The Distance Transform

ROB 102: Introduction to AI & Programming

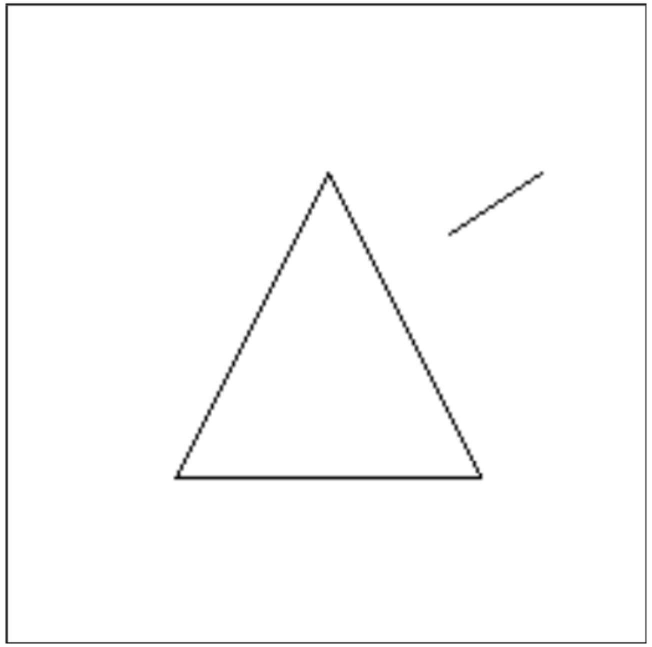
2021/10/13

Today

1. Summary
   - What is a distance transform?
2. Group activity
   - Manhattan & Euclidean distance transform by hand
3. C++ activity
   - 1D distance transform
   - 2D Manhattan distance transform

Summary: Distance Transform

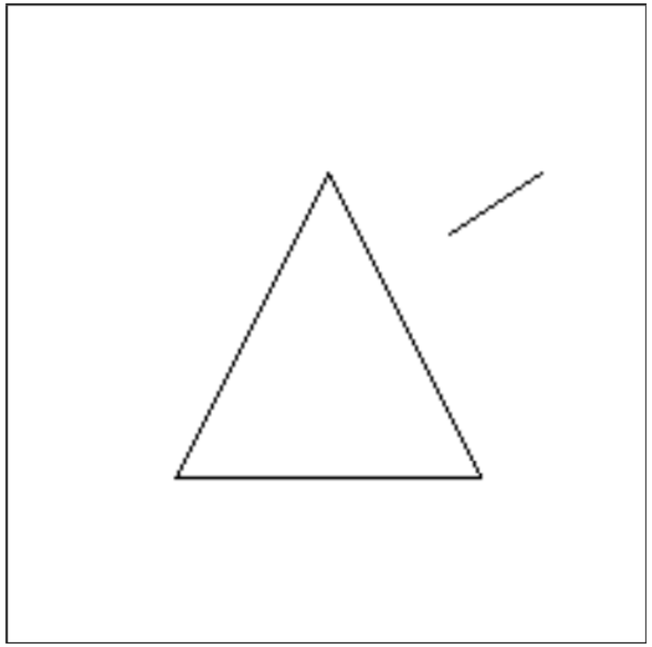
What is a distance transform?



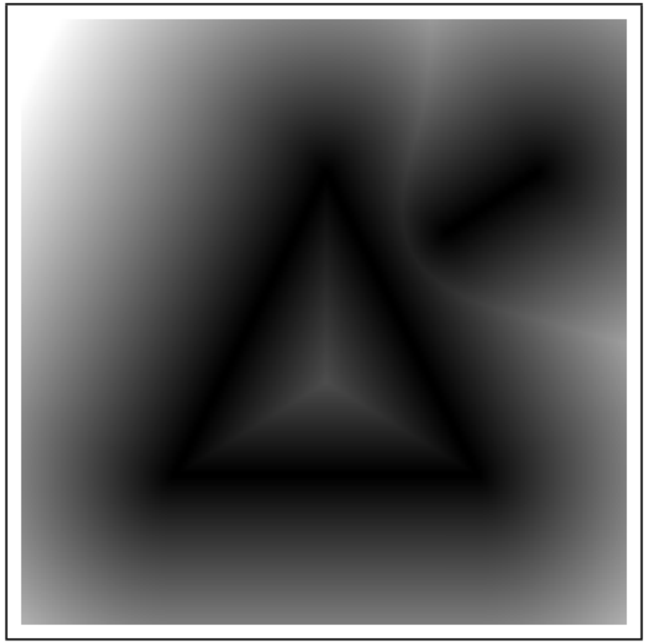
A binary image or map, where
each value is either 0 or 1.

