DATA STRUCTURE SORTING ALGORITHMS AND TIME COMPLEXITY

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Topic:Data structure Sorting Algorithms and its Time Complexity

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Objective:

The objective of this project is to compare and execute the sorting algorithms on a list of random values and conclude the fastest among the defined algorithms.

Data Structure is a concept of Data organization, management and storage format that helps in efficient functioning of the block of codes for a particular task.One part of Data organization in Data Structure is the sorting Algorithms.
There are several Sorting Algorithms that sort data based on unique methods. Few of the sorting algorithms are,

- Selection Sort
- Bubble Sort
- Insertion Sort
- Quick Sort
- Merge Sort
- Heap Sort,etc.

In this project, we will have a look at four Sorting algorithms

- Selection Sort
- Insertion Sort
- Bubble Sort
- Quick Sort.

```
(*ClearAll["Global`*"]*)
```

Selection Sort Algorithm:

Selection Sort Algorithm sorts the list of values by repeatedly finding the minimum element from unsorted list and swaps it to the beginning of the list.Once the sorting is done, the elements are placed in the ascending order.

In[22]:=
```
selectionSort[values1_] := Module[{listval = values1, i, j, temp, n = Length[values1]},
  For[i = 0, i < n , i++;
   temp = i;
   (*Print[listval[[i]]]*) (*These print statements
    can be used as a debugging step while running the function.*)
   For[j = i, j < n , j++;
        If[listval[[j]] < listval[[temp]],
         (*Print[listval[[j]]];Print[listval[[j]]];*)
             temp = j;
    ];
   ];
   (*Print[listval[[{i,temp}]]];*)
   listval[[{i, temp}]] = listval[[{temp, i}]];
   (*listval*)
  ];
  listval
 ]
```

Insertion Sort Algorithm:

This type of sorting method works on all the values of the list. It compares the element with other elements in list and inserts it to the existing list.

In[23]:=
```
insertionSort[values1_] := Module[{listval = values1, i, j, temp, n = Length[values1]},
  For[i = 1, i < n, i++;
   temp = listval[[i]];
   j = i;
   While[j > 0 && (temp < listval[[j - 1]]),
    listval[[j]] = listval[[j - 1]];
    j--];
   listval[[j]] = temp;
  ];
  listval
 ]
```

Bubble Sort Algorithm:

This is the simplest sorting Algorithm which is executed by comparing and swapping the elements in the list based on the order. If number is larger than the number next to it, then it is swapped and the smaller numbers are placed in ascending order.

In[24]:=
```
bubbleSort[values1_] := Module[{listval = values1, i, j, temp, n = Length[values1]},
  For[i = 0, i <  n - 1, i++;
       For[j = 0, j < (n - i), j++;
    If[listval[[j]] > listval[[j + 1]],
     temp = listval[[j]];
     listval[[j]] = listval[[j + 1]];
     listval[[j + 1]] = temp;
    ];
   ];
  ];
  listval
 ]
```

Quick Sort Algorithm:

The Quick Sort is a type of Divide and COnquer Algorithm which picks the elements as pivot and splits the list and sorts the sublists seperately. This partition of values helps in re-arranging the values in the both the sublists and then combines it to form a complete sorted list.

In[25]:=
```
quickSort[list_] := Module[{listval = list},
  listval = subSort[listval, 1, Length[listval]];
  listval
 ]
subSort[values_, start_, end_] :=
 Module[{llist = values, pivot = values[[Floor[(start + end) / 2]]], i = start, j = end},
  While[True,
   While[llist[[i]] < pivot, i++];
   While[llist[[j]] > pivot, j--];
   If[i ≥ j, Break[]];
   llist = swap[llist, i, j];
   i = start;
   j = end;
   pivot = llist[[Floor[(start + end) / 2]]];
  Flatten[ If[start ≠ end,
            {If[start == Floor[(start + end) / 2],
                  llist[[start]],
                  subSort[llist, start, Floor[(start + end) / 2]]],
                  If[end == Floor[(start + end) / 2],
      llist[[end]], subSort[llist, Floor[(start + end) / 2] + 1, end]]},
        {llist[[start]]}]]
 ]
swap[list_, i_, j_] := Module[{l = list}, {l[[i]], l[[j]]} = {l[[j]], l[[i]]};
  l
 ]
```

Random Values Generation:

In this project, I've taken four different range of random values and used these sorting algorithms to check the duration in which the functions sort the list of random values. In other words, this is done to check the time complexity of the algorithms.

