Topic 9

Potential fields:

Follow your potential

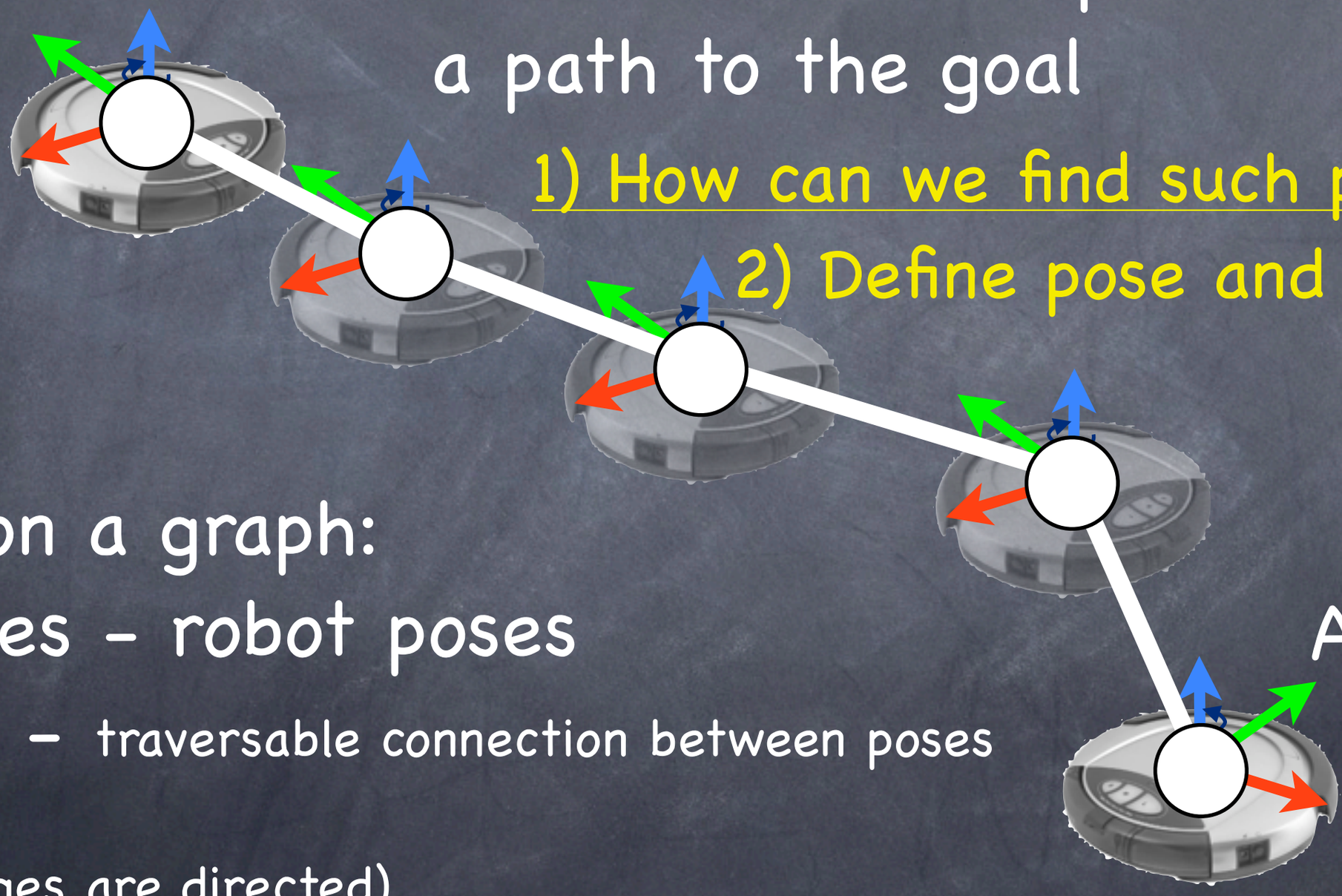
Path Planning

B: Goal

Find intermediate poses forming a path to the goal

1) How can we find such paths?

2) Define pose and controls?



A: Start

Path on a graph:

vertices - robot poses

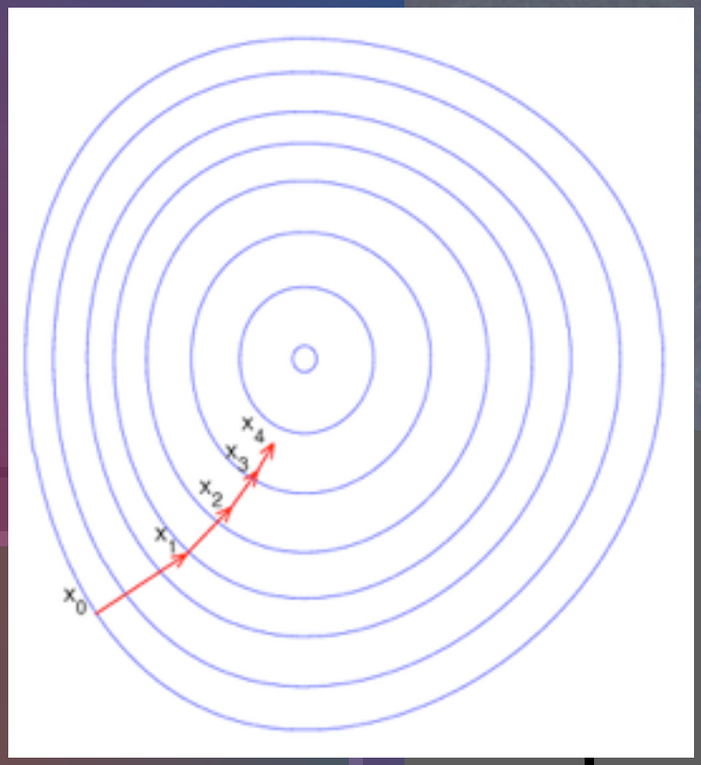
edges - traversable connection between poses

(note edges are directed)

Approaches to path planning

- Search (fixed graph)
  - DFS, BFS, Dijkstra, A*
- Search (build graph):
  - Probabilistic Road Maps
  - Rapidly-exploring Random Trees
- Optimization (local search):
  - Potential fields, gradient descent

Potential field



Energy potential converges at goal

volcanic

on fire

heating up

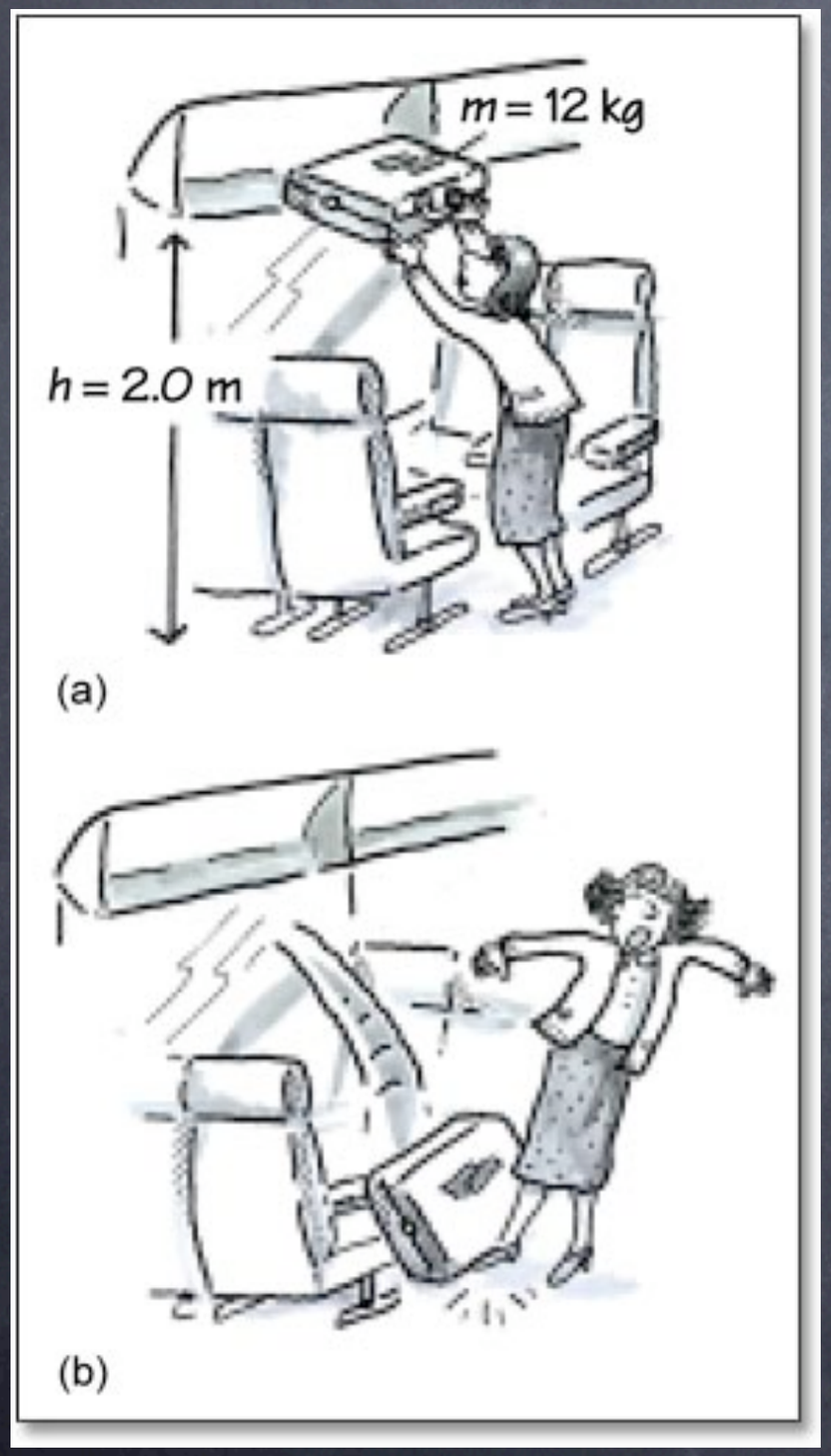
a little warmer

cold

colder

How do we define this potential?