Summary: Distance Transform

What is a distance transform?

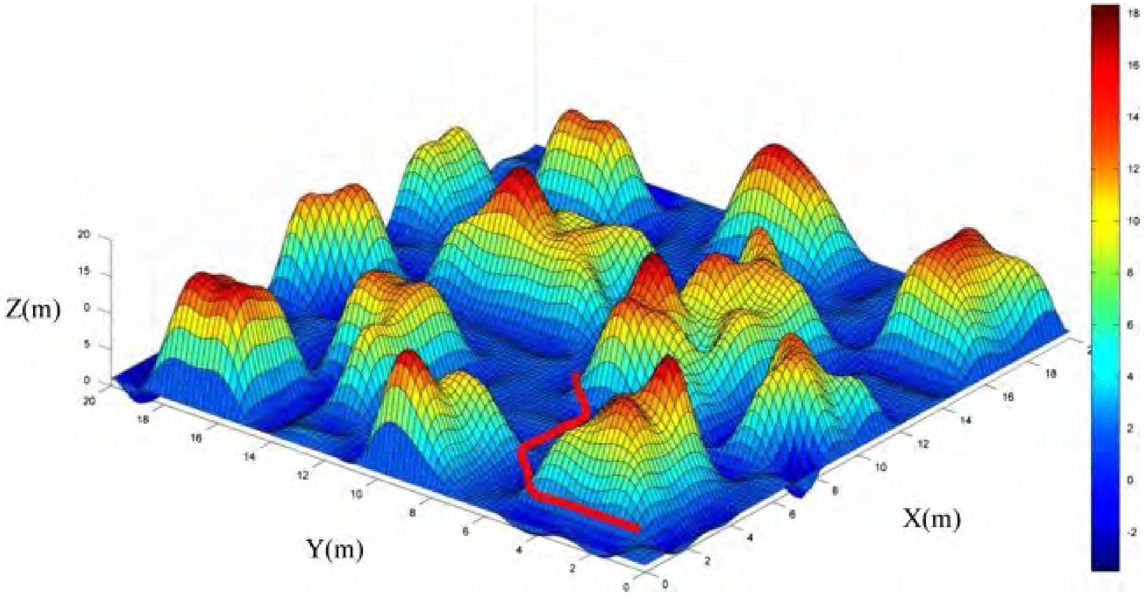


A binary image or map, where each value is either 0 or 1.



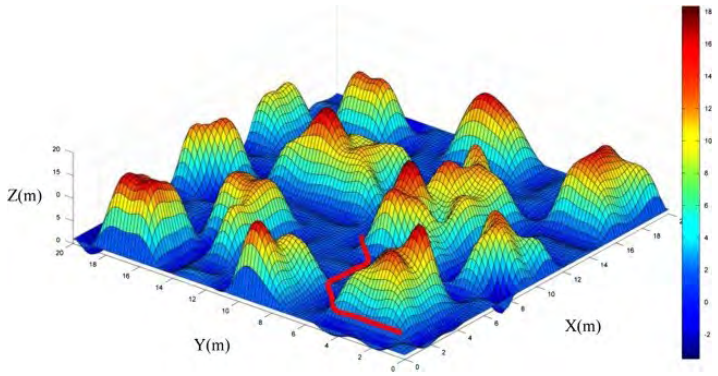
The distance transform gives the distance to the nearest occupied cell at each cell.

