Brushfire Algorithm

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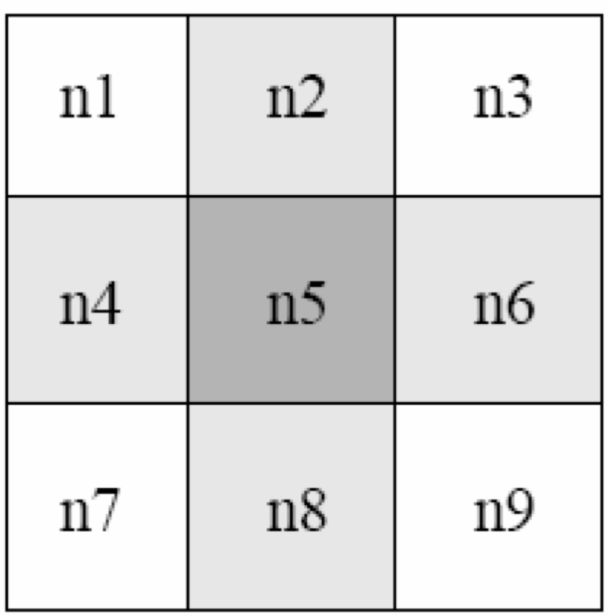
Brushfire Algorithm

- The Brushfire Algorithm uses a grid, a 2D array of cells or pixels, to compute approximate distances from obstacles, equivalent to a repulsive function.
- The result is a distance map where each cell holds the minimum distance to the nearest obstacle.
- These values can be used to compute a repulsive potential functions, as well as its gradient.
- The gradient of distance at a pixel is determined by finding a neighbor with the lowest pixel value.
- The gradient is then a vector which points to this neighbor. If multiple neighbors have the same value, then pick one to define the gradient.

Brushfire Algorithm

- A grid is a 2D discrete representation of space called "pixels":
  - "0" value if space is free of obstacles
  - "1" if space is completely or partially occupied by an obstacle
- Neighboring relationships between pixels can be:
  - "4" point connectivity
  - "8" point connectivity



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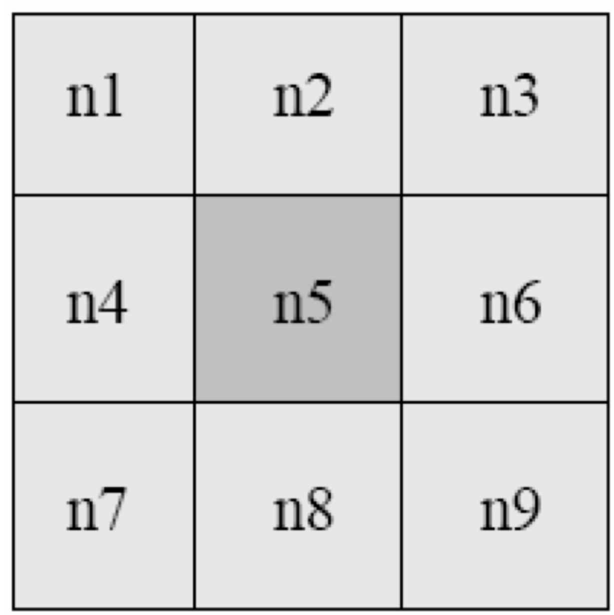

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Brushfire Algorithm

- Initially: set “1” to all pixels inside obstacles, and “0” to all pixels outside obstacles (free space)
- While there are still pixels with value of “0” and starting next to pixels of value “1”.
- All “0” value pixels adjacent to pixels with value “i” are set to “i+1” value using either 4 or 8 point connectivity.
- Solid lines in following graphs show lines passing through pixels whose front collide surrounding all obstacles.

Brushfire Algorithm (1)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the "collision front" lines corresponding to the maximum gradient repulsive fields between obstacles.

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

Brushfire Algorithm (2)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “collision front” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	0	0	2	2	2	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	2	1	1	1	2	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	2	1	1	1	2	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm (3)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles.

