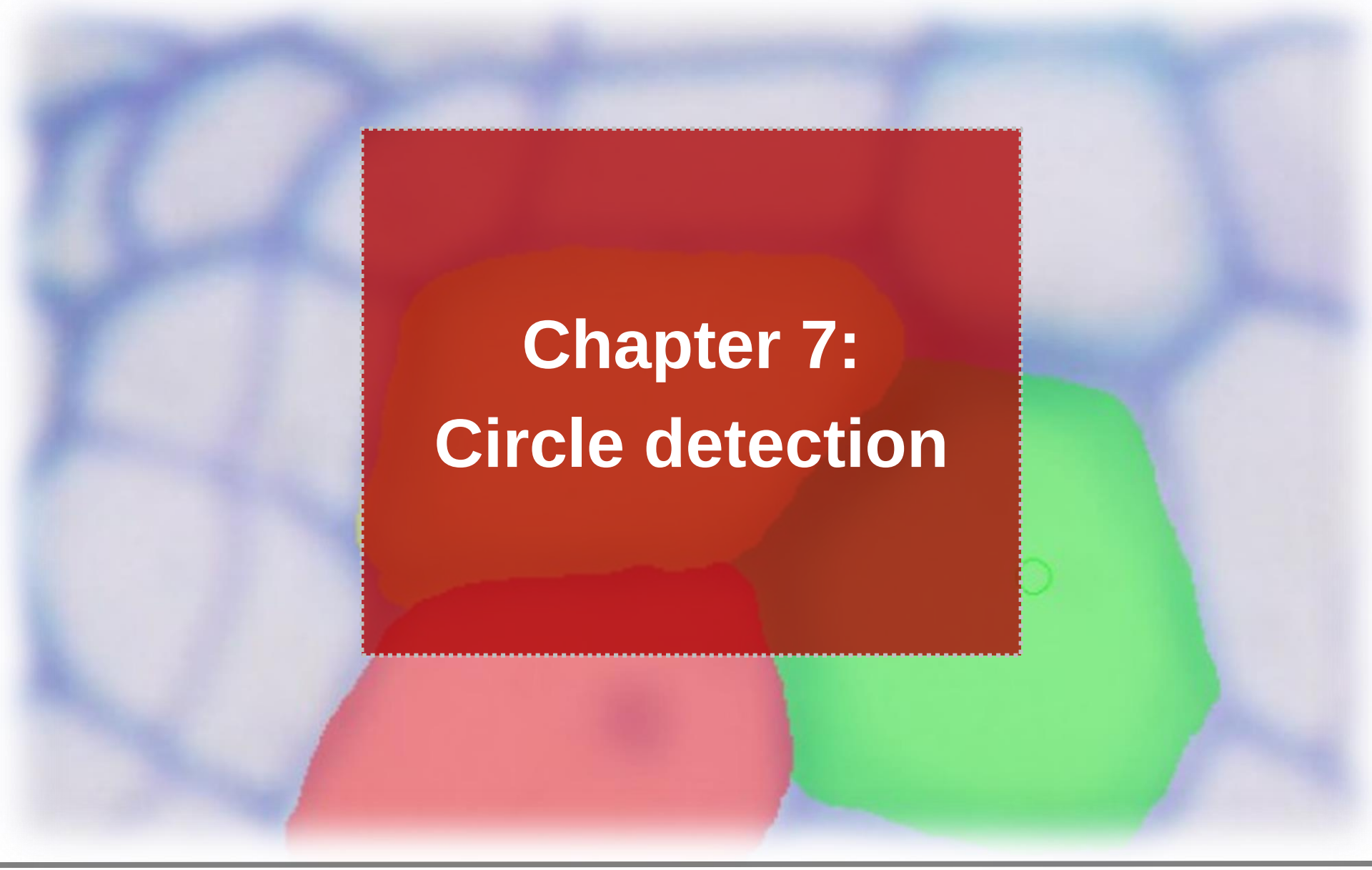
Solution Exercise 6



Chapter 7:
Circle detection

Circle detection

We will combine the knowledge of the past lectures to create a simple circle detection.