In[28]:=
```
randomvalues10000 = RandomSample[Range[100 000], 10 000];
```

In[29]:=
```
randomvalues50000 = RandomSample[Range[1 000 000], 50 000];
```

In[30]:=
```
randomvalues1000 = RandomSample[Range[10 000], 1000];
```

In[31]:=
```
randomvalues10 = RandomSample[Range[100], 10]
```

Out[31]=
```
{92, 83, 62, 94, 11, 72, 43, 36, 75, 22}
```

Sorting 10 Random Values:

In[32]:=
```
selectionsort10 = selectionSort[randomvalues10] // Timing
insertionsort10 = Timing[insertionSort[randomvalues10]];
bubblesort10 = Timing[bubbleSort[randomvalues10]];
quicksort10 = Timing[quickSort[randomvalues10]];
```

Out[32]=
```
{0., {11, 22, 36, 43, 62, 72, 75, 83, 92, 94}}
```

Sorting 1000 Random Values:

In[36]:=
```
selectionsort1000 = Timing[selectionSort[randomvalues1000]]
insertionsort1000 = Timing[insertionSort[randomvalues1000]];
bubblesort1000 = Timing[bubbleSort[randomvalues1000]];
quicksort1000 = Timing[quickSort[randomvalues1000]];
```

Out[36]=
```
{0.59375, {3, 7, 48, 69, 78, 79, 84, 87, 109, 122, 138, 151, 200, 219, 220, 268, 282, 304,
  310, 313, 315, 317, 318, 319, 327, 329, 333, 350, 352, 355, 367, 368, 381, 410, 417, 426,
  441, 485, 488, 492, 524, 529, 531, 532, 541, 542, 545, 552, 579, 582, 583, 593, 622,
  630, 634, 647, 659, 671, 679, 682, 686, 688, 692, 699, 706, 731, 740, 741, 762, 773,
  782, 783, 789, 798, 805, 819, 852, 865, 866, 879, 882, 892, 902, 912, 918, 921, 924,
  928, 958, 984, 992, 1003, 1009, 1012, 1024, 1027, 1034, 1062, 1063, 1064, 1088, 1093,
  1100, 1105, 1111, 1121, 1122, 1124, 1132, 1149, 1156, 1170, 1176, 1179, 1201, 1206,
  1226, 1235, 1246, 1247, 1251, 1253, 1254, 1257, 1267, 1275, 1283, 1311, 1330, 1332,
  1340, 1341, 1374, 1383, 1395, 1398, 1415, 1418, 1420, 1425, 1430, 1431, 1439, 1441,
  1445, 1448, 1461, 1478, 1489, 1499, 1553, 1574, 1575, 1583, 1584, 1590, 1605, 1616,
  1619, 1621, 1623, 1632, 1648, 1656, 1660, 1679, 1690, 1732, 1740, 1752, 1758, 1762,
  1766, 1768, 1790, 1803, 1808, 1817, 1835, 1860, 1864, 1866, 1867, 1899, 1901, 1903,
  1904, 1914, 1932, 1936, 1937, 1958, 1972, 1979, 1993, 1998, 2000, 2005, 2015, 2021,
  2028, 2029, 2042, 2058, 2064, 2073, 2075, 2086, 2087, 2094, 2099, 2103, 2111, 2123,
  2133, 2164, 2178, 2196, 2209, 2211, 2219, 2226, 2232, 2233, 2237, 2251, 2256, 2268,
  2271, 2279, 2281, 2289, 2292, 2299, 2301, 2305, 2306, 2330, 2339, 2346, 2349, 2382,
