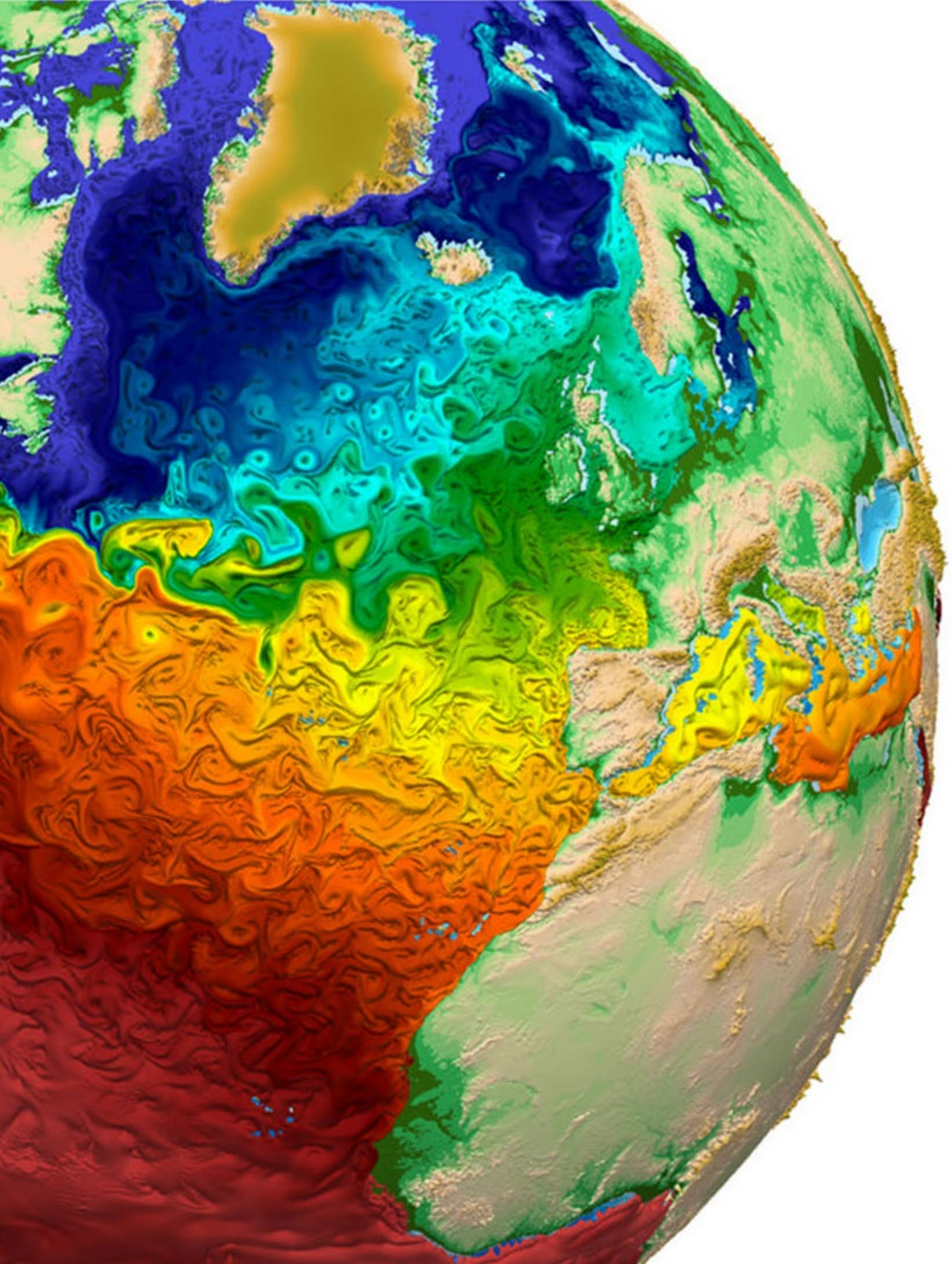


Image Segmentation

Graph Cuts

Scientific Visualization

Professor Eric Shaffer

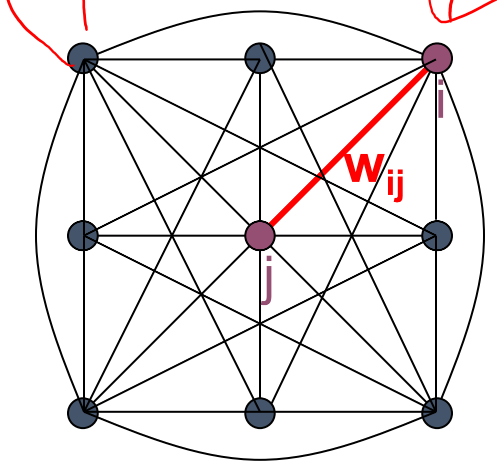
ILLINOIS

Segmentation with Graph Cuts

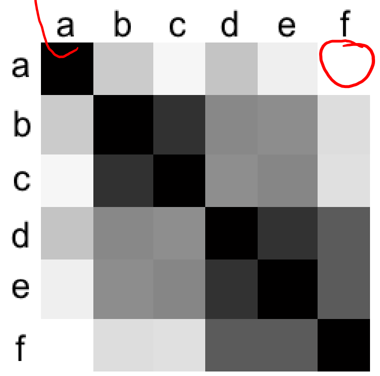
Another approach to segmentation in general is to use a graph cut method

Represent image as a fully-connected graph

- node for every pixel
- link between *every* pair of pixels, p_i p_j
- similarity w_{ij} for each link



Similarity matrix using distance metric



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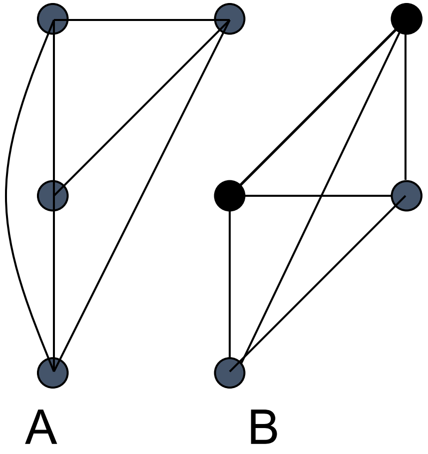
Segmentation by Graph Cuts