Distance Transform Applications



Obstacle avoidance for robot navigation (link)

Distance Transform Applications



Obstacle avoidance for robot navigation (link)

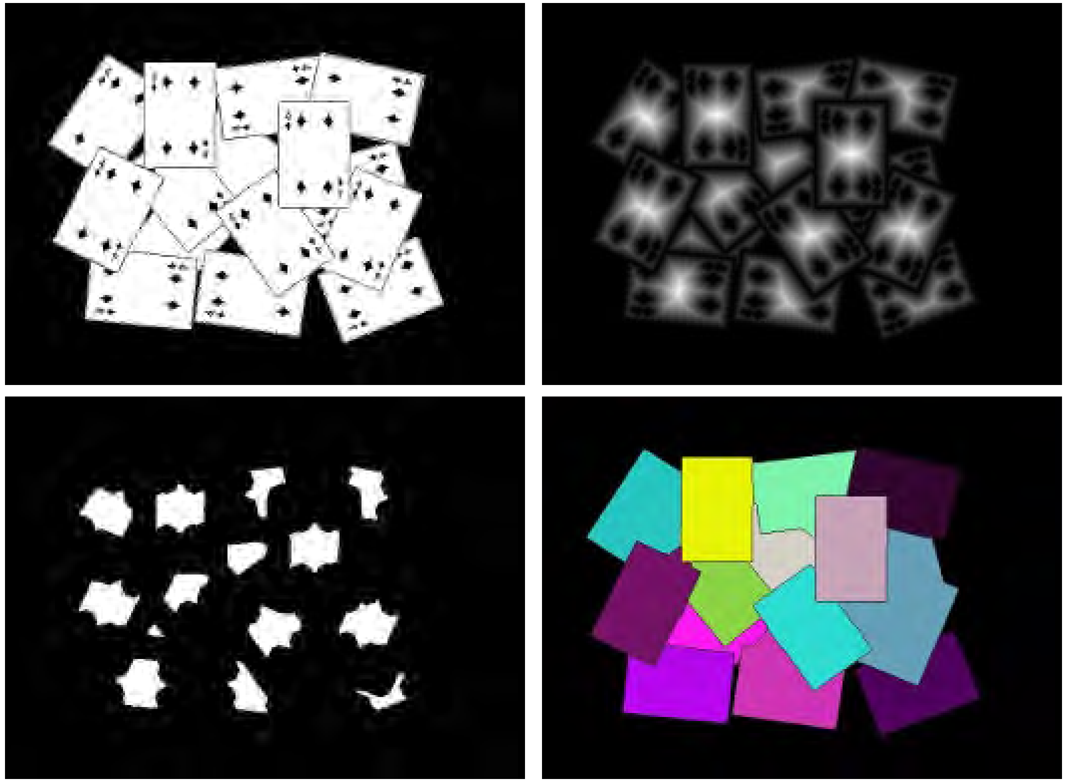
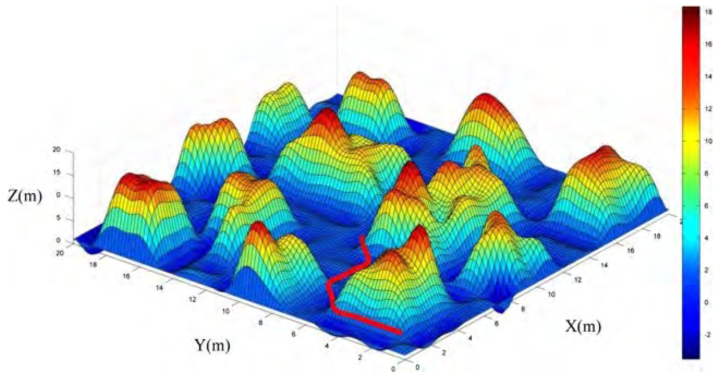


Image segmentation (link)

Distance Transform Applications



Obstacle avoidance for robot navigation ([link]())