  2394, 2407, 2408, 2420, 2421, 2438, 2442, 2443, 2449, 2455, 2466, 2469, 2472, 2473,
  2476, 2540, 2551, 2563, 2566, 2569, 2578, 2589, 2620, 2634, 2647, 2648, 2659, 2680,
  2692, 2695, 2696, 2698, 2699, 2718, 2726, 2728, 2760, 2764, 2797, 2804, 2807, 2817,
  2830, 2835, 2837, 2847, 2876, 2888, 2894, 2903, 2921, 2928, 2939, 2946, 2964, 2977,
  2984, 2990, 2997, 3019, 3020, 3039, 3065, 3095, 3098, 3108, 3111, 3117, 3119, 3127, 3129,
  3136, 3137, 3139, 3162, 3182, 3206, 3211, 3213, 3216, 3223, 3234, 3241, 3244, 3256,
  3257, 3259, 3262, 3311, 3323, 3330, 3332, 3345, 3376, 3378, 3383, 3385, 3387, 3389,
  3392, 3424, 3450, 3454, 3456, 3466, 3470, 3477, 3510, 3527, 3536, 3543, 3549, 3550,
  3554, 3556, 3573, 3599, 3601, 3610, 3613, 3625, 3633, 3647, 3649, 3677, 3678, 3687,
  3692, 3710, 3726, 3753, 3789, 3793, 3797, 3801, 3807, 3822, 3824, 3830, 3831, 3833,
  3838, 3847, 3856, 3857, 3862, 3887, 3891, 3901, 3914, 3919, 3942, 3945, 3952, 3966,
  3980, 3997, 4001, 4010, 4017, 4041, 4044, 4048, 4061, 4086, 4091, 4095, 4113, 4115,
  4116, 4136, 4138, 4146, 4155, 4167, 4190, 4198, 4218, 4222, 4233, 4238, 4240, 4299, 4302,
  4339, 4341, 4350, 4351, 4355, 4357, 4365, 4367, 4372, 4382, 4397, 4403, 4407, 4424,
  4448, 4493, 4497, 4498, 4499, 4501, 4505, 4506, 4511, 4525, 4527, 4530, 4534, 4553,
  4556, 4557, 4567, 4571, 4576, 4577, 4578, 4583, 4585, 4589, 4602, 4610, 4611, 4643,
```

```
4663, 4668, 4671, 4680, 4701, 4704, 4726, 4730, 4735, 4740, 4745, 4748, 4759, 4761,
4772, 4778, 4781, 4822, 4824, 4834, 4863, 4877, 4899, 4901, 4914, 4937, 4941, 4942,
4959, 4973, 4974, 4980, 4985, 4990, 4997, 5026, 5034, 5040, 5048, 5053, 5061, 5080,
5141, 5142, 5154, 5155, 5158, 5161, 5173, 5195, 5223, 5230, 5233, 5234, 5242, 5247,
5267, 5272, 5282, 5305, 5306, 5310, 5321, 5343, 5345, 5346, 5350, 5358, 5372, 5377,
5388, 5396, 5399, 5421, 5424, 5430, 5450, 5460, 5472, 5477, 5487, 5489, 5506, 5523,
5538, 5542, 5558, 5564, 5589, 5603, 5605, 5615, 5616, 5623, 5640, 5643, 5651, 5653,
5656, 5657, 5670, 5672, 5690, 5707, 5710, 5714, 5720, 5728, 5743, 5755, 5774, 5790,
5795, 5796, 5819, 5822, 5858, 5872, 5880, 5886, 5916, 5924, 5925, 5929, 5935, 5951,
5977, 5997, 5998, 6005, 6008, 6018, 6021, 6032, 6037, 6040, 6041, 6042, 6043, 6049,
