Sorting

David Croft

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Stable sort

Selection sort

algorithms

QUICKSOFT
Divide & Conquer

Divide & Conquer

Recap

# Sorting algorithms

**David Croft** 

Coventry University david.croft@coventry.ac.uk

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Bubblesort
Stable sort
In-place

Selection sort

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Divide & Conqu

Comparing

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Other algorithm:

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Sorting is one of the classic problems for learning algorithms.

- Requirement for everything.
- Obvious applications like sorting text, statistics (median calculations).
- Less obvious, sorting objects in games for FOV (Field Of View) calculations.
- Route planning.



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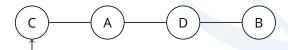
- Compares each item to the next in the sequence.
  - Swap items if in wrong order.



Very simple sort.

Compares each item to the next in the sequence.

Swap items if in wrong order.



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Bubblesort Stable sort

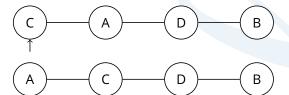
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Bubblesort Stable sort

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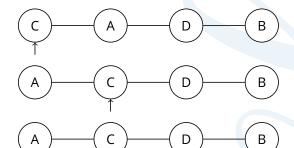
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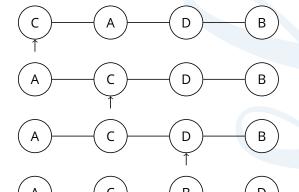
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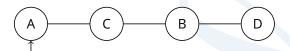
Other algorithm:

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Iterating over the sequence once isn't typically enough.

■ Keep iterating over the sequence until elements are sorted.

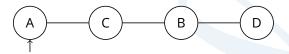




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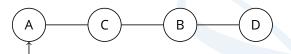


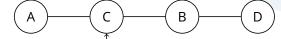


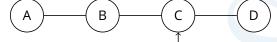
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Bubblesort Stable sort

Selection sort

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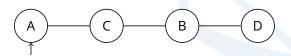
Divide & Conque

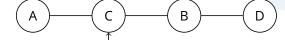
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Bubble sort is what's known as a stable in-place sort.



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Bubble sort is what's known as a stable in-place sort.

Stable meaning that equivalent elements do not change their relative orders.

■ Not important if e.g. sorting people by height.



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  - Imagine a queue in an emergency room.



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Comparing Recap Bubble sort is what's known as a stable in-place sort.

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  - Imagine a queue in an emergency room.
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With unstable sorting algorithm the relative orders of equivalent elements can be changed.



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In-place meaning that it only needs a small amount of additional memory in order to work.

- More memory efficient than the alternative.
- Can be important if...
  - ...dealing with large amounts of data.
  - ...have limited resources (i.e. embedded systems).
- Bubble sort only needs a few extra variables to swap the elements and to step through the sequence.



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- Explained here to introduce you to sorting concepts.
  - In-place, stable.



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- Explained here to introduce you to sorting concepts.
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- Is rubbish.



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  - Horrible performance, average is  $O(n^2)$ .



Stable sort In-place

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Recap

- Explained here to introduce you to sorting concepts.
  - In-place, stable.
- Is rubbish.
  - Horrible performance, average is  $O(n^2)$ .
  - But best case is only O(n).



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The time taken to sort a sequence depends on:

■ The starting order of the sequence.

For example, Bubblesorting a 100 elements:



Other

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■ The starting order of the sequence.

For example, Bubblesorting a 100 elements:

- Best case, are already sorted.
  - Iterate over sequence once.
  - 100 comparisons.



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The time taken to sort a sequence depends on:

■ The starting order of the sequence.

For example, Bubblesorting a 100 elements:

- Best case, are already sorted.
  - Iterate over sequence once.
  - 100 comparisons.
- Worst case, in reverse order.
  - Iterate over sequence 100 times.
  - 10,000 comparisons.



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The time taken to sort a sequence depends on:

■ The starting order of the sequence.

For example, Bubblesorting a 100 elements:

- Best case, are already sorted.
  - Iterate over sequence once.
  - 100 comparisons.
- Worst case, in reverse order.
  - Iterate over sequence 100 times.
  - 10,000 comparisons.
- Average case, random order.
  - Somewhere in between.





