02/25/10

Graph-based Segmentation

Computer Vision

CS 543 / ECE 549

University of Illinois

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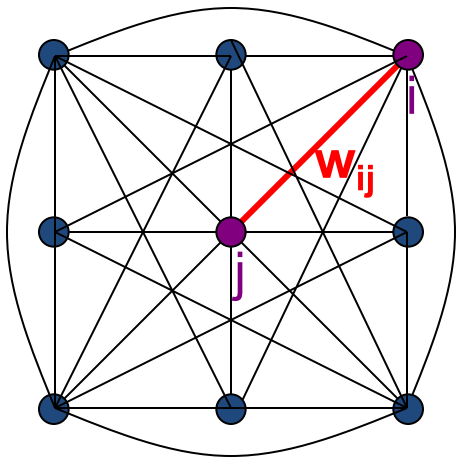
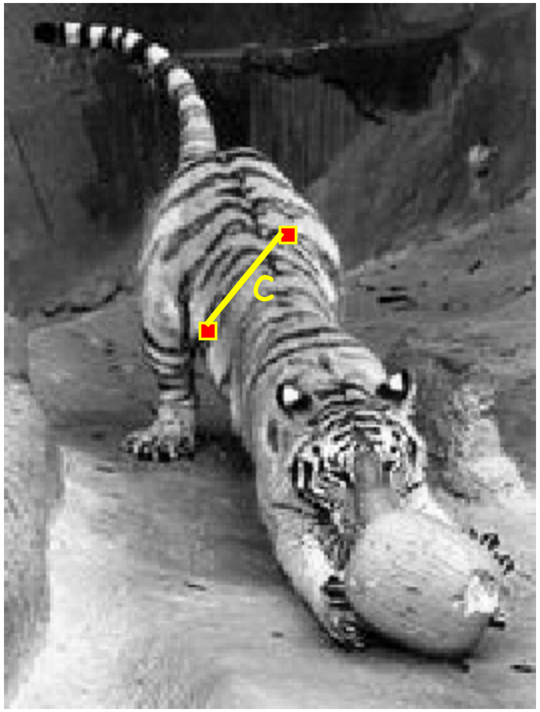
Images as graphs

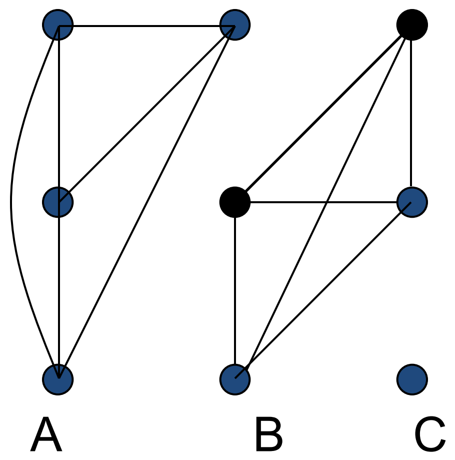




- *Fully-connected* graph
  - node for every pixel
  - link between *every* pair of pixels, **p**,**q**
  - similarity $\mathbf{w_{ij}}$ for each link