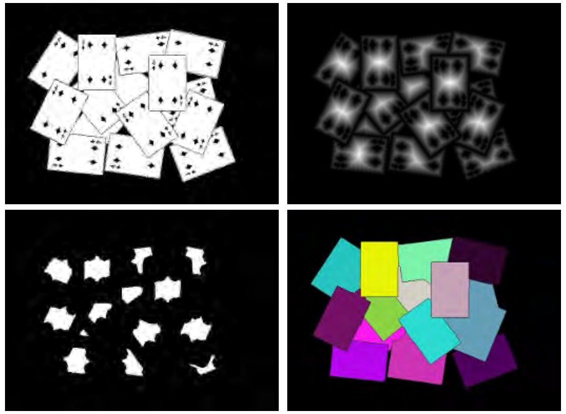
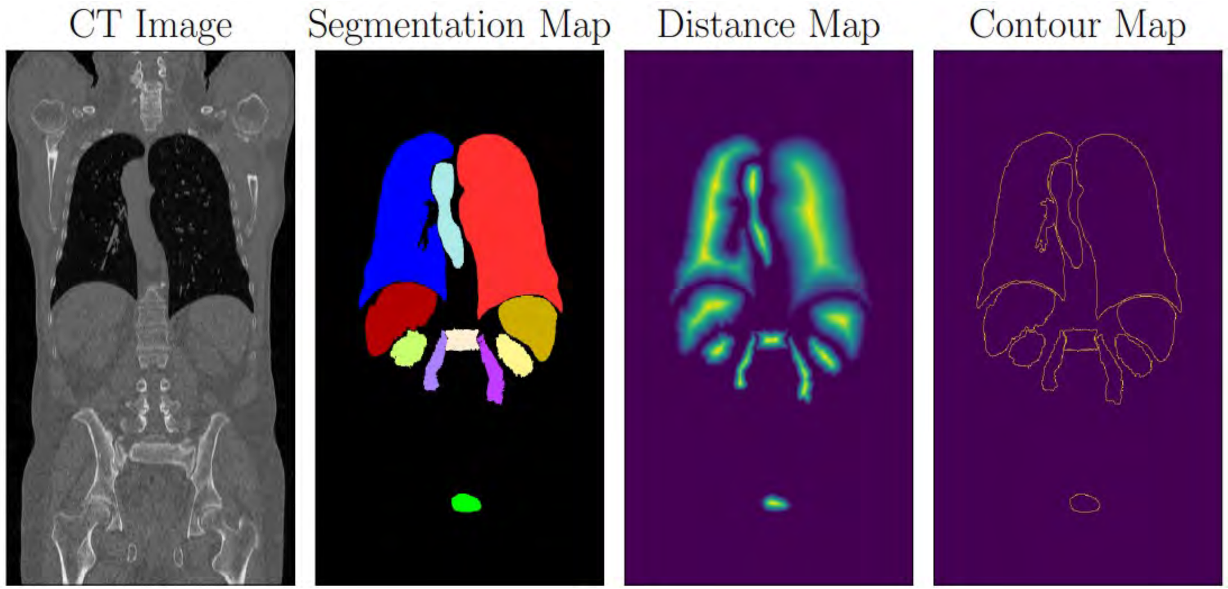
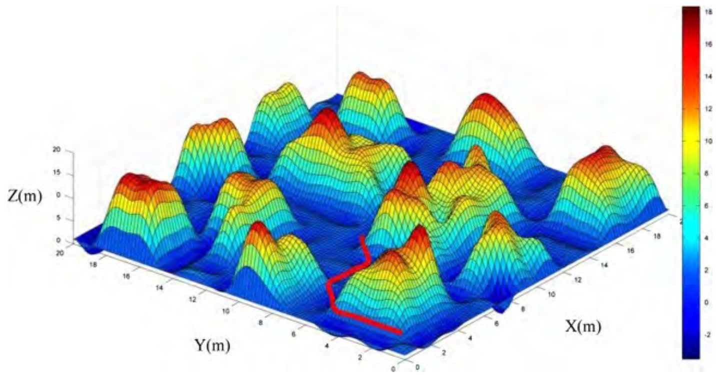


