ALADDIN Workshop on Graph Partitioning in Vision and Machine Learning

Jan 9-11, 2003

Welcome!

[Organizers:
Avrim Blum, Jon Kleinberg, John Lafferty, Jianbo Shi, Eva Tardos, Ramin Zabih]

Graph partitioning

Coming up recently in

- Vision (image segmentation, image cleaning,...)
- Machine Learning (learning from labeled & unlabeled data, clustering).

Central problem in Algorithms (max-flow min-cut, balanced separators)

Goals of the Workshop

- Exchange of ideas among people in 3 areas.
- Understanding of similarities and differences in problems, objectives.
- Formulate good questions.

This is supposed to be informal!

Thanks to our sponsor

ALADDIN Center

- NSF-supported center on ALgorithms, ADaptation, Dissemination, and INtegration
- Support work/interaction between algorithms and application areas.

More announcements at the break

Graph partitioning for Machine Learning from Labeled and Unlabeled data

Avrim Blum, CMU

Combining Labeled and Unlabeled Data

- Hot topic in recent years. Many applications have lots of unlabeled data, but labeled data is rare or expensive. E.g.,
  - Web page, document classification
  - OCR, Image classification
  - Text extraction

Can we use the unlabeled data to help?

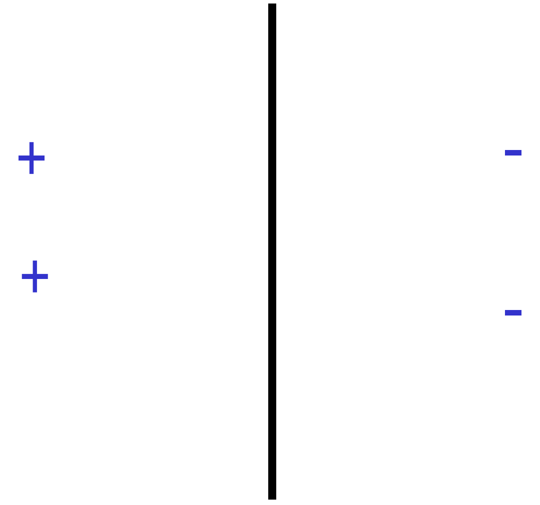
[lots of relevant references omitted here]

How can unlabeled data help?

- Unlabeled data + assumptions ! reduce space of "reasonable" distinctions.
  - E.g., OCR data might cluster. We hope each digit is one or more clusters.
  - Assumptions about world add a "self-consistency" component to optimization.
- In the presence of other kinds of info, can provide ability to bootstrap (co-training).
  - e.g., video, word-sense disambiguation.

Unlabeled data + assumptions ! reasonableness criteria

- Suppose we are looking for a linear separator. We believe should exist one with large separation. SVM.



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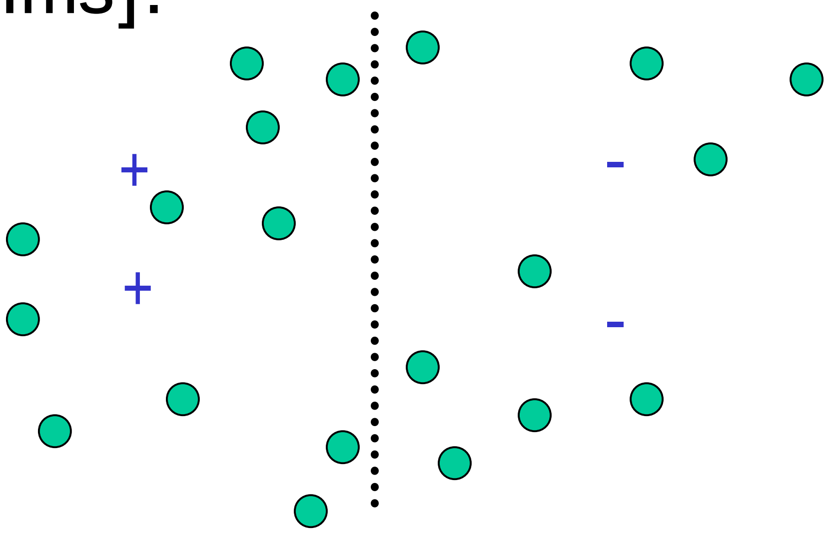

