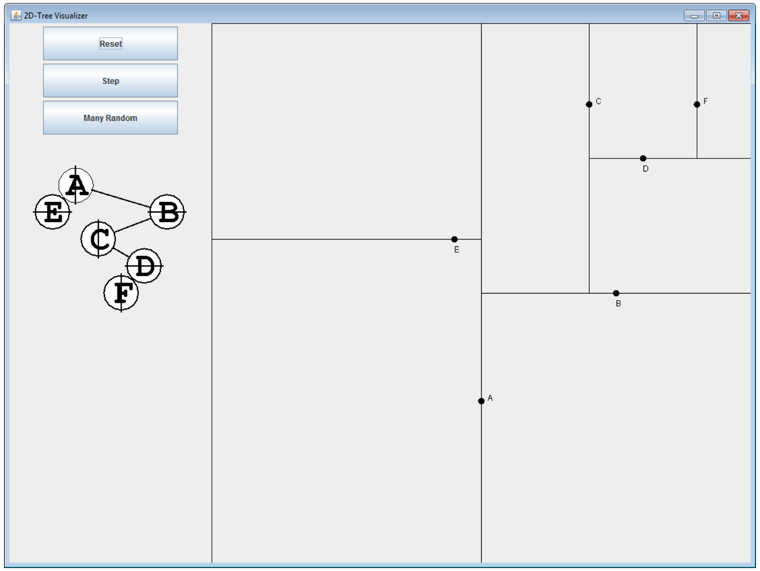
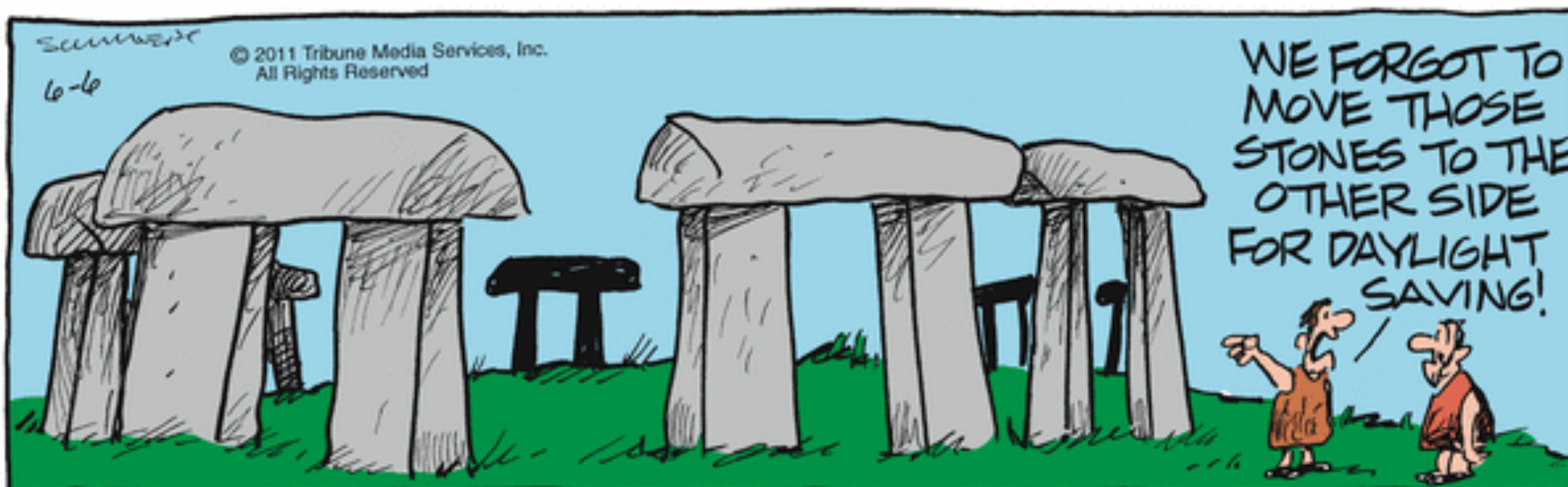


CSSE 230 Day 23

2D Trees

After today, you should be able to …
… explain insert and nearest-neighbor in 2D trees
… implement these algorithms

