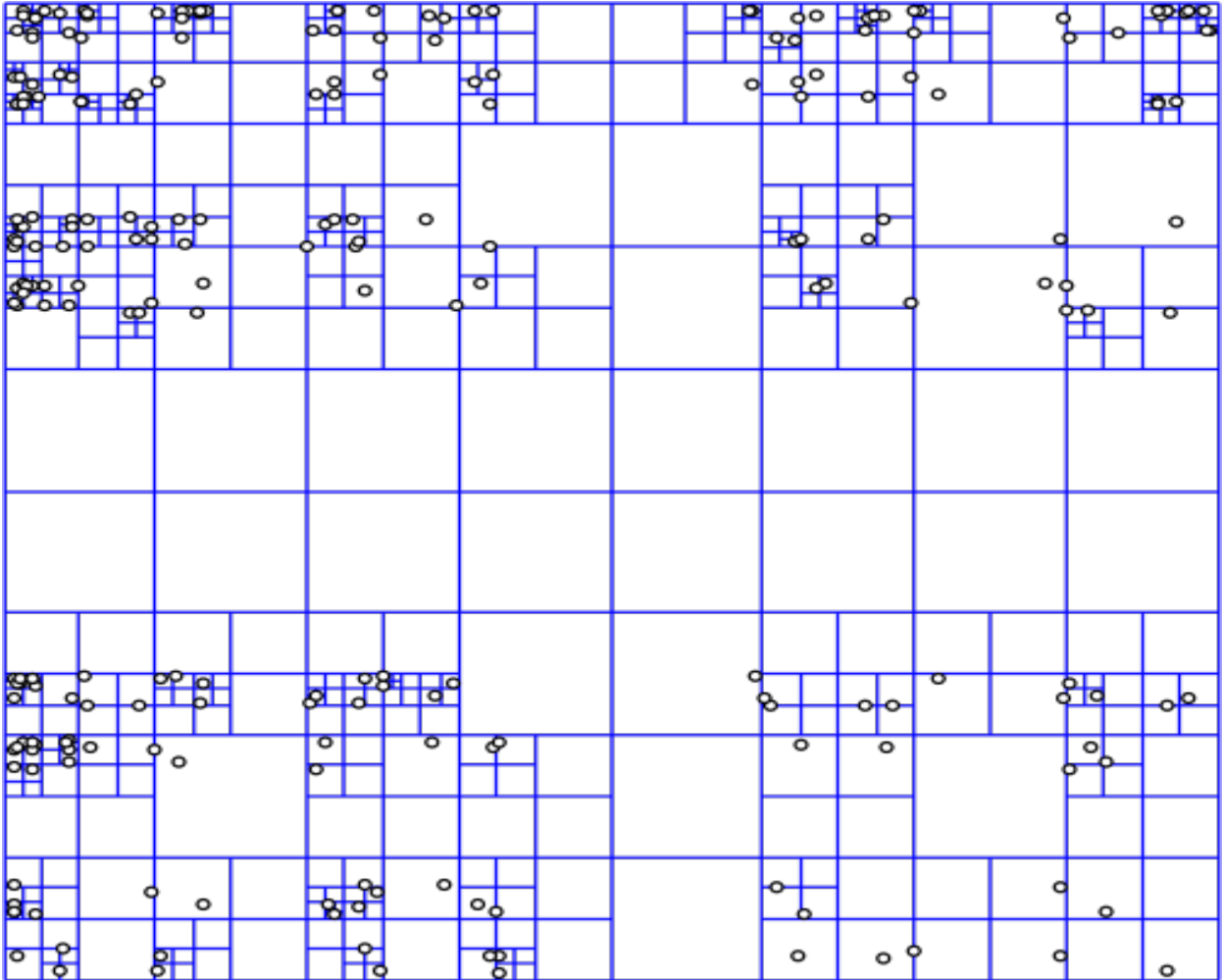


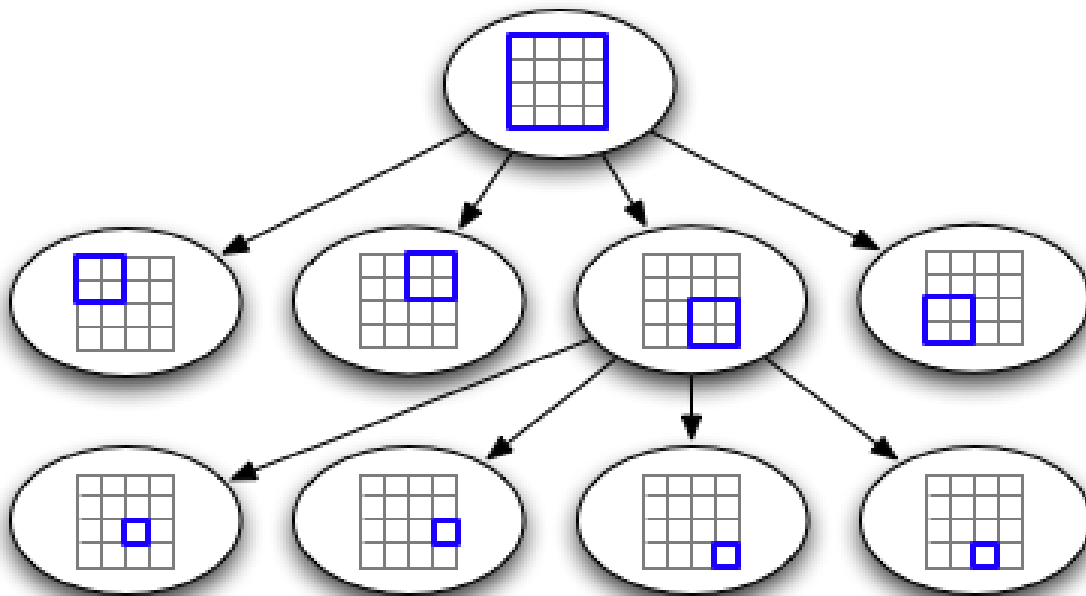
Quad Trees

By Alan Solitar



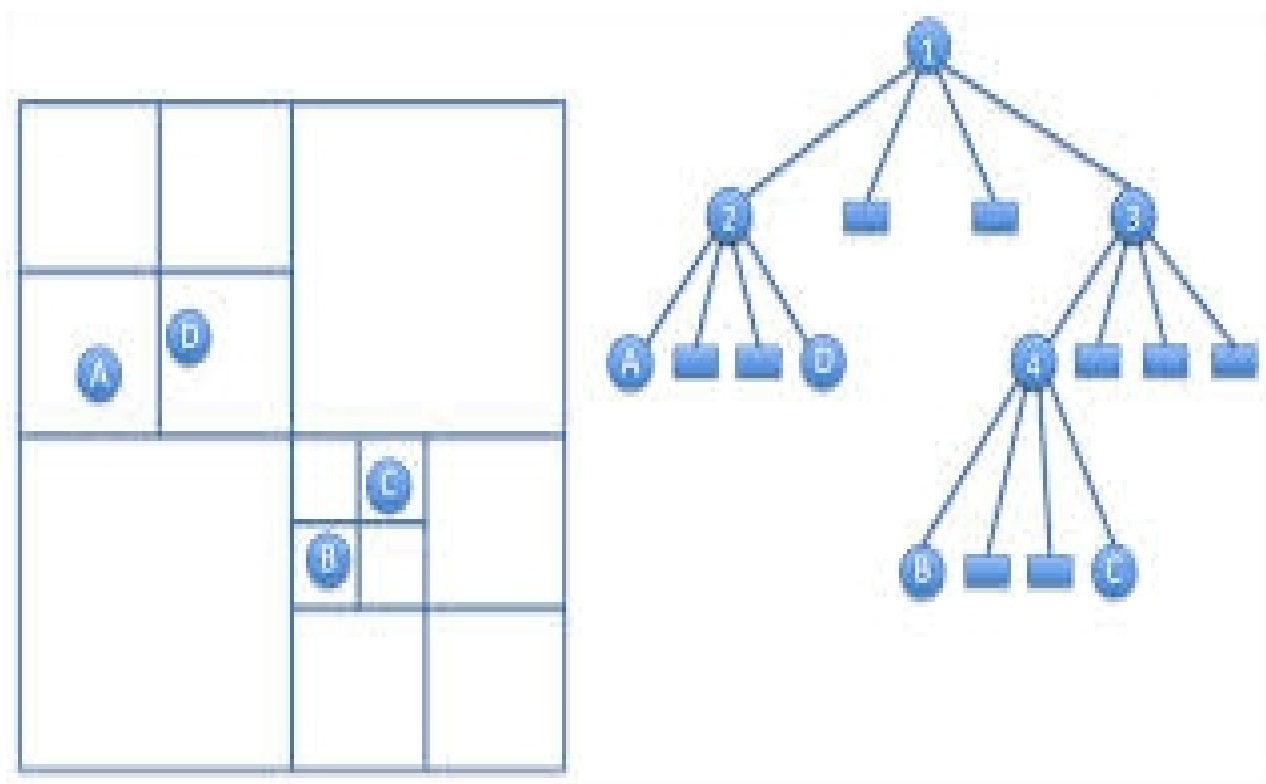
What Are Quad Trees?

- Tree Data structure used to represent/partition space
- root will represent the entire space
- In general – each node will have either 4 or 0 children
- General process – split area into 4 quadrants recursively



Region Quad Tree

- root is entire space
- 4 or 0 children per node
- Objects are stored in the leafs
- Objects in between regions can be stored in parent or as duplicates within leafs



Operations:

Query

- $O(h)$ for traversal

- ($n+h$) worst case for points – all points may be in same quadrant

Insertion

- From root - traverse through quadrants which hold the point. If leaf, add point to list of points – $O(h)$

- If you exceed some number of points, split the leaf into quadrants and redistribute the points

Checking Neighbors

- There will be times when you need to check the neighbors of a node

- very simple – traverse up until you find a common ancestor, then traverse back down

Application 1: Collision Detection

- Used in games or in simulations (particle collision)
- Can be used in any dimension – nodes have 2^d pointers (can use a ton of a memory)
- example: 3D – 8 pointers (octo tree)

How to do it:

- Traverse to leaf the same as in insert
- Run collision detection algorithm for all points in that quadrant
- If storing duplicates – need outside structure

Why is this structure is good for collision detection?

