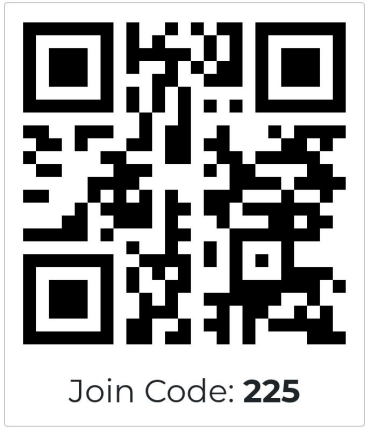
Announcements

1. MP Lists due Today!
2. Exam 2 this week! (M-W)
3. Exam 1 Grades Released
    a. Exam Regrade Form Online
4. Extra Credit Survey Form (2pts, 70% of class must respond)
5. MP Mosaics will be released soon

Extra Credit Survey!



Warm-Up Question: What is the worst case runtime of Quick Select?

KD Trees

Learning Objectives

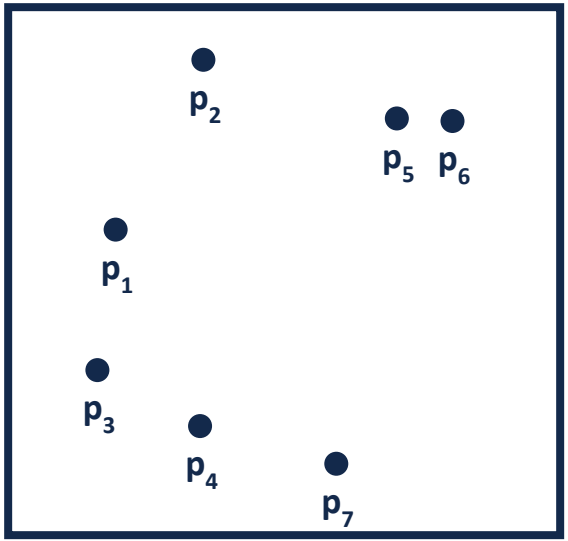
1. Understand the worst and average case runtime of Quick Select
2. Understand nearest-neighbor search with a KD-Tree
3. Define and Implement Lambda Functions

2D Range Based Searches

Consider points in 2D: $\mathbf{p = \{p_1, p_2, \ldots, p_n\}}$

Tree Construction:

1. Find median point along a dimension and partition nodes
2. Go to next dimension
3. Recursively build left subtree
4. Recursively build right subtree



Quick Select Algorithm

Partitions elements about the median

Smaller Values are on the left of the median

Larger Values are on the right of the median

Faster than sorting O(n log n)

Ex. Input: [11, 6, 44, 41, 33, 57, 2]

Output: [11, 6, 2, 33, 41, 57, 44]

Worst Case Analysis

Ex. Input: [11, 6, 44, 41, 33, 57, 2]

Average Case Analysis

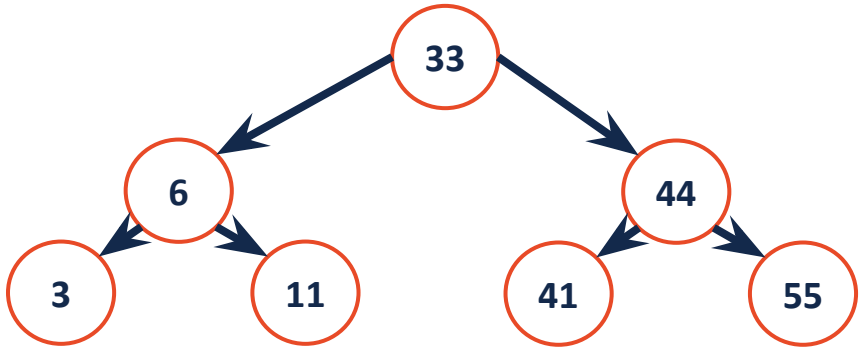
Ex. Input: [11, 6, 44, 41, 33, 57, 2]

Closest Element

BSTs are useful structures for range-based and nearest-neighbor searches.

