Lecture 10: Tutorial

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Part I: Media Streaming

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Q1

- Consider a video-on-demand system designed for streaming video and audio content over the internet. What problems would you encounter, if you tried to stream the video and audio content directly over UDP/IP without using RTP?

- Cannot detect lost packets
- Unable to reorder received packets
- Unable to do audio-video stream synchronization

RTP provides:

- Pay load identification, and
- Frame indication to support applications / decoders

Q2

- Consider streaming of a live event from a video source (i.e. sender) to a client (i.e. receiver) using RTP/RTCP. After some time of successful operation, the video source ignores all RTCP receiver reports (RR) from the client. What problems could arise if all RR are ignored by the video source?

- Not enough information to adapt to network

RTCP Receiver Report (RR)

- Sent by receivers (not active senders)
- Provides a report of reception statistics

Q3

- What functionality does RTSP provide?
- What transport protocol is specified (if any) for RTSP?

- Establishes and controls one or more continuous media streams
- Provides “Internet VCR controls”

- Transport-independent

Q4

- In a peer-to-peer video conferencing situation what tools or techniques are available to achieve better resilience to packet loss?

Receiver

- Error concealment
  - Fill in missing blocks

Sender

- Adaptive rate control
- Packetization strategy
- Error resilience
  - increase intra-frames
  - intra-block refresh
  - introduce redundancies

Part II: Multimedia Information Retrieval

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Tutorial – Question 1

Consider an image with 2 distinct grey-levels

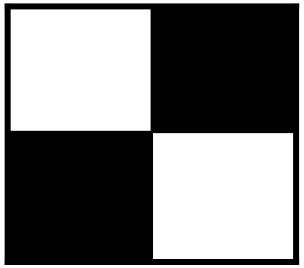
1	0	1	0	1
1	0	1	0	1
1	1	1	1	1
1	0	1	0	1
1	0	1	0	1

Calculate the co-occurrence matrix if the position operator is defined as "one pixel to the left"

Revision on Texture

- The Grey-level Co-occurrence Matrix (GLCM) can be used to calculate the second-order statistics.
- Given the following 2x2 pixel image with 2 distinct grey-levels:

1	0
0	1



And the position operator defined as “one pixel to the left”

Revision on co-occurrence matrix

- The 2x2 co-occurrence matrix can be calculated as follows:-

		Gray-Levels at current pel	
		0	1
Gray-Levels at left	0	**N00**	**N01**
	1	**N10**	**N11**

- **N00** = the number of pixels with grey-level **0** that have a gray-level of **0** one pixel to the left
- **N01** = the number of pixels with grey-level **1** that have a gray-level of **0** one pixel to the left
- **N10** = the number of pixels with grey-level **0** that have a gray-level of **1** one pixel to the left
- **N11** = the number of pixels with grey-level **1** that have a gray-level of **1** one pixel to the left

Revision on co-occurrence matrix

Position Operator (One pixel to the left) can not be defined

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Grey-level of 0 with grey level of 1 one pixel to the left

$$\begin{bmatrix} 1 & \boxed{0} \\ 0 & 1 \end{bmatrix}$$

Current Pixel

Revision on co-occurrence matrix

$$\begin{bmatrix} 1 & 0 \\ 0 & \boxed{1} \end{bmatrix}$$

Grey-level of 1 with grey level of 0 one pixel to the left

Current Pixel

Hence, the final co-occurrence matrix will be equal to

		Gray-Levels at current pel	
		0	1
Gray-Levels at left	0	**0**	**1**
	1	**1**	**0**

Tutorial Question 1 – Step 1

- Step 1 – The size of the co-occurrence matrix will be equal to the number of distinct grey-levels x the number of distinct grey-levels (L x L)

- Since, the image has 2 distinct grey-levels, the size of the co-occurrence matrix is 2 x 2.