Working principle:

1. Preparing the image (brightness, contrast)
2. Blur
3. Detect edges
4. Find circles with Hough transformation for circles

Input image

Brightness and contrast adjustment

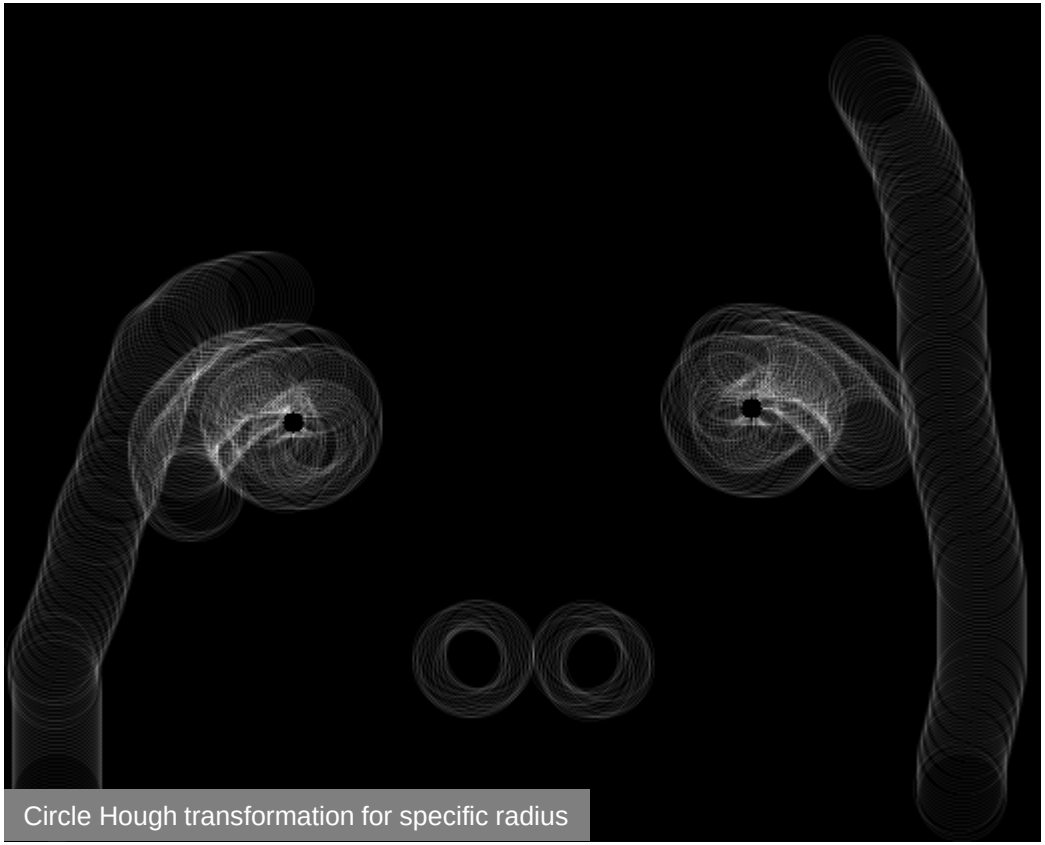
Edge detection

Circle detection

We will combine the knowledge of the past lectures to create a simple circle detection.

Working principle:

1. Preparing the image (brightness, contrast)
2. Blur
3. Detect edges
4. Find circles with Hough transformation for circles



Circle Hough transformation for specific radius

Maxima in Hough space are the centers of circles

Hough Transformation for circles

- same procedure as for straight lines (see lecture 6)
- Uses circle equation

$$(x - x_C)^2 + (y - y_C)^2 = r^2$$

- 3 parameters → 3D accumulator space

Algorithm

1. Start with empty 3D accumulator A[a,b,r] = 0
2. Use the image with detected edges and do for each (not black) pixel

For each possible radius r with r = [r_{min}, r_{max}]
For each θ with θ = [0°, 360°]
a = x – r * cos(θ * π / 180°)
b = y – r * sin (θ * π / 180°)
A[a,b,r] += 1