6061, 6071, 6074, 6079, 6089, 6116, 6132, 6140, 6147, 6148, 6152, 6156, 6161, 6163,
6167, 6183, 6192, 6204, 6215, 6218, 6222, 6236, 6243, 6250, 6274, 6278, 6279, 6285,
6298, 6299, 6302, 6304, 6310, 6319, 6339, 6347, 6350, 6355, 6383, 6392, 6405, 6406,
6427, 6439, 6465, 6473, 6477, 6490, 6494, 6503, 6514, 6521, 6523, 6527, 6529, 6550,
6559, 6570, 6572, 6573, 6579, 6586, 6588, 6595, 6599, 6608, 6610, 6632, 6636, 6637,
6643, 6646, 6650, 6654, 6657, 6663, 6667, 6668, 6674, 6682, 6688, 6690, 6695, 6696,
6697, 6705, 6711, 6713, 6721, 6726, 6749, 6758, 6773, 6777, 6787, 6804, 6816, 6824,
6842, 6848, 6862, 6873, 6883, 6898, 6910, 6914, 6916, 6918, 6921, 6928, 6933, 6941,
6946, 6992, 6993, 6997, 7031, 7039, 7054, 7057, 7078, 7091, 7094, 7095, 7098, 7106,
7109, 7141, 7144, 7164, 7176, 7188, 7200, 7205, 7219, 7241, 7253, 7262, 7285, 7301,
7310, 7312, 7316, 7322, 7329, 7346, 7353, 7378, 7387, 7388, 7391, 7400, 7410, 7430,
7435, 7444, 7445, 7456, 7476, 7479, 7481, 7486, 7495, 7501, 7516, 7526, 7535, 7555,
7556, 7563, 7566, 7569, 7586, 7612, 7625, 7640, 7664, 7677, 7687, 7688, 7694, 7714,
7723, 7763, 7770, 7795, 7810, 7829, 7846, 7848, 7863, 7891, 7902, 7919, 7927, 7932,
7936, 7969, 7984, 8005, 8008, 8037, 8038, 8044, 8048, 8055, 8057, 8058, 8076, 8082,
8096, 8127, 8131, 8173, 8175, 8179, 8189, 8200, 8204, 8205, 8211, 8215, 8216, 8219,
8245, 8259, 8261, 8263, 8267, 8303, 8306, 8318, 8323, 8336, 8350, 8366, 8371, 8373,
8399, 8400, 8426, 8434, 8438, 8444, 8446, 8447, 8448, 8453, 8455, 8462, 8463, 8466,
8481, 8493, 8494, 8495, 8506, 8519, 8526, 8548, 8558, 8568, 8580, 8584, 8592, 8593,
8597, 8601, 8608, 8612, 8620, 8624, 8631, 8655, 8669, 8694, 8703, 8706, 8720, 8728,
8734, 8737, 8765, 8770, 8771, 8782, 8790, 8796, 8797, 8800, 8804, 8816, 8829, 8831,
8841, 8869, 8888, 8896, 8904, 8908, 8933, 8998, 9006, 9016, 9018, 9042, 9044, 9057,
9059, 9070, 9084, 9098, 9103, 9116, 9120, 9121, 9140, 9163, 9174, 9178, 9180, 9185,
9200, 9204, 9210, 9214, 9220, 9257, 9282, 9288, 9297, 9309, 9314, 9327, 9353, 9371,
9373, 9381, 9402, 9424, 9431, 9438, 9485, 9486, 9492, 9506, 9511, 9512, 9515, 9521,
9541, 9542, 9574, 9576, 9577, 9591, 9597, 9602, 9604, 9616, 9636, 9648, 9652, 9657,
9662, 9682, 9697, 9698, 9711, 9723, 9728, 9730, 9732, 9747, 9753, 9775, 9792, 9814,
9823, 9825, 9833, 9834, 9850, 9893, 9910, 9939, 9959, 9960, 9973, 9982, 9983, 9986}}
```