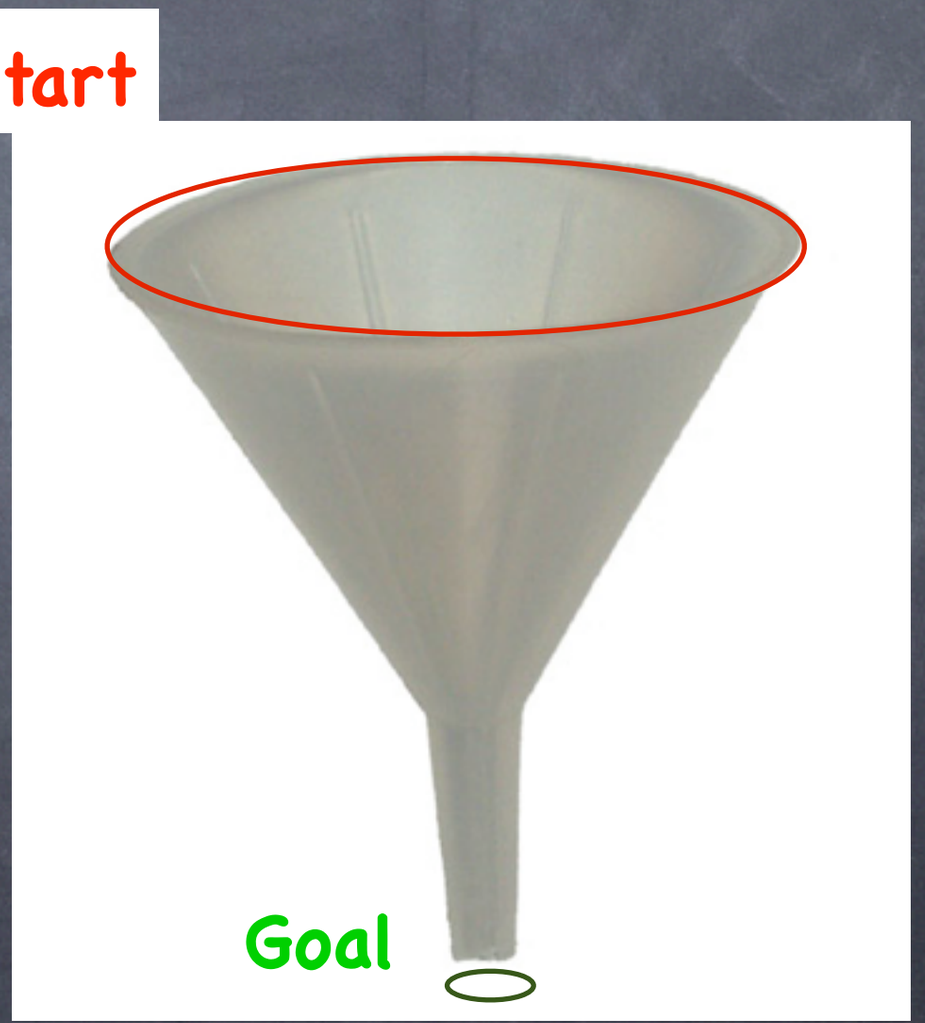
Potential Energy



- Energy stored in a physical system
- For objects acting only w.r.t. gravity
  - PE = mass*height*gravity

Convergent Potentials

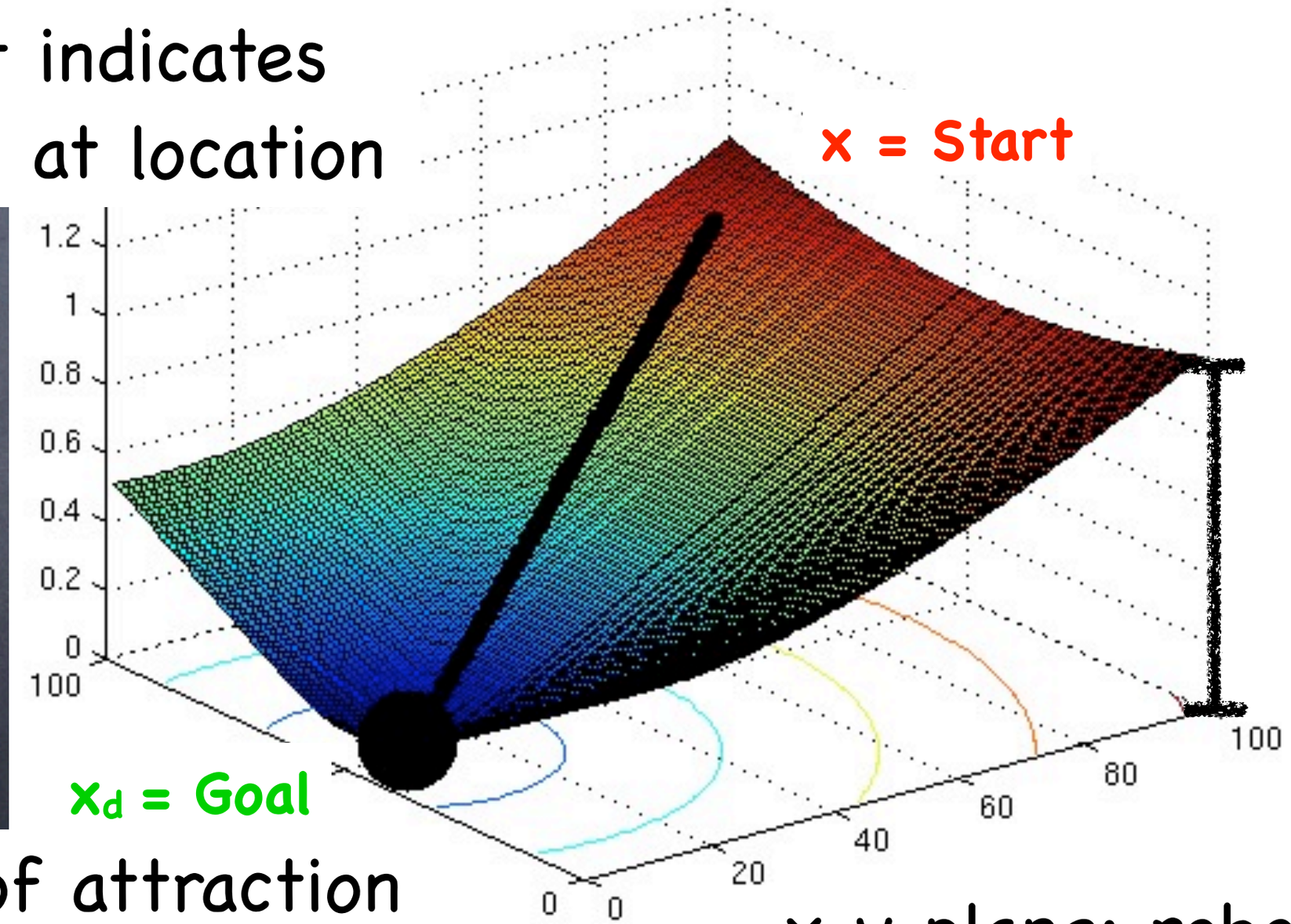
let's call these "attractor landscapes"



basin of attraction

2D potential navigation

z: height indicates potential at location



basin of attraction

x-y plane: robot position

"Cone" Attractor

x_d = Goal
"Attractor"

$u = w(x_d - x)/\|x_d - x\|$

x = Start

top view

w: weight
$(x_d - x)$: direction
$\|x_d - x\|$: distance

Start

Goal

side view

"Cone" Attractor

x_d = Goal
"Attractor"

$\|x_d - x\|$

$(x_d - x)$

$u = w(x_d - x)/\|x_d - x\|$

x = Start

top view

w: weight
$(x_d - x)$: direction
$\|x_d - x\|$: distance

Start

Goal

side view

"Cone" Attractor

x_d = Goal
"Attractor"

$\|x_d - x\|$

$(x_d - x)$

unit vector
$(x_d - x)/\|x_d - x\|$

$u = w(x_d - x)/\|x_d - x\|$

x = Start

top view

w: weight
$(x_d - x)$: direction
$\|x_d - x\|$: distance

Start

Goal

side view

"Cone" Attractor

x_d = Goal
"Attractor"