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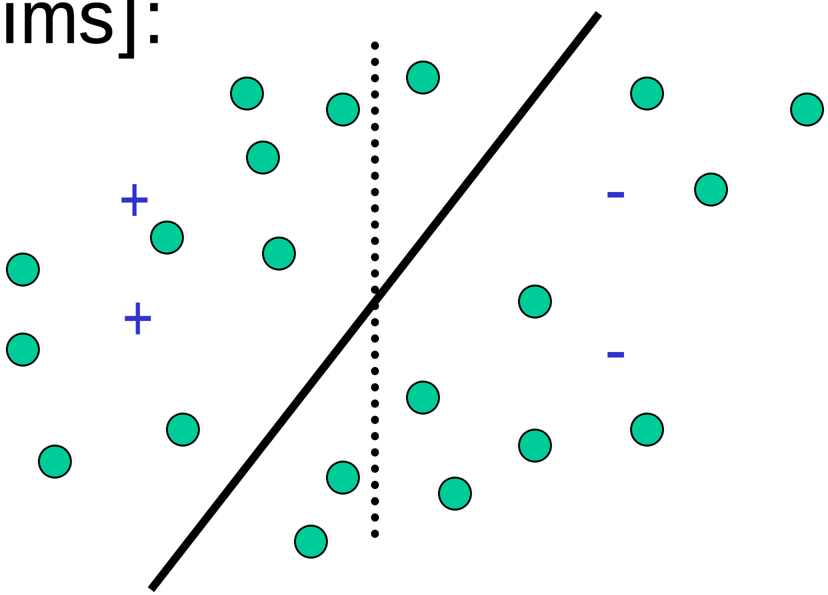


Unlabeled data + assumptions ! reasonableness criteria

- Suppose we believe that in general, similar examples have the same label.
  - Suggests NearestNeighbor or locally-weighted voting alg for standard problem.
  - Why not extend to objective function over unlabeled data too?

Unlabeled data + assumptions ! reasonableness criteria

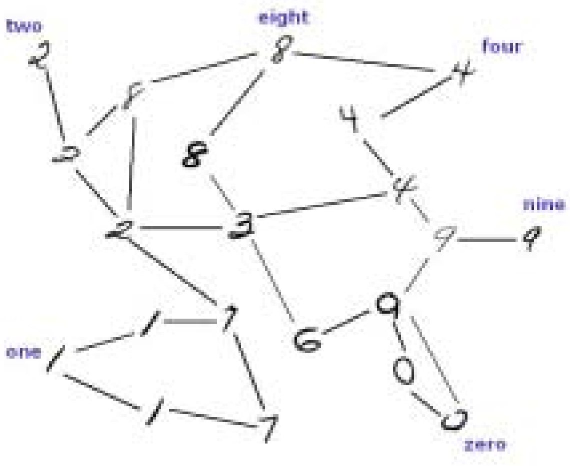
- Suppose we believe that in general, similar examples have the same label.
  - Given set of labeled and unlabeled data, classify unlabeled data to minimize penalty = #pairs of similar examples with different labels.