Sorting 10,000 Random Values:

In[40]:=
```
ClearSystemCache[]
selectionsort10000 = Timing[selectionSort[randomvalues10000]];
insertionsort10000 = Timing[insertionSort[randomvalues10000]];
bubblesort10000 = Timing[bubbleSort[randomvalues10000]];
quicksort10000 = Timing[quickSort[randomvalues10000]];
```

Sorting 50,000 Random Values:

In[54]:=
```
ClearSystemCache[]
```

```
selectionsort50000 = Timing[selectionSort[randomvalues50000]];
(* Sorting 50,000 values takes more time compared with other data range.*)
```

In[49]:=
```
insertionsort50000 = Timing[insertionSort[randomvalues50000]];
```

```
bubblesort50000 = Timing[bubbleSort[randomvalues50000]];
```

In[52]:=
```
quicksort50000 = Timing[quickSort[randomvalues50000]];
```

In[ ]:=
```
selectionsort50000
```

Out[ ]=
```
{1909.16, {7, 61, 74, 108, 120, 174, 190, 196, 225, 244, 265, 318, 329, 359, 368, 374,
  402, 412, 416, 440, 463, 497, 525, 541, 550, 592, 599, 613, 640, 663, 669, 676,
  719, 722, 724, 838, 844, 858, 922, 929, 973, 1000, 1022, 1028, 1037, 1046, 1058,
  1064, 1102, 1149, 1181, 1221, 1284, 1285, 1291, 1292, 1307, 1329, 1346, 1350,
  1356, 1401, 1414, ··· 49 874 ···, 998 778, 998 802, 998 804, 998 855, 998 856, 998 880,
  998 892, 998 897, 998 913, 998 928, 998 932, 998 953, 998 986, 999 130, 999 140, 999 155,
  999 156, 999 184, 999 189, 999 207, 999 209, 999 227, 999 229, 999 245, 999 258, 999 290,
  999 293, 999 298, 999 316, 999 349, 999 362, 999 368, 999 398, 999 418, 999 440, 999 470,
  999 472, 999 528, 999 531, 999 537, 999 540, 999 560, 999 569, 999 570, 999 576,
  999 591, 999 604, 999 615, 999 640, 999 643, 999 646, 999 648, 999 666, 999 667,
  999 704, 999 714, 999 722, 999 740, 999 817, 999 849, 999 907, 999 923, 999 938}}
```

large output | show less | show more | show all | set size limit...

In[ ]:=
```
insertionsort50000
```

Out[ ]=
```
{1621.55, {7, 61, 74, 108, 120, 174, 190, 196, 225, 244, 265, 318, 329, 359, 368, 374,
  402, 412, 416, 440, 463, 497, 525, 541, 550, 592, 599, 613, 640, 663, 669, 676,
  719, 722, 724, 838, 844, 858, 922, 929, 973, 1000, 1022, 1028, 1037, 1046, 1058,
  1064, 1102, 1149, 1181, 1221, 1284, 1285, 1291, 1292, 1307, 1329, 1346, 1350,
  1356, 1401, 1414, ··· 49 874 ···, 998 778, 998 802, 998 804, 998 855, 998 856, 998 880,
  998 892, 998 897, 998 913, 998 928, 998 932, 998 953, 998 986, 999 130, 999 140, 999 155,
  999 156, 999 184, 999 189, 999 207, 999 209, 999 227, 999 229, 999 245, 999 258, 999 290,
  999 293, 999 298, 999 316, 999 349, 999 362, 999 368, 999 398, 999 418, 999 440, 999 470,
  999 472, 999 528, 999 531, 999 537, 999 540, 999 560, 999 569, 999 570, 999 576,
  999 591, 999 604, 999 615, 999 640, 999 643, 999 646, 999 648, 999 666, 999 667,
  999 704, 999 714, 999 722, 999 740, 999 817, 999 849, 999 907, 999 923, 999 938}}
```

large output | show less | show more | show all | set size limit...

In[56]:=
```
bubblesort50000
```

Out[56]=
```
{4670.83, {6, 26, 51, 58, 60, 89, 93, 95, 156, 174, 184, 207, 236, 278, 294, 302, 360,
  385, 434, 474, 517, 529, 580, 636, 645, 655, 677, 680, 711, 719, 720, 769, 770,
  833, 838, 867, 915, 916, 921, 924, 947, 957, 971, 982, 989, 1003, 1026, 1055, 1063,
  1073, 1090, 1150, 1163, 1177, 1192, 1225, 1247, 1267, 1292, 1342, 1345, 1379, 1382,
  1392, ··· 49 872 ···, 998 721, 998 731, 998 735, 998 763, 998 826, 998 831, 998 845,
  998 852, 998 865, 998 885, 998 920, 998 927, 998 945, 998 952, 998 985, 998 986, 999 024,
  999 030, 999 036, 999 095, 999 097, 999 106, 999 114, 999 115, 999 129, 999 141, 999 161,
  999 216, 999 235, 999 262, 999 281, 999 353, 999 356, 999 370, 999 391, 999 427, 999 496,
  999 506, 999 514, 999 517, 999 526, 999 563, 999 600, 999 606, 999 623, 999 640,
  999 655, 999 687, 999 692, 999 716, 999 719, 999 726, 999 752, 999 810, 999 815,
  999 844, 999 861, 999 873, 999 887, 999 895, 999 932, 999 941, 999 951, 999 959}}
```

large output | show less | show more | show all | set size limit...