		Gray-Levels at current pel	
		0	1
Gray-Levels at left	0		
	1		

Tutorial Question 1 – Step 2

- Step 2 – Count the number of pixels in the image which have the relationship between itself and its neighbors specified by position operator.

- The position operator in our question is defined as “one pixel to the left”

1	0	1	0	1
1	0	1	0	1
1	1	1	1	1
1	0	1	0	1
1	0	1	0	1

N00 = the number of pixels with grey-level **0** that have a gray-level of **0** one pixel to the left

= 0

Tutorial Question 1 – Step 2

- Step 2 – Count the number of pixels in the image which have the relationship between itself and its neighbors specified by position operator.

- The position operator in our question is defined as “one pixel to the left”

1	0	$\boxed{1}$	0	$\boxed{1}$
1	0	$\boxed{1}$	0	$\boxed{1}$
1	1	1	1	1
1	0	$\boxed{1}$	0	$\boxed{1}$
1	0	$\boxed{1}$	0	$\boxed{1}$

N01 = the number of pixels with grey-level **1** that have a gray-level of **0** one pixel to the left

= 8

Tutorial Question 1 – Step 2

- Step 2 – Count the number of pixels in the image which have the relationship between itself and its neighbors specified by position operator.

- The position operator in our question is defined as “one pixel to the left”

1	0	1	0	1
1	0	1	0	1
1	1	1	1	1
1	0	1	0	1
1	0	1	0	1

N10 = the number of pixels with grey-level **0** that have a gray-level of **1** one pixel to the left

= 8

Tutorial Question 1 – Step 2

- Step 2 – Count the number of pixels in the image which have the relationship between itself and its neighbors specified by position operator.
- The position operator in our question is defined as “one pixel to the left”

1	0	1	0	1
1	0	1	0	1
1	1	1	1	1
1	0	1	0	1
1	0	1	0	1

N11 = the number of pixels with grey-level **1** that have a gray-level of **1** one pixel to the left

= 4

Tutorial Question 1 – Step 3

- Step 3 – Fill in the answers calculated from Step 2
- Hence, the final co-occurrence matrix will be:-

		Gray-Levels at current pel	
		0	1
Gray-Levels at left	0	**0**	**8**
	1	**8**	**4**

Tutorial – Question 2

Consider two images A and B, and histogram similarity matrix C

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

A

1	2	1	2	1
2	2	1	2	1
3	1	1	1	1
3	3	3	3	3
2	2	2	3	3

B

1	0.5	0
0.5	1	0.5
0	0.5	1

C

- For each image, calculate histogram, cumulative histogram and CCV
- For the two images, calculate L1 histogram distance, L1 cumulative histogram distance, histogram intersection, Normalized CCV distance and Niblack's histogram similarity value.
- Assume that average filtering has already been applied to the image.
- Suppose that the threshold for the size of the connected component is 3.

Revision - Histogram

- A histogram is a graphical display of tabulated frequencies.

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Grey-Level	Frequency
1	11
2	
3	

Revision - Histogram

- A histogram is a graphical display of tabulated frequencies.

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Grey-Level	Frequency
1	11
2	8
3	

Revision - Histogram

- A histogram is a graphical display of tabulated frequencies.

