Algorithms Final Project
Longest Increasing Subsequence

by Ted Johansmeyer, Andrew Holmes & Todd Weisse

Finding the longest increasing sequence of consecutive or nonconsecutive numbers within a set of random numbers is known as the longest increasing subsequence problem. To tackle this our function needs three vectors; vector<int> a which contains the initial vector, vector<int> b which is constantly extended by the next smallest possible value and contains the indexes in regards to vector a, and a third vector<int> p which tells us the previous element of the subsequence and ultimately helps us reconstruct the result. We need to use a binary search to search for the next smallest value and thus our **runtime is O(nlogn)**. We also leverage a random number generating function to initially fill our starting vector with 1000 random integers. Every time the function is executed a new random vector is solved and printed in the output.

Work Breakdown

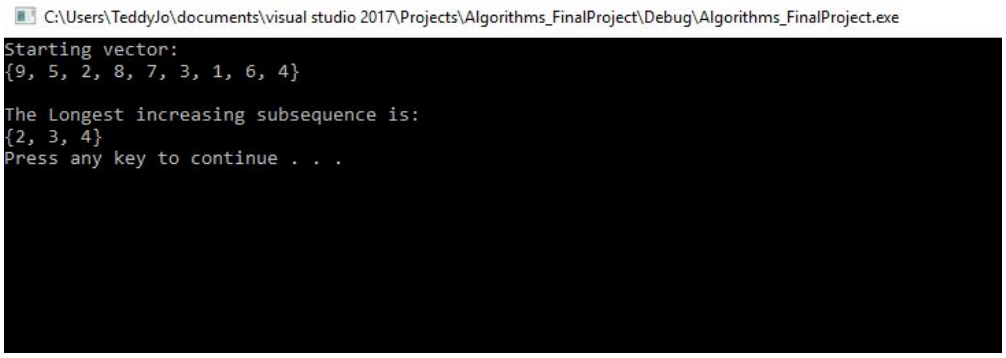
Ted: Designing algorithm, writing algorithm, writing the written portion, determining runtime
Andrew: Designing algorithm, writing algorithm, random number generating function
Todd: Designing algorithm, writing algorithm, verifying test cases

Pseudocode

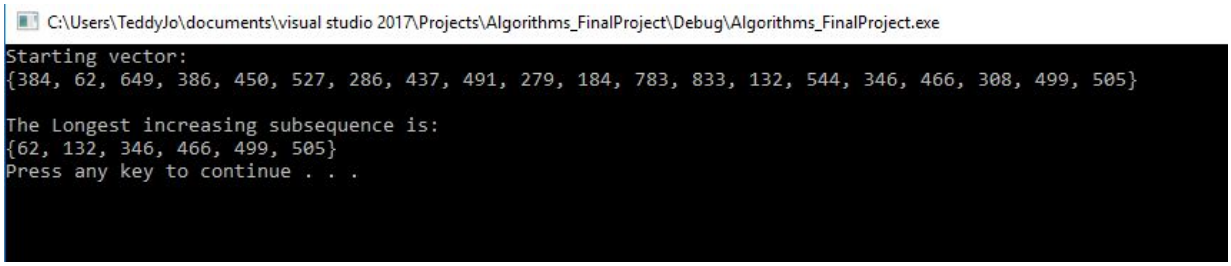
```
1.  longestIncreasingSubsequence(vector<int> &a, vector<int> &b)
2.  if(a is empty) return;          // Special case of empty initial vector
3.  Initialize vector<int>p to size of initial sequence
4.  Push 0 to vector b
5.  for( i = 1; i < size of a; i++)                 // Loop through initial sequence
6.          if(a[b.back()] < a[i])                  // Check the upper bound
7.                  set p[i] to the last element in b and push i onto b; continue
8.          set low to 0 and high to the length of b for the binary search
9.          while(low < high)                       // Start binary search
10.                 mid = (low + high)/2            // Find Mid Point
11.                 if(a[b[mid]] < a[i])
12.                         low = mid + 1
13.                 else
14.                         high = mid              // End Binary Search
15.         if(a[i] < a[b[low]])    // If the element at i is less than the element at b[low]
16.                 p[i] = b[low -1]
17.                 b[low] = i
18. // End of for loop
19. Initialize an int iterator to the size of b & an int index to the last element of b
20. while(it > 0)                                   // Begin reconstructing result to vector b
21.         it--
22.         b[it] = index
23.         index = p[index]
24. // end longestIncreasingSubsequence
```