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

Brushfire Algorithm (4)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	4	4	4	4	4	4	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	0	0	0	0	0	4	3	2	1
1	2	3	3	2	1	2	3	2	2	2	2	2	3	4	0	0	0	0	0	4	3	2	1
1	2	3	3	2	1	2	3	3	3	3	3	3	3	4	0	0	0	0	0	4	3	2	1
1	2	3	3	2	1	2	3	4	4	4	4	4	4	4	0	0	0	0	0	4	3	2	1
1	2	3	3	2	1	2	3	4	0	0	0	0	0	0	0	0	0	0	0	4	3	2	1
1	2	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm (5)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	4	4	4	4	4	4	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	5	5	5	5	5	4	3	2	1
1	2	3	3	2	1	2	3	2	2	2	2	2	3	4	5	0	0	0	5	4	3	2	1
1	2	3	3	2	1	2	3	3	3	3	3	3	3	4	5	0	0	0	5	4	3	2	1
1	2	3	3	2	1	2	3	4	4	4	4	4	4	4	5	0	0	0	5	4	3	2	1
1	2	3	3	2	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	4	3	2	1
1	2	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm (6)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	4	4	4	4	4	4	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	5	5	5	5	5	4	3	2	1
1	2	3	3	2	1	2	3	2	2	2	2	2	3	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	3	3	3	3	3	3	4	5	6	0	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	4	4	4	4	4	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	4	3	2	1
1	2	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm (7)

Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	4	4	4	4	4	4	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	5	5	5	5	5	4	3	2	1
1	2	3	3	2	1	2	3	2	2	2	2	2	3	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	3	3	3	3	3	3	4	5	6	7	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	4	4	4	4	4	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	4	3	2	1
1	2	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm
Collision Front

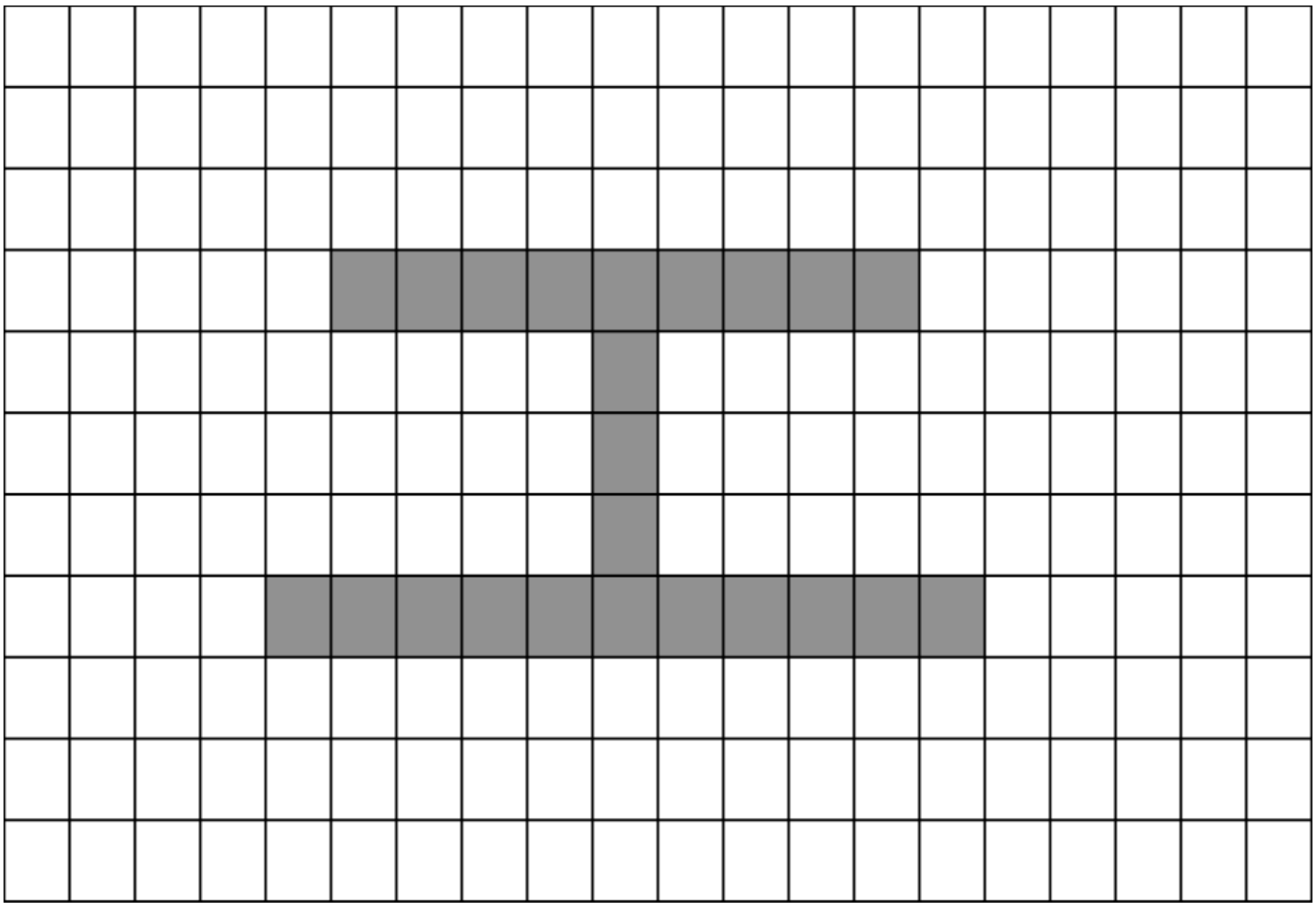
Apply the Brushfire algorithm to the scene below using 8-point connectivity where darker elements correspond to obstacles. Show the “collision front” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	1
1	2	3	3	2	1	2	3	2	1	1	1	2	3	4	4	4	4	4	4	4	3	2	1
1	2	3	3	2	1	2	3	2	1	1		2	3	4	5	5	5	5	5	4	3	2	1
1	2	3	3	2	1	2	3	2	2	2	2	2	3	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	3	3	3	3	3	3	4	5	6	7	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	4	4	4	4	4	4	5	6	6	6	5	4	3	2	1
1	2	3	3	2	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	4	3	2	1
1	2	3	3	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Brushfire Algorithm