Image segmentation ([link]())

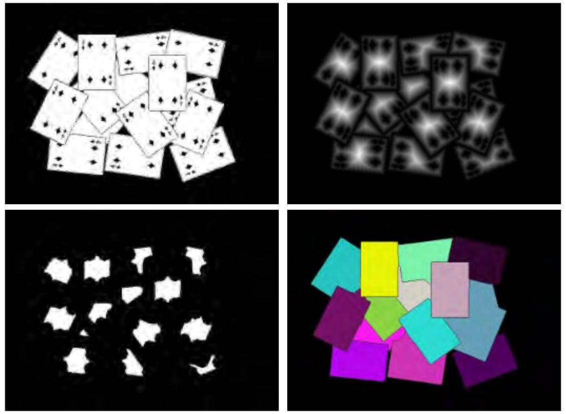


Deep Learning for medical imaging ([link]())

Distance Transform Applications



Obstacle avoidance for robot navigation (link)



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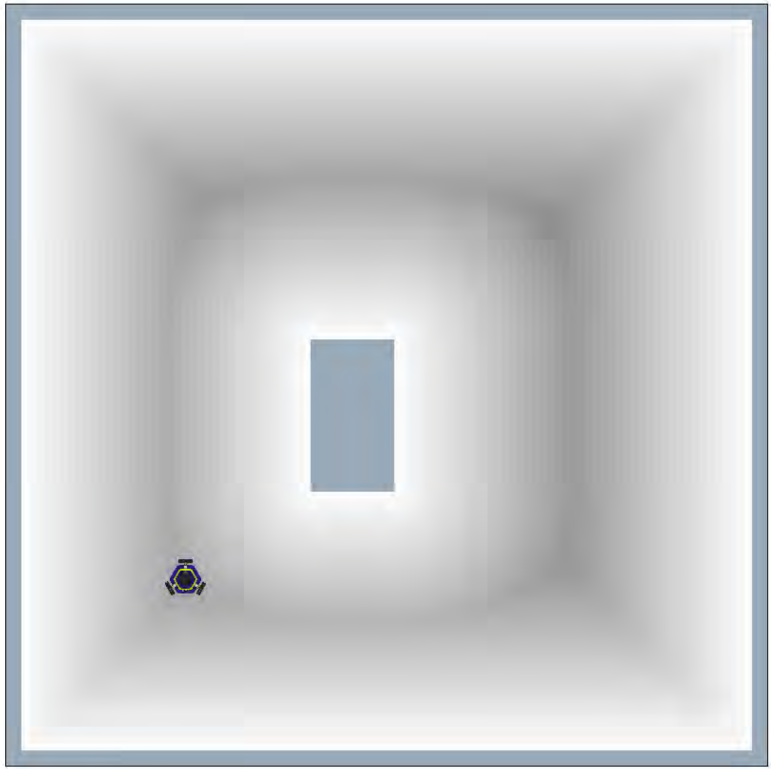
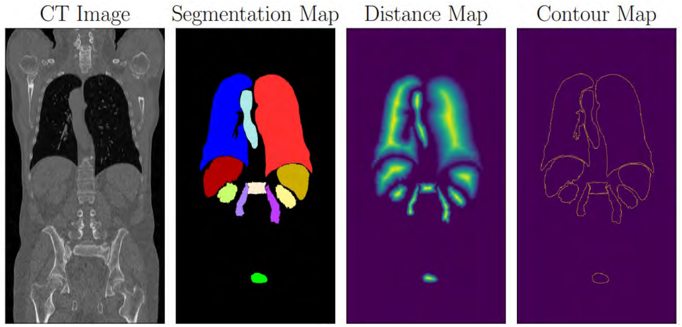




Deep Learning for medical imaging (link)

ROB 102: The distance transform can help us build the repulsion potential to perform autonomous navigation.