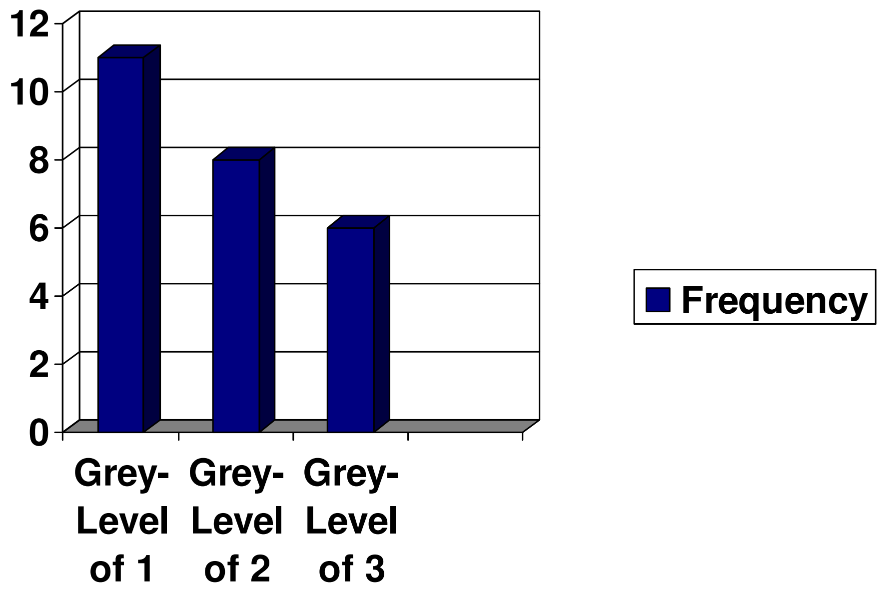
1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Grey-Level	No. of Observations
1	11
2	8
3	6

Revision - Histogram

- A histogram is a graphical display of tabulated frequencies.

Grey-Level	Frequency
1	11
2	8
3	6



Tutorial Question 2 - Histogram

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Image A

1	2	1	2	1
2	2	1	2	1
3	1	1	1	1
3	3	3	3	3
2	2	2	3	3

Image B

Grey-Level	Frequency
1	11
2	8
3	6

Histogram of Image A

Grey-Level	Frequency
1	9
2	8
3	8

Histogram of Image B

Revision – Cumulative Histogram

- A cumulative histogram is a mapping that counts the cumulative number of observations in all of the bins up to the specified bin.

Histogram

Grey-Level	No. of Observations
1	11
2	8
3	6

Cumulative Histogram

Grey-Level	No. of Observations
1	11
2	11+8 = 19
3	19+6 = 25

Tutorial Question 2 – Cumulative Histogram

Grey-Level	Frequency
1	11
2	8
3	6

Histogram of image A

Grey-Level	Frequency
1	9
2	8
3	8

Histogram of image B

Grey-Level	Frequency
1	11
2	19
3	25

Cumulative Histogram of image A

Grey-Level	Frequency
1	9
2	17
3	25

Cumulative Histogram of image B

Revision - Niblack's Similarity Measurement

X – the query histogram; Y – the histogram of an image in the database
Z – the bin-to-bin similarity histogram

The Similarity between X and Y ➔, $\| Z \| = Z^t A Z$

Where A is a symmetric color similarity matrix with $a(i,j) = 1 - d(c_i,c_j)/d_{max}$

c_i *and* c_j *are the ith and jth color bins in the color histogram*

$d(c_i,c_j)$ *is the color distance in the mathematical transform to Munsell color space and* d_{max} *is the maximum distance between any two colors in the color space.*

Revision – Color Coherence Vector

- Color coherence vector (CCV) is a tool to distinguish images whose color histograms are indistinguishable.
- Coherence measure classifies pixels as either coherent or incoherent.
- 4 Steps to compute CCV
  - **Step1**: conduct average filtering
  - **Step2**: discretize the image into n distinct colors
  - **Step3**: Classify the pixels within a given color bucket as either coherent or incoherent – a pixel is coherent if the size of the connected component exceeds a fixed value.
  - **Step4**: Obtain CCV by collecting the information of both coherent and incoherent.

Revision – CCV (Step 1,2)

- Step1 – Since average filter has already been applied, this step will be skipped.
- Step2 – Discretize the image
  - We discretize both images into three distinct colors

Revision – CCV (Step 3)

- Step3 – Classify the pixels as either coherent or incoherent.