$\|x_d - x\|$

$(x_d - x)$

w

unit vector
$(x_d - x)/\|x_d - x\|$

$u = w(x_d - x)/\|x_d - x\|$

x = Start

top view

w: weight
$(x_d - x)$: direction
$\|x_d - x\|$: distance

Start

Goal

side view

"Bowl" Attractor

x_d = Goal

$u = \exp(-\|x_d - x\|/w)\ (x_d - x)$

x = Start

top view

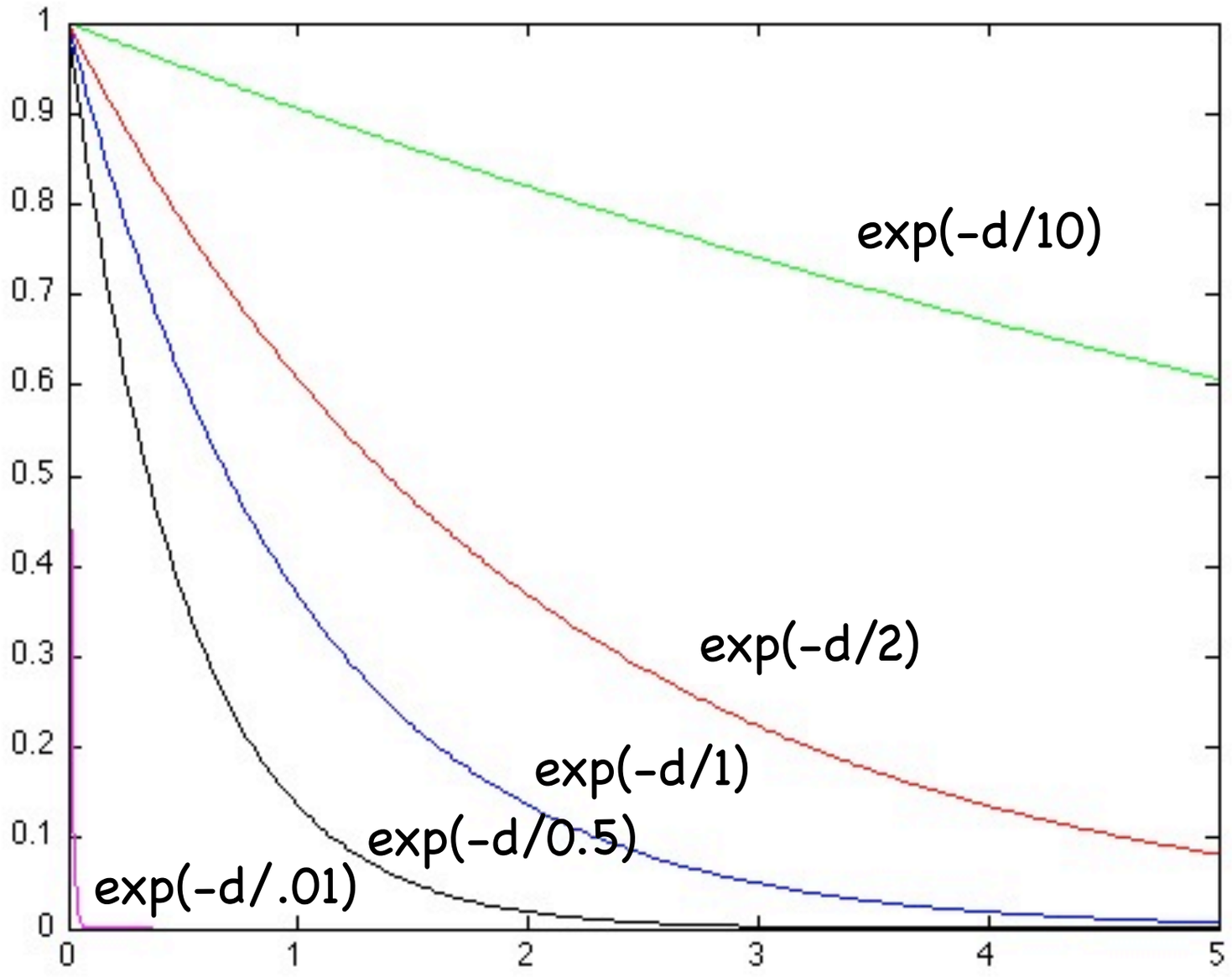
Start

Goal

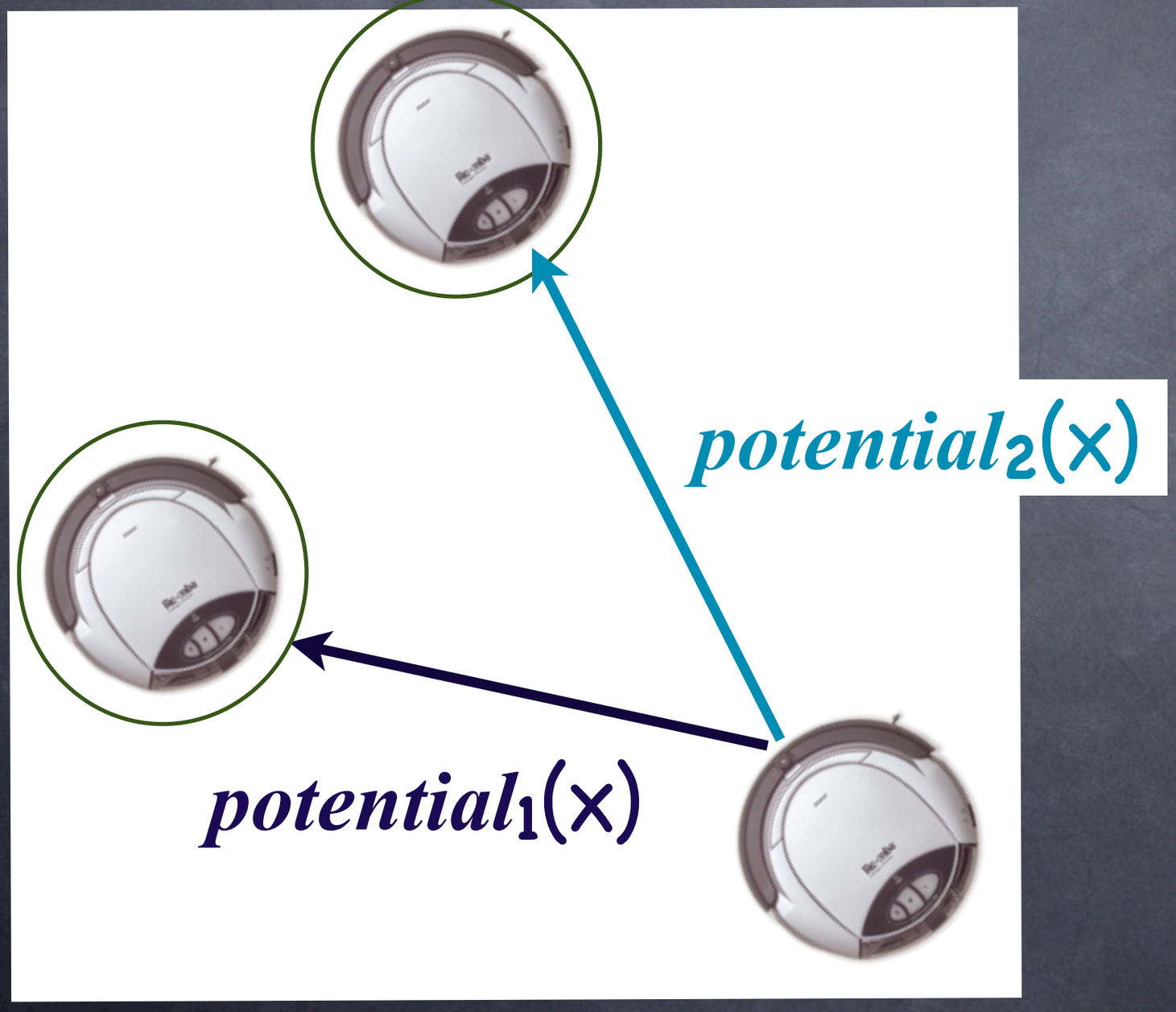
side view

exp(-d/w)

exp(-d/w) : influence of potential

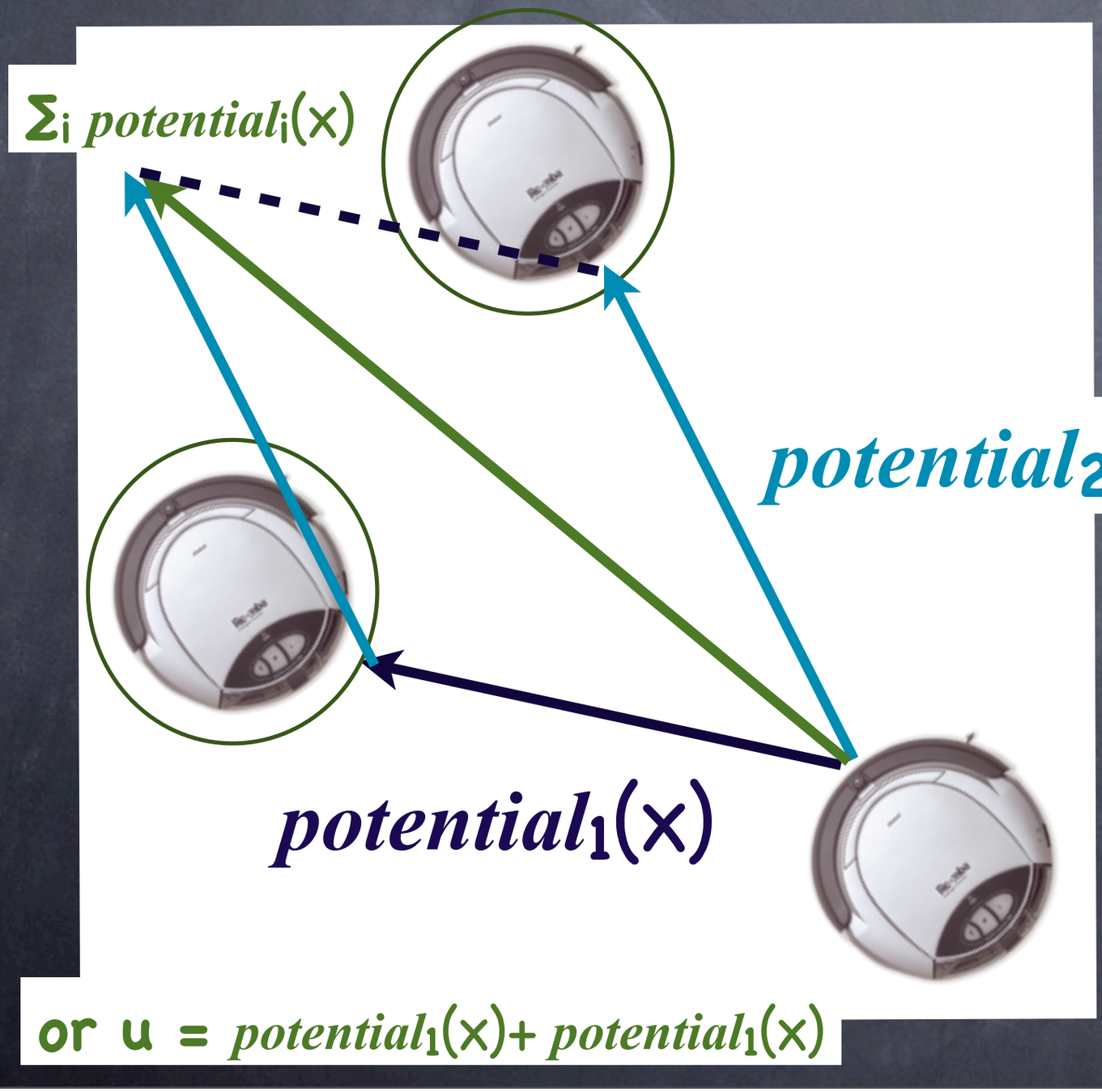


Multiple potentials



- Output of potential field is a vector
- How to combine or select between multiple potentials?