In[ ]:=
```
quicksort50000
```

Out[ ]=
```
{626.891, {7, 61, 74, 108, 120, 174, 190, 196, 225, 244, 265, 318, 329, 359, 368, 374,
  402, 412, 416, 440, 463, 497, 525, 541, 550, 592, 599, 613, 640, 663, 669, 676,
  719, 722, 724, 838, 844, 858, 922, 929, 973, 1000, 1022, 1028, 1037, 1046, 1058,
  1064, 1102, 1149, 1181, 1221, 1284, 1285, 1291, 1292, 1307, 1329, 1346, 1350,
  1356, 1401, 1414, ··· 49 874 ···, 998 778, 998 802, 998 804, 998 855, 998 856, 998 880,
  998 892, 998 897, 998 913, 998 928, 998 932, 998 953, 998 986, 999 130, 999 140, 999 155,
  999 156, 999 184, 999 189, 999 207, 999 209, 999 227, 999 229, 999 245, 999 258, 999 290,
  999 293, 999 298, 999 316, 999 349, 999 362, 999 368, 999 398, 999 418, 999 440, 999 470,
  999 472, 999 528, 999 531, 999 537, 999 540, 999 560, 999 569, 999 570, 999 576,
  999 591, 999 604, 999 615, 999 640, 999 643, 999 646, 999 648, 999 666, 999 667,
  999 704, 999 714, 999 722, 999 740, 999 817, 999 849, 999 907, 999 923, 999 938}}
```

large output | show less | show more | show all | set size limit...

Table of time taken by each Algorithm for all the list range

In[57]:=
```
data =
  {{"10 Random Values", selectionsort10[[1]], insertionsort10[[1]], bubblesort10[[1]],
    quicksort10[[1]]}, {"1000 Random Values", selectionsort1000[[1]],
    insertionsort1000[[1]], bubblesort1000[[1]], quicksort1000[[1]]},
   {"10,000 Random Values", selectionsort10000[[1]], insertionsort10000[[1]],
    bubblesort10000[[1]], quicksort10000[[1]]},
   {"50,000 Random Values", selectionsort50000[[1]], insertionsort50000[[1]],
    bubblesort50000[[1]], quicksort50000[[1]]}};
(*{"50,000 Random Values",1664.484375`,1288.53125`,3963.515625`,551.234375`}};
The values vary based on the use of internal system caches,
which can be cleared with clear system cache*)
```

In[ ]:=
```
data
```

Out[ ]=
```
{{10 Random Values, 0., 0., 0., 0.},
 {1000 Random Values, 0.703125, 0.5625, 1.5, 0.28125},
 {10,000 Random Values, 70.5156, 56.3438, 155.547, 23.0313},
 {50,000 Random Values, 1909.16, 1621.55, 4117., 626.891}}
```

The time complexity of the lower data range list is approximately equal to zero since all the algorithms sort the list with minimal time. But as the range increases, the time complexity increases. This become evident from the timing difference between the four Algorithms.

In[58]:=
```
Text@Grid[Prepend[data, {"Count of Random Values", "Selection Sort",
     "Insertion Sort", "Bubble Sort", "Quick Sort"}], Background →
   {None, {Lighter[Yellow, .9], {White, Lighter[Blend[{Blue, Green}], .8]}}},
  Dividers → {{Darker[Gray, .6], {Lighter[Gray, .5]}, Darker[Gray, .6]},
    {Darker[Gray, .6], Darker[Gray, .6], {False}, Darker[Gray, .6]}},
  Alignment → {Center}, ItemSize → {{20, 10, 10, 10}}, Frame → Darker[Gray, .6],
  ItemStyle → 14, Spacings → {Automatic, .8}]
```

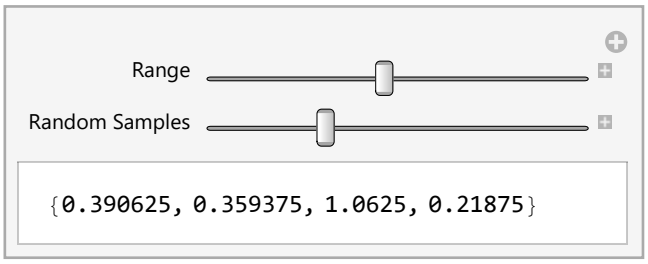
Out[58]=

Count of Random Values	Selection Sort	Insertion Sort	Bubble Sort	Quick
10 Random Values	0.	0.	0.	0.
1000 Random Values	0.59375	0.515625	1.34375	0.2
10,000 Random Values	61.1875	51.9844	142.516	21.1
50,000 Random Values	1761.17	1419.88	4670.83	552.5

Manipulate for calculating the time range among the four Algorithms based on interactive range up to 5000 and its random samples.