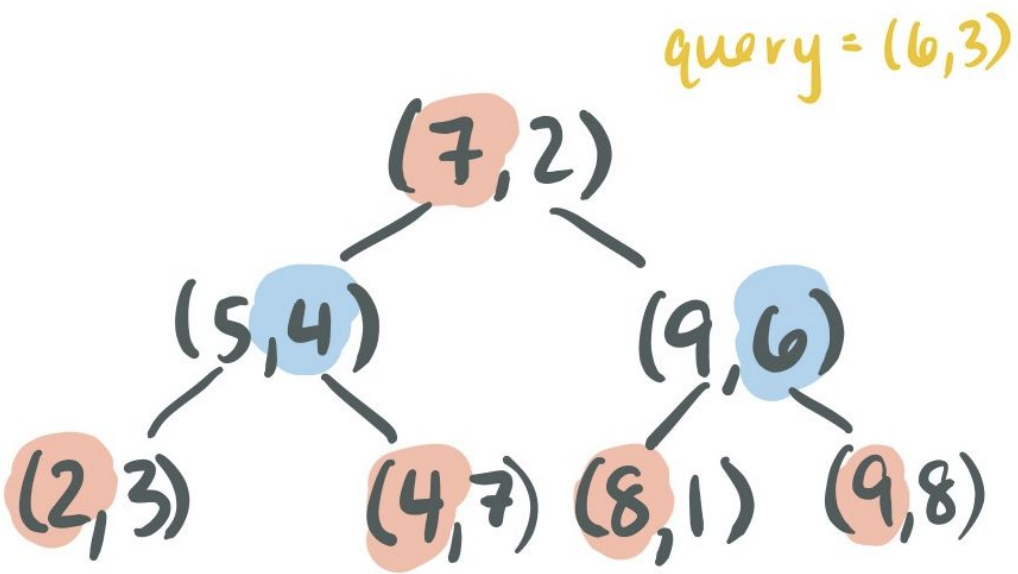
Q: Consider points in 1D: $\mathbf{p = \{p_1, p_2, \ldots, p_n\}}$.

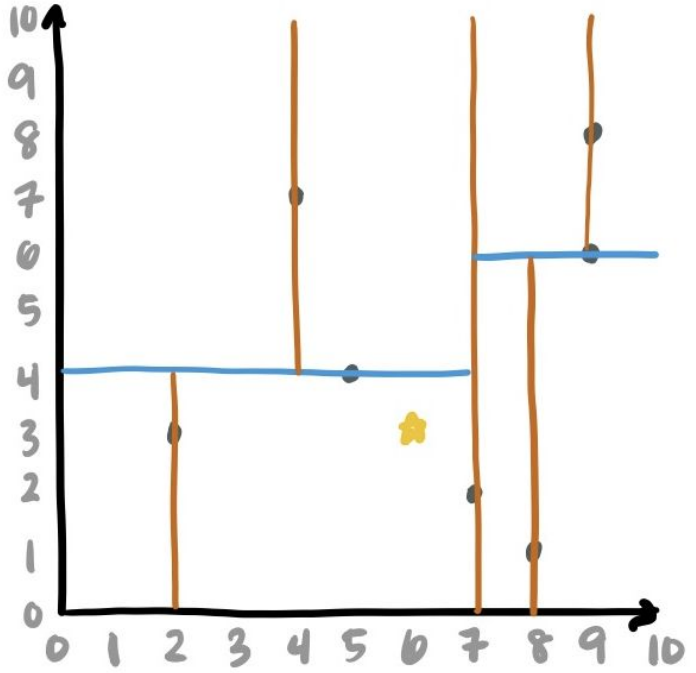
…what point is closest to 16?



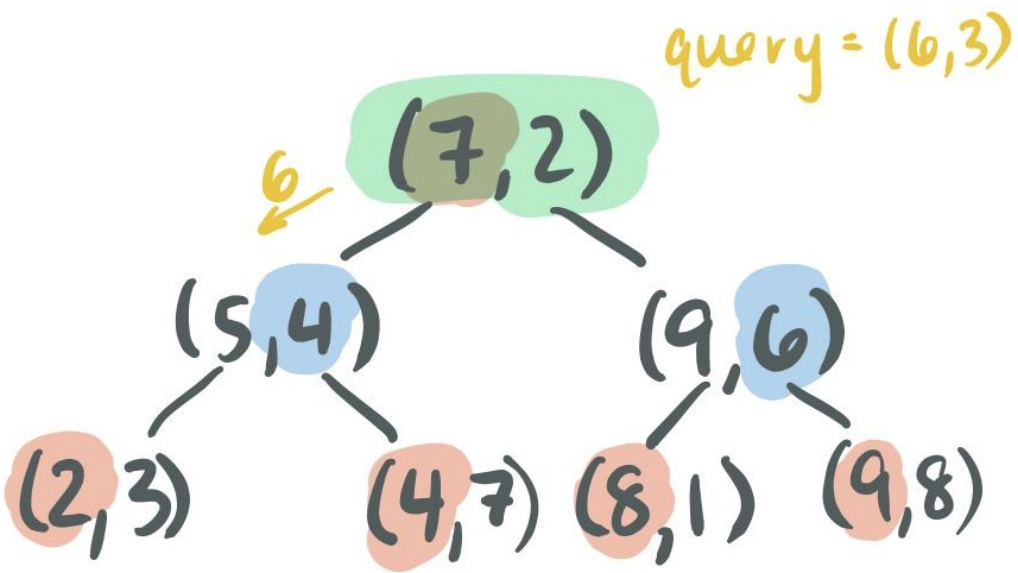
Ex:

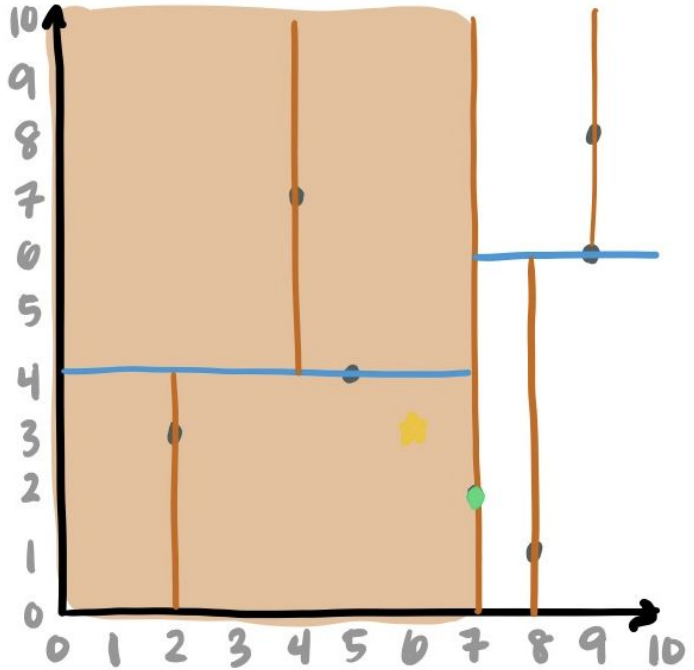
Nearest Neighbor KD Tree



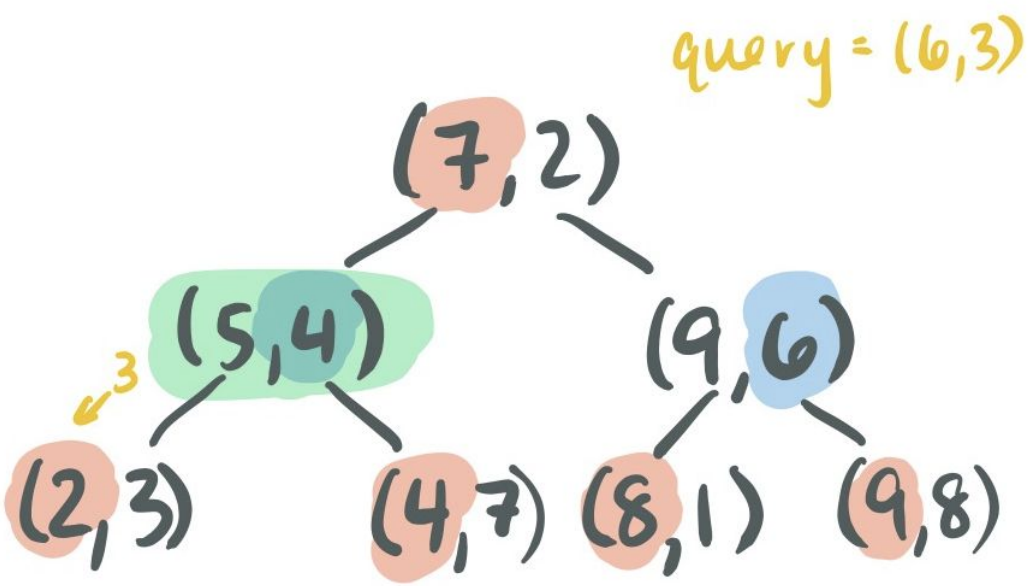


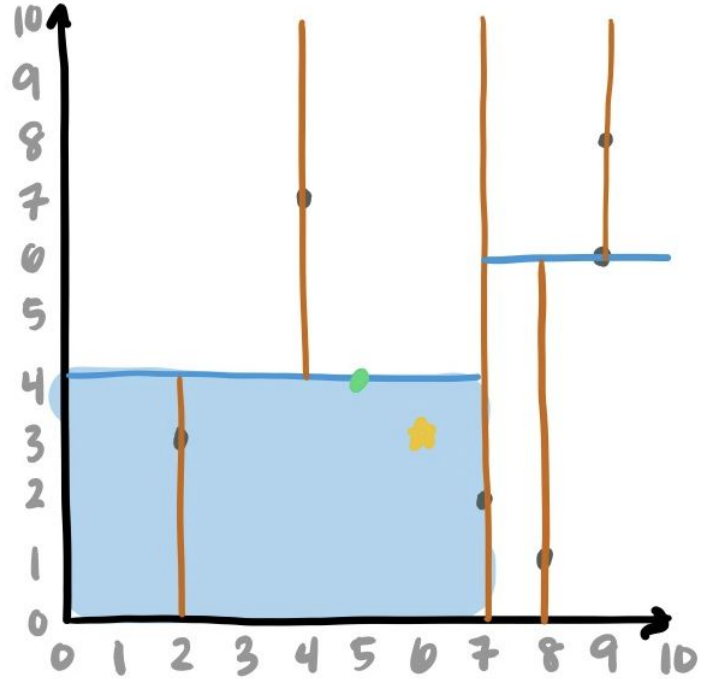