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Discretized Image

A	B	A	D	D
A	B	A	E	D
A	A	A	E	E
A	C	A	F	E
A	C	A	E	E

Connected Component

Label	A	B	C	D	E	F
Color	1	2	3	3	2	3
Size	11	2	2	3	6	1

Connected Table

Revision – CCV (Step 3)

- Step3 – Classify the pixels as either coherent or incoherent – A pixel is coherent if the size of the connected component exceeds a fixed value of 3; otherwise, the pixel is incoherent.

Label	A	B	C	D	E	F
Color	1	2	3	3	2	3
Size	11	2	2	3	6	1

Connected Table

Color	1	2	3
α	11		
β	0		

Color Coherent Vector

Revision – CCV (Step 3)

- Step3 – Classify the pixels as either coherent or incoherent – A pixel is coherent if the size of the connected component exceeds a fixed value of 3; otherwise, the pixel is incoherent.

Label	A	B	C	D	E	F
Color	1	2	3	3	2	3
Size	11	$\boxed{2}$	2	3	6	1

Connected Table

Color	1	2	3
α	11	6	
β	0	$\boxed{2}$	

Color Coherent Vector

Revision – CCV (Step 3)

- Step3 – Classify the pixels as either coherent or incoherent – A pixel is coherent if the size of the connected component exceeds a fixed value of 3; otherwise, the pixel is incoherent.

Label	**A**	**B**	**C**	**D**	**E**	**F**
Color	1	2	3	3	2	3
Size	11	2	$\boxed{2}$	3	6	$\boxed{1}$

Connected Table

Color	**1**	**2**	**3**
α	11	6	3
β	0	2	$\boxed{3}$

Color Coherent Vector

Tutorial Question 2 - CCV

Image A

1	2	1	3	3
1	2	1	2	3
1	1	1	2	2
1	3	1	3	2
1	3	1	2	2

Image B

1	2	1	2	1
2	2	1	2	1
3	1	1	1	1
3	3	3	3	3
2	2	2	3	3

Color	1	2	3
α	11	6	3
β	0	2	3

Color Coherent Vector of Image A

Color	1	2	3
α	8	6	8
β	1	2	0

Color Coherent Vector of Image B

Tutorial – Question 2

Bin		1	2	3
Histogram		11	8	6
Cumulative Histogram		11	19	25
CCV	α	11	6	3
	β	0	2	3
Image A				

Bin		1	2	3
Histogram		9	8	8
Cumulative Histogram		9	17	25
CCV	α	8	6	8
	β	1	2	0
Image B				

Tutorial – Question 2

- L1 Histogram Distance

$$D = |11-9| + |8-8| + |6-8| = 4$$

- L1 Cumulative Histogram Distance

$$D = |11-9| + |19-17| + |25-25| = 4$$

- Histogram Intersection

$$D = [\min(11,9) + \min(8,8) + \min(6,8)] / (11 + 8 + 6)$$
$$= [9 + 8 + 6] / 25$$
$$= 23 / 25$$
$$= 0.92$$

Tutorial – Question 2

- Normalized CCV

D = |(11-8)/(11+8+1)| + |(0-1)/(0+1+1)|
+ |(6-6)/(6+6+1)| + |(2-2)/(2+2+1)|
+ |(3-8)/(3+8+1)| + |(3-3)/(3+3+1)|
= 3/20 + 1/2 +5/12
= 1.1817