Distance Functions

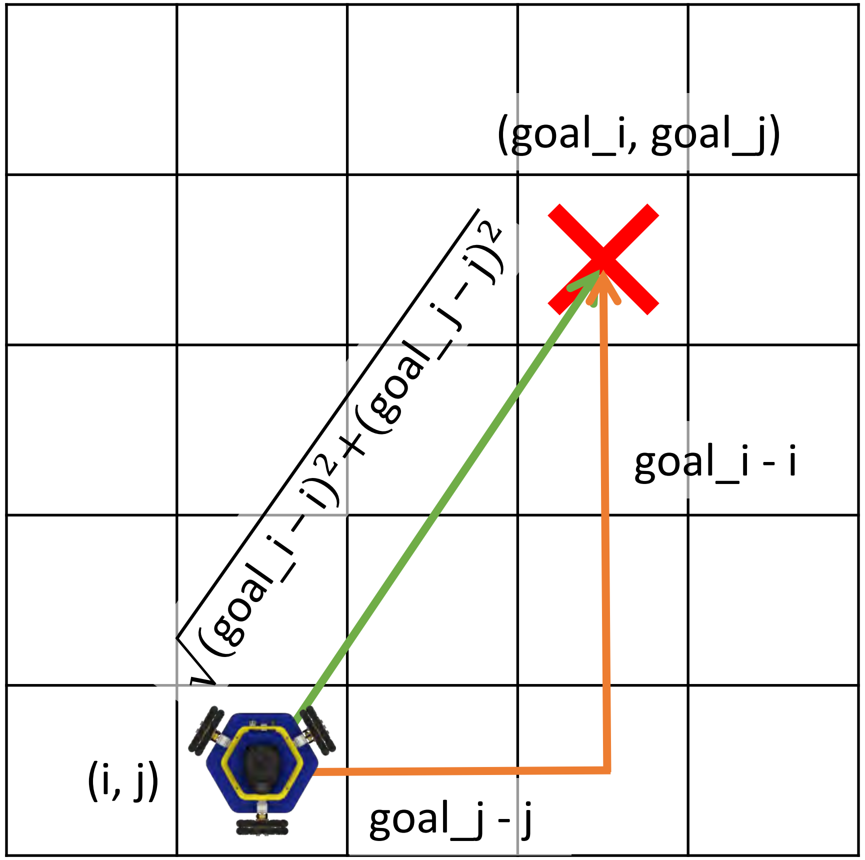
In lecture, we saw two distance functions.

Euclidean:

$$\text{dist} = \sqrt{(\text{goal\_i} - \text{i})^2 + (\text{goal\_j} - \text{j})^2}$$

Manhattan:

$$\text{dist} = |\text{goal\_i} - \text{i}| + |\text{goal\_j} - \text{j}|$$



The name “Manhattan distance” comes from the grid layout of city blocks in Manhattan. The shortest path from one location to another requires walking along the grid.

Distance Functions

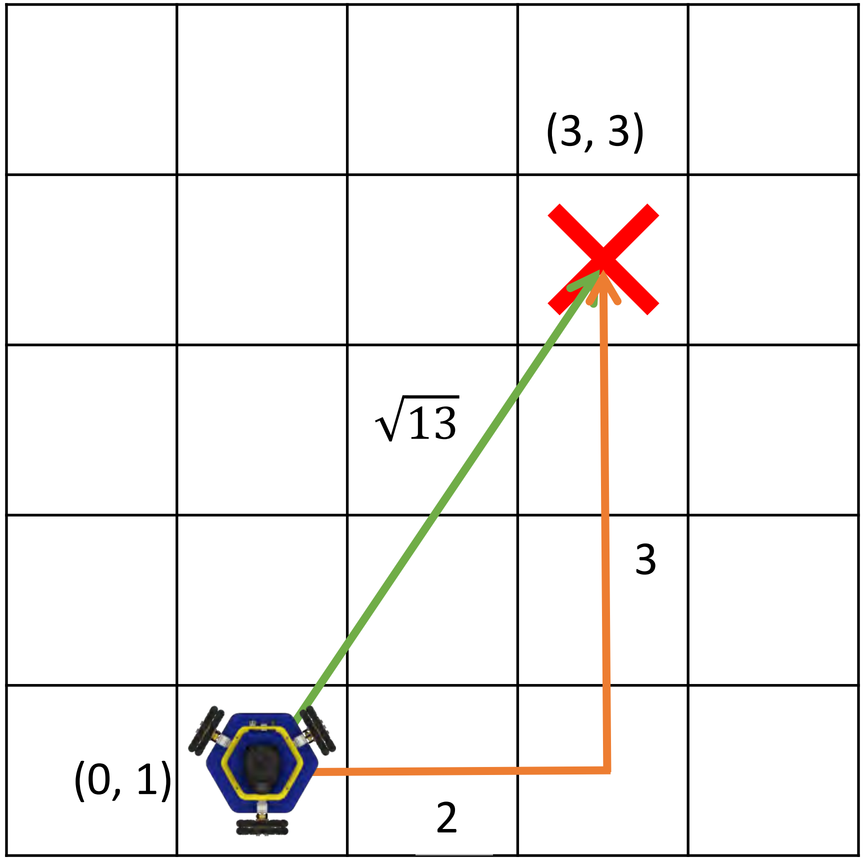
In lecture, we saw two distance functions.