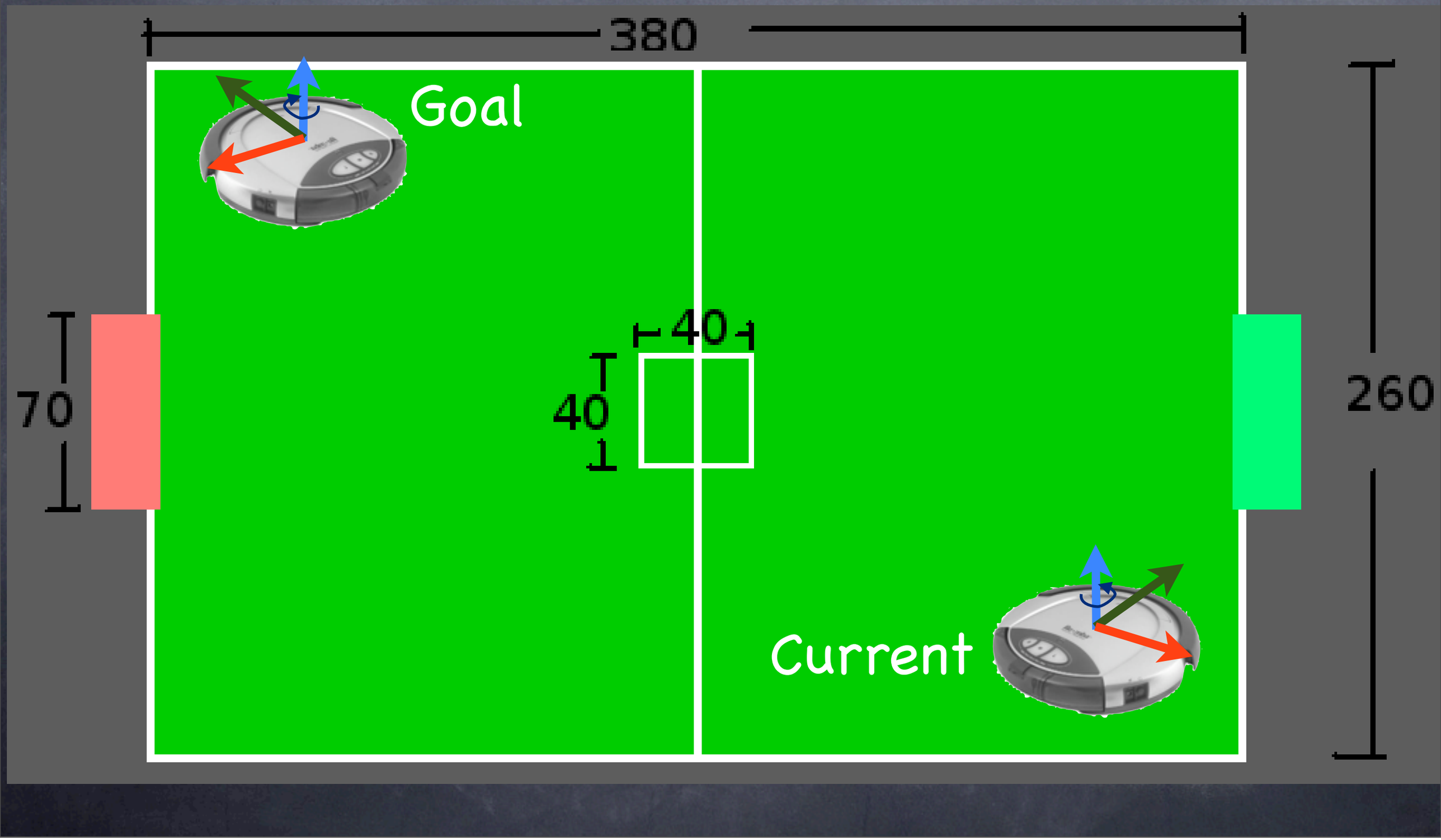
Multiple potentials



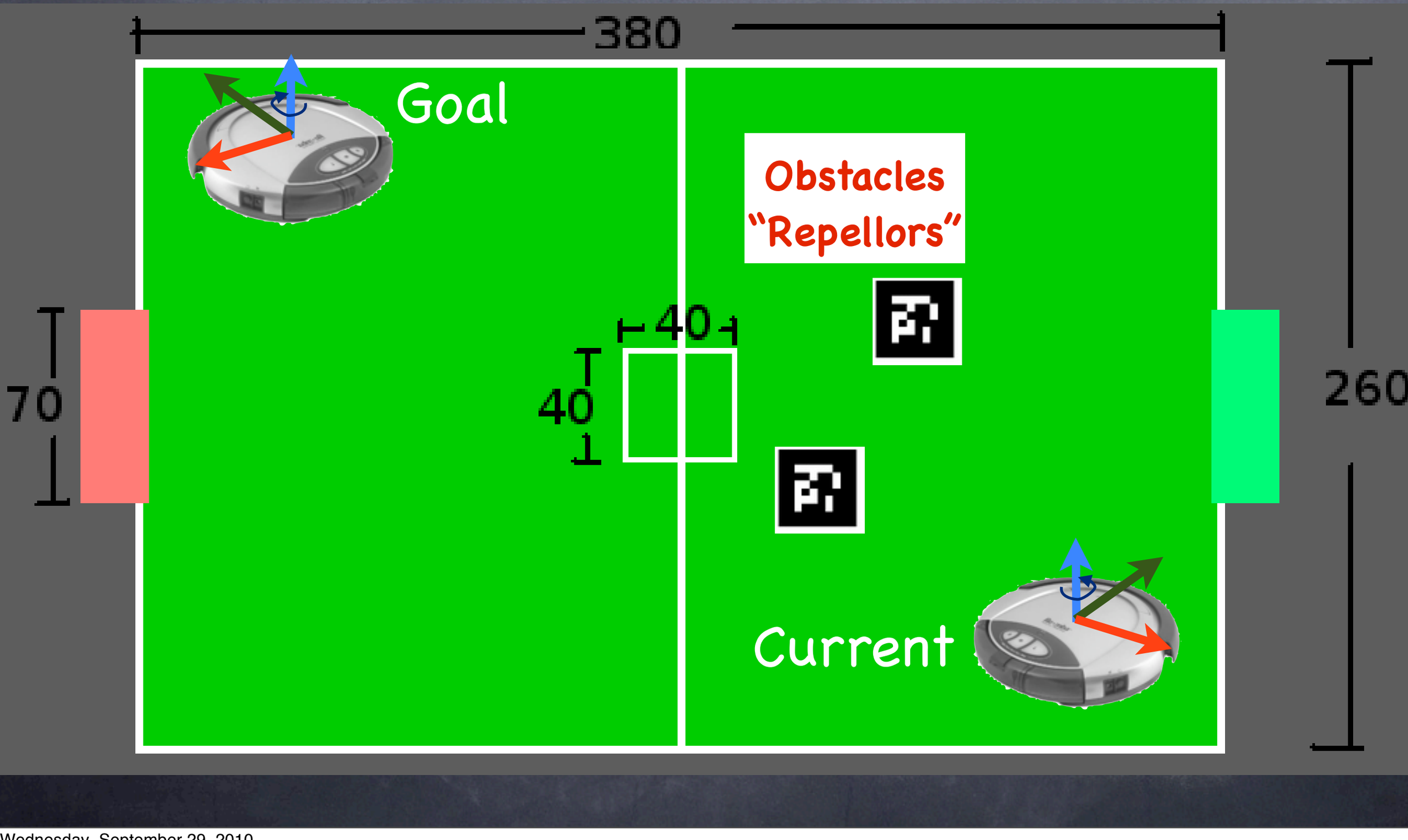
- Output of potential field is a vector
- Combine multiple potentials through vector summation

$$u = \Sigma_i \, potential_i(x)$$

describe performance for this case

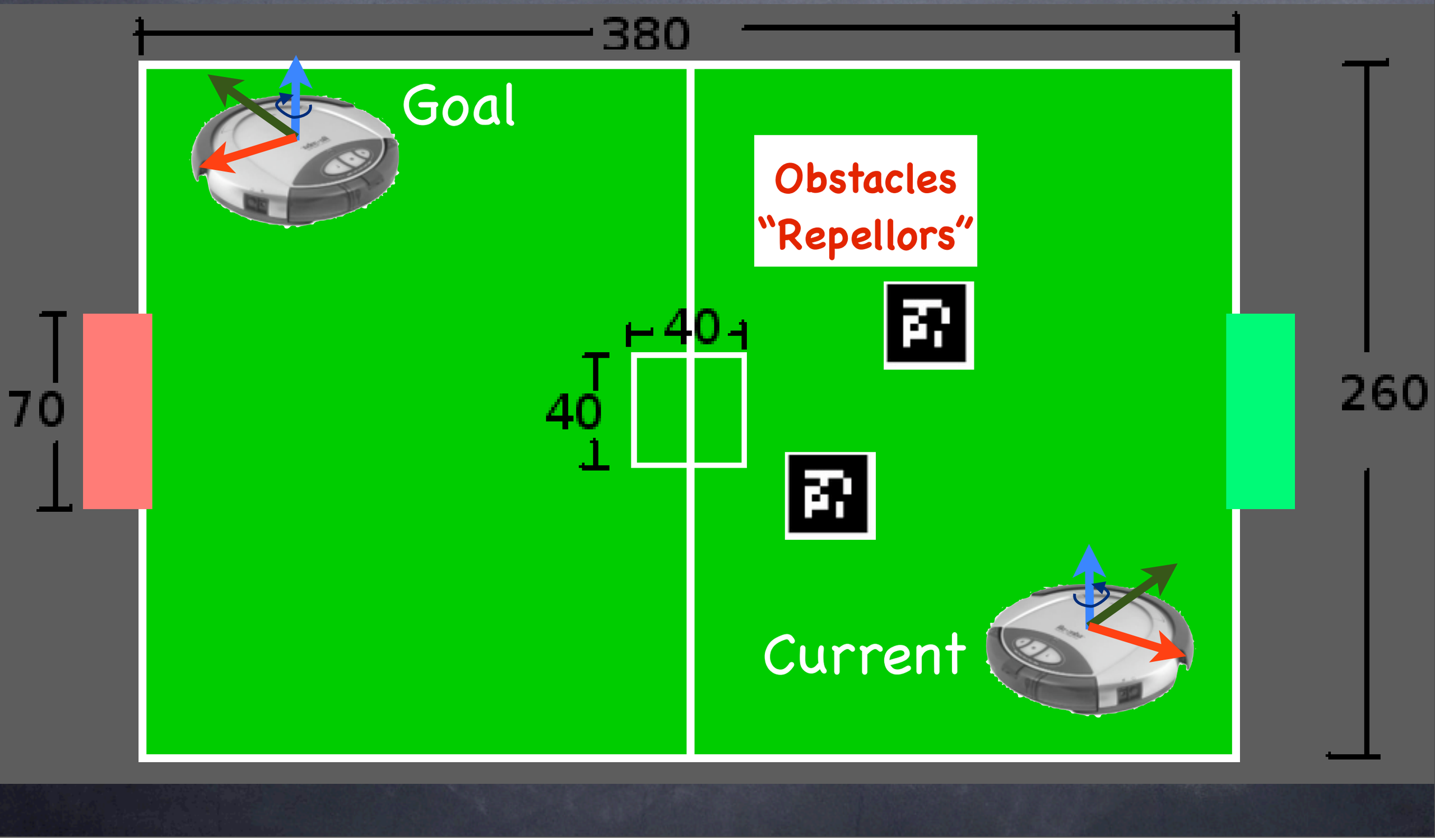


describe performance for this case



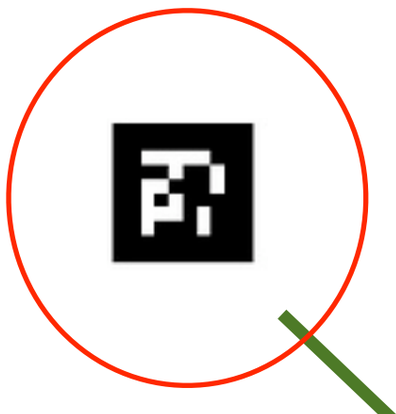
describe performance for this case

how do we deal with repellors?



"Cone" Repellor

potential problems



Obstacle
"Repellor"

reverse direction

$u = w(x-x_d)/\|x_d - x\|$

x = Start

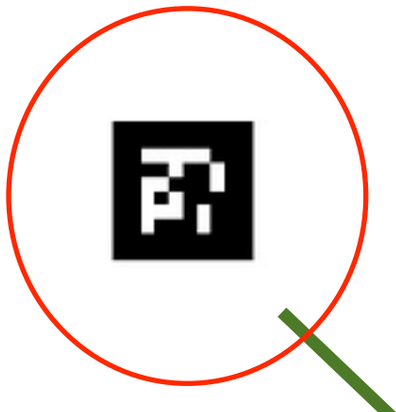
top view

Goal

Start

side view

"Bowl" Repellor



Obstacle
"Repellor"

