**K-d tree**

Used for point location and multiple database queries,

- $k$ – number of the attributes to perform the search

Geometric interpretation – to perform search in 2D space – 2-d tree

Search components $(x,y)$ interchange!
k-d tree
Kd tree example
Kd tree example
function kdtree (list of points pointList, int depth)
{
    // Select axis based on depth so that axis cycles
    // through all valid values
    var int axis := depth mod k;

    // Sort point list and choose median as pivot element
    select median by axis from pointList;

    // Create node and construct subtree
    node.data := median;
    node.leftChild := kdtree(points in pointList before median, depth+1);
    node.rightChild := kdtree(points in pointList after median, depth+1);
    return node;
}
Finding the nearest neighbor

Given example x and a k-d tree
Descend to the leaf where x would be, finding the distance from x to every point in the path (there are log n points in the path) and storing the closest one
Traverse back from the leaf to the root
At every node, determine if it is possible to find the nearest neighbor in the subtree not traversed in the descent. If it’s possible to find the nearest neighbor in that subtree, apply search recursively to that subtree
- The savings come from NOT traversing the subtrees that were not visited in the descent
Example

Build a k-d tree with the following training examples:
t1: (1, 3)
t2: (2, 5)
t3: (3, 4)
t4: (4, 1)
t5: (5, 6)
t6: (6, 7)
t7: (7, 2)
Example

```
(4,1)  x
   / \
(3,4) (5,6)  y
  /   /   \   \   
(1,3) (2,5) (7,2) (6,7) x
```
Example

Find the nearest neighbor of (7,10)
After descending, the nearest neighbor found so far is (6,7) (dist = 4)
Example

Backtracking
Can we have examples in the left subtree of (5,6) with a distance to (7,10) of less than 4?
No! (since |10-6| = 4)
Backtracking
Can we have examples in the left subtree of (4,1) with a distance to (7,10) of less than 4?
Yes! (since |7-4| = 3) (point (4,10) could be there)
Example

Descent
Nothing found in the descent that is closer
Backtracking
Can we have examples in the left subtree of (3,4) with a distance to (7,10) of less than 4?
No! (since |10-4| = 6)
Example

Done
(6,7) is the nearest neighbor of (7,10)