Selection sort

- Divides sequence into sorted and unsorted regions.
- Stable/Unstable, depends on implementation.
- In place.
- Iterate over sequence.
- For each element search the remaining elements on its right for the smallest value.
- 3 Swap smallest element with current element.



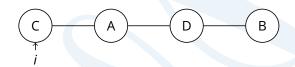
Bubblesort Stable sort In-place

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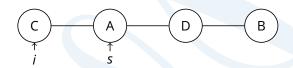
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Bubblesor Stable sort

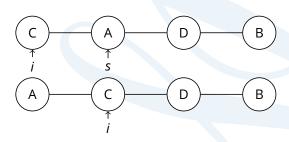
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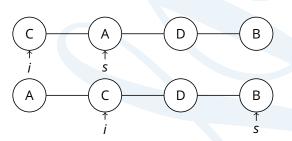
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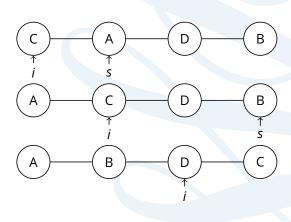
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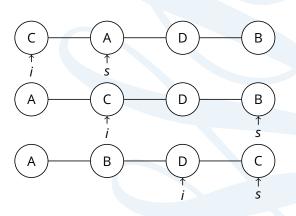
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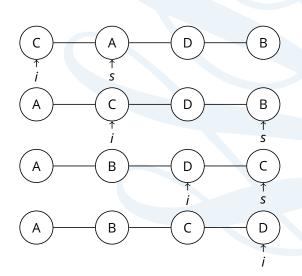
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Selection sort

Bubblesort is  $O(n^2)$  worst and average case. Selection sort is  $O(n^2)$  worst and average case.

- Selection sort is generally faster than bubble.
  - But have same *O*() complexity.
  - What?



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Comparin;

Bubblesort is  $O(n^2)$  worst and average case . Selection sort is  $O(n^2)$  worst and average case.

- Selection sort is generally faster than bubble.
  - But have same *O*() complexity.
  - What?
- $\circ$  O() notation describes how an algorithm will grow.
- Not good at absolute performances.
- Selection sort typically does fewer comparisons and swaps than bubblesort.
  - Therefore typically faster.
- Best case bubblesort is O(n), selection is  $O(n^2)$ .
  - Occasionally faster.





Selection sort

Other algorithms

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#### Many sorting algorithms

- Different trade-offs, performances. https://www.youtube.com/watch?v=ZZuD6iUe3Pc
- Some are just jokes.

- Bogo
  - Bubble
- 4 Circle
- 5 Cocktail
- 6 Comb
- Counting
- 8 Cycle

#### g Gnome

- 10 Неар
- 11 Insert
- 12 Merge
- 13 Pancake
- 14 Patience
- 15 Permutation
- 16 Quick

#### 17 Radix

- 18 Selection
- 19 Shell
- 20 Sleep
- 21 Stooge
- 22 Strand
- 23 Tree





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Neither bubble or selection sort are very good.

- Simple algorithms but slow.
- Not used in real life.

One of the fastest sorting algorithms.

- Used in real life.
- Recursively breaks the sequence in half.
  - Divide & Conquer.



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- Select a value from the sequence, this is the pivot.
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- Treat each group as a new sequence and repeat from step 1.