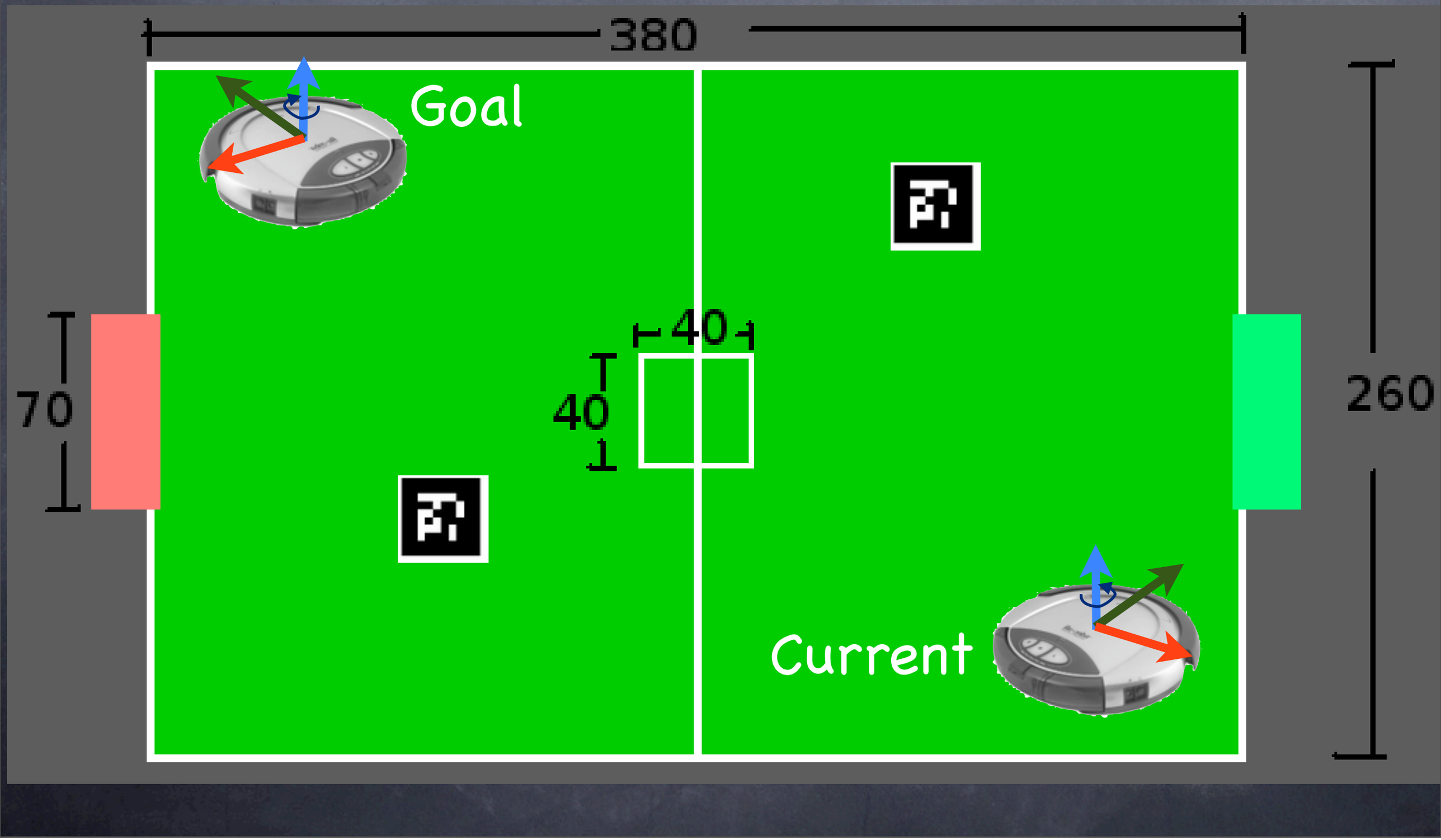
$u = \exp(-\|x-x_d\|/w)\ (x_d - x)$

x = Start

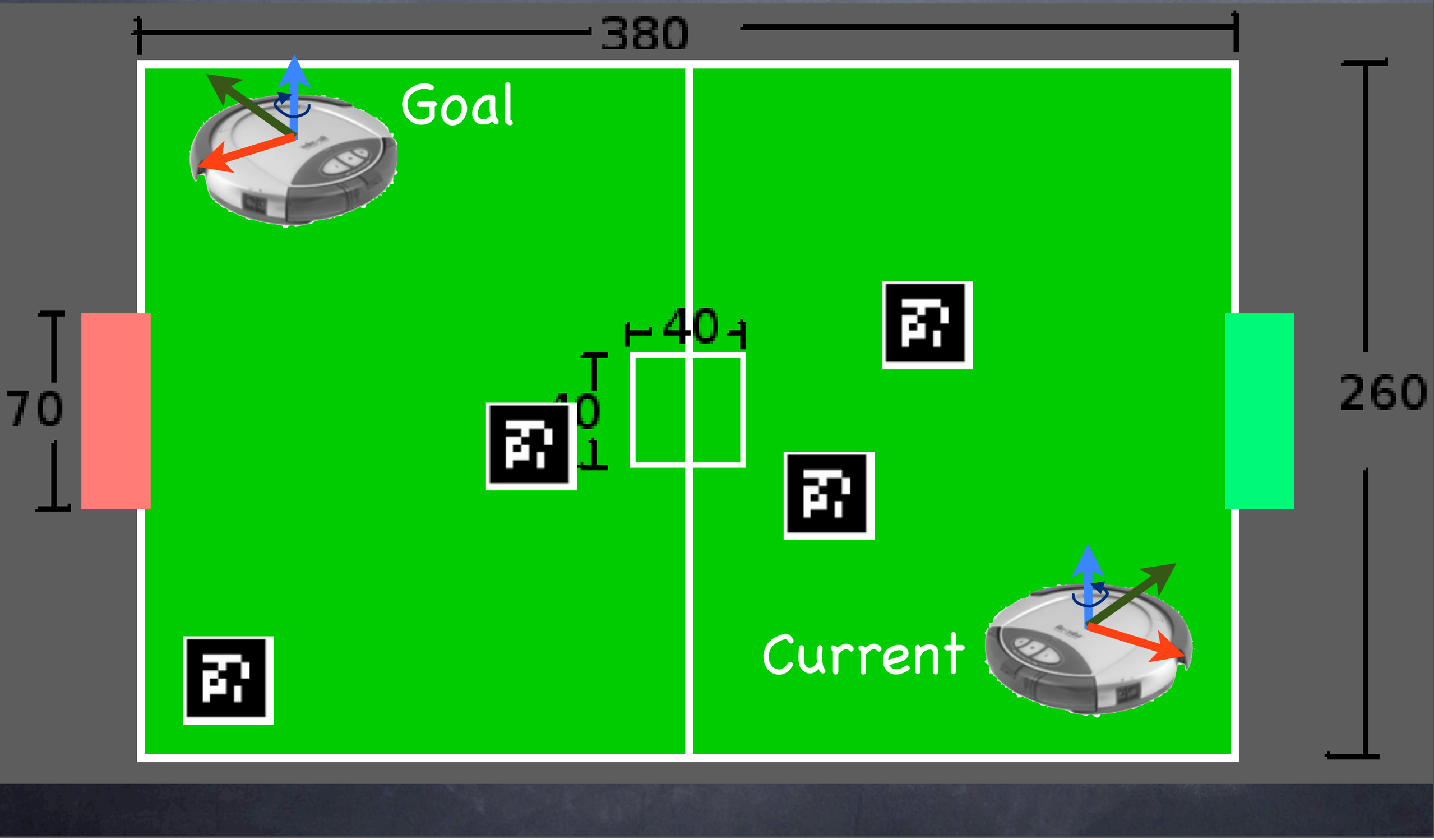
top view

side view

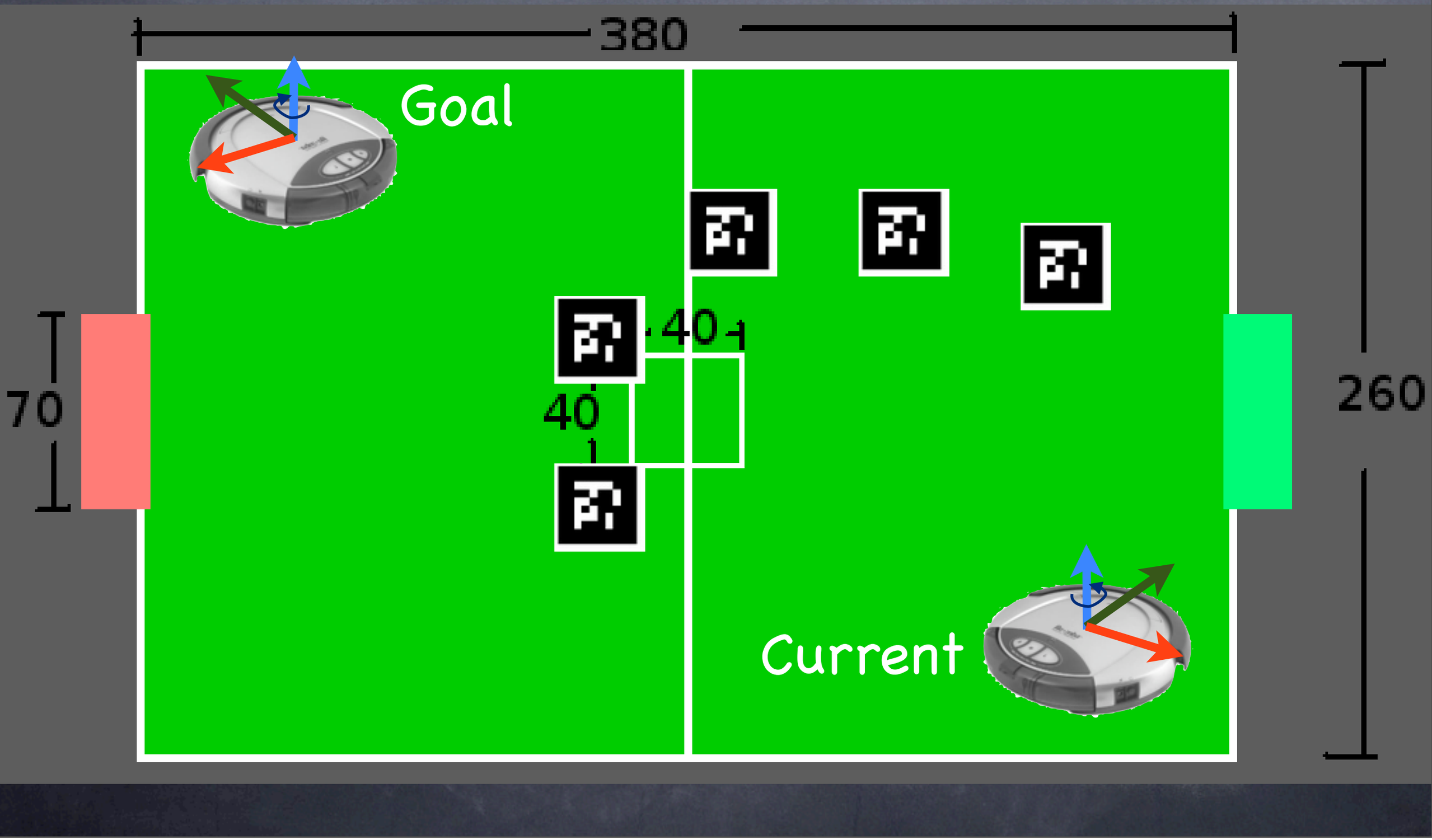
describe performance for this case



describe performance for this case

