Announcements

- Mailing list: cse455@cs.washington.edu
  - you should have received messages
- Office hours online
  - start next week
    - » this week: by appt. only
    - » next week: Tu 1:30-2:30 slot is cancelled
- Project 1 out today (due in two weeks)
  - posted on course web page
  - help session today
- Your ID card should open Sieg 327
  - check to make sure ASAP

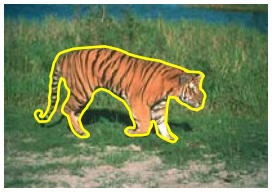
Image Scissors

From Sandlot Science

Today's Readings

- Intelligent Scissors, Mortensen et. al, SIGGRAPH 1995

Extracting objects



How could this be done?

- hard to do manually
- hard to do automatically ("image segmentation")
- easy to do *semi-automatically*

Intelligent Scissors (demo)

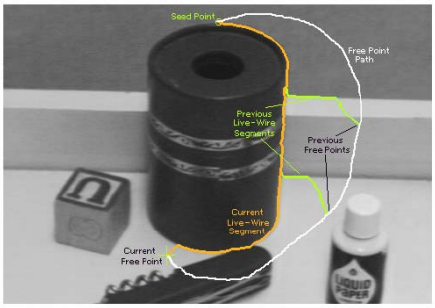


Figure 2: *Image demonstrating how the live-wire segment adapts and snaps to an object boundary as the free point moves (via cursor movement). The path of the free point is shown in white. Live-wire segments from previous free point positions (t_0, t_1, and t_2) are shown in green.*

Intelligent Scissors

Approach answers a basic question

- Q: how to find a path from seed to mouse that follows object boundary as closely as possible?
- A: define a path that stays as close as possible to edges

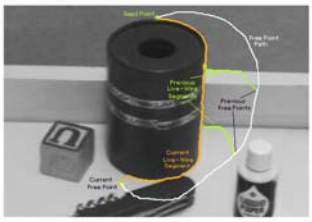
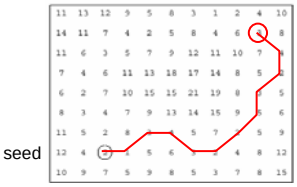


Figure 2: *Image demonstrating how the live-wire segment adapts and snaps to an object boundary as the free point moves (via cursor movement). The path of the free point is shown in white. Live-wire segments from previous free point positions (t_0, t_1, and t_2) are shown in green.*

Intelligent Scissors

Basic Idea

- Define edge score for each pixel
  - edge pixels have low cost
- Find lowest cost path from seed to mouse



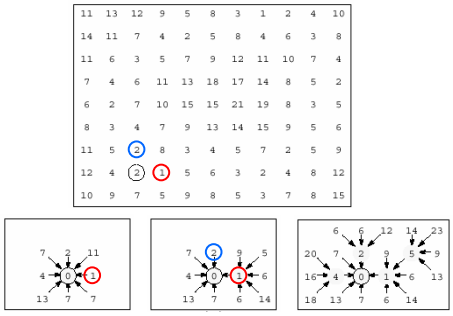
Questions

- How to define costs?
- How to find the path?

Path Search (basic idea)

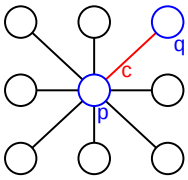
Graph Search Algorithm

- Computes minimum cost path from seed to *all other pixels*



How does this really work?

Treat the image as a graph



Graph

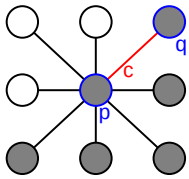
- node for every pixel **p**
- link between every adjacent pair of pixels, **p**,**q**
- cost **c** for each link

Note: each *link* has a cost

- this is a little different than the figure before where each pixel had a cost

Defining the costs

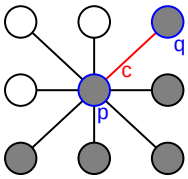
Treat the image as a graph



Want to hug image edges: how to define cost of a link?

- the link should follow the intensity edge
  - want intensity to change rapidly ? to the link
- c≈ - |difference of intensity ? to link|

Defining the costs



H_c

c can be computed using a cross-correlation filter

- assume it is centered at p

Also typically scale c by its length

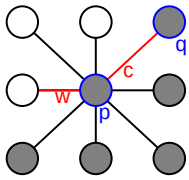
- set c = (max-|filter response|)
  - where max = maximum |filter response| over all pixels in the image

Defining the costs

$\frac{1}{4}$

1	1	
-1	-1	

H_w



$\frac{1}{\sqrt{2}}$

	1	
		-1

H_c

c can be computed using a cross-correlation filter

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Also typically scale c by its length

- set c = (max-|filter response|)×length
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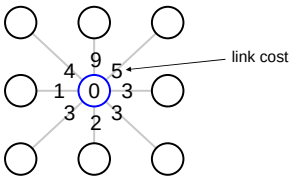
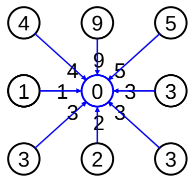
Dijkstra's shortest path algorithm



Algorithm

1. init node costs to ∞, set p = seed point, cost(p) = 0
2. expand p as follows:
   for each of p's neighbors q that are not expanded
   - » set cost(q) = min(cost(p) + c_{pq}, cost(q))

Dijkstra's shortest path algorithm



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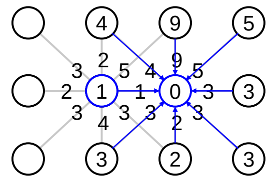

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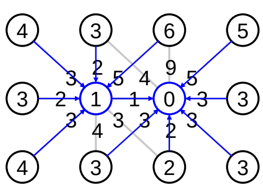
3. set r = node with minimum cost on the ACTIVE list
4. repeat Step 2 for p = r

Dijkstra's shortest path algorithm



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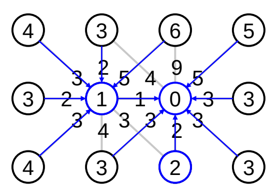

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Dijkstra's shortest path algorithm

Properties

- It computes the minimum cost path from the seed to every node in the graph. This set of minimum paths is represented as a *tree*
- Running time, with N pixels:
  - $O(N^2)$ time if you use an active list
  - O(N log N) if you use an active priority queue (heap)
  - takes fraction of a second for a typical (640x480) image
- Once this tree is computed once, we can extract the optimal path from any point to the seed in O(N) time.
  - it runs in real time as the mouse moves
- What happens when the user specifies a new seed?

Results

http://www.cs.washington.edu/education/courses/455/03wi/projects/project1/artifacts/index.html

Help session—Jeff