Reminders/Announcements



Reminders/Announcements

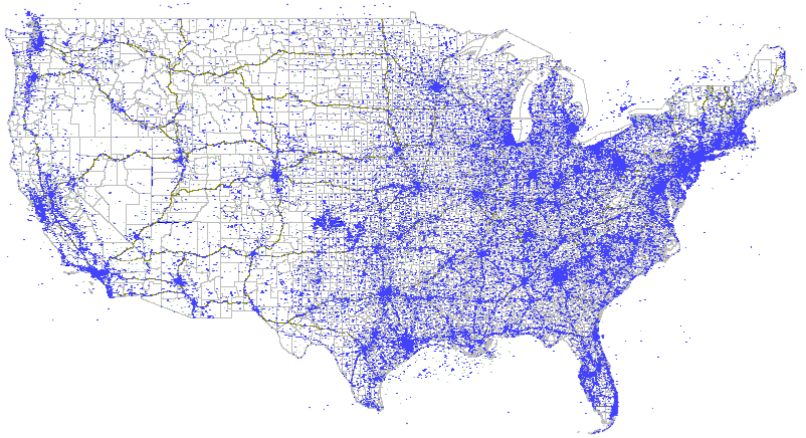
- EditorTrees evals due tonight

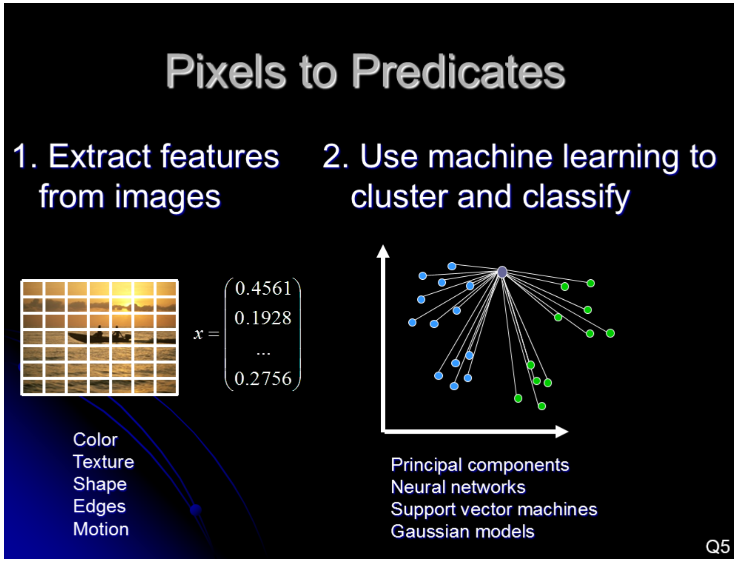
- Would do ONLY if we want them to extend it on the exam:

- Before the final exam, **copy your team's EditorTreesMilestone2 project** to your individual CSSE 230 repository
  - Team > Update
  - Team > Disconnect
    - Before you press the Yes button, choose "Also Delete SVN metadata"
  - Team > Share Project > SVN > Next, choose your repo
  - Team>Commit
    - Just to be sure everything is there.

2D Data

- A large set of (x,y) points
- Which cell phone tower is closest to me?
- Which image is most like this one?
- In general:
  - Find the nearest neighbor of a query point (today).
  - Find or return all points in a certain range.



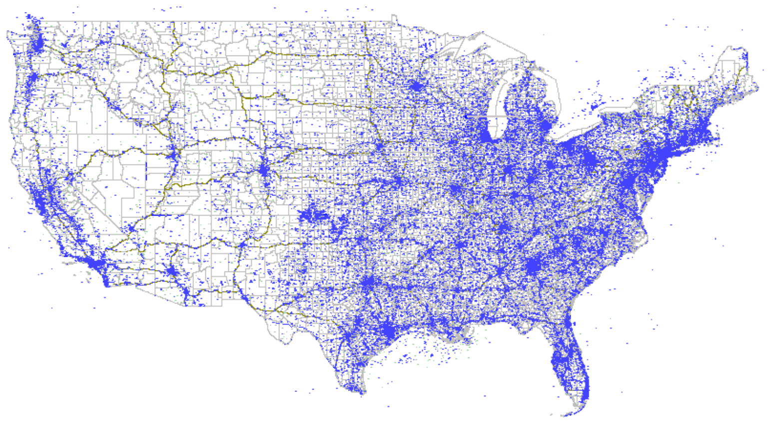


https://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/atlas/tower_maps_large.gif
https://www.rose-hulman.edu/class/csse/csse463/201520/Slides/01%20Introduction.pdf

2a

How to represent 2D data?