Spring 2017

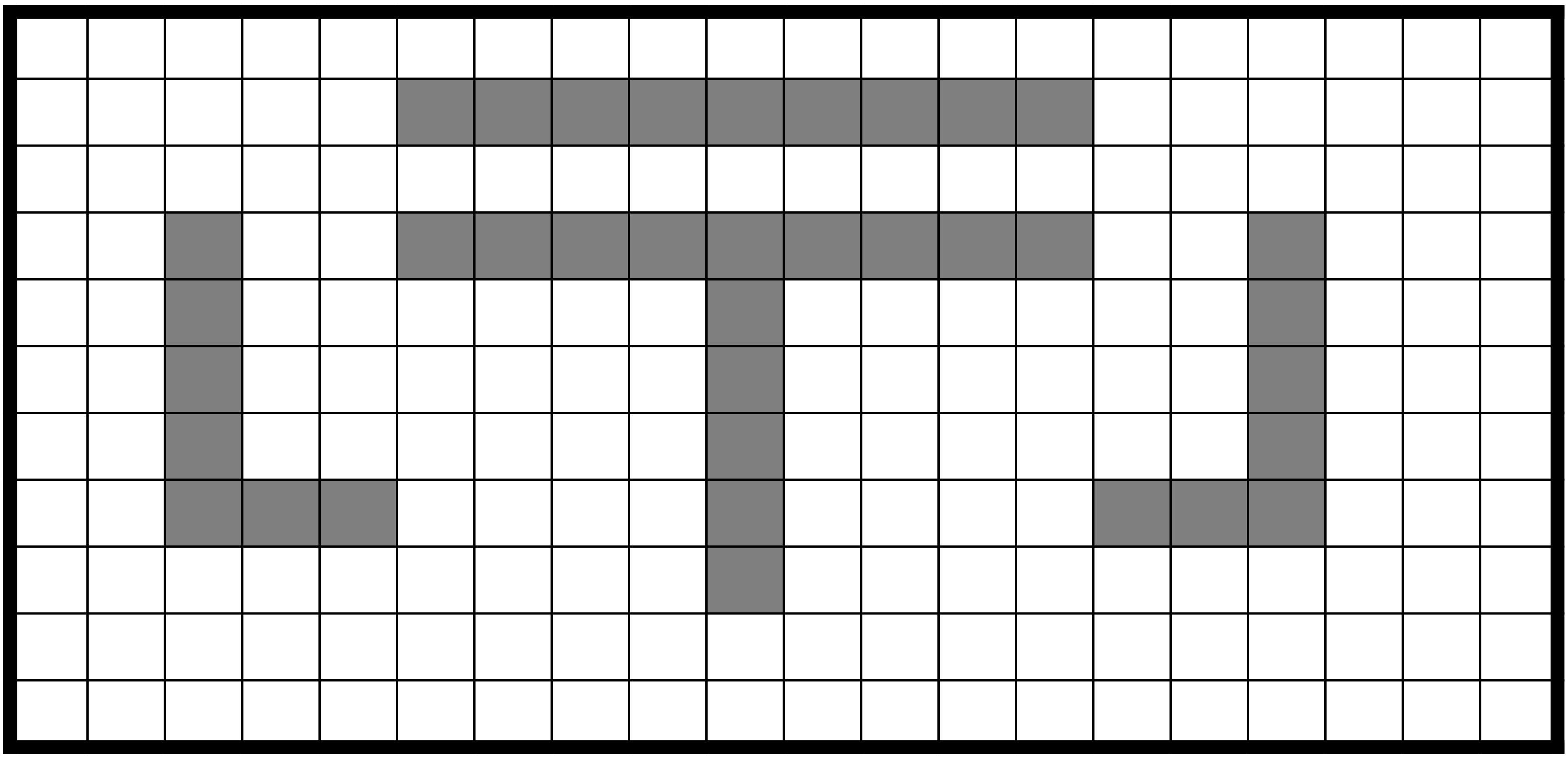
Apply the Brushfire algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.