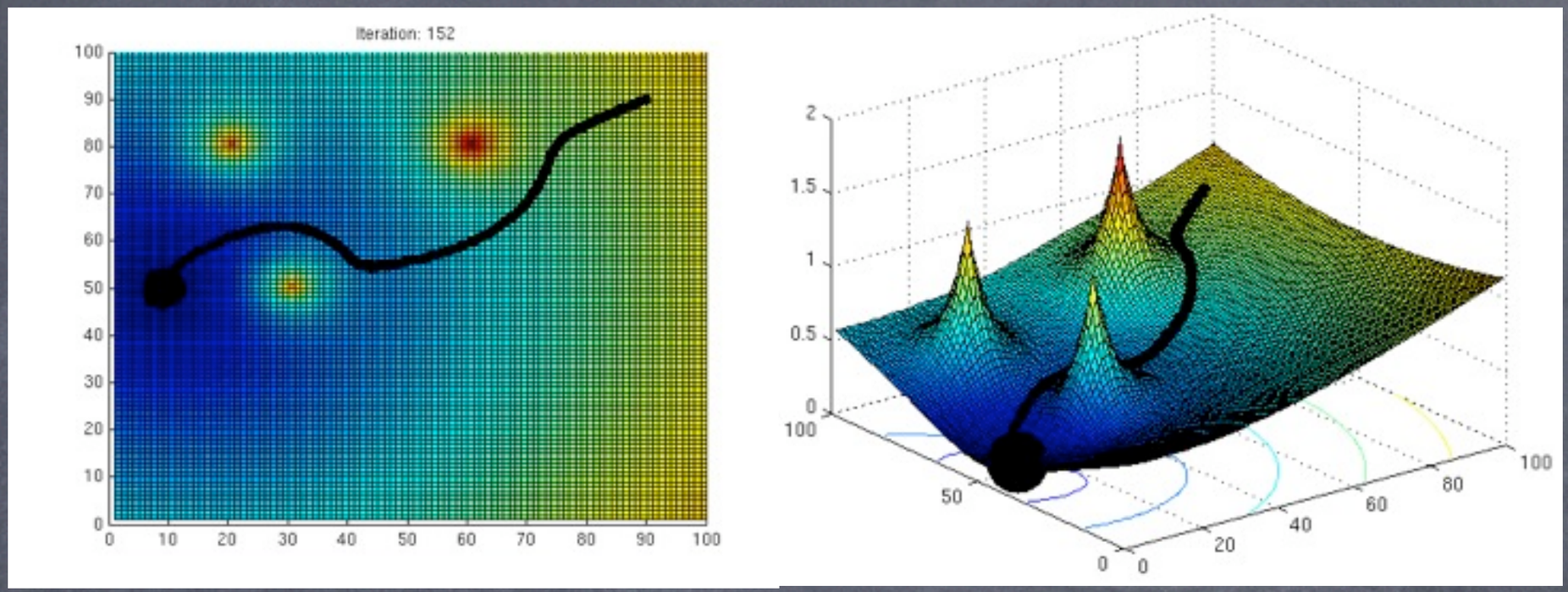


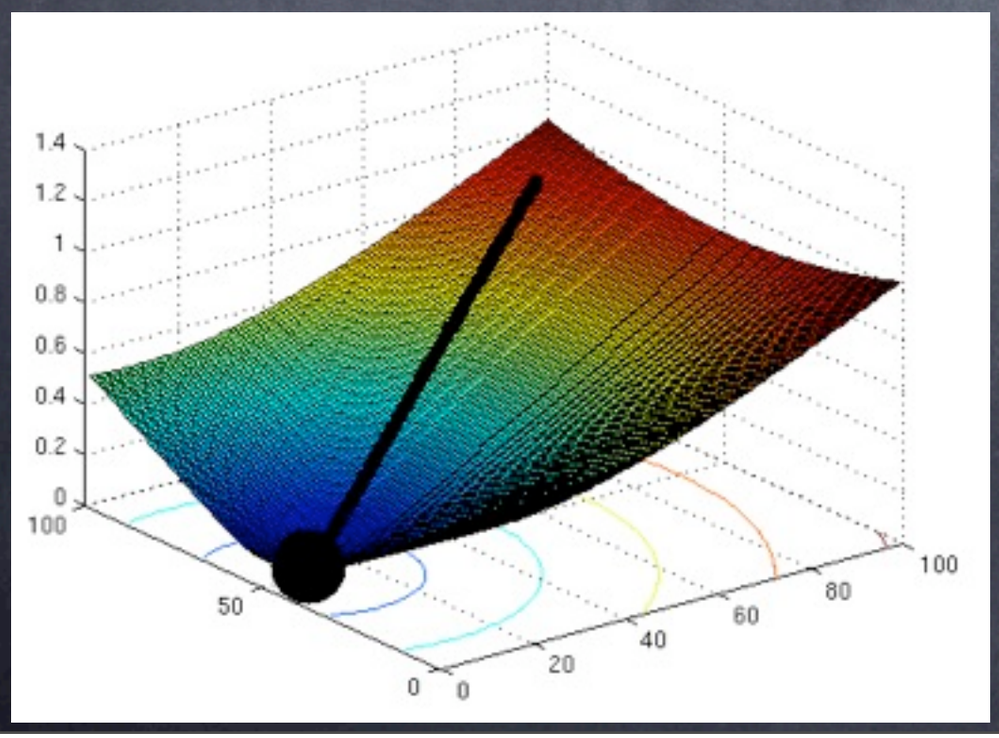
describe performance for this case



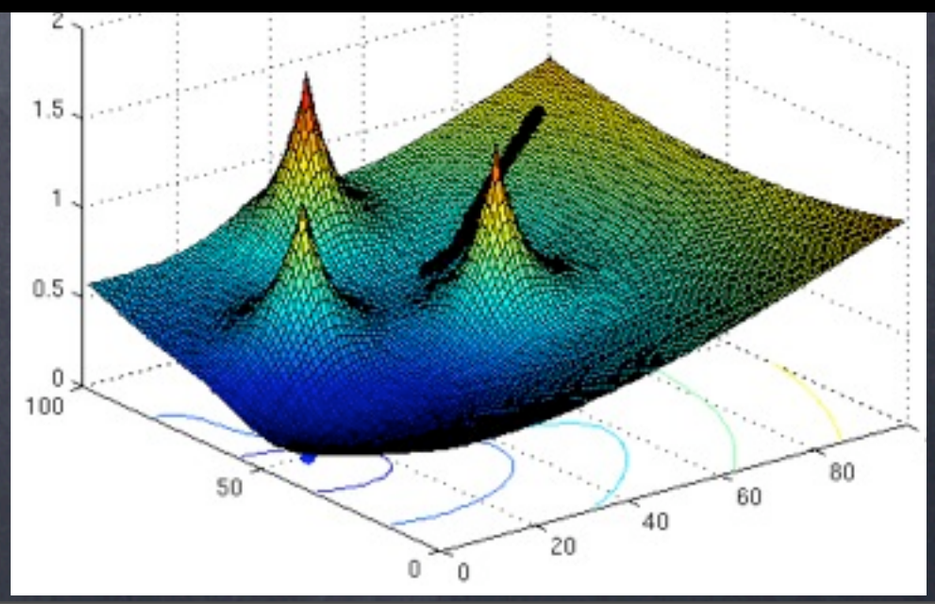
matlab example

- /course/cs148/pub/pfield.m



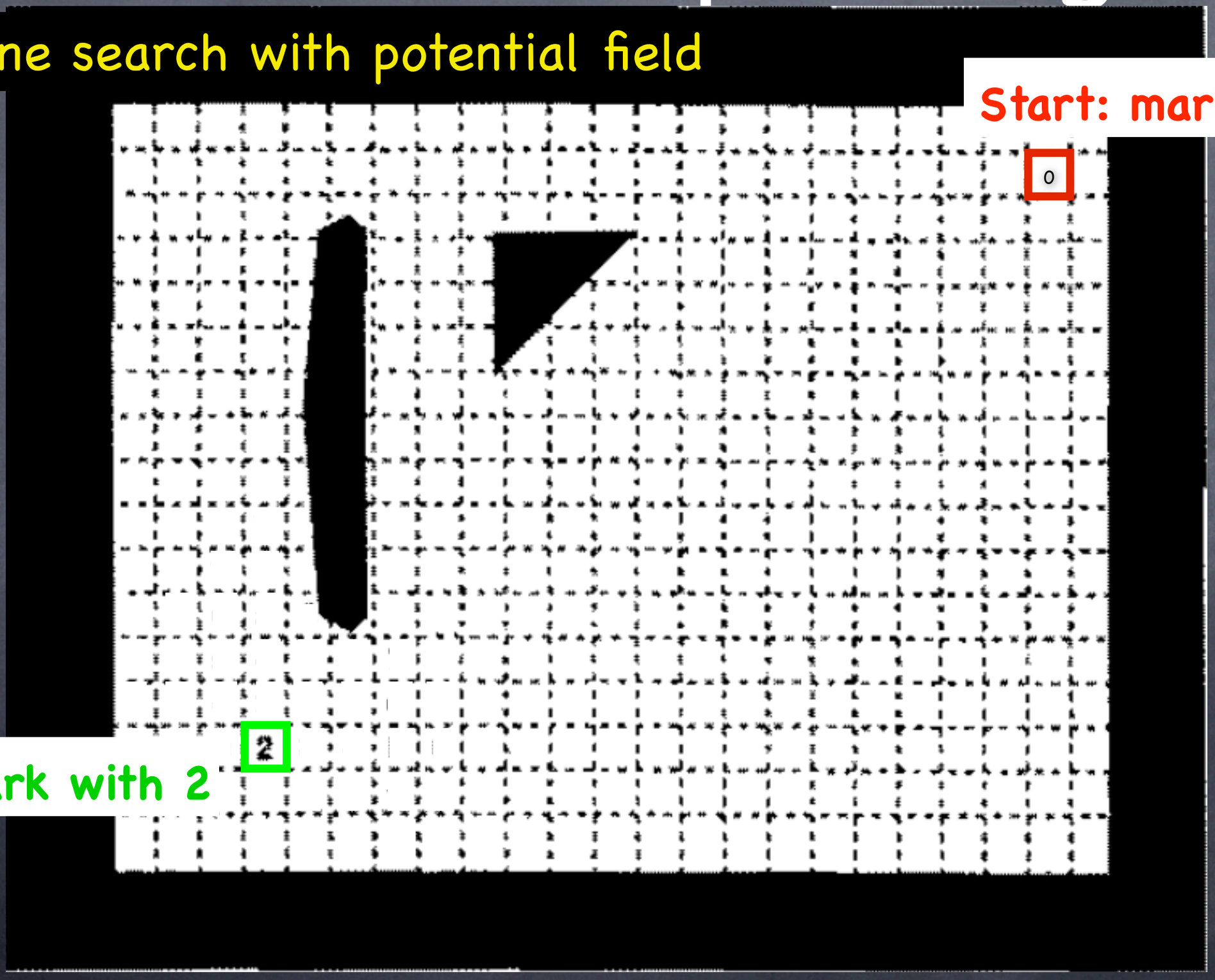


How to address local minima?