Bubblesort Stable sort In-place

Selection sort

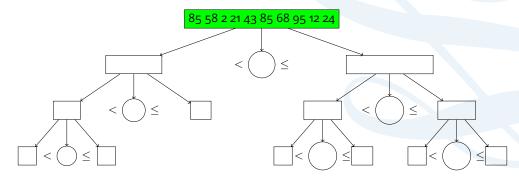
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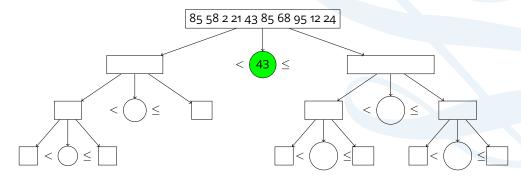
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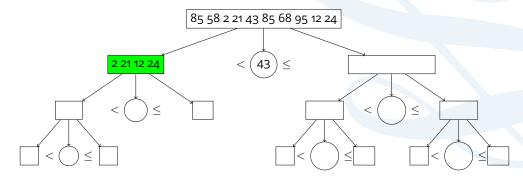
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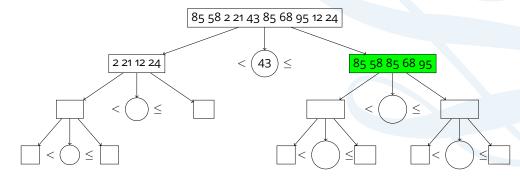




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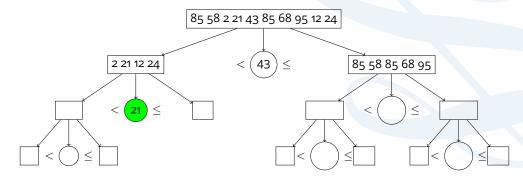
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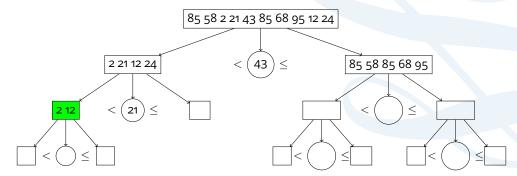
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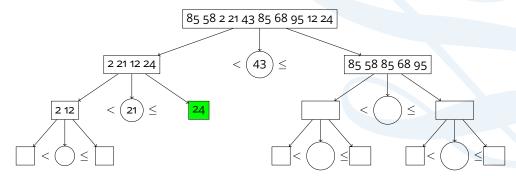
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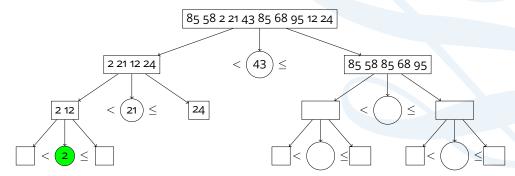
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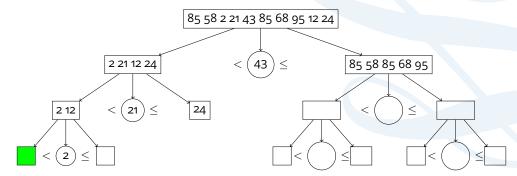
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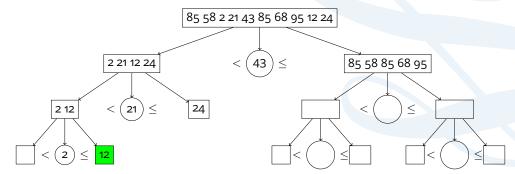
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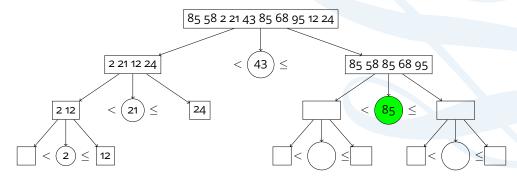
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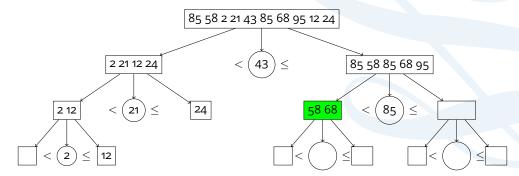
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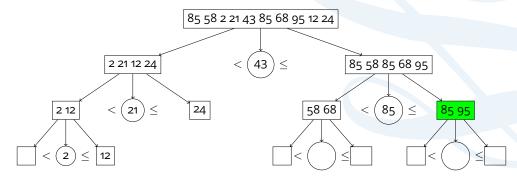
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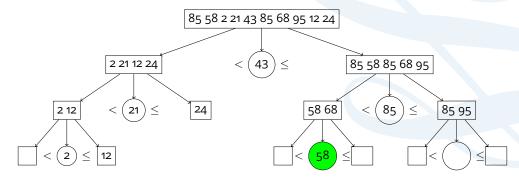
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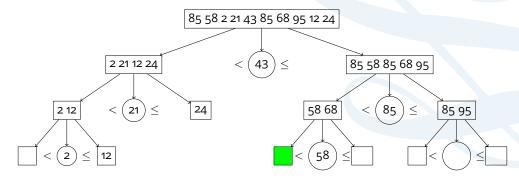
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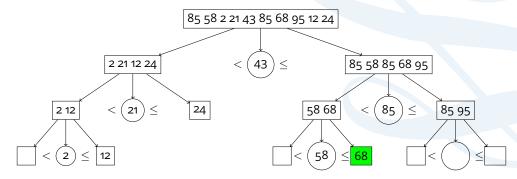
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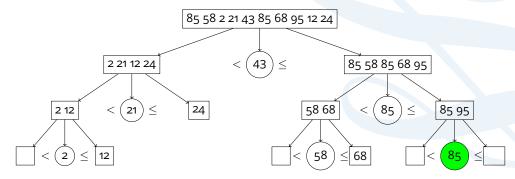
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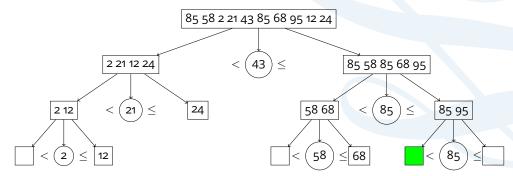
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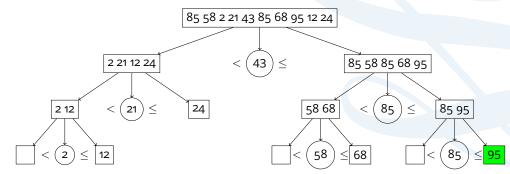
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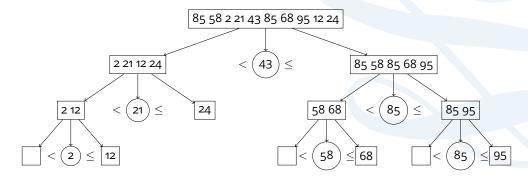
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#### Quicksort is...

