CS GY 6643 - Computer Vision, Spring 2024 **Guido Gerig**

Homework 1: Pencil and Paper, should take about 1.5 hrs.

Out: 02/12/2024
Due: 02/19/2024

Late submissions: Late submissions result in 10% deduction for each day. The assignment will no longer be accepted 3 days after the deadline.

Office hours:

		Mon	Tue	Wed	Thur	Fri
Guido Gerig	gerig@nyu.edu				2-3pm (ZOOM)	
Pragnavi Ravuluri Sai	pr2370@nyu.edu					8am – 10am EST
Sai Rajeev Koppuravuri	rk4305@nyu.edu			12.00-13.00 EST		

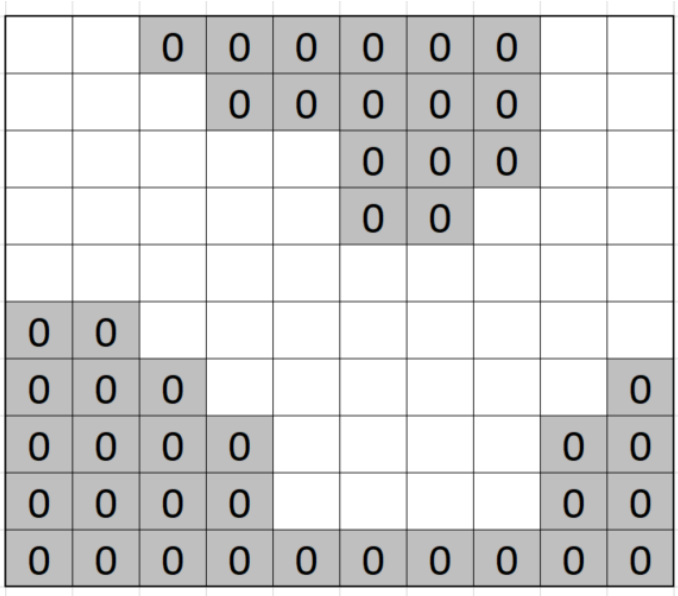
Please remember that we also use campuswire for communication on homeworks.

Please submit a **pdf document** where you combine the questions with your answers. You can use pencil&paper for handwritten answers or some other tools for graphing of plots or lists, then scan all pages with an app such as CamScanner or similar, and finally combine into a single pdf document. Please make sure that your answers are well readable for our grading (contrast, hand-writing, etc.).

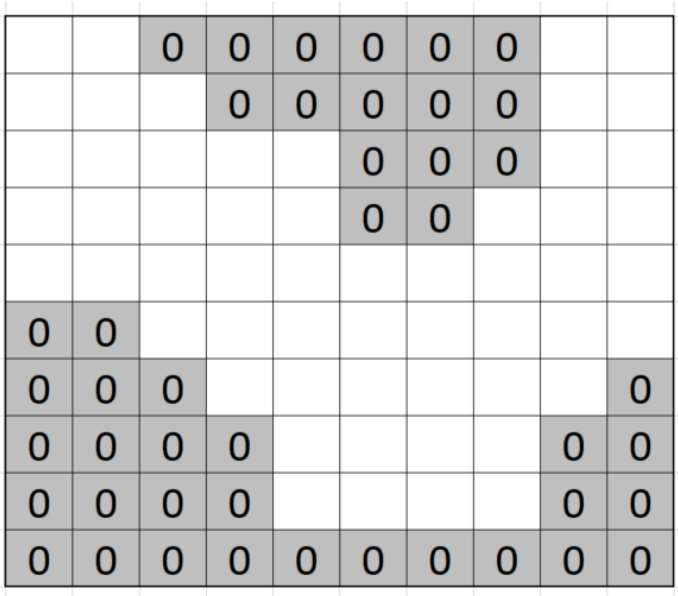
This is a project to be solved by **each student individually**. Solutions and reports that may indicate copying materials from other students or from web resources are considered plagiarism and subject to violation of the honor code.