The good, the bad, and the ugly…

The good

Suggests natural alg approach along lines of [GPS,BVZ,SVZ,KT]:

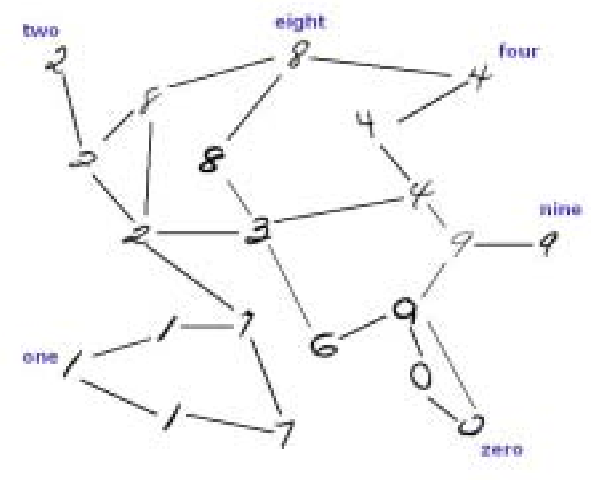
1. Define graph with edges between similar examples (perhaps weighted).



The good

Suggests natural alg approach along lines of [GPS,BVZ,SVZ,KT]:

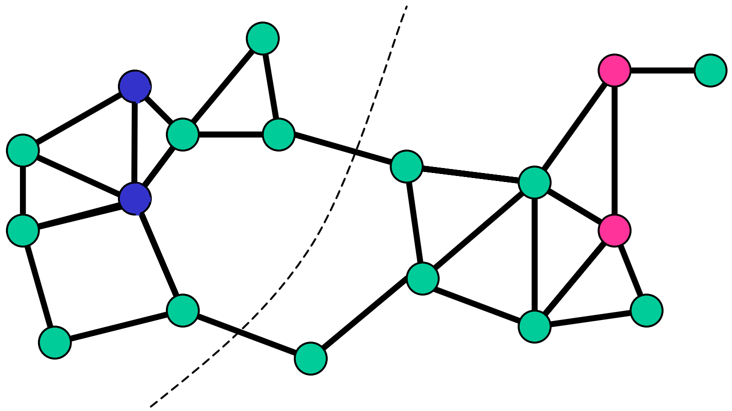
2. Solve for labeling that minimizes weight of bad edges.



The good

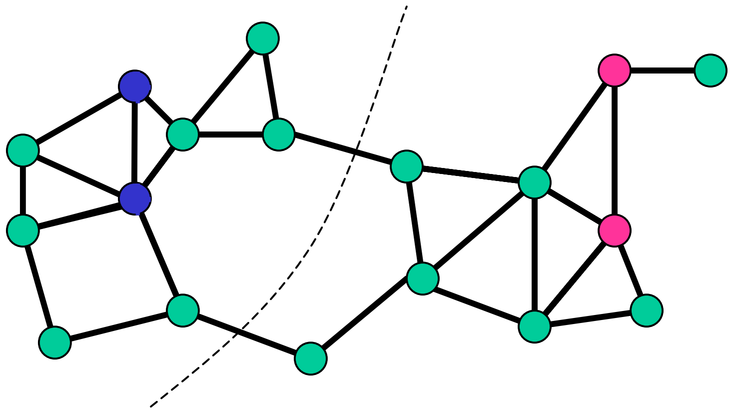
Much of ML is just 2-class problems, so (2) becomes just a minimum cut.

S.Chawla will discuss some exptl results and design issues.



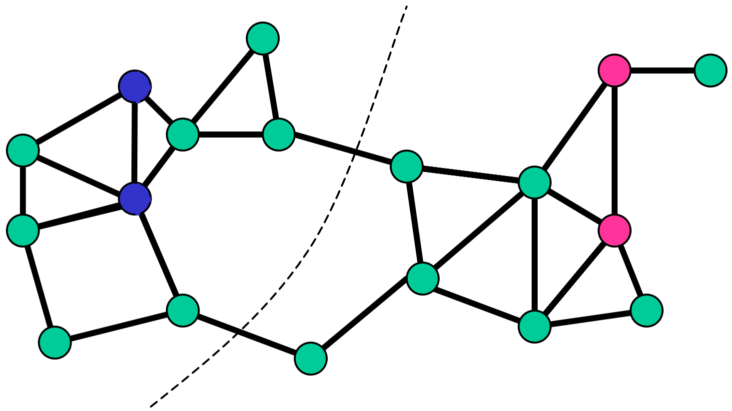
The good

Another view: if we created graph by connecting each to nearest neighbor, this is the labeling s.t. NN would have smallest leave-one-out error. [see also Joachims' talk]



The bad

- Is this really what we want to do? Assumptions swamp our evidence?



