Spatial Trees

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Opening Discussion

- Minute essay comment:
  - Is Scala better than other languages at context-sensitive grammars?
- IcP solutions.

Motivation

- Lots of applications have data that has a spatial component to it. Simple examples are characters in a world or particles in space.
- Consider you want to find all other things within a certain distance of one of them.
- How do you do this? What is the order of your approach?

Grids

- One way to speed this up is to just put everything into a grid.
- Make a 2-D array of linked lists. Make grid cells the size of the region you are searching. Only have to look in adjacent cells.
- This works fine if the distribution is fairly uniform. When the distribution isn't uniform it has problems.
- It also can run into memory issues above 2-D.

Spatial Trees

- We saw earlier that trees are highly flexible. The BST can do some things like an array, but perform all operations in O(log n) time.
- We can also make trees that break things up spatially.
- These deal well with non-uniform distributions and also give roughly O(log n) performance for single operations.
- You can use recursion to search for neighbors.

Quad-tree

- As the name implies, this type of tree has four children at each node.
- Typical implementation starts with a box and recursively splits it in the center along x and y.
- Data goes in leaves and splitting stops when you get down to a certain number of particles.
- Octree is the equivalent in 3-D. Approach doesn't scale well above that.

kD-Tree

- This is a move flexible option that splits on a particular axis at each node. (e.g. x=3)
- Internal nodes have two children.
- Split direction can change regularly or go in the direction of greatest spread.
- Scales well to high dimensions. Can be built in a way that is perfectly balanced.
- Let's write one.

Other Options

- There are lots of options for these.
- Point based trees keep data in all nodes and split on points.
- BSP-trees used in games/graphics. (Binary Space Partition) Like kD-trees, but split can be an arbitrary plane.
- etc.

Minute Essay

- If we were going to spend more time on any one topic we have covered, what would you want it to be?