1. Distance Transform for path planning: Distance transforms are used for path planning in robotics, for example. The following figure shows a typical example. Given the 10x10 pixel grid and the boundary regions marked as shaded “0”s, we try to find the best pixel path (pixel line) from upper left to upper right that is as far away as possible from the “0” regions to allow a safe passage.

1a) Use $\mathbf{d_4}$ and $\mathbf{d_8}$ metrics to generate a distance transform for the 10x10 grid to quantify the distances to the nearest boundaries, here marked as shaded “0”s. Please note that a pixel may see several boundaries, so that with several possibilities we choose the smallest value which identifies the distance to the closest boundary. Draw your distance values into the grids shown below, or draw the grid on paper and fill in the values.



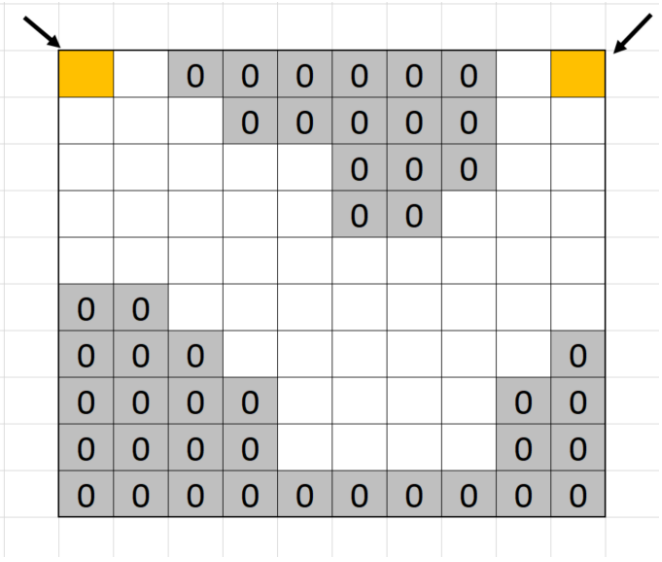
d_4



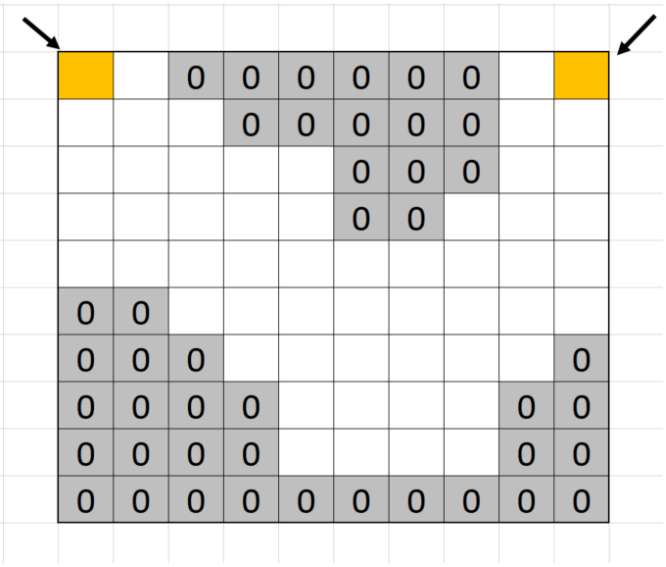
d_8

1b) Describe your strategy/algorithm to obtain these results (just briefly):

1c) Given your distance transforms as solved in a (copy them over to here and then draw a thin pixel path between upper left and upper right), select a pixel path between lower right and upper left that is most distant from the two boundary regions. Please note that for thin pixel lines, we can use the d_8 distance metric where the path can be a combination of corner and also edge neighbors. Please also note that your path **is not unique** as there may be multiple equally good solutions, but a general strategy would be to select the shortest path. Mark your selected pixel path in your distance transform results copied over from above.



