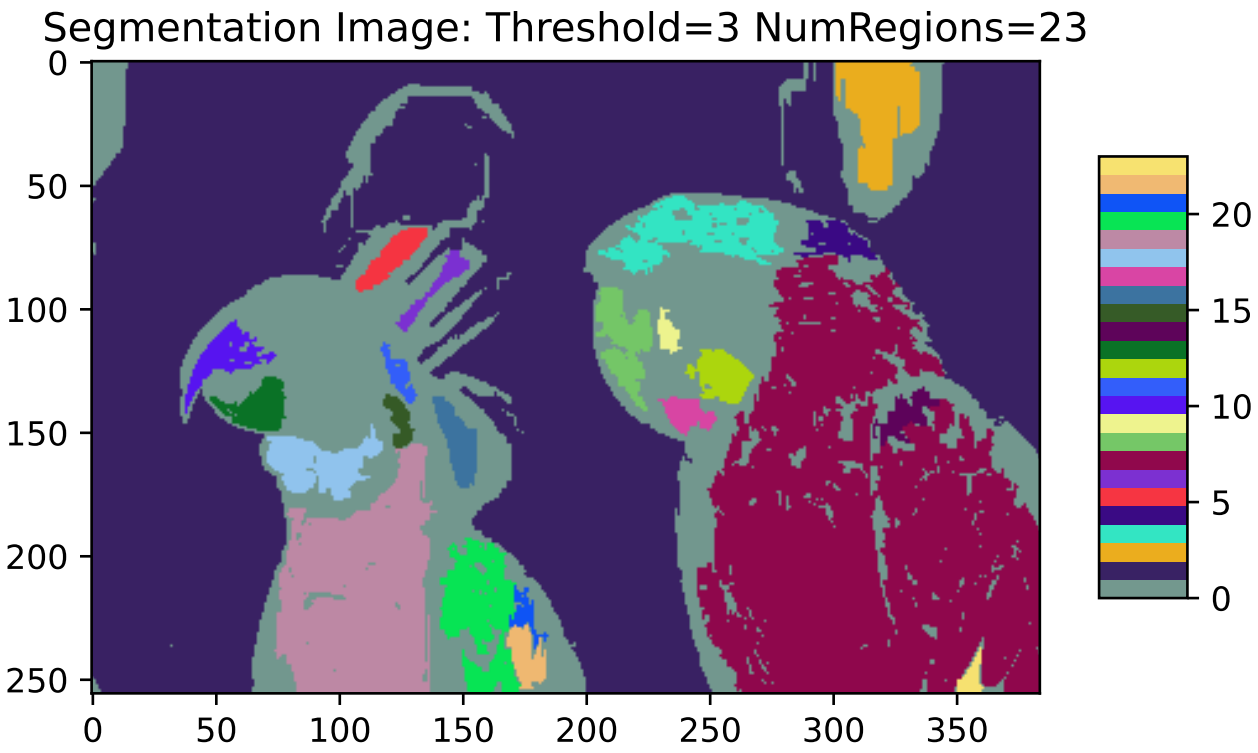


Figure 4: segmentation result for T=3

2. Listing of the number of regions generated for each of the values of $T = 1$, $T = 2$ and $T = 3$.

Listing 1: Text output

```
1  T =  2
2  Number of pixels in connected set: 36317
3  Number of regions in connected components: 41
4  T =  1
5  Number of pixels in connected set: 3
6  Number of regions in connected components: 36
7  T =  3
8  Number of pixels in connected set: 48926
9  Number of regions in connected components: 23
10 done
```