Brushfire Algorithm

Fall 2017

Apply the Brushfire algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.



Brushfire Algorithm

Fall 2017

Apply the Brushfire algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.

2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	2
2	3	4	4	3	3	2										2	3	3	4	4	3	2
2	3	4	3	2	3	3	2	2	2	2	2	2	2	2	2	3	3	2	3	4	3	2
2	3	3	2		2	2										2	2		2	3	3	2
2	3	3	2		2	3	2	2	2	2		2	2	2	2	3	2		2	3	3	2
2	3	3	2		2	3	3	3	3	2		2	3	3	3	3	2		2	3	3	2
2	3	3	2		2	2	3	4	3	2		2	3	4	3	2	2		2	3	3	2
2	3	3	2				2	3	3	2		2	3	3	2				2	3	3	2
2	3	4	3	2	2	2	3	4	3	2		2	3	4	3	2	2	2	3	4	3	2
2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Brushfire Algorithm

Fall 2017

Apply the Brushfire algorithm to the scene below using 4-point connectivity where darker elements correspond to obstacles. Show the “front collision” lines corresponding to the maximum gradient repulsive fields between obstacles. Note the outside boundaries on the outside of the scene that may also be considered as obstacles.

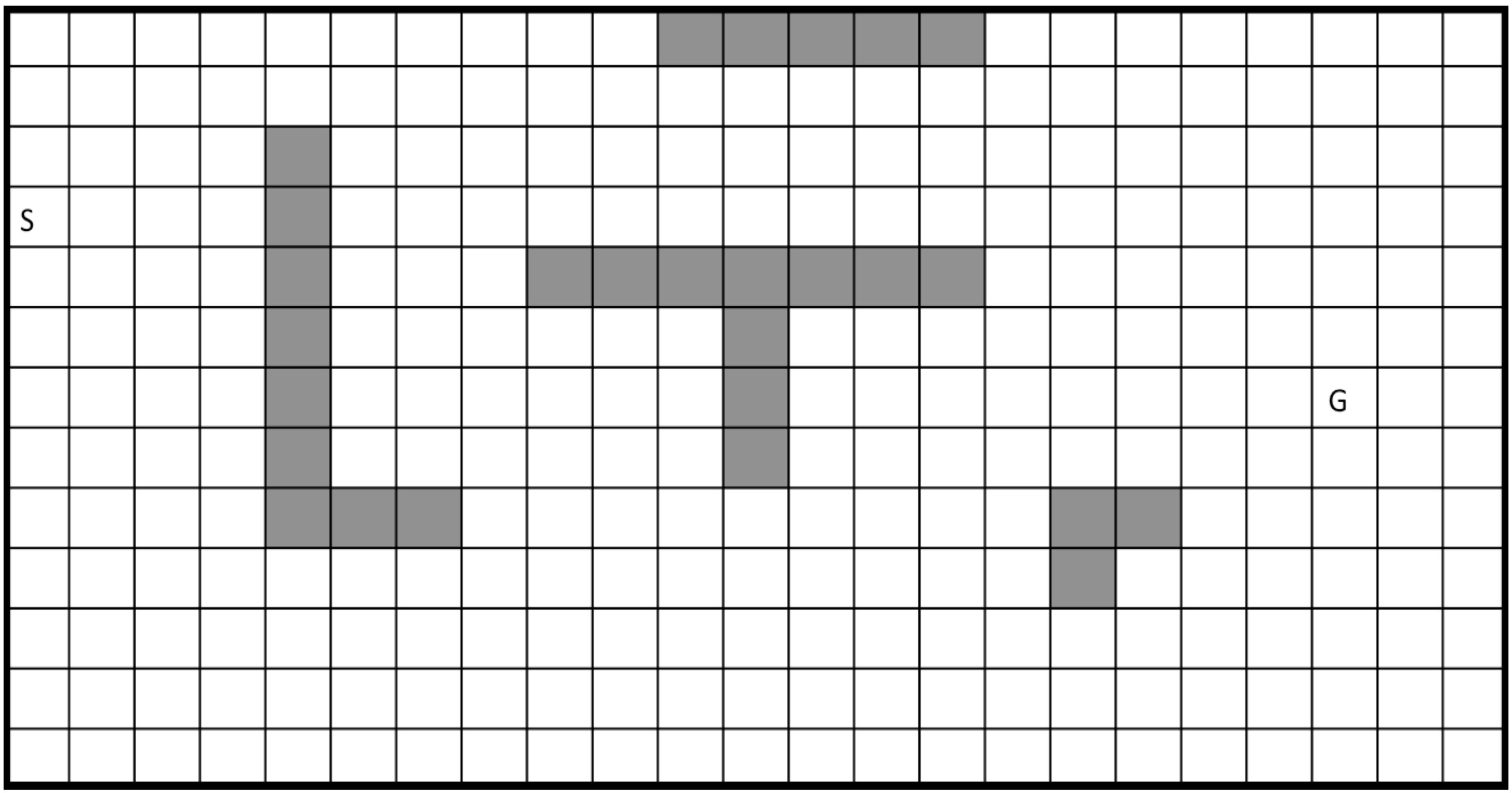
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	3	3	3	2										2	3	3	3	3	2
2	3	2	3	3	2	2	2	2		2	2	2	2	3	3	2	3	3	2
2	2		2	2										2	2		2	3	2
2	2		2	3	2	2	2	2		2	2	2	2	3	2		2	3	2
2	2		2	3	3	3	3	2		2	3	3	3	3	2		2	3	2
2	2		2	2	2	2	2	2		2	2	2	2	2	2		2	3	2
2	2																2	3	2
2	3	2	2	2	2	2	2	2		2	2	2	2	2	2	2	3	3	2
2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Brushfire Algorithm

Spring 2018

Apply the Brushfire algorithm to the scene below using <u>8-point</u> connectivity where darker elements correspond to obstacles.

