Why isn't heapsort stable?

Asked 9 years, 7 months ago Modified 4 years, 3 months ago Viewed 51k times

41

I'm trying to understand why heapsort isn't stable. I've googled this, but haven't found a good, intuitive explanation.

I understand the importance of stable sorting - it allows us to sort based on more than one key, which can be very beneficial (i.e., do multiple sortings, each based on a different key. Since every sort will preserve the relative order of elements, previous sortings can add up to give a final list of elements sorted by multiple criteria). However, why wouldn't heapsort preserve this as well?

Thanks for your help!

sorting heapsort stable-sort

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asked Oct 12, 2013 at 17:05
JMS
1,061 4 12 19

6 Answers

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53

Heap sort unstable example

Consider array `21 20a 20b  12 11 8 7` (already in max-heap format)

here `20a = 20b` just to differentiate the order we represent them as `20a` and `20b`

While heapsort first `21` is removed and placed in the last index then `20a` is removed and placed in last but one index and `20b` in the last but two index so after heap sort the array looks like

```
7 8 11 12 20b 20a 21.
```

It does not preserve the order of elements and hence can't be stable

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edited Oct 31, 2014 at 7:11
Marcin Nabiałek
109k 42 257 291

answered Oct 31, 2014 at 6:51
KD157
763 7 16

What if we started to paste the element in a different array and started with the leftmost index i.e. 0. So, the largest element in pasted at index 0. – AvinashK Oct 20, 2017 at 0:29

1 @AvinashKumar, If you plan on keeping the order and make in stable, the time complexity wouldn't be O(n logn). And it won't help to push the largest element to the front of the list, it may solve the problem for the largest

element, but the elements in the lower order(like second largest element) can still be in unstable sort.
– Vineeth Chitteti Apr 8, 2020 at 21:52

30

The final sequence of the results from heapsort comes from removing items from the created heap in purely size order (based on the key field).

Any information about the ordering of the items in the original sequence was lost during the heap creation stage, which came first.

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answered Oct 12, 2013 at 17:10
Baldrick
11.7k 2 30 34

20

Stable means if the two elements have the same key, they remain in the same order or positions. But that is not the case for Heap sort.

Heapsort is not stable because operations on the heap can change the relative order of equal items.

From here:

> When sorting (in ascending order) heapsort first peaks the largest element and put it in the last of the list. So, the element that have been picked first, stays last and the element that have been picked second stays to the second last element in the sorted list.
>
> Again, Build-Max-Heap procedure works such that it preserve the order of same value (ex:3a,3b) in building the heap tree. For extracting the maximum element it also works from the root and try to preserve the structure of the tree (except the change for Heapify).
>
> So, what happens, for elements with same value [3a,3b] heapsort picks 3a before 3b but puts 3a to the right of 3b. So, As the list is sorted in ascending order we get 3b before 3a in the list .
>
> If you try heapsort with (3a,3b,3b) then you can visualize the situation.

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edited Oct 12, 2013 at 17:16

answered Oct 12, 2013 at 17:08
Rahul Tripathi
167k 31 276 330

7

I know this is a late answers but I will add my 2 cents here. Consider a simple array of 3 integers. 2,2,2 now if you build a max heap using build max heap function, you will find that the array storing the input has not changed as it is already in Max heap form. Now when we put the root of the tree at the end of the array in first iteration of heap sort the stability of array is already gone. So there you have an simple example of instability of heap sort.

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answered Apr 29, 2018 at 6:46

Dipendra bhatt
699 5 14

1 I think this should be way up. – Essam Dec 2, 2020 at 12:13

7

Stable sort algorithms sort elements such that order of repeating elements in the input is maintained in the output as well.

Heap-Sort involves two steps:

- Heap creation
- Removing and adding the root element from heap tree into a new array which will be sorted in order

1. Order breaks during Heap Creation

Let's say the input array is {1, 5, 2, 3, 2, 6, 2} and for the purpose of seeing the order of 2's, say they are 2a, 2b and 2c so the array would be {1, 5, 2a, 3, 2b, 6, 2c}

Now if you create a heap (min-heap here) out of it, it's array representation will be {1, 2b, 2a, 3, 5, 6, 2c} where order of 2a and 2b has already changed.

2. Order breaks during removal of root element

Now when we have to remove root element (1 in our case) from the heap to put it into another new array, we swap it with the last position and remove it from there, hence changing the heap into {2c, 2b, 2a, 3, 5, 6}. We repeat the same and this time we will remove '2c' from the heap and put it at end of the array where we had put '1'.

When we finish repeating this step until the heap is empty and every element is transferred to the new array, the new array (sorted) it will look like {1, 2c, 2b, 2a, 3, 5, 6}.

Input to Heap-Sort: {1, 5, 2a, 3, 2b, 6, 2c} --> **Output:** {1, 2c, 2b, 2a, 3, 5, 6}

Hence we see that repeating elements (2's) are not in same order in heap-sorted array as they appear in the input and therefore **Heap-Sort is not stable !**

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edited Jan 23, 2019 at 3:38

answered Jan 22, 2019 at 5:22
user0904
210 3 7

1

Suppose take an array of size n (arbitrary value) and if there are two consecutive elements(assume 15) in heap and if their parent indices have values like 4 and 20.(this is the actual order (....4,20 ,.....,15,15.....). the relative order of 4 and 1st 15 remains same but as 20>15,the 2nd 15 comes to front(swap) as defined in heap sort algorithm, the relative order is gone.

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edited Aug 28, 2015 at 9:37
serenesat
4,601 10 36 53

answered Aug 27, 2015 at 8:04
Karthik Priyatham
81 10