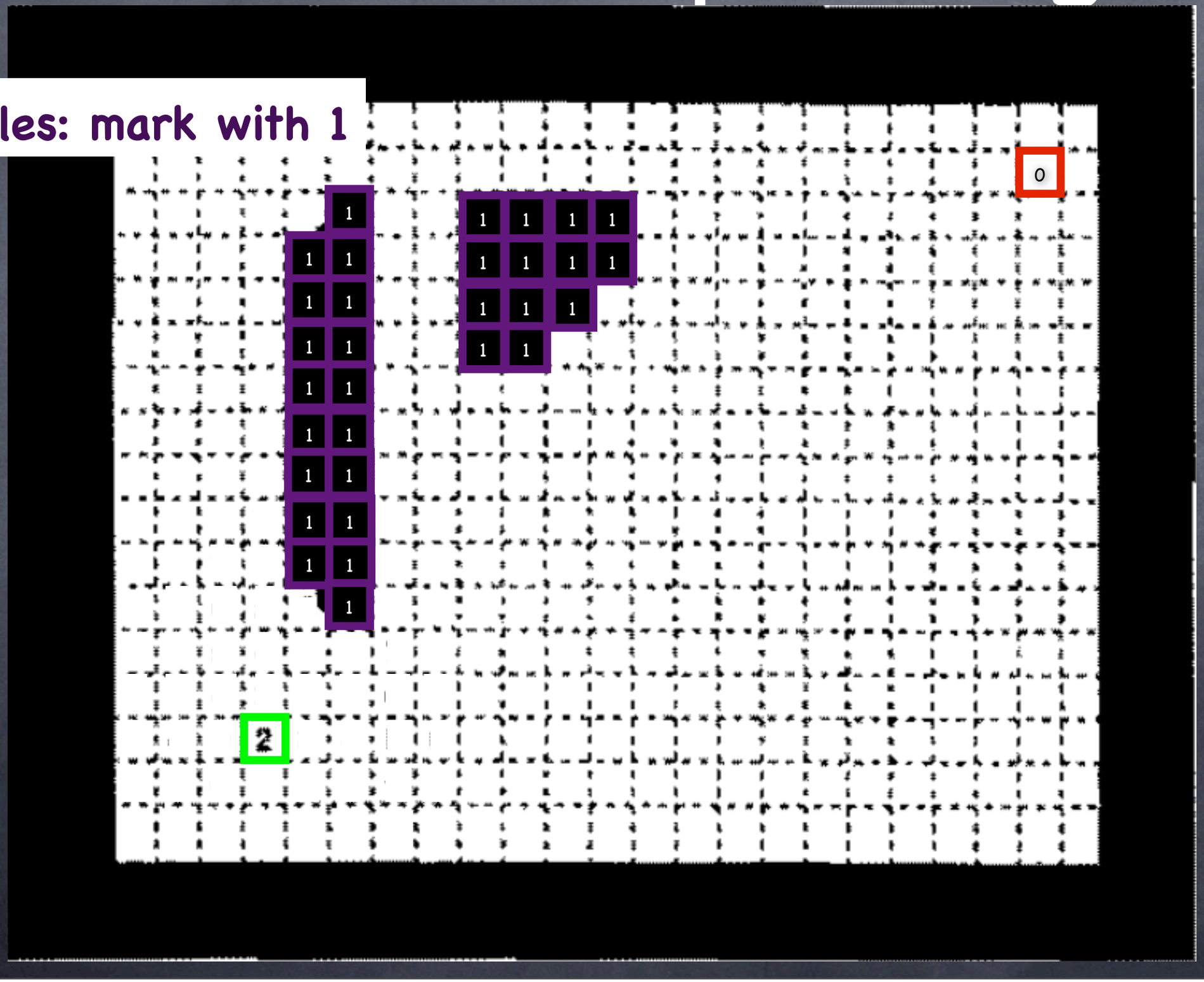
Wavefront planning

Combine search with potential field

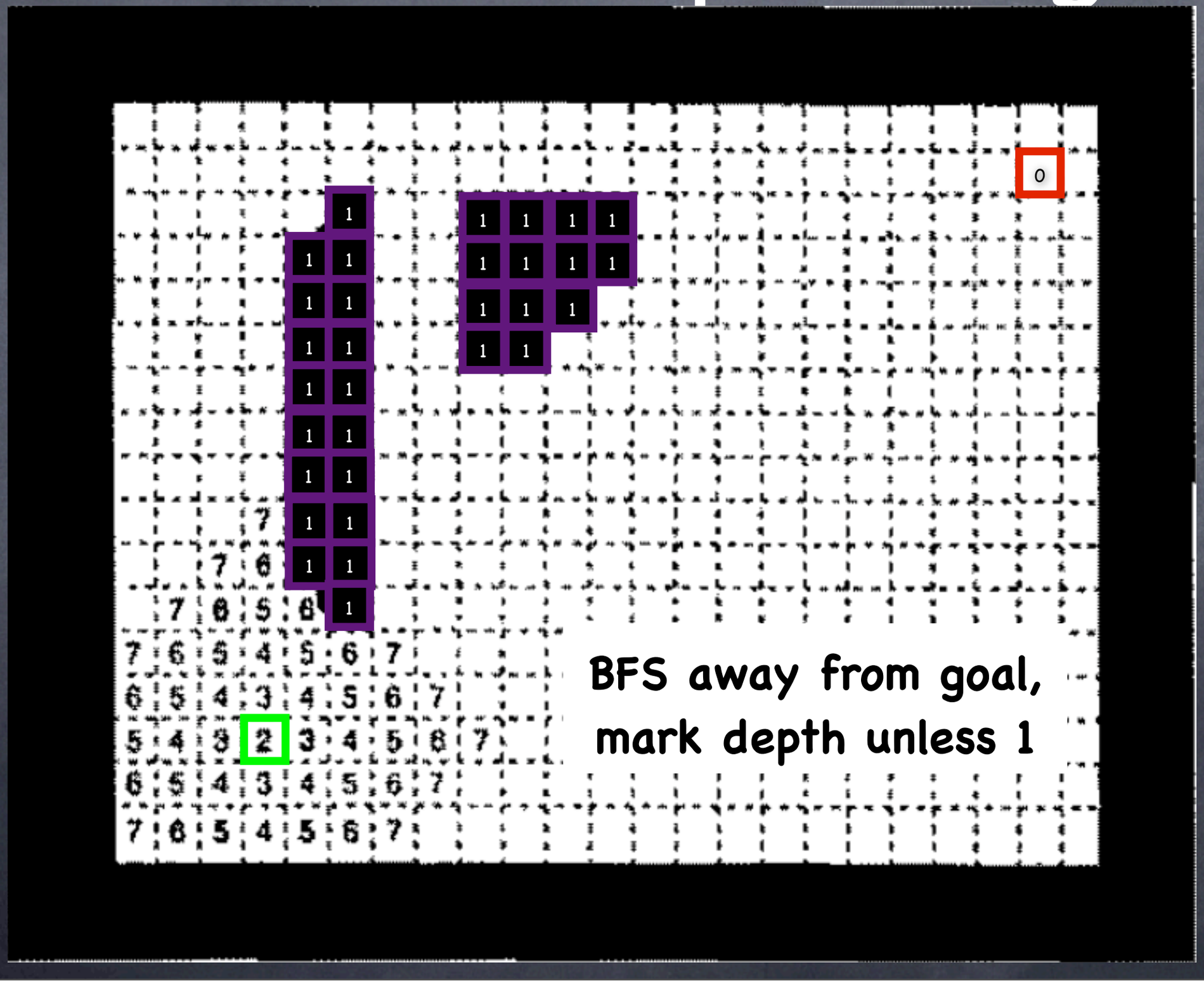


Wavefront planning

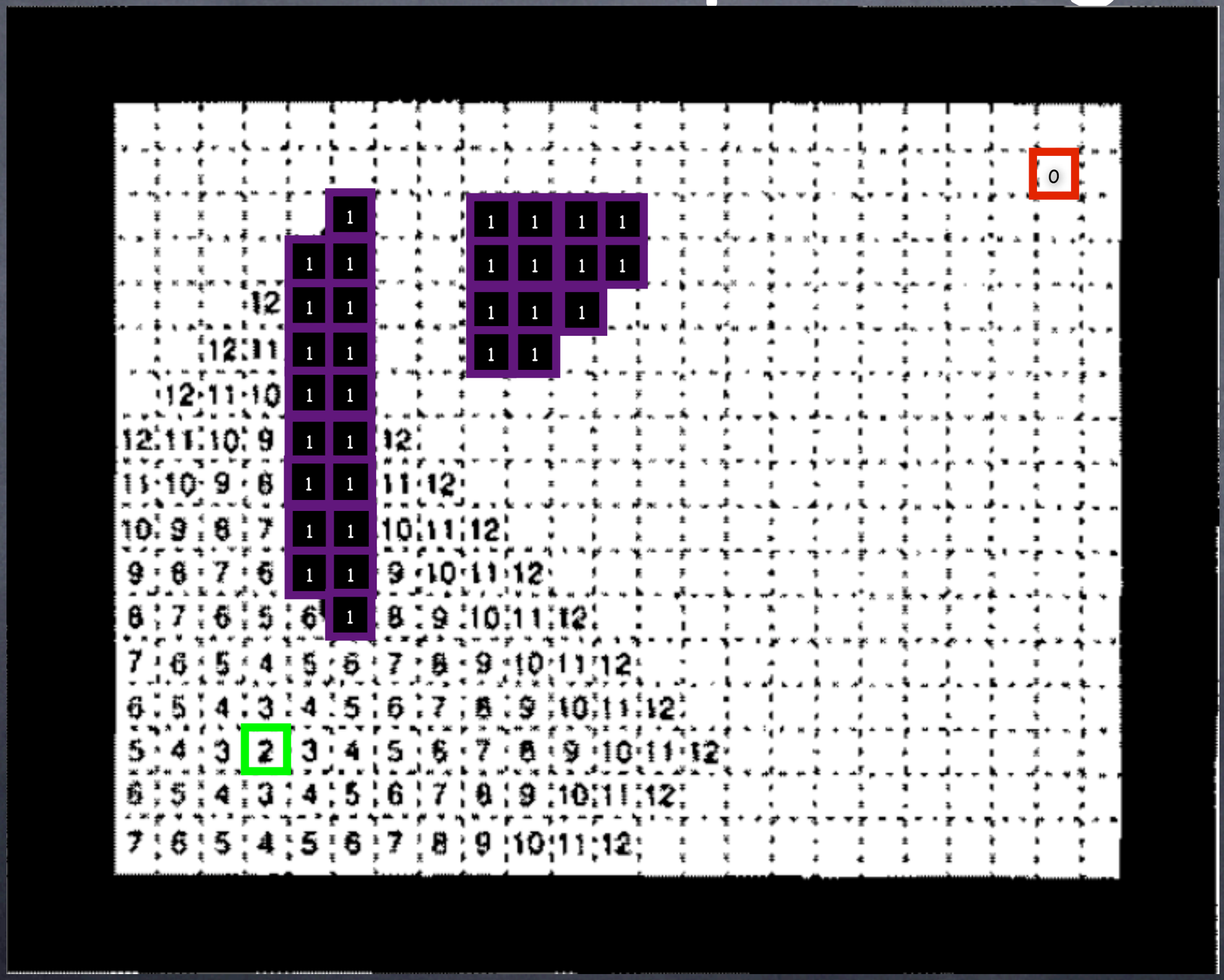
Obstacles: mark with 1



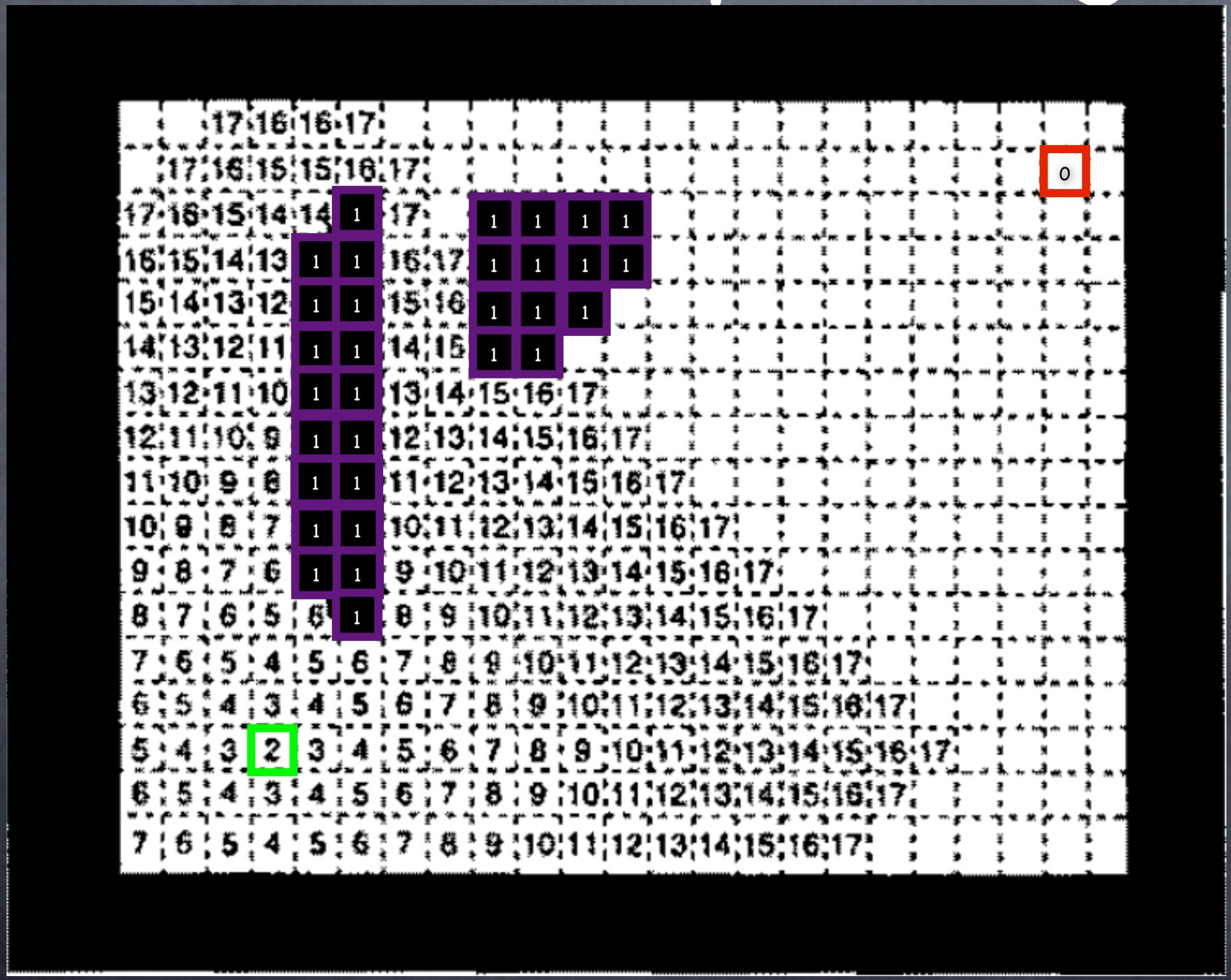
Wavefront planning