Nearest Neighbor KD Tree



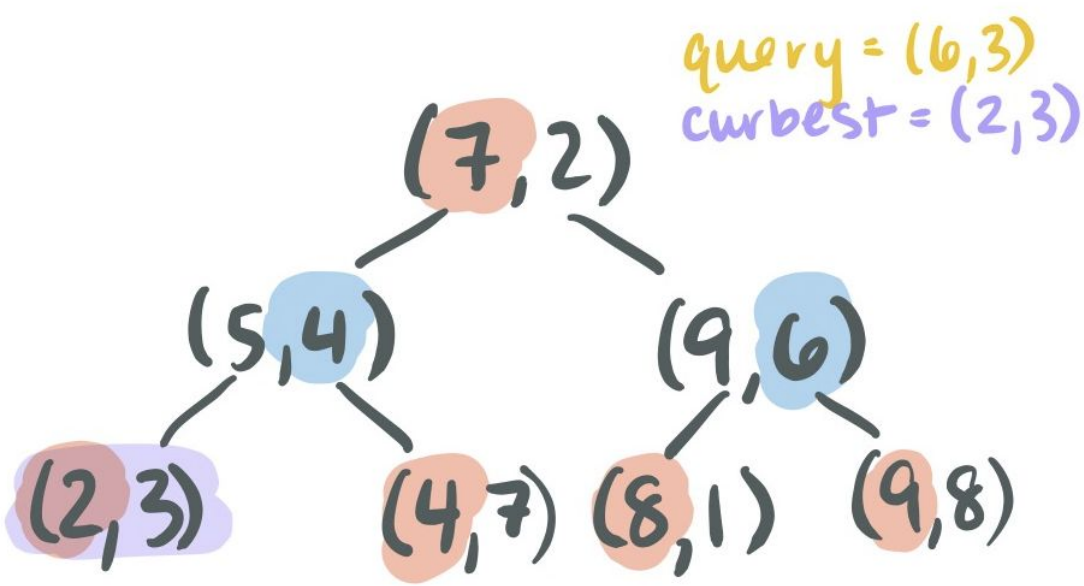


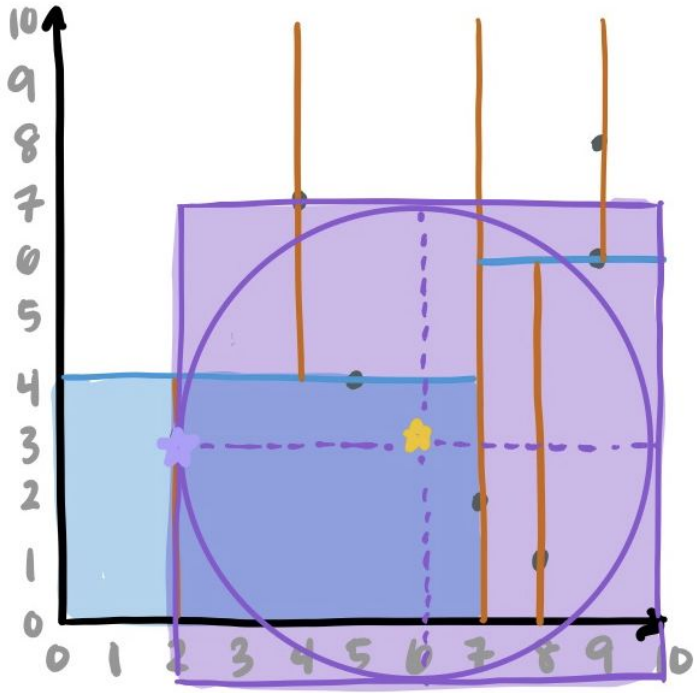
Nearest Neighbor KD Tree





