Algorithms and Data Structures

A15. Sorting: Overview & Outlook

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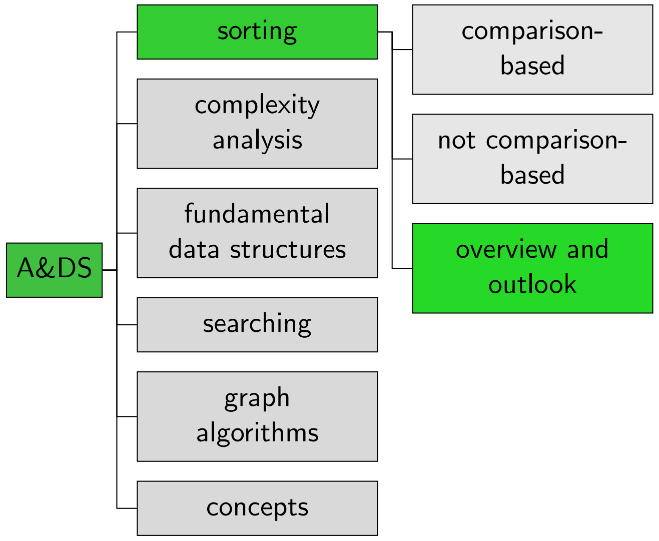
Content of the Course



A15.1 Overview

Comparison-based Sorting: Overview

Algorithm	Running time $O(\cdot)$	Memory $O(\cdot)$	stable
	best/avg./worst	best/avg./worst	
Selection sort	n^2	1	no
Insertion sort	$n/n^2/n^2$	1	yes
Merge sort	$n \log n$	n	yes
Quicksort	$n \log n/n \log n/n^2$	$\log n/\log n/n$	no
Heapsort	$n \log n$	1	no

Very nice visualization of the algorithms at
`https://www.toptal.com/developers/sorting-algorithms/`

Comparison-based Algorithms: Comments

- Insertion sort is very fast on short sequences and can be used to improve merge sort or quicksort for short ranges.
- Quicksort has a very short (= fast) inner loop. With randomization, the worst case almost never happens.
- Merge sort has the advantage of being stable.
  The merge step is also relevant for external sorting.
  Gets for example often used for database applications.
- Heapsort is in practise slightly slower than merge sort, but interesting because it is an in-place approach.
  e.g. for embedded systems.
- Equal asymptotic running time does not mean that algorithms take equally long (different hidden constants in $O(\cdot)$).
  Heapsort needs twice as many comparisons as merge sort.

A15.2 Outlook

Partially Sorted Data

- Often some subsequences of the input are already sorted (so-called runs).
- Insertion sort directly benefits from this.
- For some other approaches, there are variants that exploit runs, e.g. natural merge sort.

Many Equivalent Keys

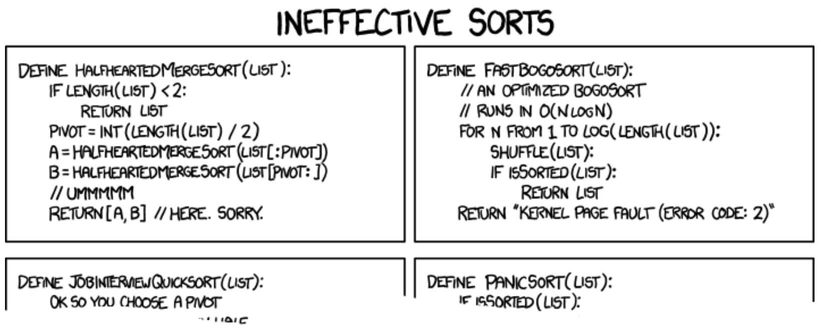
- Quite common in practical applications.
  e.g. sorting students by place of residence
- There are special variants for some algorithms.
- For example, 3-way partitioning in quicksort

$< P$	$= P$	$> P$

Sorting Complex Objects

- Most of the time, we do not want to sort numbers but complex objects.
- It would be extremely expensive to move them in memory for every swap.
- Instead: Sort elements that only consist of the key and a pointer/reference to the actual object.

Not So Correct Algorithms



```
DEFINE HALFHEARTEDMERGESORT(LIST):
    IF LENGTH(LIST) < 2:
        RETURN LIST
    PIVOT = INT(LENGTH(LIST) / 2)
    A = HALFHEARTEDMERGESORT(LIST[:PIVOT])
    B = HALFHEARTEDMERGESORT(LIST[PIVOT:])
    // UMMMMM
    RETURN [A, B] // HERE. SORRY.
```

```
DEFINE FASTBOGOSORT(LIST):
    // AN OPTIMIZED BOGOSORT
    // RUNS IN O(N LOG N)
    FOR N FROM 1 TO LOG(LENGTH(LIST)):
        SHUFFLE(LIST):
        IF ISSORTED(LIST):
            RETURN LIST
    RETURN "KERNEL PAGE FAULT (ERROR CODE: 2)"
```

```
DEFINE JOBINTERVIEWQUICKSORT(LIST):
    OK SO YOU CHOOSE A PIVOT
```

```
DEFINE PANICSORT(LIST):
    IF ISSORTED(LIST):
```

full comic at `https://xkcd.com/1185/`
(CC BY-NC 2.5)

Solve other Problems by Sorting

k-smallest element

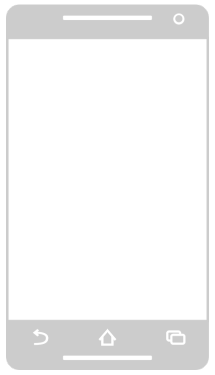
- For example, identifying the median ($k = \lfloor n/2 \rfloor$).
- Use quicksort but only perform the recursive call for the relevant range ($\rightarrow$ quickselect).

Duplicates

- How many different keys are there? Which value is most common? Are there duplicate keys?
- Can be solved directly with quadratic algorithms.
- Or – more clever – sort first and then use a single scan.

A15.3 Quiz

Quiz



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