3. For C-code of function *ConnectedComponents()* refer to Listing 2 at page 8.

Source Code

Listing 2: C-Code

```
1
2  #include <math.h>
3  #include <stdlib.h>
4  #include <list>
5  #include "tiff.h"
6  #include "allocate.h"
7  #include "randlib.h"
8  #include "typeutil.h"
9  using namespace std;
10
11 #define MinPixCount 100
12
13 struct pixel{int m, n; /*m= row, n= col*/};
14
15 void ConnectedNeighbors(
16 struct pixel s,
17 double threshold,
18 unsigned char **img,
19 int width,
20 int height,
21 int *M,
22 struct pixel c[4]);
23
24 void ConnectedSet(
25 struct pixel s,
26 double threshold,
27 unsigned char **img,
28 int width,
29 int height,
30 int ClassLabel,
31 unsigned char **seg,
32 int *NumConPixels);
33
34 void ConnectedSet_LL(
35 struct pixel s,
36 double threshold,
37 unsigned char **img,
38 int width,
39 int height,
40 int ClassLabel,
41 unsigned char **seg,
42 int *NumConPixels);
43
44 void ConnectedComponents(
45 double threshold,
46 unsigned char **img,
47 int width,
48 int height,
49 unsigned char **seg_out,
50 unsigned char **connected_set,
51 int *NumRegions
52 );
53
54 void error(char *name);
55
```

```
56 int main (int argc, char **argv)
57 {
58   FILE *fp;
59   struct TIFF_img input_img, seg_img, cs_img, temp_img;
60   int32_t i,j,NumConPixels=0, ClassLabel=1, NumRegions=0;
61   double threshold;
62   struct pixel s0;
63
64   if ( argc != 5) error( argv[0] );
65   s0.m = atof(argv[2]);//row
66   s0.n = atof(argv[3]);//col
67   threshold = atof(argv[4]);
68
69   /* open image file */
70   if ( ( fp = fopen ( argv[1], "rb" ) ) == NULL ) {
71     fprintf ( stderr, "cannot open file %s\n", argv[1] );
72     exit ( 1 );
73   }
74
75   /* read image */
76   if ( read_TIFF ( fp, &input_img ) ) {
77     fprintf ( stderr, "error reading file %s\n", argv[1] );
78     exit ( 1 );
79   }
80
81   /* close image file */
82   fclose ( fp );
83
84   /* check the type of image data */
85   if ( input_img.TIFF_type != 'g' ) {
86     fprintf ( stderr, "error:  image must be 8-bit monochrome\n" );
87     exit ( 1 );
88   }
89
90   /* set up structure for output achromatic image */
91   /* to allocate a full color image use type 'c' */
92   get_TIFF ( &cs_img, input_img.height, input_img.width, 'g' );
93   get_TIFF ( &seg_img, input_img.height, input_img.width, 'g' );
94   get_TIFF ( &temp_img, input_img.height, input_img.width, 'g' );
95
96   /* initialize segmentation map as 0 */
97   for ( i = 0; i < input_img.height; i++ ){
98   for ( j = 0; j < input_img.width; j++ ) {
99     cs_img.mono[i][j] = 0;
100    temp_img.mono[i][j] = 0;
101    seg_img.mono[i][j]=0;
102  }}
103
104  /* find connected set*/
105 //  ConnectedSet(s0,threshold,input_img.mono,input_img.width,input_img.height,\
106 //       ClassLabel,cs_img.mono,&NumConPixels);
107
108
109  ConnectedSet_LL(s0,threshold,input_img.mono,input_img.width,input_img.height,\
110       ClassLabel,cs_img.mono,&NumConPixels);
111  fprintf(stdout, "Number of pixels in connected set: %d\n", NumConPixels);
112
113  /* change 1-black 0-white */
114  for ( i = 0; i < input_img.height; i++ ){
```

```
115   for ( j = 0; j < input_img.width; j++ ) {
116     if(cs_img.mono[i][j]==1){
117     cs_img.mono[i][j] = 0;//black
118     }
119     else{
120       cs_img.mono[i][j] = 255;//white
121     }
122     }
123   }
124
125   /*Connected Components based Segmentation */
126   ConnectedComponents(threshold, input_img.mono, input_img.width, input_img.height,\
127                       seg_img.mono,temp_img.mono, &NumRegions);
128   fprintf(stdout, "Number of regions in connected components: %d\n", NumRegions);
129
130   /* open grayscale image file */
131   if ( ( fp = fopen ( "connected_set.tif", "wb" ) ) == NULL ) {
132       fprintf ( stderr, "cannot open file connected_set.tif\n");
133       exit ( 1 );
134   }
135
136   /* write grayscale image */
137   if ( write_TIFF ( fp, &cs_img ) ) {
138       fprintf ( stderr, "error writing TIFF file connected_set.tif\n" );
139       exit ( 1 );
140   }
141
142   /* close image file */
143   fclose ( fp );
144
145   /* open grayscale image file */
146   if ( ( fp = fopen ( "segmented.tif", "wb" ) ) == NULL ) {
147       fprintf ( stderr, "cannot open file segmented.tif\n");
148       exit ( 1 );
149   }
150
151   /* write grayscale image */
152   if ( write_TIFF ( fp, &seg_img ) ) {
153       fprintf ( stderr, "error writing TIFF file segmented.tif\n" );
154       exit ( 1 );
155   }
156
157   /* close image file */
158   fclose ( fp );
159
160   /* de-allocate space which was used for the images */
161   free_TIFF ( &(input_img) );
162   free_TIFF ( &(cs_img) );
163   free_TIFF ( &(seg_img) );
164   free_TIFF ( &(temp_img) );
165
166   return(0);
167 }
168
169 void error(char *name)
170 {
171     printf("usage:  %s  input_image.tiff output.tiff s0.row s0.col Threshold\n\n",