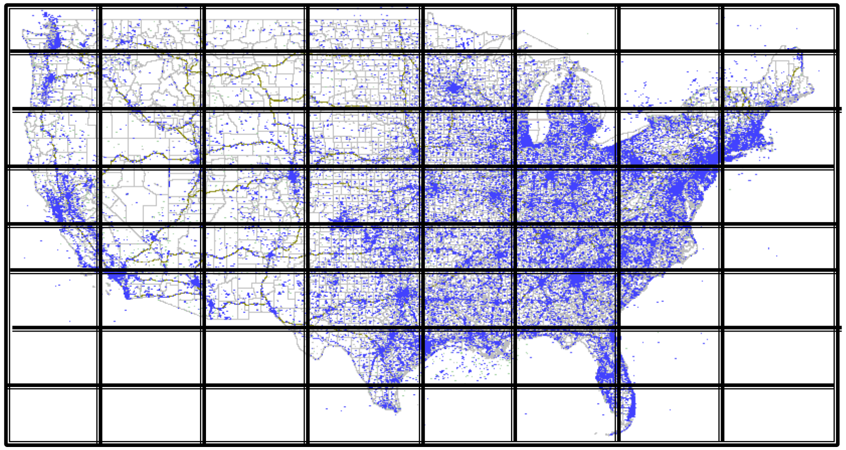
- List of points. Simple but slow
  - [p1, p2, …, pN]
  - To find closest to q, find smallest of dist(q, p1), dist(q, p2), …



Representation	Average nearest-nbr efficiency
List of points	N

How to represent 2D data?

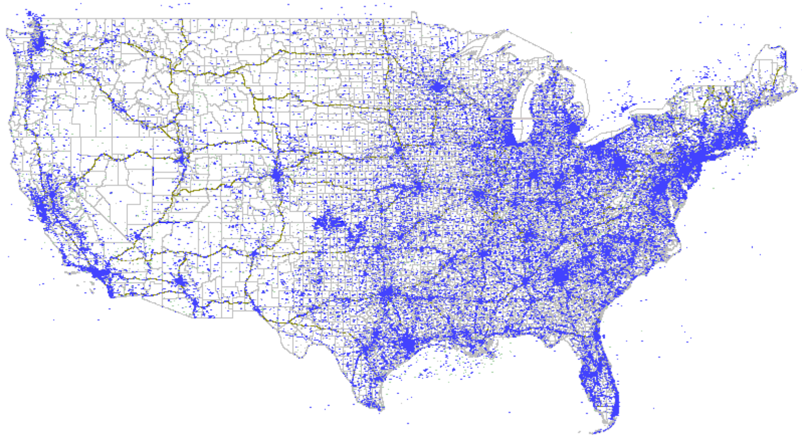
- List of points. Simple but slow
- Use a regular grid.
  - 2D array of lists
  - Faster, but which resolution?
  - Example, M=8



Representation	Average nearest-nbr efficiency
List of points	N
Regular grid	$1 + N/M^2$ but space = $N + M^2$, clustering degrades

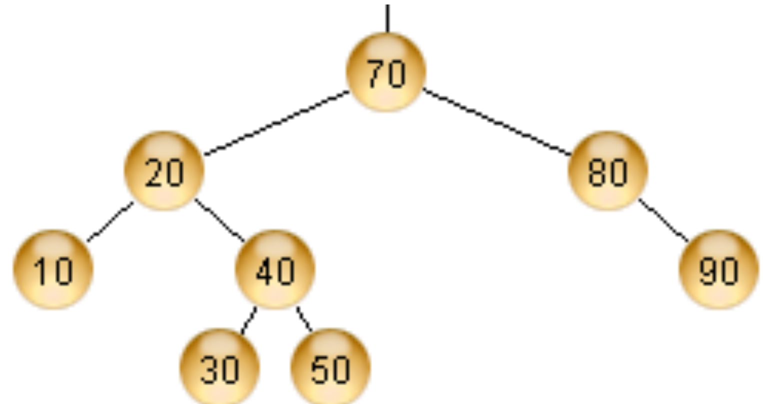
How to represent 2D data?

- List of points. Simple but slow
- Use a regular grid.
- ???



Representation	Average nearest-nbr efficiency
List of points	N
Regular grid	$1 + N/M^2$ but space = $N + M^2$, clustering degrades
???	log N

Binary search trees partition the number line



- Split at 70
- Split at 20
- etc

- Any value inserted to the left of 30 must be in what range?