Idea: break graph into segments by deleting links

- Break links that have low cost (low similarity)
  - similar pixels should be in the same segment
  - dissimilar pixels should be in different segment

Do We Need All those Edges?

Fully connected:

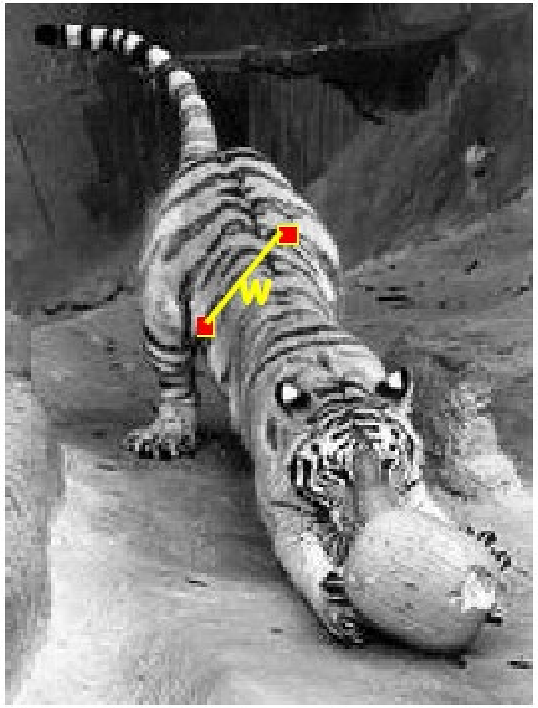
- Captures all pairwise similarities
- Infeasible for most images

Neighboring pixels (4 or 8 connected)

- Very fast to compute
- Only captures very local interactions

Local neighborhood (…more than 8)

- Reasonably fast, graph still very sparse



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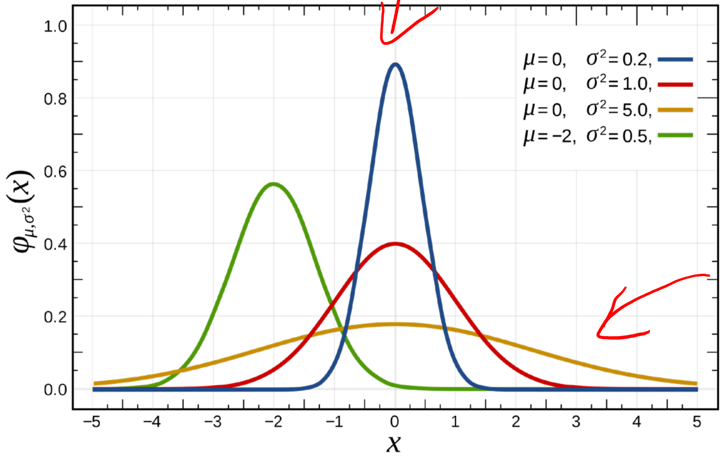
How to Calculate Weights?