Sample input & output

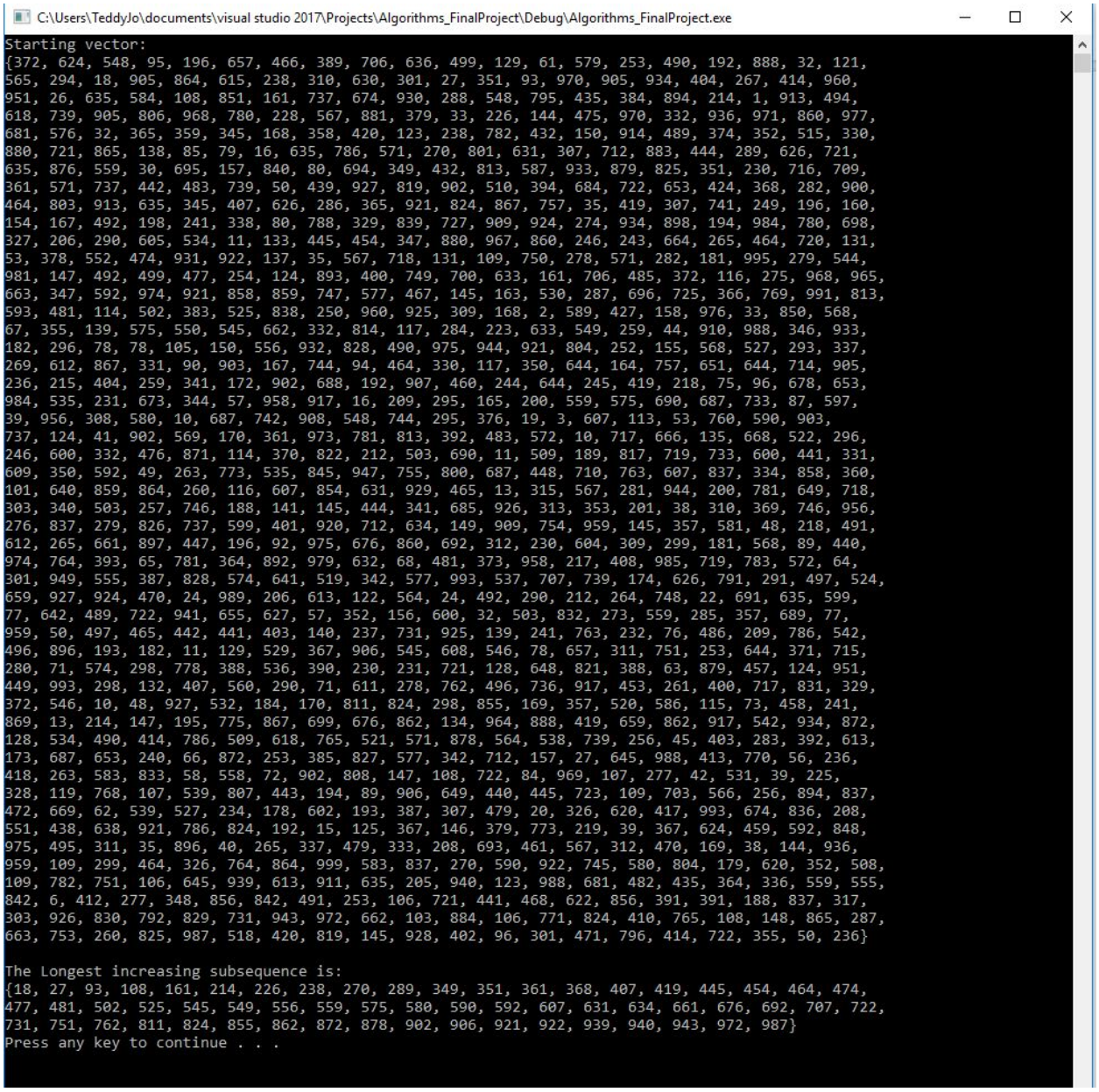
1. Sample input from question



2. n = 20



3. n = 1000


C:\Users\TeddyJo\documents\visual studio 2017\Projects\Algorithms_FinalProject\Debug\Algorithms_FinalProject.exe
Starting vector:
{372, 624, 548, 95, 196, 657, 466, 389, 706, 636, 499, 129, 61, 579, 253, 490, 192, 888, 32, 121,
565, 294, 18, 905, 864, 615, 238, 310, 630, 301, 27, 351, 93, 970, 905, 934, 404, 267, 414, 960,
951, 26, 635, 584, 108, 851, 161, 737, 674, 930, 288, 548, 795, 435, 384, 894, 214, 1, 913, 494,
618, 739, 905, 806, 968, 780, 228, 567, 881, 379, 33, 226, 144, 475, 970, 332, 936, 971, 860, 977,
681, 576, 32, 365, 359, 345, 168, 358, 420, 123, 238, 782, 432, 150, 914, 489, 374, 352, 515, 330,
880, 721, 865, 138, 85, 79, 16, 635, 786, 571, 270, 801, 631, 307, 712, 883, 444, 289, 626, 721,
635, 876, 559, 30, 695, 157, 840, 80, 694, 349, 432, 813, 587, 933, 879, 825, 351, 230, 716, 709,
361, 571, 737, 442, 483, 739, 50, 439, 927, 819, 902, 510, 394, 684, 722, 653, 424, 368, 282, 900,
464, 803, 913, 635, 345, 407, 626, 286, 365, 921, 824, 867, 757, 35, 419, 307, 741, 249, 196, 160,
154, 167, 492, 198, 241, 338, 80, 788, 329, 839, 727, 909, 924, 274, 934, 898, 194, 984, 780, 698,
327, 206, 290, 605, 534, 11, 133, 445, 454, 347, 880, 967, 860, 246, 243, 664, 265, 464, 720, 131,
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449, 993, 298, 132, 407, 560, 290, 71, 611, 278, 762, 496, 736, 917, 453, 261, 400, 717, 831, 329,
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The Longest increasing subsequence is:
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731, 751, 762, 811, 824, 855, 862, 872, 878, 902, 906, 921, 922, 939, 940, 943, 972, 987}
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