You can partition the coordinate plane with a variation of BSTs

- Root splits plane using x-coordinate and each level splits the plane in one direction only.

- Use the insert algorithm to build a tree from points:

```
A (0.5, 0.7)
B (0.75, 0.5)
C (0.7, 0.15)
D (0.8, 0.25)
E (0.45, 0.4)
F (0.9, 0.15)
```

You can partition the coordinate plane with a variation of BSTs

- Root splits plane using x-coordinate and each level splits the plane in one direction only.

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  A (0.5, 0.7)
  B (0.75, 0.5)
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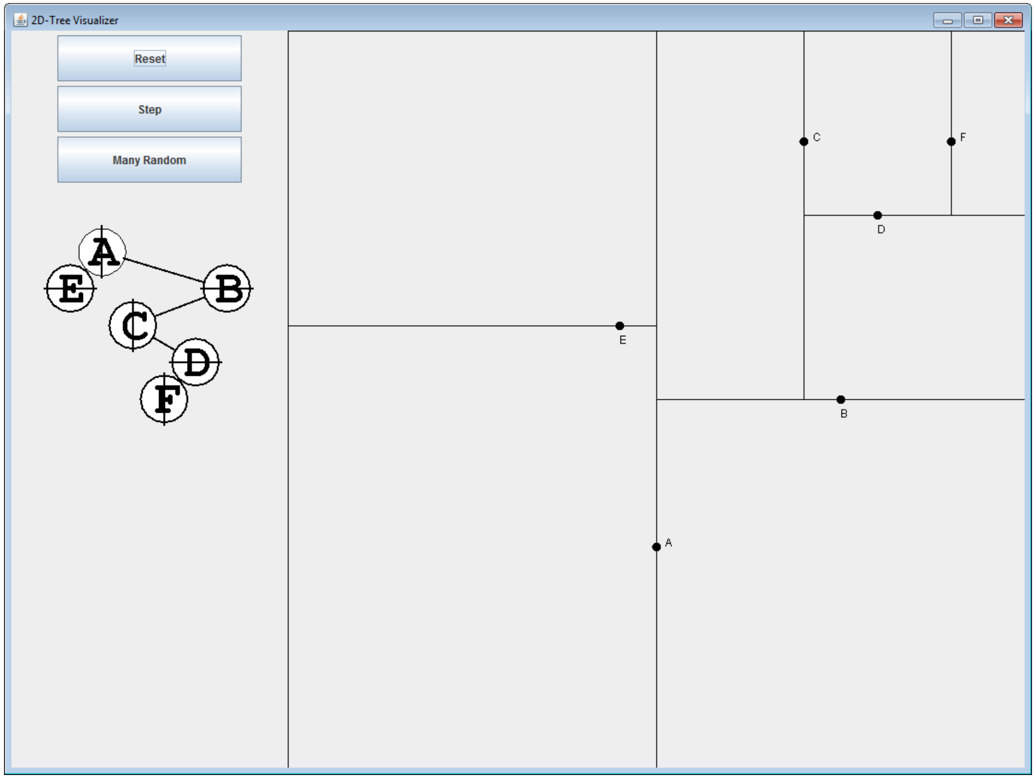

Nearest neighbor using a 2D Tree

- Initialize the closest point as the root.
- Recursively go to each side if it could be closer:
  - To left/top and update closest if one found
  - To right/bottom and update closest if one found
  - When hit a null node, just return

- New idea: don't always recurse to left/top first. Instead, first recurse to the **same side** as the query point, and then **only** recurse to the other side **if** it *could* yield a closer point
  - To do this, each node also stores the bounds of rectangle it is part of
  - I give you a Rectangle class with a method to find closest distance from a point that that rectangle.

Nearest neighbor using a 2D Tree

Initialize the closest point as the root.