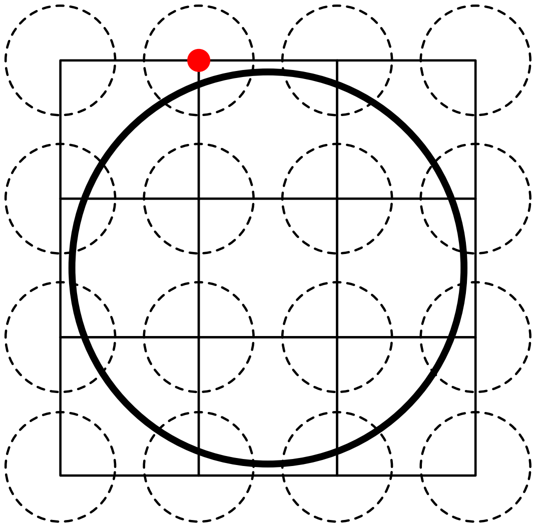
- Niblack's similarity measure

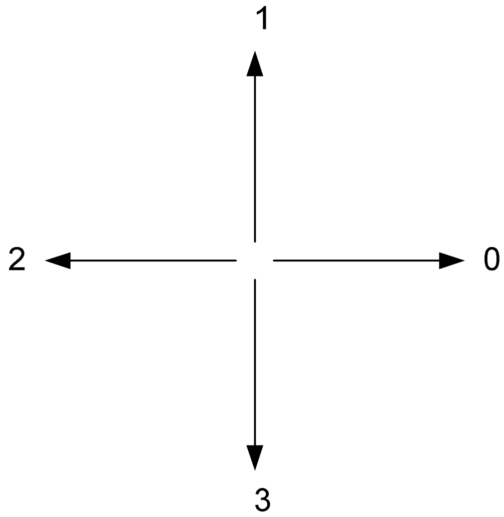
Transpose(Z) = [|11-9|, |8-8|, |6-8|] = [2, 0, 2]

$$D = Z^T C Z = [2 \quad 0 \quad 2] \begin{bmatrix} 1 & 0.5 & 0 \\ 0.5 & 1 & 0.5 \\ 0 & 0.5 & 1 \end{bmatrix} [2 \quad 0 \quad 2] = 8$$

Tutorial – Question 3

Consider the boundary and the numbering schemes

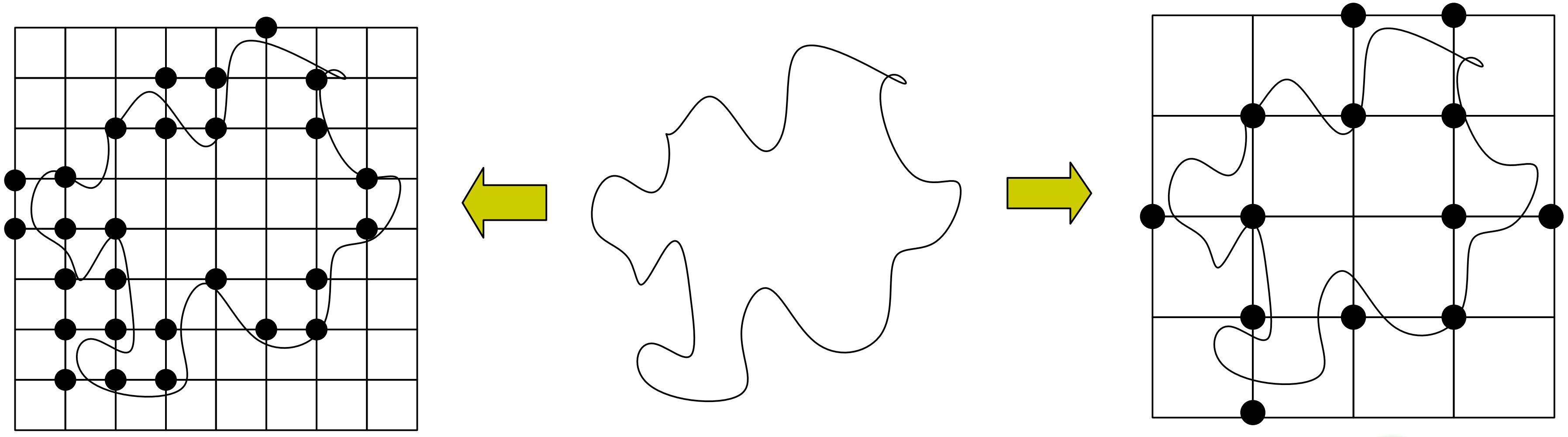




- Digitize the boundary
- Select the red node as starting point, calculate the chain code in counter-clockwise direction
- Calculate the normalized chain code by using the **first difference** of the chain code