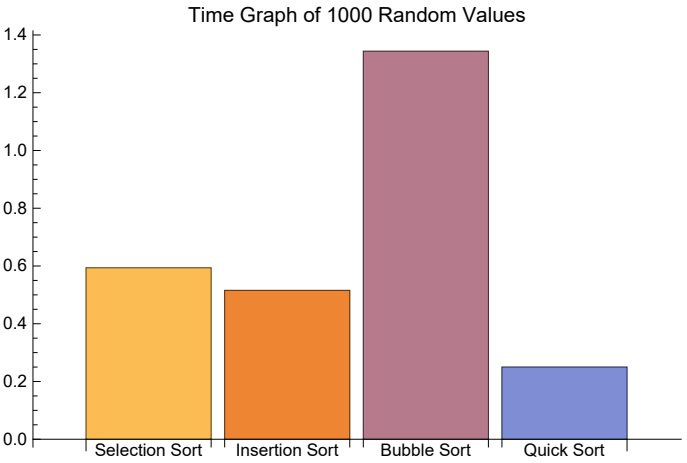
In[59]:=
```
F1[x_, y_] := {Timing[selectionSort[RandomSample[Range[x], y]]][[1]],
   Timing[insertionSort[RandomSample[Range[x], y]]][[1]],
   Timing[bubbleSort[RandomSample[Range[x], y]]][[1]],
   Timing[quickSort[RandomSample[Range[x], y]]][[1]]}
Manipulate[F1[i, j], {{i, 1, "Range"}, 1, 5000, 1}, {{j, 1, "Random Samples"}, 1, i - 1, 1}]
```

Out[60]=



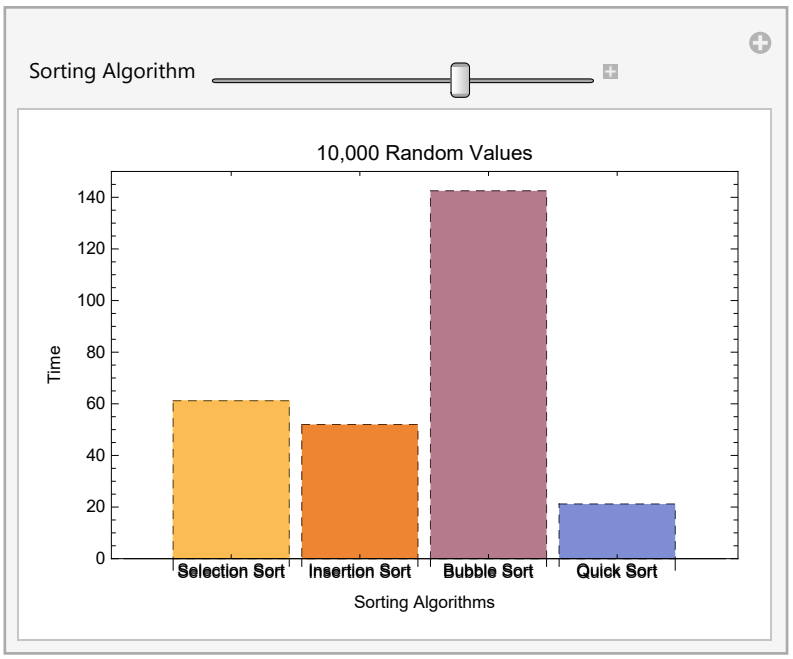
In[61]:=
```
BarChart[{{selectionsort1000[[1]],
    insertionsort1000[[1]], bubblesort1000[[1]], quicksort1000[[1]]}},
 ChartLabels → {"Selection Sort", "Insertion Sort", "Bubble Sort", "Quick Sort"},
 Axes → True, PlotLabel → "Time Graph of 1000 Random Values"]
```