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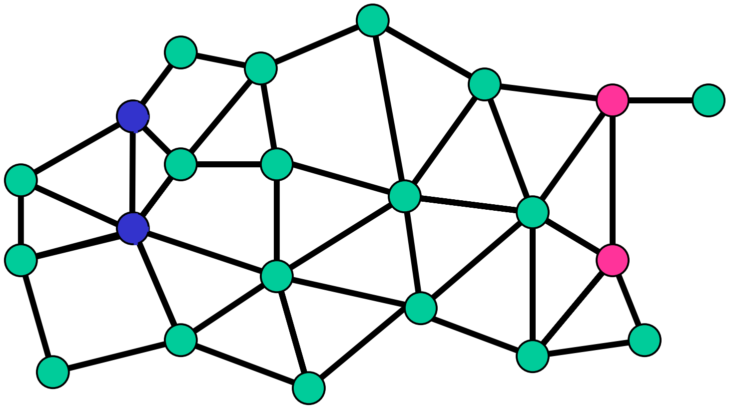

The ugly

1. Who defined "similar" anyway?
2. Given a distance metric, how should we construct graph?
3. Given graph, several possible objectives.

Will skip 1 but see Murphy, Dietterich, Lafferty talks.

2:given d, how to create G?

- weird issue: for just *labeled* data, kNN (k=1,3,5) makes more sense than fixed radius because of unevenness of distribution. (I.e., for each test point you want to grow radius until hit k labeled points).
- But for unlabeled data, fixed k has problems.

Given d, how to create G?

- Say we connect each example to nearest nbr.

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- w(u,v) = f(d(u,v)) at least has property that graph gets more connected...

Given d, how to create G?

- [BC]: use unweighted graph. Edge between any pair of distance < δ.

Dataset	$\|L\|+\|U\|$	number of features	Mincut				ID3	3-NN
			Mincut-3	Mincut-δ_{opt}	Mincut-δ_0	Mincut-$\delta_{1/2}$		
Mush	20+1000	22	82.1	97.7	97.7	97.0	93.3	91.1
Mush*	20+1000	22	74.2	88.7	56.9	87.0	80.8	83.3
Tac	10+100	5	86.0	99.0	96.0	97.0	86.0	80.0
Tac*	10+100	5	76.0	96.0	86.0	94.0	76.0	62.0
Voting	45+390	16	89.1	91.3	66.1	83.3	86.4	89.6
Musk	40+200	166	73.0	92.5	91.0	92.5	83.5	87.0
Pima	50+718	8	63.8	72.3	48.8	72.3	70.0	68.1
Iono	50+300	34	71.0	81.6	78.0	77.6	88.6	69.6
Bupa	45+300	6	53.3	59.3	48.0	41.7	55.5	52.7
MI	124+432	6	70.0	64.4	64.4	64.4	98.6	81.1
MII	169+432	6	68.6	67.2	57.2	67.2	67.9	63.6
MIII*	122+432	6	79.1	80.6	64.8	80.6	94.4	83.6

- Is there a "correct" way? GW-moats?

Given G, several natural objectives

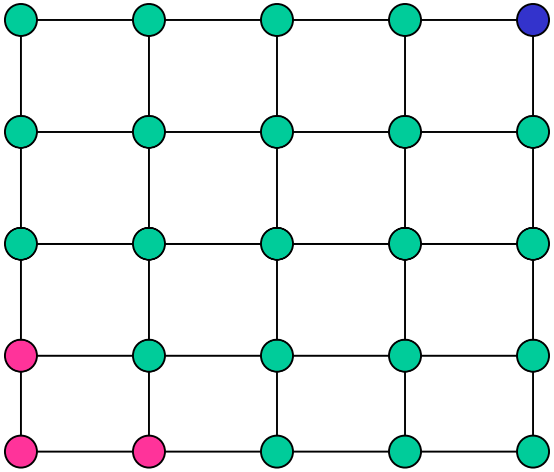
Say f(v)= fractional label of v.