Source: Seitz

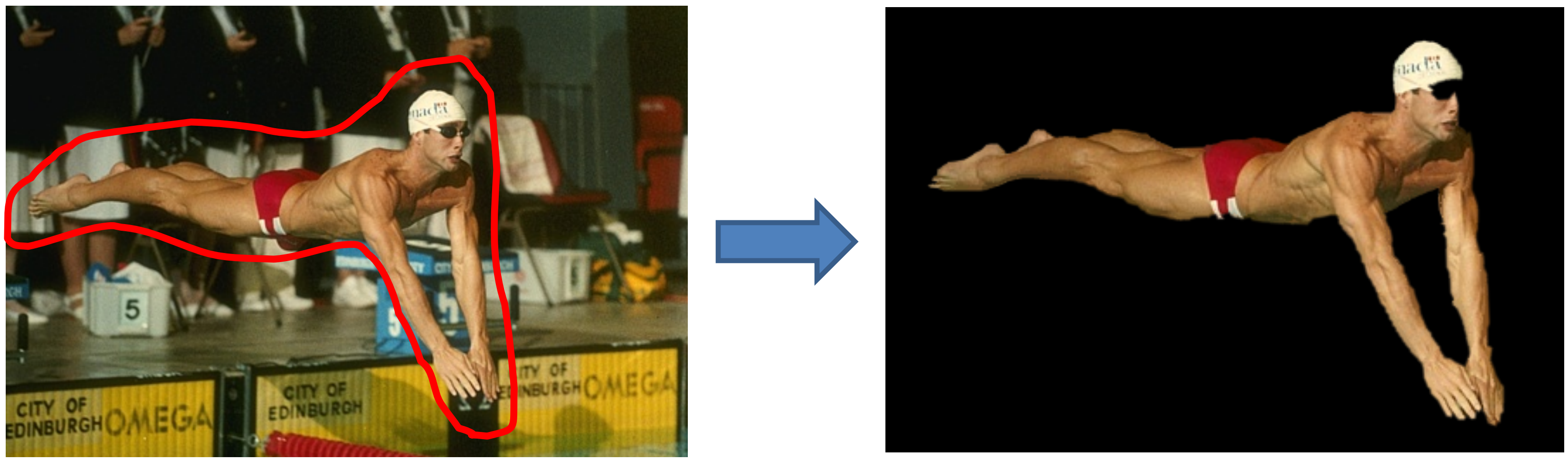
Segmentation by Graph Cuts



- Break Graph into Segments
  - Delete links that cross between segments
  - Easiest to break links that have low cost (low similarity)
    - similar pixels should be in the same segments
    - dissimilar pixels should be in different segments