Nearest Neighbor KD Tree

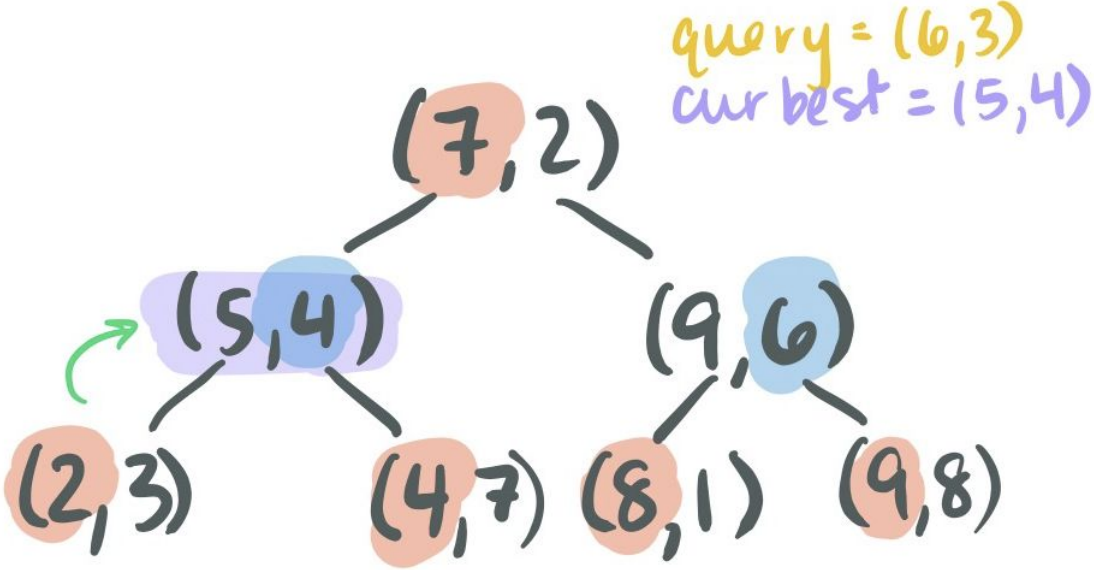


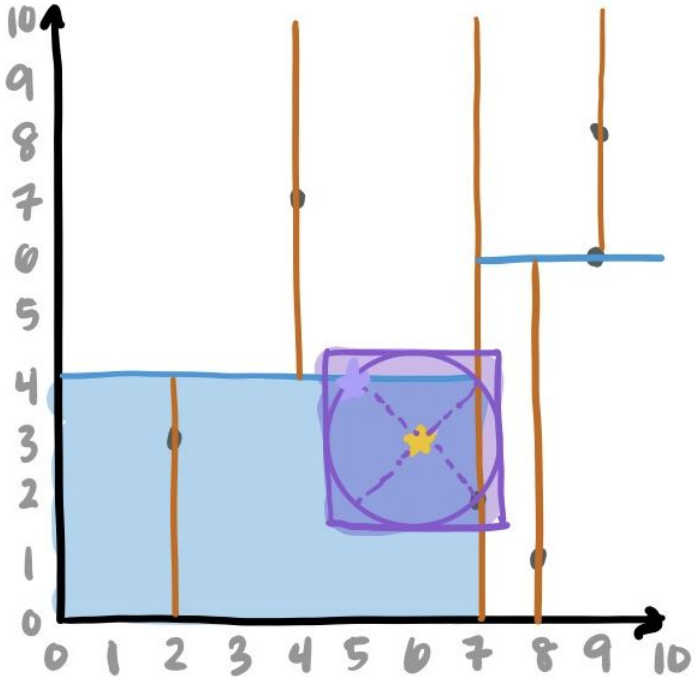


Nearest Neighbor KD Tree

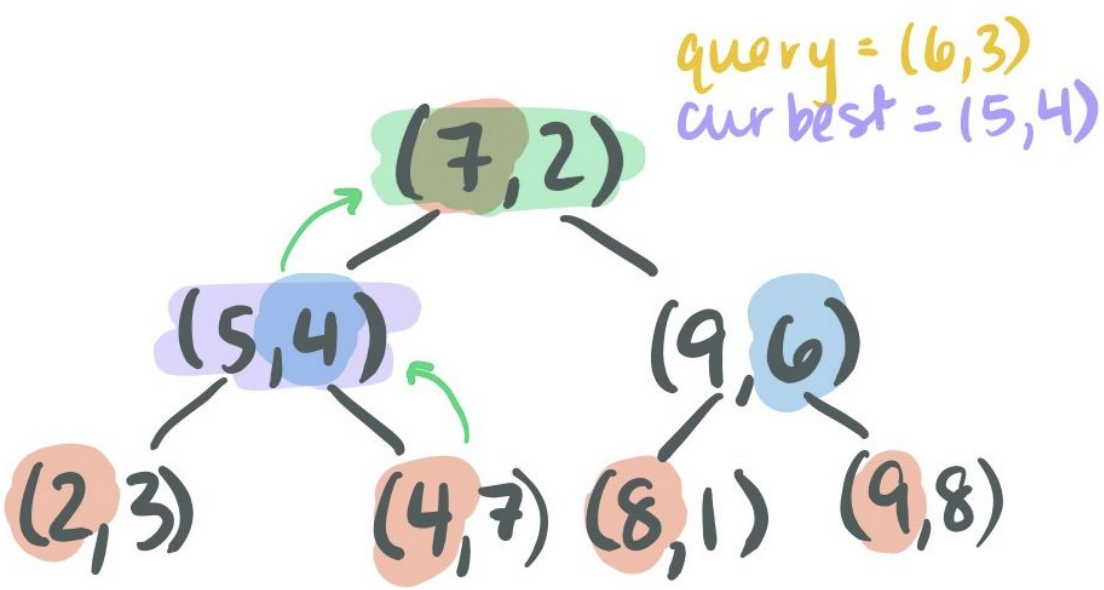