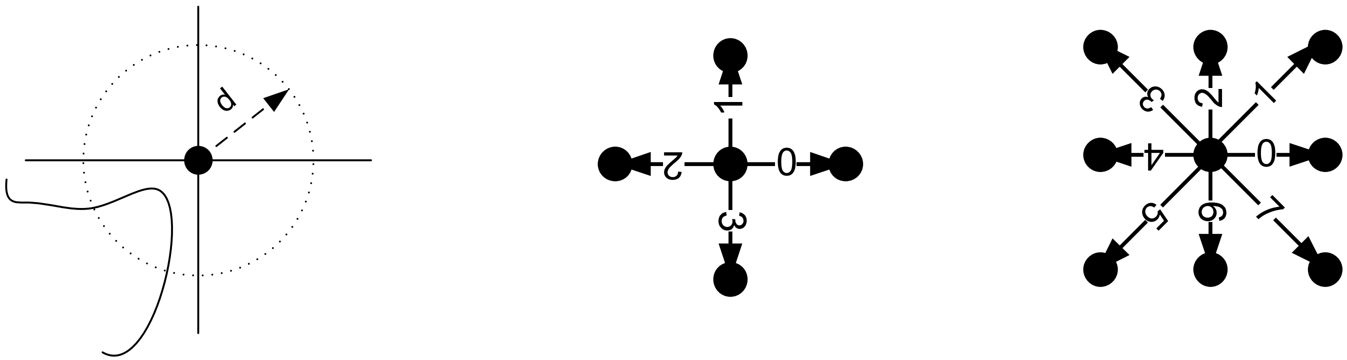
Tutorial – Question 3

- Revision on Chain Code
  - Represent a boundary by a connected sequence of straight-line segments of specified length and direction
  - Based on 4- or 8- connectivity
  - Depends on the starting point and the spacing of the sampling grid