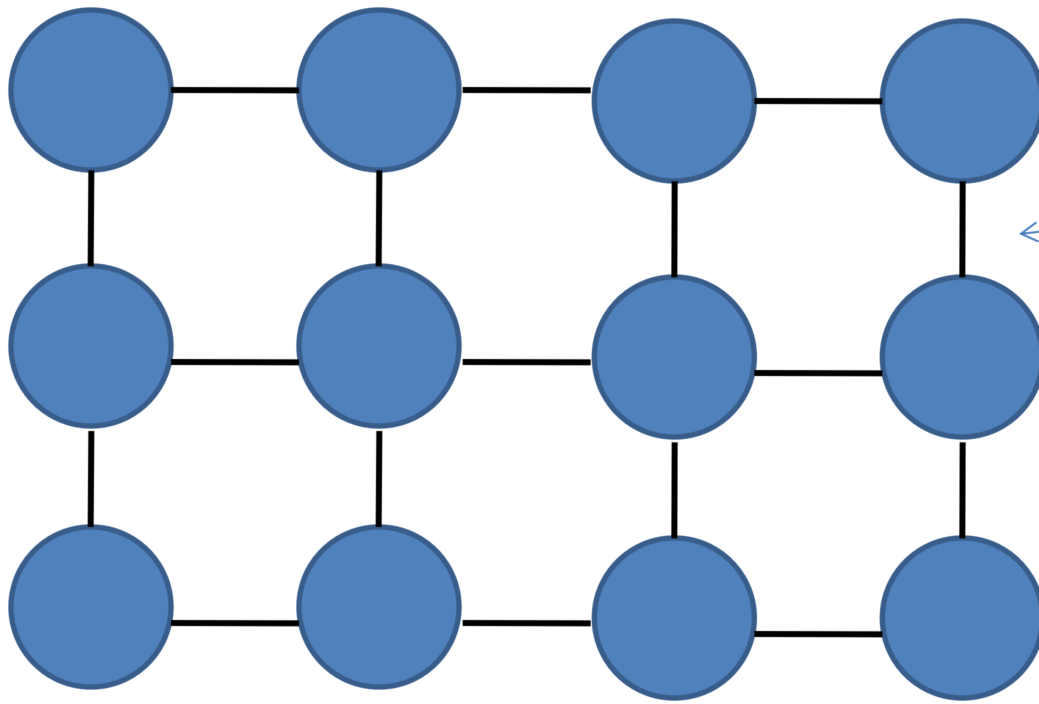
Source: Seitz

Graph cuts segmentation



Markov Random Fields

Node y_i: pixel label



Edge: constrained pairs

Cost to assign a label to each pixel

Cost to assign a pair of labels to connected pixels

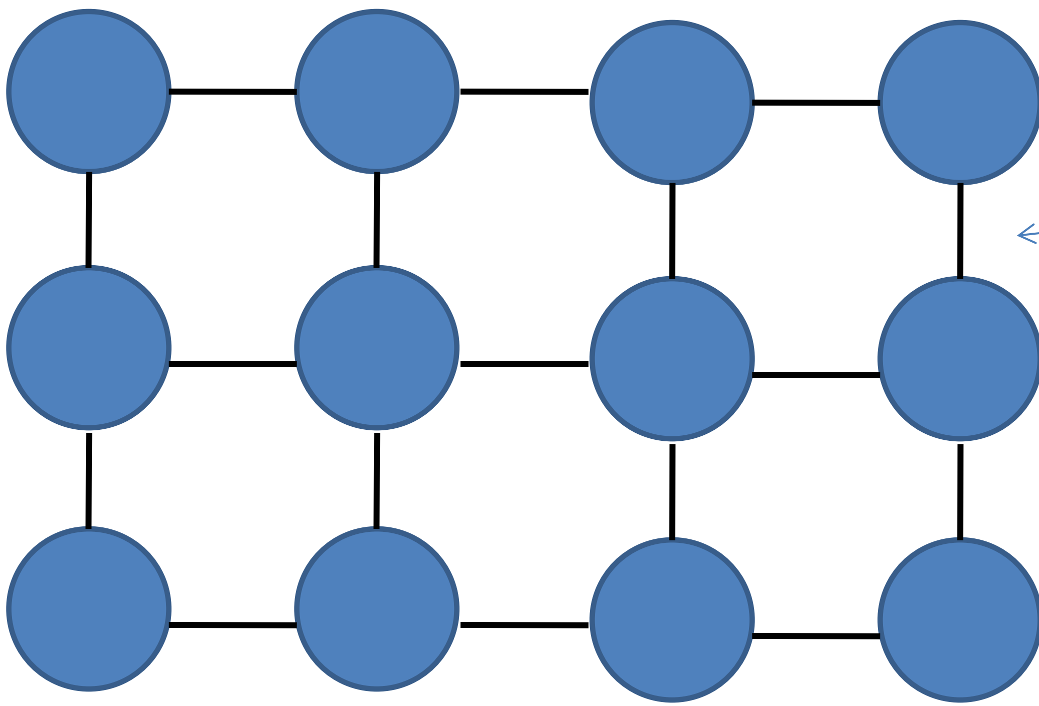
$$Energy(\mathbf{y};\theta,data)=\sum_{i}\psi_1(y_i;\theta,data)\ \sum_{i,j\in edges}\psi_2(y_i,y_j;\theta,data)$$

Markov Random Fields

- Example: “label smoothing” grid

Unary potential

0: -logP(y_i = 0 ; data)
1: -logP(y_i = 1 ; data)