d_4



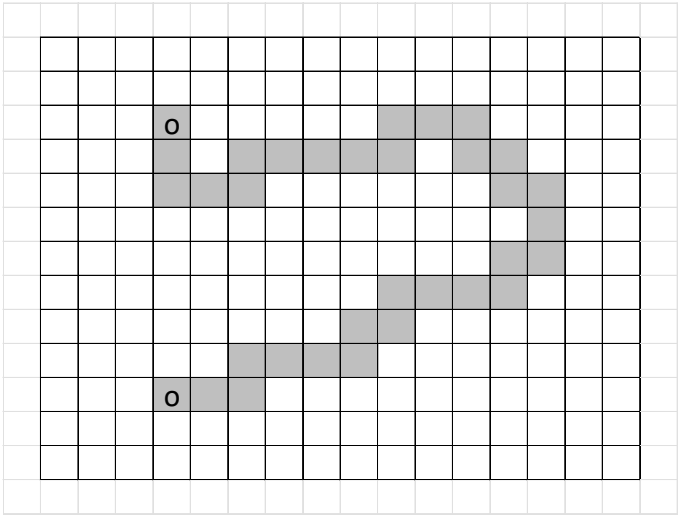
d_8

Observation, which metric would you prefer to find a path, and why?:

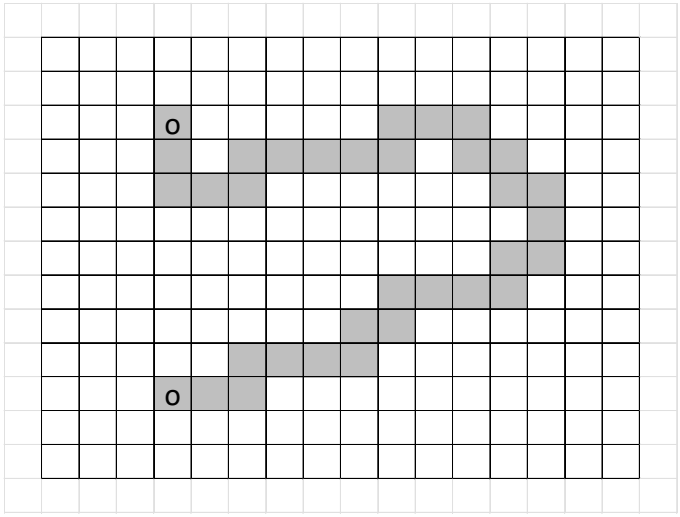
2 Length of a discrete curve: We have discussed that the pixel grid brings challenges to measurements of distances and lengths, requiring us to use pre-defined grid connectivity and distance options. Given the following discrete pixel curve, calculate the length of the curve based on the metric used to describe the pixel-by-pixel moves from end to end. Choose the shortest path which you can find, which means to use "short-cuts" whenever you see possible.

2.1: How long is the curve if you can only use D_4 connections, i.e. only vertical and horizontal directions? Please note that pixel by pixel-by-pixel distances are defined in the metric of the distance definitions, which means that one move counts as "1". . Draw your moves into the graph to backup your result.

2.2: How long is the curve if you can use D_8 connections? Draw your moves into the graph to back up your result.



a) D_4 connections



b) D_8 connections

2.3: How long is the curve if you can use D_8 connections but then count diagonal moves with length of $\sqrt{2}$ rather than "1"?

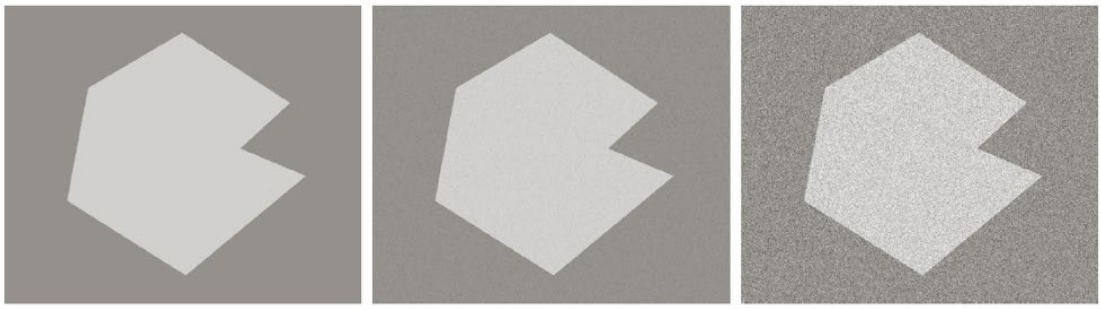
1.2.3: Brief discussion of the three results: Would you have the three choices as above, which one would you prefer if you wanted to get a result which comes close to the real length of the curve before pixelation?