Backtracking: start recursing backwards

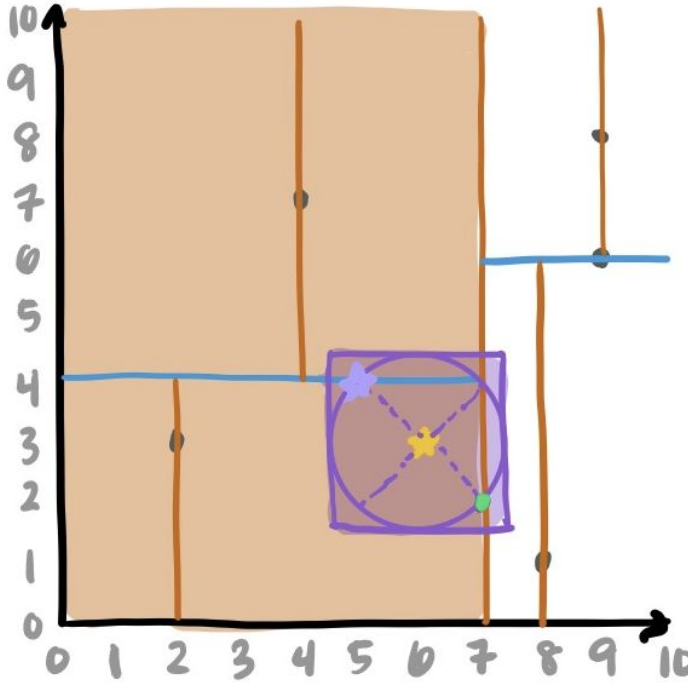
-- store “best” possibility as you trace back