3. Circles are maxima in the accumulator

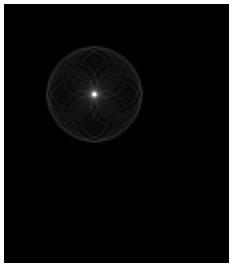
Seventh Exercise, Part A

- Implement the Hough Transformation for circles with a fixed radius

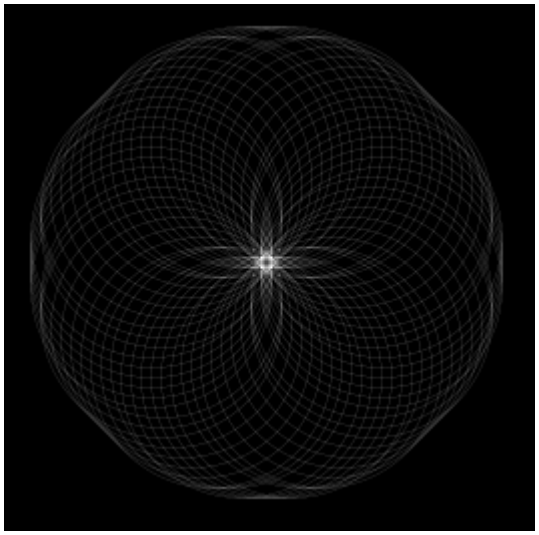
Expected Output: Hough space

one circle, r=12 with
(a) default step size and (b) smaller step size

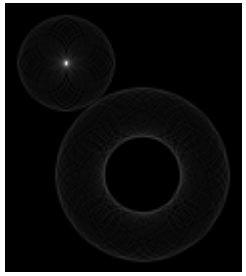
two circles with
(c) r=12 and (d) r=30



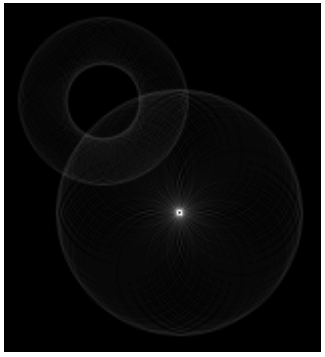
(a)



(b), selection of the output image



(c)



(d)

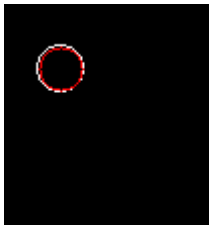
Part B

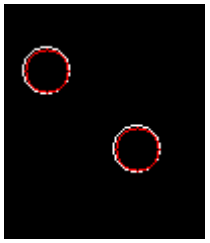
- Implement a function which uses the Hough transformation from *Part A* to find circles of different sizes.

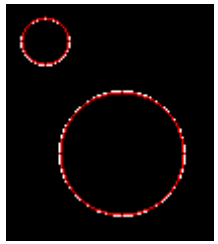
Expected Output

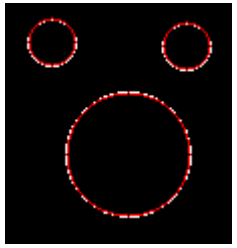
white: given circle

red: found circle









Part C

- Use the functions from *Part A* and *Part B* for eye tracking.

Expected Output

Terminal output

```
##########
# PART A #
##########

press any key to continue ...
##########
# PART B #
##########

one_circle_r12.tiff
       1 cirles found:
        #1      center: (38,36),        radius=11

two_circles_r12.tiff
       2 cirles found:
        #1      center: (38,36),        radius=11
        #2      center: (83,75),        radius=11

two_circles_different_size.tiff
       2 cirles found:
        #1      center: (24,21),        radius=12
        #2      center: (62,77),        radius=31

3_circles.tiff
       3 cirles found:
        #1      center: (24,21),        radius=12
        #2      center: (91,23),        radius=12
        #3      center: (62,77),        radius=31

press any key to continue ...
##########
# PART C #
##########

face.tiff
  found circle   center: 61,93
  found circle   center: 176,90
```

That is all for today.