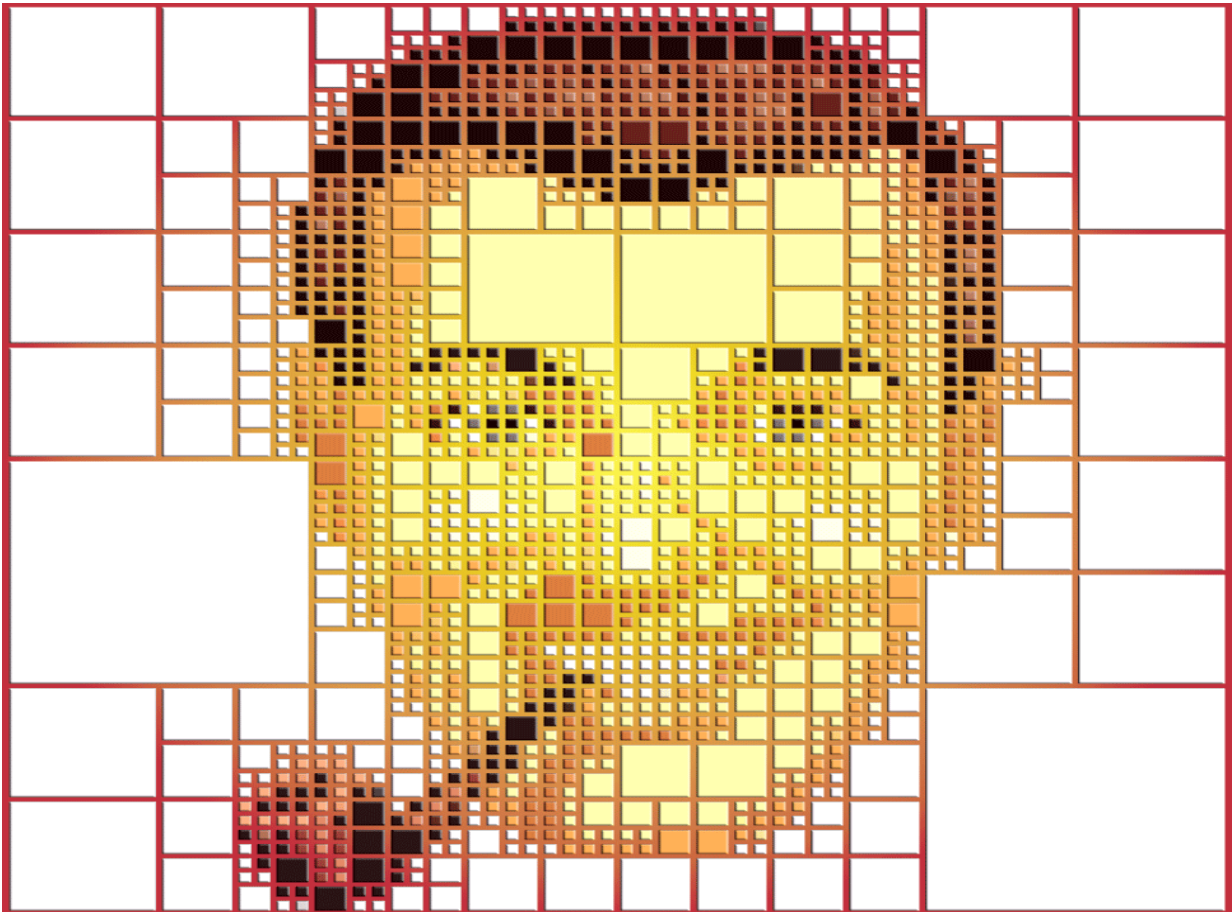
- With the way we partition the space, we don't have to run a costly collision algorithm on objects that can't possibly collide

[Collision Video 1](#)

[Collision Video 2](#)

Application 2: Image

- Can be used to represent an image where the length and width must be powers of two
- root is entire image
- you keep splitting until you reach leaf nodes that only contains 0's or 1's



Other Types:

PR Quad Tree

- very similar to a binary tree
- Balanced – $H = \log_4 n$
- instead of “left” and “right”, “NW”, “NE”, “SW”, “SE”
- Divide into quadrants until each quadrant holds at most 1 point

Edge Quad Tree

- stores lines instead of points

Others

- There are also many other types such as PM quad trees, MX quad trees, etc...

Thank you for listening

Sources:

Text

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Videos

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<https://www.youtube.com/watch?v=fuexOsLOfl0>

Pictures

<http://static.notdot.net/uploads/quadtree.png>
http://news.povray.org/povray.binaries.images/attachment/%3Ck2p3709vo79hm3concehbm30217n29io6l@4ax.com%3E/quadtree_dobbs.png?ttop=365492&toff=4750
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