3) Histograms

3a) Effect of noise on histograms

Sketch the histograms for the following 3 images corrupted by different noise levels.

Images



No noise With noise More noise

3b) Effect on illumination inhomogeneities on histograms

Sketch the histograms of the following images where the original, low-noise image is corrupted by a multiplicative inhomogeneity (here left to right change of intensity as shown in the middle image.

Images

f x g = h

Original image Illumination image Final image

3c) Describe how noise in 3a and illumination in 3b may affect segmentation by simple image thresholding/binarization.

4: 1D image filtering

Given the following 1-D filter and 1-D pixel image:

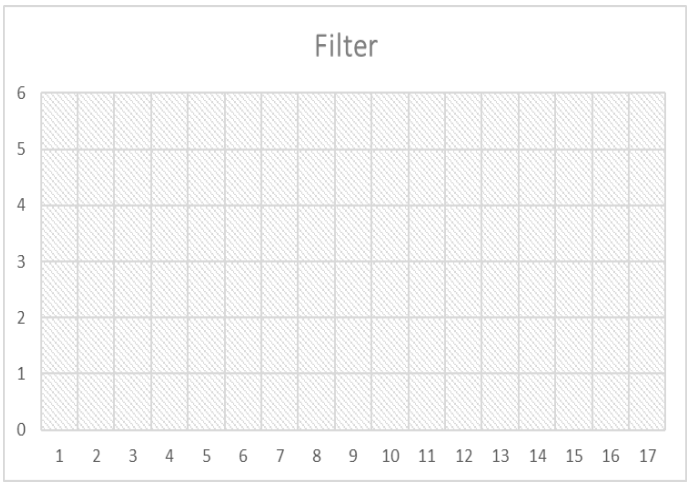
4.1 Apply a 3pixel average box filter and add the resulting values into the empty boxes below.

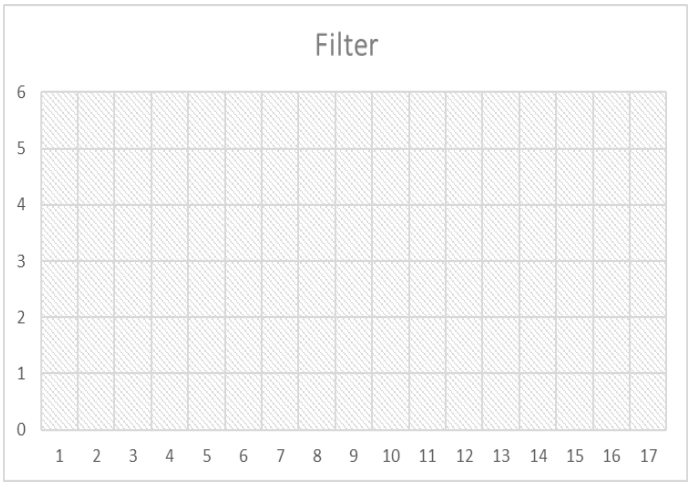
(1/3)	1	1	1

Box Filter

Image Signal																		
0	1	1	1	5	1	1	1	5	5	5	5	5	4	3	2	1	1	0
Filtered Signal																		

4.2 Plot the original image signal into the left graph, and the filtered signal into the right one. The horizontal axis is the pixel location, and the vertical axis the intensity value.





4.3 Briefly discuss the result after linear filtering when comparing the two plots.