- ...sometimes in-place.
  - Depends on implementation.
- ...sometimes stable.
  - Depends on implementation.

Some issues with the original algorithms (1959).

- Choosing the pivot.
  - First element.
  - Middle element.
  - Average of first, middle and last.
- Repeated elements.
  - Fat partition.



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Recap

Quicksort is a divide and conquer algorithm.

- Too hard to sort the whole sequence?
- Divide the problem.
  - Still too hard?
  - Divide the problem.
    - Still too hard?
    - Divide the problem.
    - Etc, etc, etc.

Naturally suited for parallelism.



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- Best sorting algorithm depends on multiple factors.
- Good in one situation is bad in another.



Comparing

- Best sorting algorithm depends on multiple factors.
- Good in one situation is bad in another.
- Stability? In place?



Comparing

- Best sorting algorithm depends on multiple factors.
- Good in one situation is bad in another.
- Stability? In place?
- What are you sorting?
  - Linked lists?
  - Sequential memory (arrays)?



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- Best sorting algorithm depends on multiple factors.
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  - Sequential memory (arrays)?
- Where are you sorting?
  - RAM?
  - EEPROM? cheap to read, expensive to write.



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Introductior Bubblesort Stable sort

Selection sor

Other algorithms

Comparing

compani

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Sorting

David Croft

Introduction

Bubblesort

In-place

Selection Sort

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Quicksort

Companing

Recap

## Quiz



Bubblesort Stable sort In-place

Selection sort

algorithm

Quicksort

Divide & Con-

Comparing

Recap

- Many sorting algorithms.
- Bubblesort.
- Selection sort.
- Quicksort
- Advantages/disadvantages.
  - In place.
  - Stable.
  - Divide and Conquer.
- Performance
  - O()
  - Sequence type.
  - Read/writes.
  - Size of *n*.



Sorting

David Croft

Introduction

Bubblesort

Selection sort

Other

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Divide & Conq

Comparing

Recap

## The End