Out[61]=



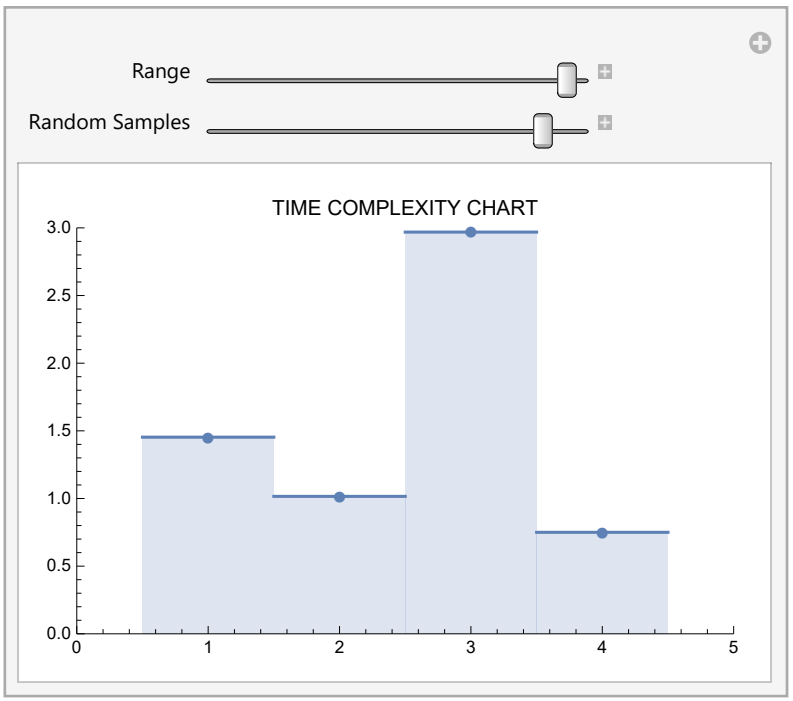
In[62]:=
```
Manipulate[BarChart[{data[[i, 2 ;; 5]]},
  ChartLabels → {"Selection Sort", "Insertion Sort", "Bubble Sort", "Quick Sort"},
  Axes → True, Frame → True, FrameLabel → {"Sorting Algorithms", "Time"},
  ChartBaseStyle → EdgeForm[Dashed], PlotLabel → data[[i]][[1]]],
 {{i, 1, "Sorting Algorithm"}, 1, 4, 1}]
(*Export[
 "C:\\Users\\harshie\\Documents\\UCD\\Mathematica\\ProjectV1\\19200349\\SortingBarPlot
   ",%];
This will export the below Bar Plot to a GIF format to the suggested location. *)
```

Out[62]=



In[63]:=
```
F2[x_, y_] := {Timing[selectionSort[RandomSample[Range[x], y]]][[1]],
   Timing[insertionSort[RandomSample[Range[x], y]]][[1]],
   Timing[bubbleSort[RandomSample[Range[x], y]]][[1]],
   Timing[quickSort[RandomSample[Range[x], y]]][[1]]}
Manipulate[DiscretePlot[F2[i, j][[k]], {k, 1, 4}, ExtentSize → All,
   PlotMarkers → Automatic, PlotLabel → "TIME COMPLEXITY CHART",
   Axes → True, PlotRange → {{0, 5}, {0, 3}}],
 {{i, 1, "Range"}, 1, 1500, 1}, {{j, 1, "Random Samples"}, 1, i - 1, 1}]
(*The plotting may take some time as the range and random samples increase*)
```

Out[64]=



From the above discrete plot, we can compare the result with the tabular representation of the time complexity of all the sorting algorithms in the Data Structure.

In[65]:=
```
Import["C:\\Users\\harshie\\Documents\\UCD\\Mathematica\\ProjectV1\\19200349\\
   TimeComplexityofAlgorithms.JPG", ImageSize → Large]
```

Out[65]=

Algorithm	Time Complexity		
	Best	Average	Worst
Selection Sort	Ω(n^2)	θ(n^2)	O(n^2)
Bubble Sort	Ω(n)	θ(n^2)	O(n^2)
Insertion Sort	Ω(n)	θ(n^2)	O(n^2)
Heap Sort	Ω(n log(n))	θ(n log(n))	O(n log(n))
Quick Sort	Ω(n log(n))	θ(n log(n))	O(n^2)
Merge Sort	Ω(n log(n))	θ(n log(n))	O(n log(n))
Bucket Sort	Ω(n+k)	θ(n+k)	O(n^2)
Radix Sort	Ω(nk)	θ(nk)	O(nk)

CONCLUSION:

As a whole, Quick Sort Algorithm is the fastest among all the other three algorithms. The time complexity of this algorithm is O(NlogN) which is the best when compared with the rest. The time complexity of Insertion sort is O(N^2) which comes after quick sort in sorting the data.The sorting algorithm after Insertion sort will be Selection sort with time complexity O(N^2) and the last will be Bubble Sort. So, the bubble sort is the slowest as it compares each element with the entire values in the list.