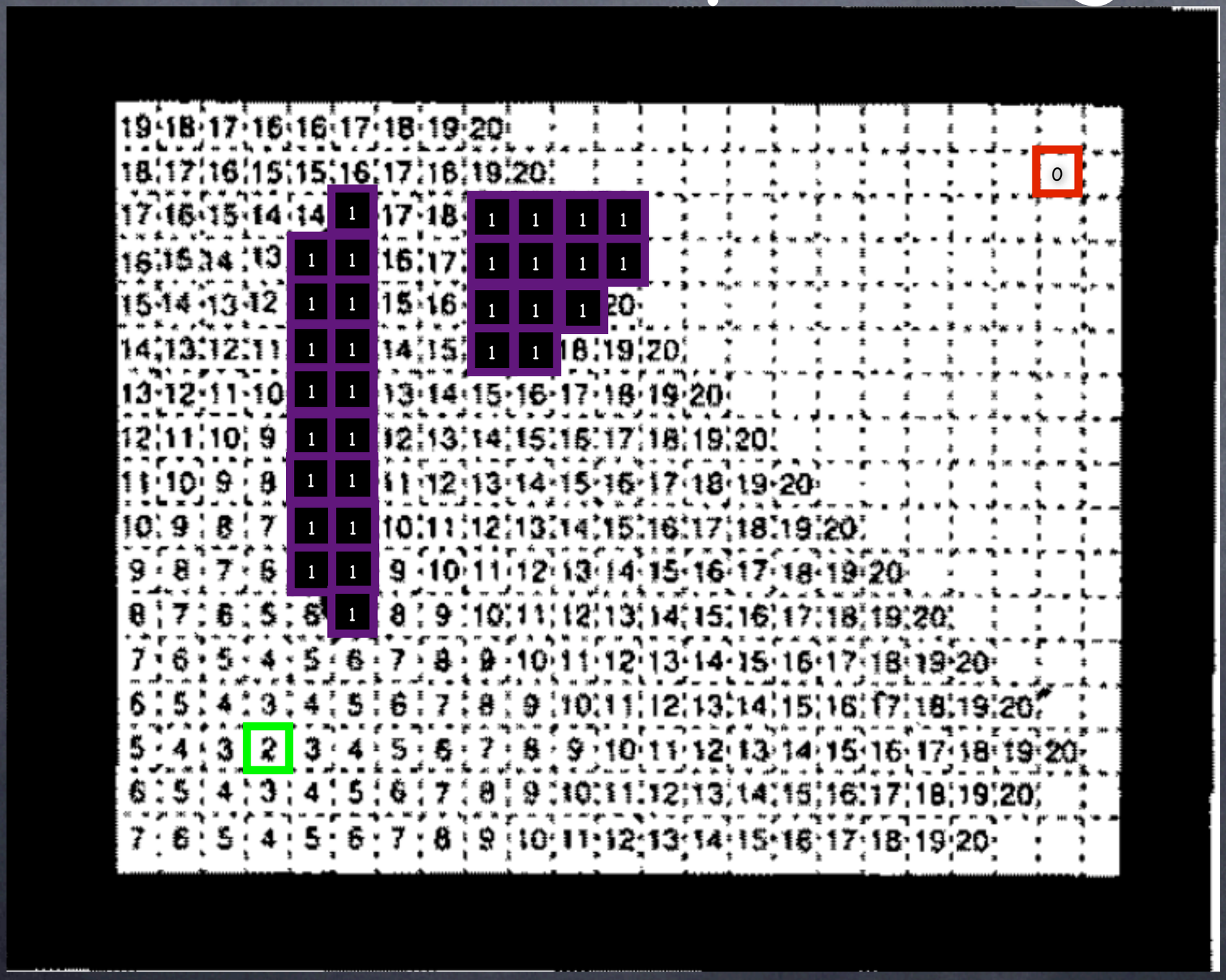
Wavefront planning



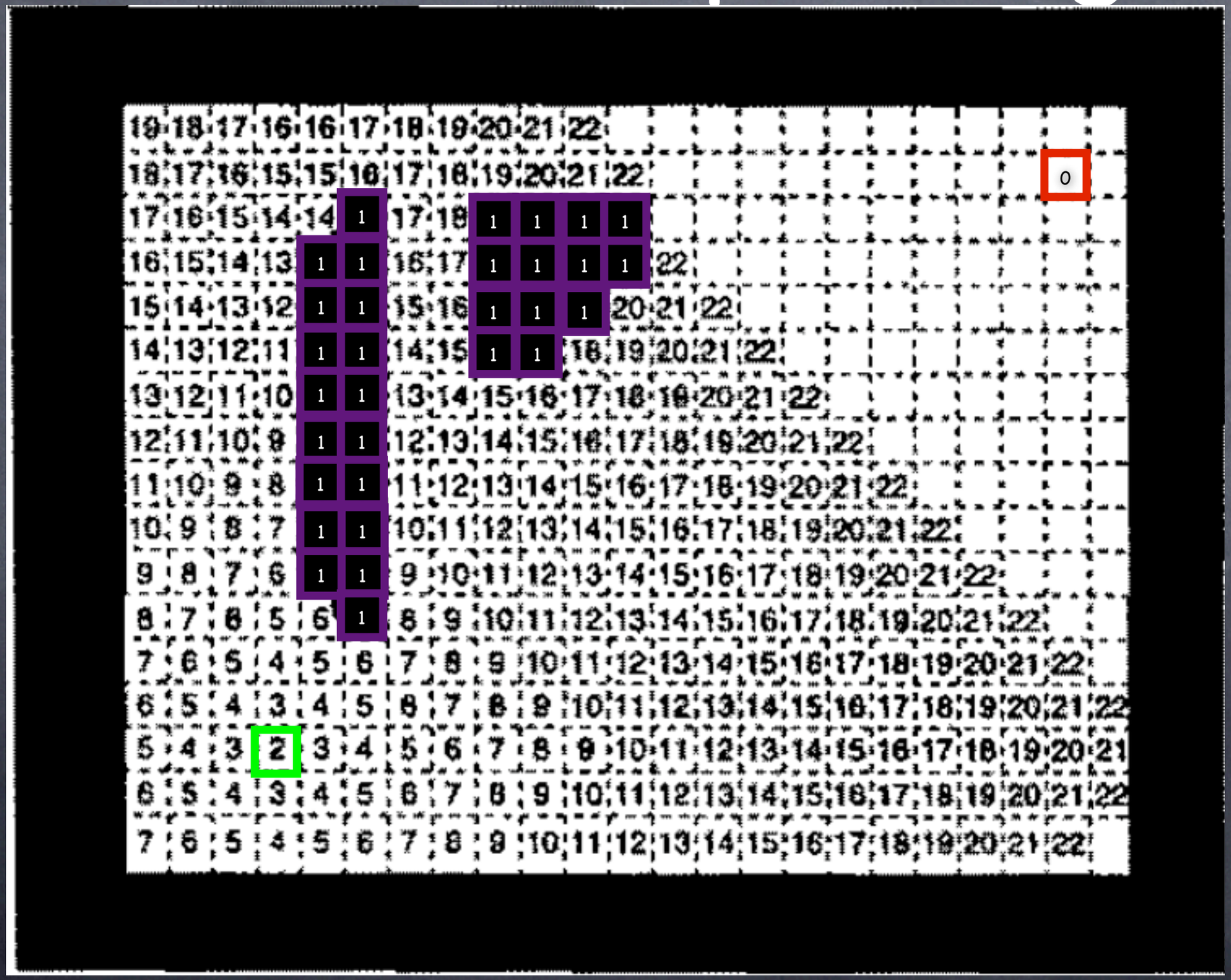
Wavefront planning



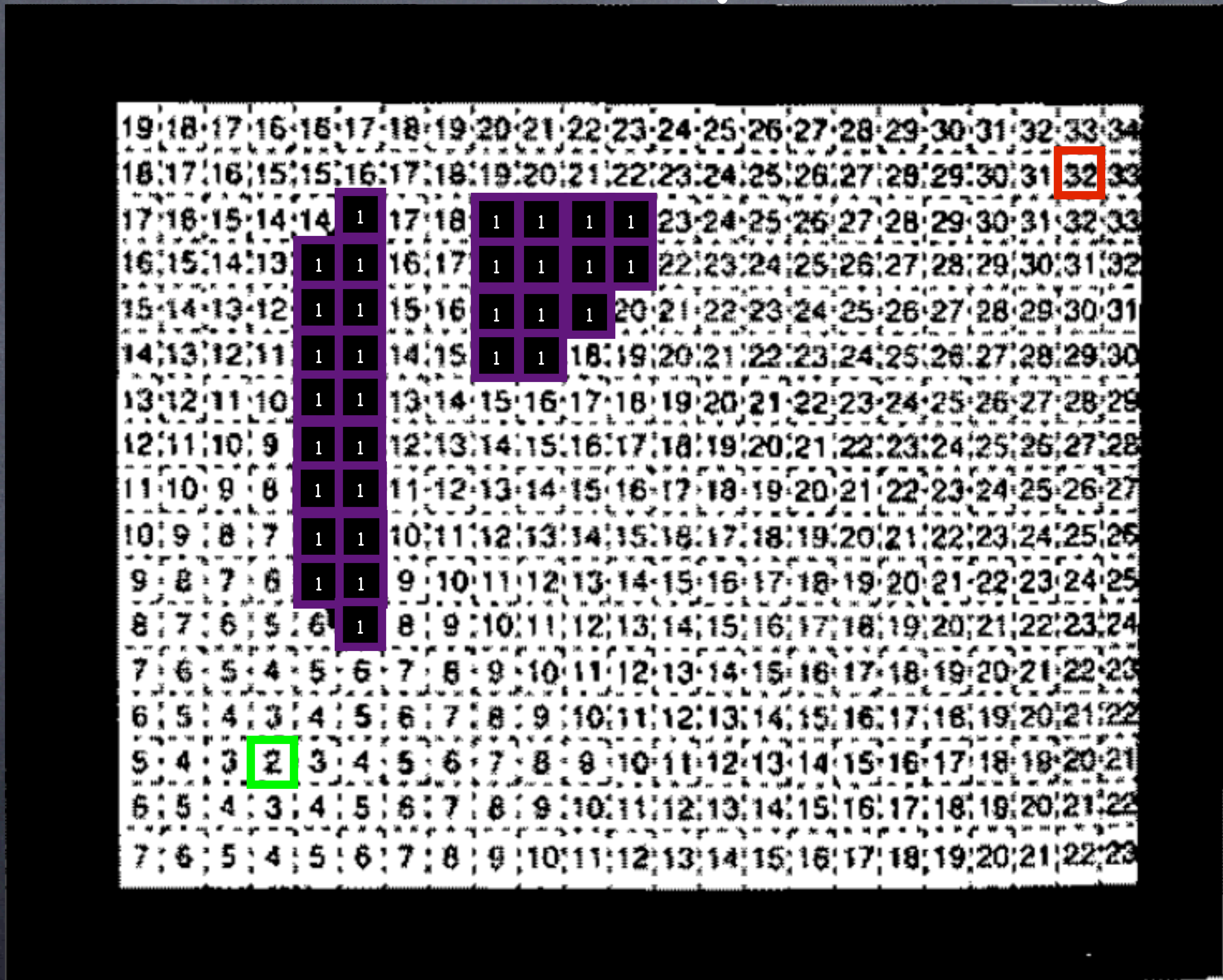
Wavefront planning



Wavefront planning



Wavefront planning



Wavefront planning

Once start reached, follow potential to goal