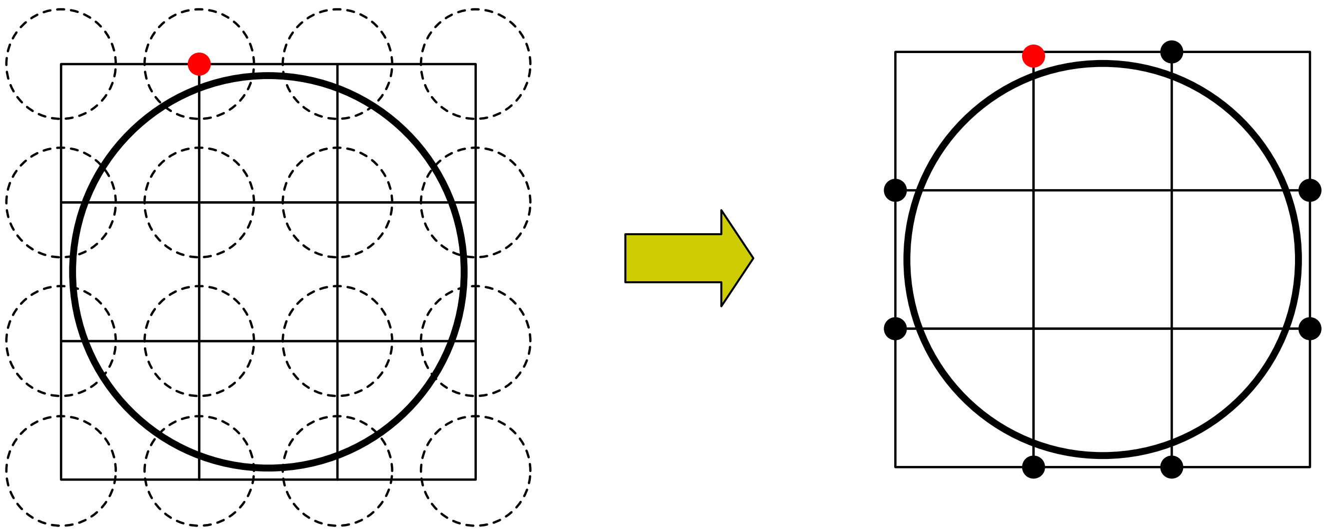
Tutorial – Question 3

- Revision on Chain Code
  - Steps to calculate chain code
    - Digitize image
      - Decide a sampling gird, the denser the more accurate
      - Assign boundary point to grid node based on the distance of the grid node to the boundary, d < threshold → assign boundary point to the node
    - Select a numbering scheme and define a starting point
    - Follow the boundary in a specified direction (clockwise or counter clockwise), assign a direction to the segments connecting neighboring boundary points



Tutorial – Question 3

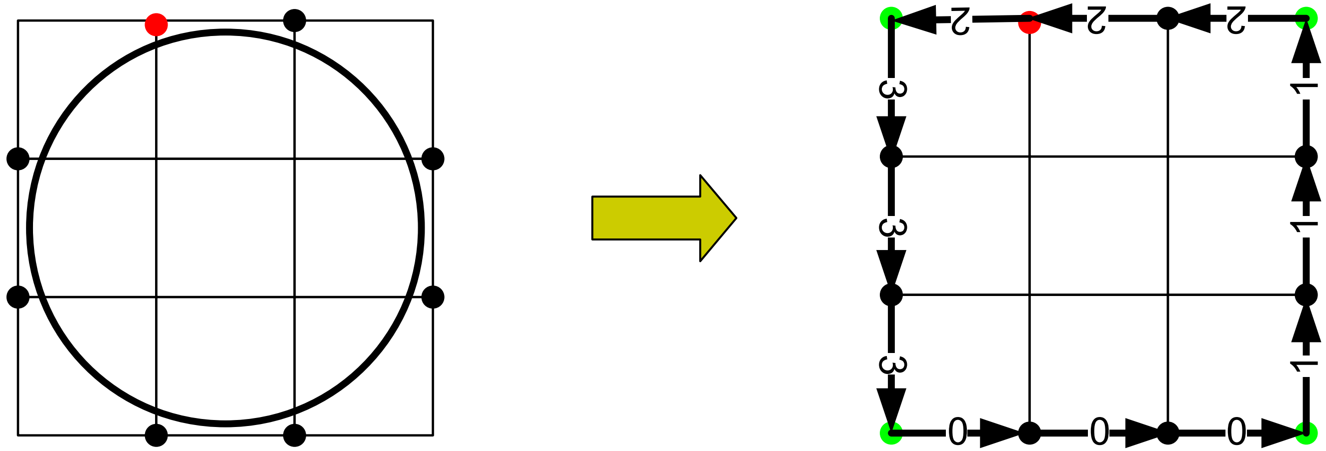
- Steps to solve question 3
  1. Digitize input boundary
     - Straightforward since the sampling grid and distance threshold are given as the rectangular grid and the dotted circles



Tutorial – Question 3

- Steps to solve question 3
  2. Boundary following is a bit more complex for 4-connectivity (starting point given as the red point, direction given as counter clockwise)