      name);
172     printf("this program reads in a 8-bit grayscale TIFF image.\n");
```

```
173     printf("It then computes segmentation mask of 4-connected component of s0,\n");
174     printf("and writes out the result as an 8-bit image\n");
175     exit(1);
176 }
177
178
179 void ConnectedNeighbors(
180 struct pixel s,
181 double threshold,
182 unsigned char **img,
183 int width,
184 int height,
185 int *M,
186 struct pixel c[4]){
187   int i,row,col, count = 0;
188   int row_offset[4]={0,0,-1,1};
189   int col_offset[4]={-1,1,0,0};
190   //iterate through neighbors
191   for(i=0; i<4; i++){
192     row = s.m + row_offset[i];
193     col = s.n + col_offset[i];
194     if ( ((row>=0) && (row<height)) &&\
195        ((col>=0) && (col<width )) ){
196       //check if in c(s)
197       if( abs(img[s.m][s.n] - img[row][col])<= threshold ){
198         c[count].m = row; c[count].n = col;
199         count+=1;
200       }
201     }
202   }
203   *M = count;
204   return;
205 }
206
207 void ConnectedSet(
208 struct pixel s,
209 double threshold,
210 unsigned char **img,
211 int width,
212 int height,
213 int ClassLabel,
214 unsigned char **seg,
215 int *NumConPixels){
216   struct pixel c[4];
217   int M=0, i;
218   bool flag_all_seg = true;
219   seg[s.m][s.n] = 1;
220   *NumConPixels+=1;
221   ConnectedNeighbors(s,threshold,img,width,height,&M,c);
222   /* base case */
223   if(M==0){return;}// no neighbors
224   for(i=0; i<M; i++){
225     if (seg[c[i].m][c[i].n]==0) {// i'th CN not accounted
226       flag_all_seg = false;
227       break;
228     }
229   }
230   if(flag_all_seg){return;}
231   else{
```

```
232     for(i=0; i<M; i++){
233       if (seg[c[i].m][c[i].n]==0){
234         ConnectedSet(c[i],threshold,img,width,height,ClassLabel,seg,NumConPixels);
235       }
236     }
237   }
238 }
239
240
241
242 void ConnectedSet_LL(
243 struct pixel s,
244 double threshold,
245 unsigned char **img,
246 int width,
247 int height,
248 int ClassLabel,
249 unsigned char **seg,
250 int *NumConPixels){
251   struct pixel c[4], i_pixel;
252   int M=0,i=0,k=0, count=0;
253 //  char temp;
254   list <struct pixel> CN_LL;
255
256   //B<-{s0}
257   CN_LL.push_back(s);
258   while(!CN_LL.empty()){
259     i_pixel = CN_LL.front();
260     CN_LL.pop_front();
261     if(seg[i_pixel.m][i_pixel.n] == 0){//not labelled
262     seg[i_pixel.m][i_pixel.n] = ClassLabel;
263     count+=1;
264     ConnectedNeighbors(i_pixel,threshold,img,width,height,&M,c);
265     if(M>0){
266     for(i=0;i<M;i++){//push not-visited pixels into list
267     if(seg[c[i].m][c[i].n] == 0){CN_LL.push_back(c[i]);k++;}
268     }}
269     k=0;
270     }
271     }
272   *NumConPixels = count;
273   return;
274 }
275
276
277 void ConnectedComponents(
278 double threshold,
279 unsigned char **img,
280 int width,
281 int height,
282 unsigned char **seg_out,
283 unsigned char **connected_set,
284 int *NumRegions
285 ){
286   int ClassLabel = 1,i_row,i_col, i,j;
287   int NumConPixels=0;
288   struct pixel seed;
289   for(i_row=0; i_row<height; i_row++){
290     for(i_col=0; i_col<width; i_col++){
```

```
291         if(seg_out[i_row][i_col]==0){//Not labelled
292           seed.m = i_row; seed.n = i_col;
293           ConnectedSet_LL(seed, threshold, img, width, height, 1, connected_set, &
        NumConPixels);
294           //set connected_set back to zeros
295           for(i=0; i<height; i++){for(j=0; j<width; j++){connected_set[i][j]=0;}}
296           if(NumConPixels>MinPixCount){
297           //Label seg_out
298           ConnectedSet_LL(seed, threshold, img, width, height, ClassLabel, seg_out, &
        NumConPixels);
299           ClassLabel+=1;
300           }
301         }
302       }
303     }
304     *NumRegions = ClassLabel-1;
305     return;
306 }
```

Appendix

Got to git repo for complete code.

Listing 3: Python code for generating segmentation image

```
#!/usr/bin/env python3
# -*- coding: utf-8 -*-
"""
@author: rahul
course: ECE637-DIP-I
lab3- Connected Components
"""
import sys, os
import numpy as np
from PIL import Image
import matplotlib.pyplot as plt
import matplotlib as mp

np.random.seed(seed=637)

def main(filename):
    basename = os.path.basename(filename).split('.')[0]
    threshold = basename.split('_')[1]
    im = Image.open(filename)
    img = np.array(im)
    NumRegions = np.max(img)
    cmap = mp.colors.ListedColormap(np.random.rand(NumRegions+1,3))
    plt.imshow(img,cmap=cmap,interpolation='none')
    plt.title('Segmentation Image: Threshold='
              +str(threshold)+' NumRegions='+str(NumRegions))
    plt.colorbar(shrink=0.5, aspect=5)
    plt.savefig(basename+'.eps',bbox_inches='tight', pad_inches = 0, format='eps')

if __name__=="__main__":
    filename = sys.argv[1]
    main(filename)
```