Recursively go to each side if it could be closer:

- To left/top and update closest if one found
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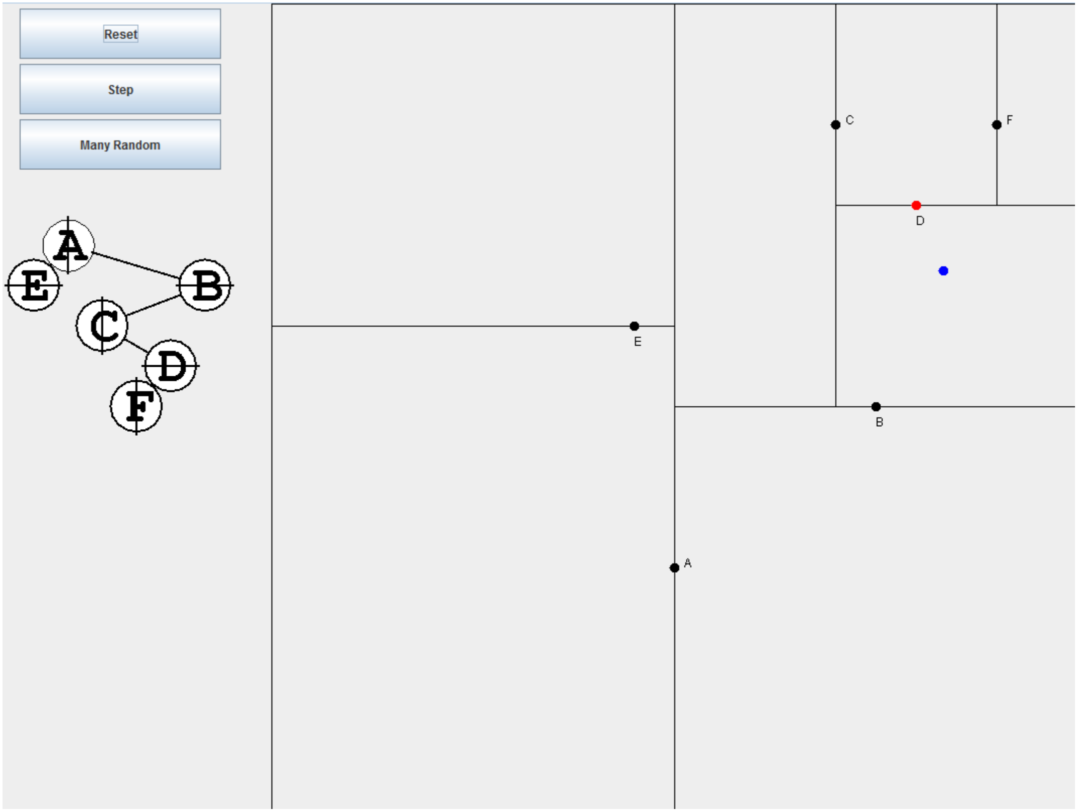
- When hit a null node, just return

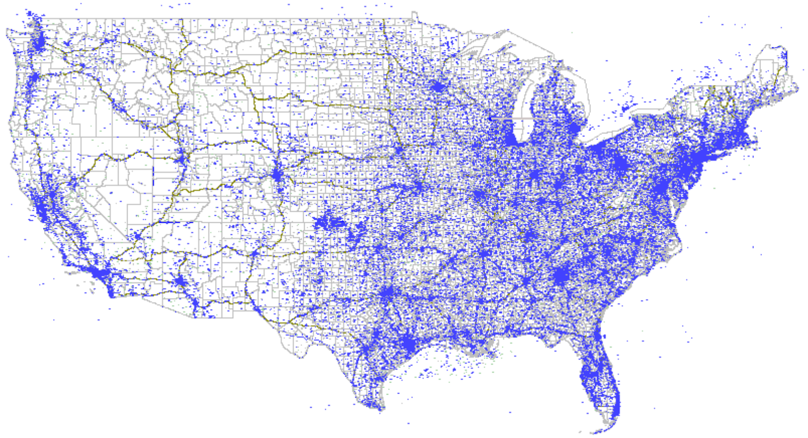


New idea: don't always recurse to left/top first. Instead, recurse to the same side as the query point, and then only recurse to the other side if it *could* yield a closer point

- To do this, each node will also store the bounds of rectangle it is part of

How to represent 2D data?

- List of points. Simple but slow
- Use a regular grid.
- Use a 2D tree
  - You can find the nearest neighbor efficiently



Representation	Average nearest-nbr efficiency
List of points	N
Regular grid	$1 + N/M^2$ but space $= N/M^2 + 1$, clustering degrades
2D tree	log N

2D Trees are useful

- Questions for thought:
  - How would you build a 3D tree?
  - … a kD tree for arbitrary dimension k?
- Summarize now
- Assignment for this week:
  - Implement insert(Point), contains(Point), and nearest(Point) using a 2D tree.
  - There are unit tests for correctness and efficiency. You must earn the correctness points to be considered for the efficiency points – efficiency first!