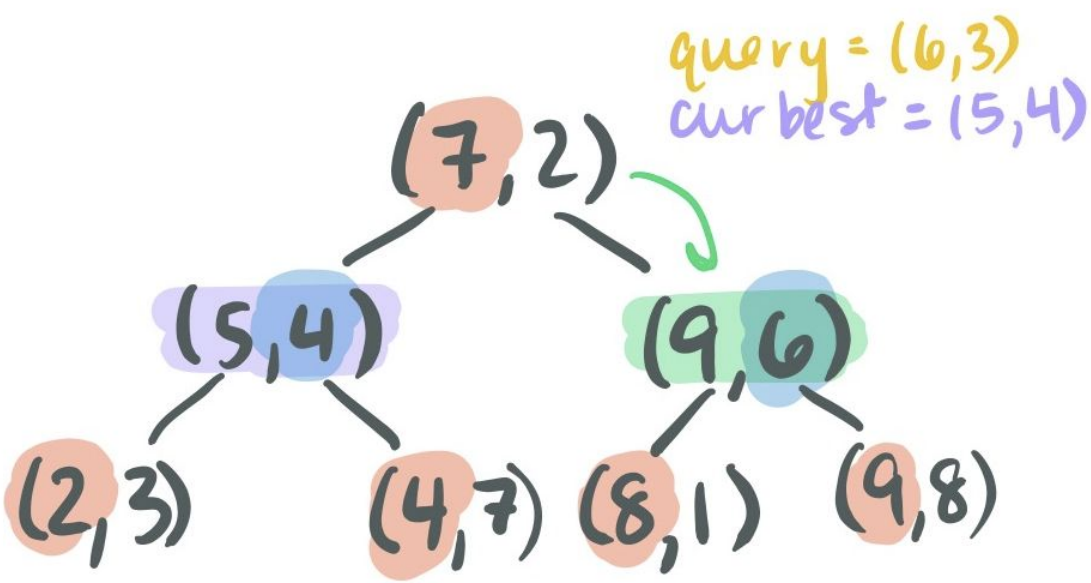


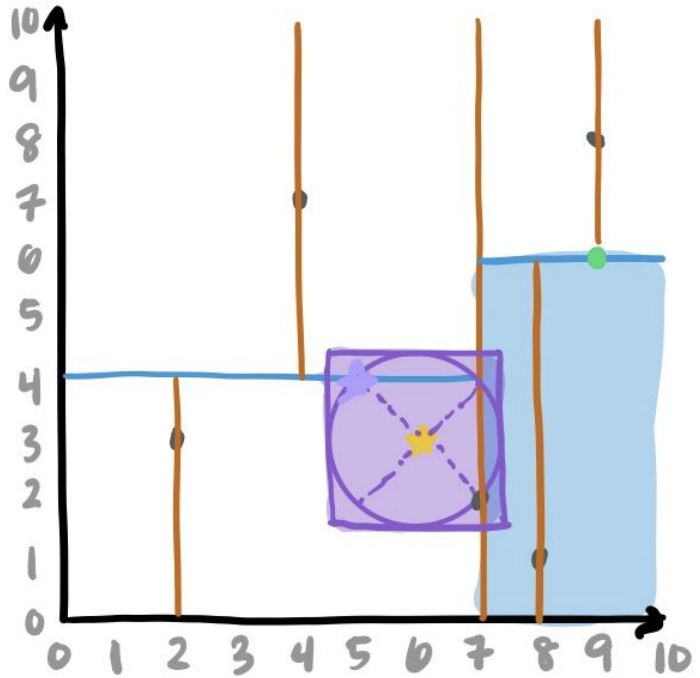
Nearest Neighbor KD Tree



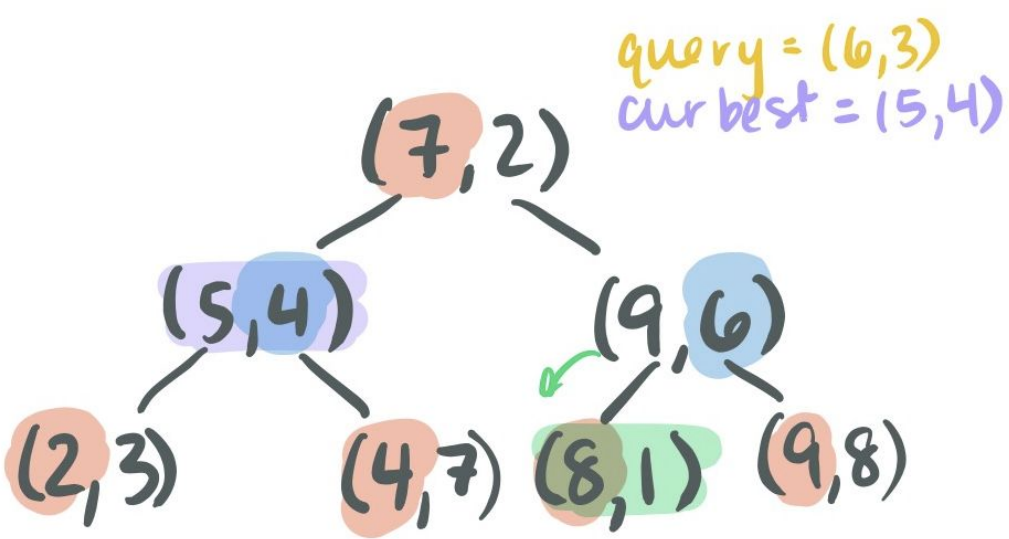


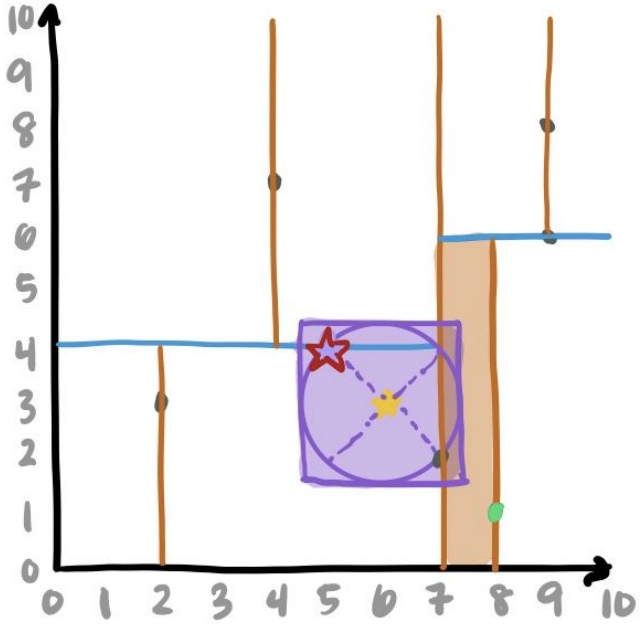
Nearest Neighbor KD Tree





Nearest Neighbor KD Tree





BEST: (5,4)

Definition of Lambda Function

A inline function without a name

Motivation

Surplus

= COUNTIF(B2:B13, “>=10”)

	Product	Quantity
2	Oranges	20
3	Lemonade	10
4	Pies	12
5	Biscuits	3
6	Bananas	20
7	Cakes	10
8	Pizza	5
9	Orange Juice	4
10	Croissants	15
11	Grapefruits	4
12	Ice Cream	12
13	Apples	20
14		
15	Surplus	8

CountIF Implementation

```
1  template <typename Iter, typename Cond>
2  int Countif(Iter begin, Iter end, Cond cond) {
3    int count = 0;
4    auto cur = begin;
5
6    while(cur != end) {
7      if(cond(*cur))
8        ++count;
9      ++cur;
10   }
11
12   return count;
13 }
```

```
1  bool isNegative(int num) { return (num < 0); }
2
3  class IsNegative {
4  public:
5      bool operator() (int num) { return (num < 0); }
6  };
7
8  int main() {
9    std::vector<int> numbers = {1, 102, 105, 4, 5, 27};
10
11   auto isneg1 = [](int num) { return (num < 0); };
12   auto isnegfp = isNegative;
13   auto isnegfunctor = IsNegative();
14
15   std::cout << "There are " <<
       Countif(numbers.begin(), numbers.end(), _______)
       << " negative numbers" << std::endl;

16 }
```

Implementation of Lambda Functions

[ ]( ){ }

Example Function

```
1   int big;
2   std::cout << "How big is big? ";
3   std::cin >> big;
4
5   auto isbig = [big](int num) { return (num >= big); };
6
7   std::cout << "There are " <<
      Countif(numbers.begin(), numbers.end(), isbig)
      << " big numbers" << std::endl;
8 }
```