1. Number ONLY the cells needed to find the "collision front". You may fill additional cells but it is not necessary to number all the cells in the graph.
2. Highlight the "collision front" lines corresponding to the maximum gradient repulsive fields between obstacles.



Brushfire Algorithm

Spring 2018

Apply the Brushfire algorithm to the scene below using <u>8-point</u> connectivity where darker elements correspond to obstacles.

1. Number ONLY the cells needed to find the “collision front”. You may fill additional cells but it is not necessary to number all the cells in the graph.
2. Highlight the “collision front” lines corresponding to the maximum gradient repulsive fields between obstacles.

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	2	3	2	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	1
1	2	3	2	1	2	3	2	2	2	2	2	2	2	2	2	3	4	4	4	3	2	1
1	2	3	2	1	2	3	2	1	1	1	1	1	1	1	2	3	4	5	4	3	2	1
1	2	3	2	1	2	3	2	2	2	2	1	2	2	2	2	3	4	4	4	3	2	1
1	2	3	2	1	2	3	3	3	3	2	1	2	3	3	3	3	3	3	3	3	2	1
1	2	3	2	1	2	2	2	3	3	2	1	2	3	3	2	2	2	2	3	3	2	1
1	2	3	2	1	1	1	2	3	3	2	2	2	3	3	2	1	1	2	3	3	2	1
1	2	3	2	2	2	2	2	3	3	3	3	3	3	3	2	1	2	2	3	3	2	1
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	3	3	2	1
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Summary

- The repulsive potential function can be computed using distance and gradient to the nearest obstacle.
- The attractive potential function can be computed analytically.
- Together, a planner can compute the additive attractive/repulsive function.