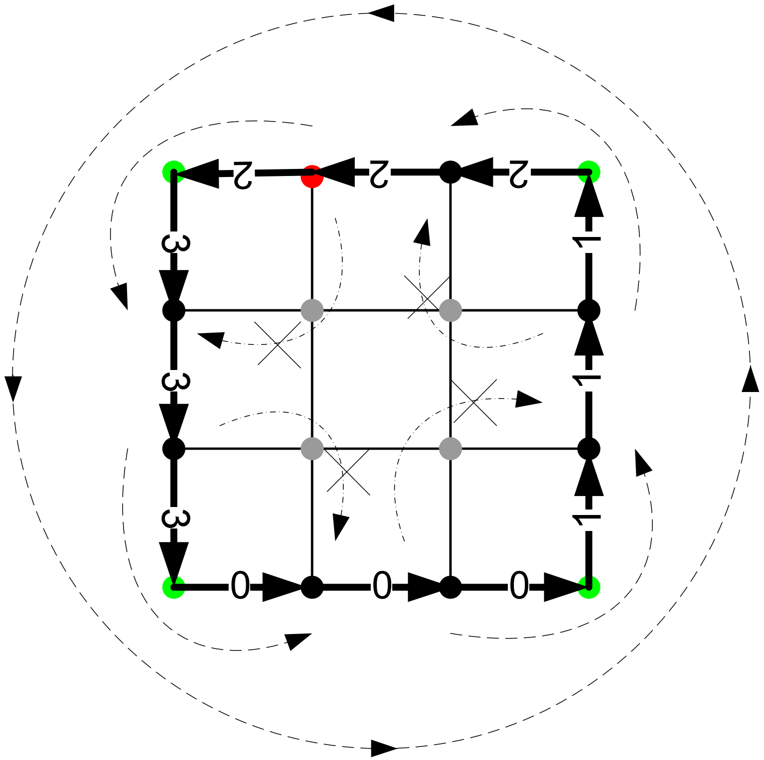
     Some ancillary boundary points have to be added



The chain code is 233300011122

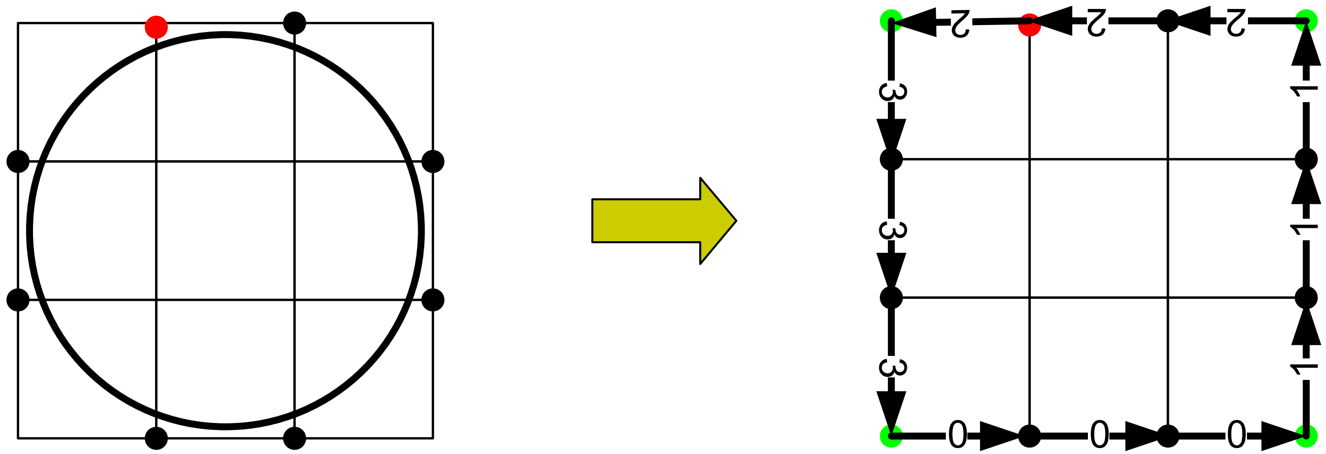
Tutorial – Question 3

- Steps to solve question 3
  - The adding of ancillary points should be consistent with the direction of boundary following



Tutorial – Question 3

- Steps to solve question 3
  2. Normalize for rotation by using the first difference of the 4-direction chain code
     - The difference is obtained by counting the number of direction changes that separate two adjacent elements of the code.



The chain code is 233300011122

The first difference of the chain code is 10010010010