Euclidean:

$$\text{dist} = \sqrt{(3-0)^2 + (3-1)^2}$$
$$= \sqrt{(3)^2 + (2)^2} = \sqrt{13}$$

Manhattan:

$$\text{dist} = |3-0| + |3-1|$$
$$= |3| + |2| = 5$$



Class Activity: 1D Distance Transform

What is the distance transform of this 1D map?

0	1	0	1	0	0	0	1	0

	0		0				0	

These cells are occupied, so their distance to the nearest occupied cell is zero

Class Activity: 1D Distance Transform

What is the distance transform of this 1D map?

0	1	0	1	0	0	0	1	0

1	0		0				0	

One cell away from
an occupied cell

Class Activity: 1D Distance Transform

What is the distance transform of this 1D map?

0	1	0	1	0	0	0	1	0

1	0	1	0				0	

One cell away from
an occupied cell

Class Activity: 1D Distance Transform

What is the distance transform of this 1D map?

0	1	0	1	0	0	0	1	0

1	0	1	0	1		1	0	1

One cell away from
an occupied cell

Class Activity: 1D Distance Transform

What is the distance transform of this 1D map?

0	1	0	1	0	0	0	1	0

1	0	1	0	1	2	1	0	1

Two cells away from
an occupied cell

Group Activity: 2D Distance Transform

Find the Euclidean and Manhattan distance transform for this binary map:

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

Group Activity: 2D Distance Transform

Find the Euclidean and Manhattan distance transform for this binary map:

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

$\sqrt{2}$	1	1	$\sqrt{2}$	$\sqrt{5}$
1	0	0	1	2
1	0	1	1	$\sqrt{2}$
$\sqrt{2}$	1	1	0	1
$\sqrt{5}$	2	$\sqrt{2}$	1	$\sqrt{2}$

Euclidean Distance Transform

Group Activity: 2D Distance Transform

Find the Euclidean and Manhattan distance transform for this binary map:

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

$\sqrt{2}$	1	1	$\sqrt{2}$	$\sqrt{5}$
1	0	0	1	2
1	0	1	1	$\sqrt{2}$
$\sqrt{2}$	1	1	0	1
$\sqrt{5}$	2	$\sqrt{2}$	1	$\sqrt{2}$

Euclidean Distance Transform

2	1	1	2	3
1	0	0	1	2
1	0	1	1	2
2	1	1	0	1
3	2	2	1	2

Manhattan Distance Transform

Coding Activity: Manhattan Distance Transform in C++

1. Get the template code from the course website
   - Find it under the in-class activities section for today's class
   - You can compile and run the code on your computer or on repl.it
2. Complete the 1D distance transform function
3. Complete the 2D Manhattan distance transform function
   - Depending on your implementation, you might need the `cellToIdx()`or `idxToCell()` functions
4. Try different binary maps to test your functions