- Mincut: minimize $\sum_{(u,v)\in E} |f(u) - f(v)|$
- [GZ]: minimize $\sum_{(u,v)\in E} (f(u) - f(v))^2$

nice random walk / electrical networks interp.

Given G, several natural objectives

- (When) is one better than the other?



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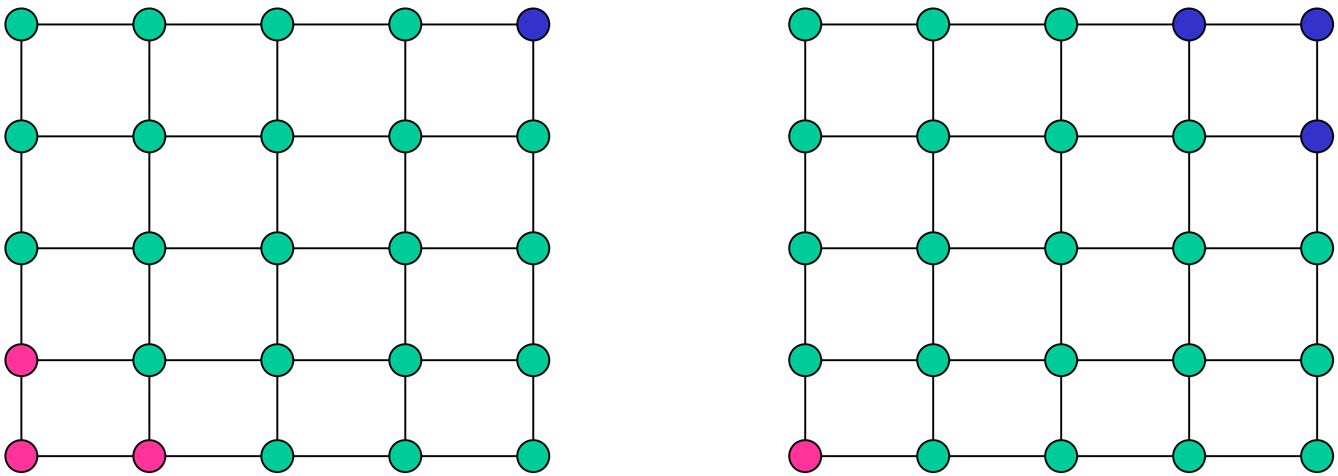

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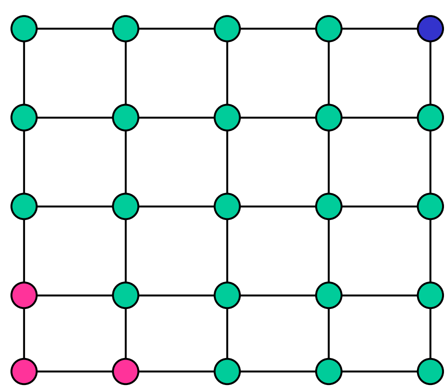
- If we view G as MRF, then mincut is finding most likely configuration.

  Cut of size k has prob $\propto e^{-k/T}$

- Instead, ask for Bayes-optimal prediction on each individual example?



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- Nice open problem: efficiently sample from this distrib? (extend [JS]?)

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- Instead, ask for Bayes-optimal prediction on each individual example?

- Hack: Repeatedly add noise to edges and solve.

More questions

- Tradeoff between *assumptions* over unlabeled data, and *evidence* from labeled data? Esp if non-uniform.
- Hypergraphs? find labeling to minimize number of points that are different from majority vote over k nearest nbrs? See [VK,RZ].

More questions

- … (we’ll see over the next 2.5 days)