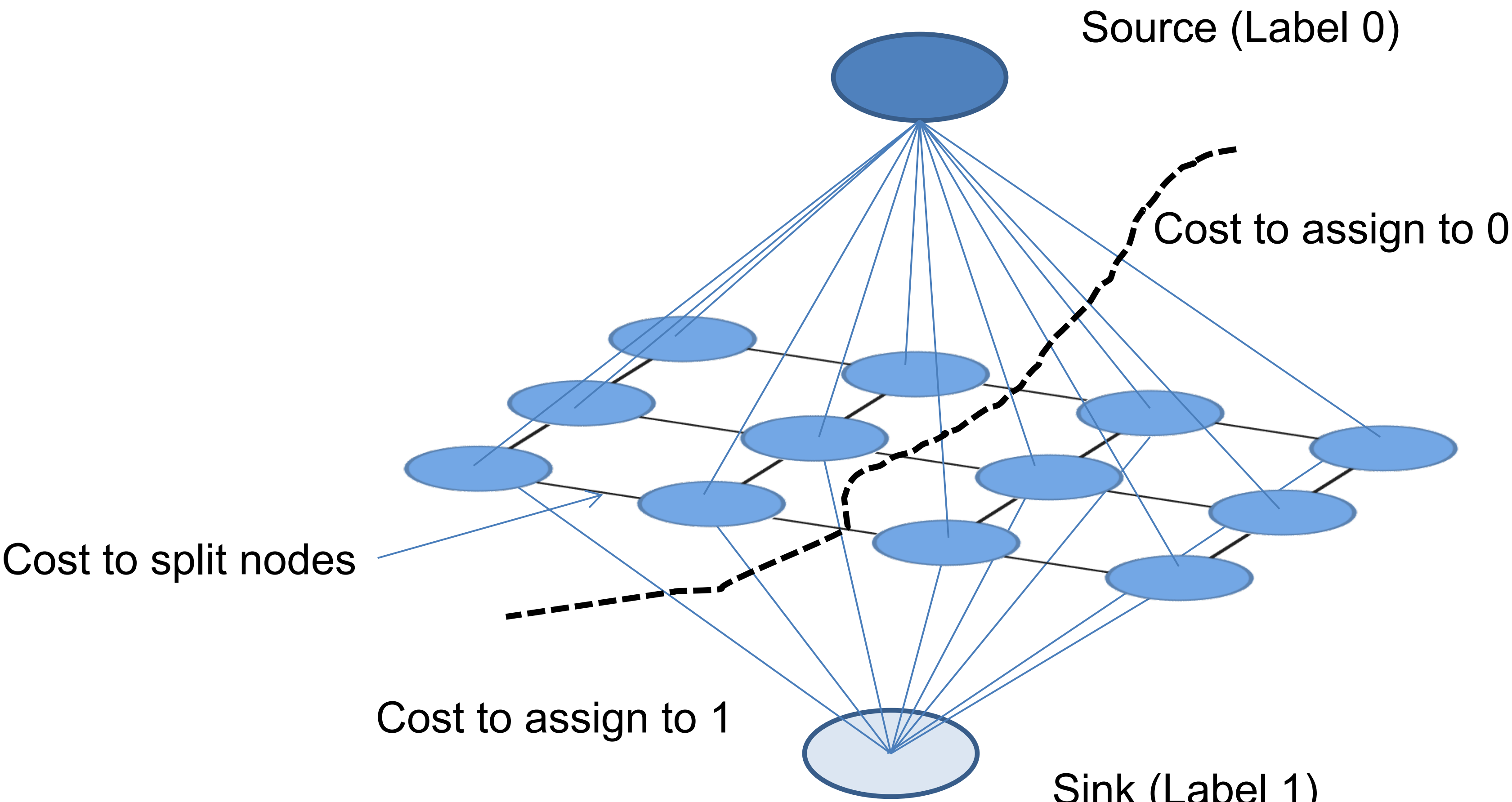


Pairwise Potential

	0	1
0	0	K
1	K	0

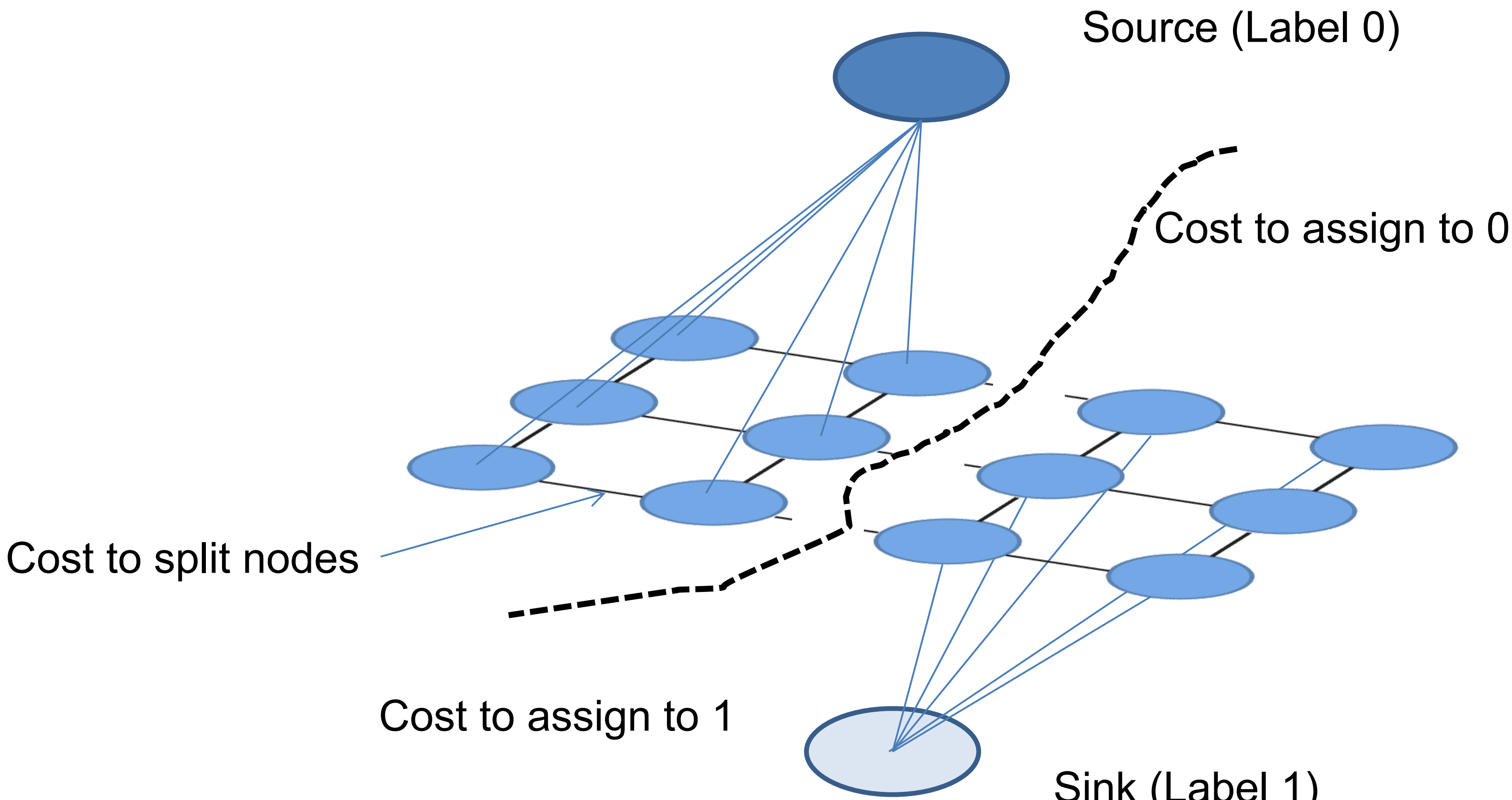
$$Energy(\mathbf{y};\theta,data) = \sum_i \psi_1(y_i;\theta,data) \quad \sum_{i,j\in edges} \psi_2(y_i,y_j;\theta,data)$$

Solving MRFs with graph cuts



$$Energy(\mathbf{y};\theta,data)=\sum_{i}\psi_1(y_i;\theta,data)\ \sum_{i,j\in edges}\psi_2(y_i,y_j;\theta,data)$$

Solving MRFs with graph cuts



$$Energy(\mathbf{y};\theta,data)=\sum_i \psi_1(y_i;\theta,data)\ \sum_{i,j\in edges}\psi_2(y_i,y_j;\theta,data)$$

Graph cuts segmentation

1. Define graph
   – usually 4-connected or 8-connected
2. Define unary potentials
   – Color histogram or mixture of Gaussians for background and foreground

$$unary\_potential(x) = -\log\left(\frac{P(c(x);\theta_{foreground})}{P(c(x);\theta_{background})}\right)$$

3. Define pairwise potentials

$$edge\_potential(x,y) = k_1 + k_2 \exp\left\{\frac{-\left\|c(x)-c(y)\right\|^2}{2\sigma^2}\right\}$$

4. Apply graph cuts
5. Return to 2, using current labels to compute foreground, background models

Moderately straightforward examples

… GrabCut completes automatically

Difficult Examples

SIGGRAPH2004

	Camouflage & Low Contrast	Fine structure	Harder Case
Initial Rectangle			
Initial Result