$$affinity(p_i, p_j) = e^{-\frac{\|f(p_i)-f(p_j)\|^2}{2\sigma^2}}$$

- p_i, p_j are pixels
- $f(p_i)$ metric for a pixel we can use in a distance function
- $2\sigma^2$ is "normalization" factor…a tweakable parameter



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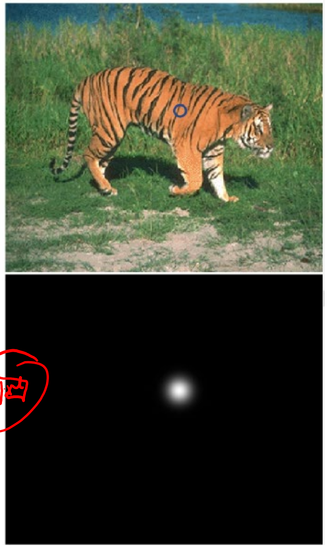
Metrics for Distance Measurement

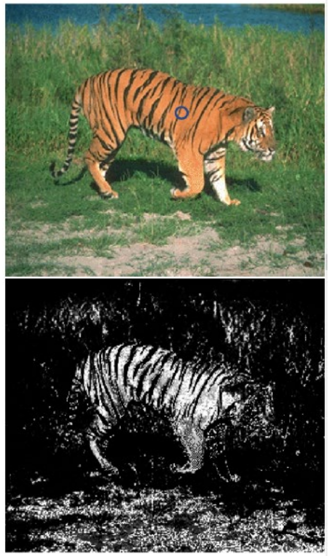
Distance:

$f(x) = location(x)$



Intensity:

$f(x) = intensity(x)$



Color:

$f(x) = color(x)$

Texture:

$f(x) = filterbank(x)$

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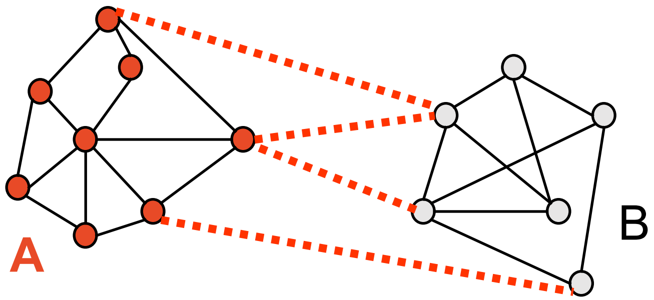
Cuts in a Graph

Definition: Cut

- set of links whose removal makes a graph disconnected
- cost of a cut: $$cut(A,B) = \sum_{p \in A, q \in B} c_{p,q}$$



Many approaches to finding a cut:

- Spectral clustering (use eigenvalues/vectors to find a cut)
- Optimization problem (minimize an energy function related to affinities)
- Minimum cut using combinatorial optimization algorithm
- Normalized cuts

With one cut we are segmenting out a single object…this approach can be extended to multiple objects as well

Cuts in a Graph

Definition: Cut

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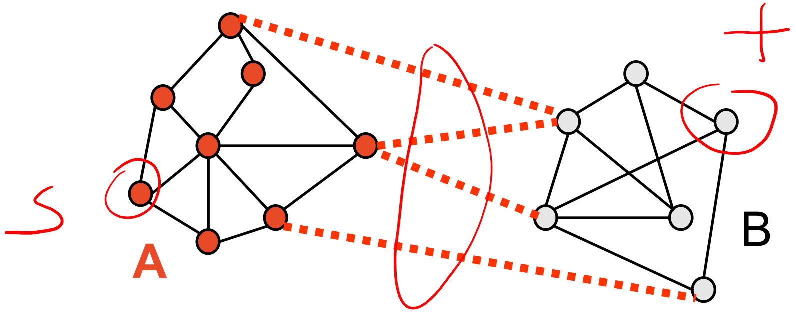

One idea: find minimum cut

- gives you a segmentation
- fast algorithms exist for doing this
- max flow - min cut algorithms
    - Ford-Fulkerson
    - Push-Relabel
    - Boykov-Komolgorov