

2014-04-06

QuickSort

└─ Quicksorts

└─ Introduction

Introduction

■ $O(n \log(n))$ Average Case Run Time

Data is partitioned By Comparing and Swapping elements

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└─ Quicksorts

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Introduction

- $O(n \log(n))$ Average Case Run Time
- In place algorithm

Data is partitioned By Comparing and Swapping elements

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Introduction

- $O(n \log(n))$ Average Case Run Time
- In place algorithm
- Picking Pivots

Data is partitioned By Comparing and Swapping elements

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Introduction

- $O(n \log(n))$ Average Case Run Time
- In place algorithm
- Picking Pivots
- Partitioning Data

Data is partitioned By Comparing and Swapping elements

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- $O(n \log(n))$ Average Case Run Time
- In place algorithm
- Picking Pivots
- Partitioning Data
- Recurse to a smaller sub-array

Data is partitioned By Comparing and Swapping elements

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Introduction

- $O(n \log(n))$ Average Case Run Time
- In place algorithm
- Picking Pivots
- Partitioning Data
- Recurse to a smaller sub-array
- Use Insertion Sort for a small sub-array

Data is partitioned By Comparing and Swapping elements

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QuickSort
└─ Quicksorts
 └─ Dual Pivot Quicksort
 └─ Dual Pivot Quicksort

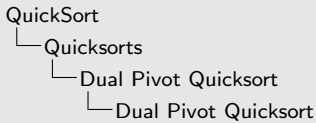
Dual Pivot Quicksort

■ $2n \log n - 1.51n + O(\log(n))$ Comparisons

[7]

Tertile Elements = Middle 2 of 5 elements (Evenly Spaced Out)

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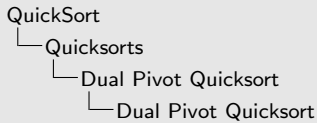
Dual Pivot Quicksort

- $2n \log n - 1.51n + O(\log(n))$ Comparisons
- $0.8n \log n - 0.3n + O(\log(n))$ Swaps

[7]

Tertile Elements = Middle 2 of 5 elements (Evenly Spaced Out)

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Dual Pivot Quicksort

- $2n \log n - 1.51n + O(\log(n))$ Comparisons
- $0.8n \log n - 0.3n + O(\log(n))$ Swaps
- Two Pivots

[7]

Tertile Elements = Middle 2 of 5 elements (Evenly Spaced Out)

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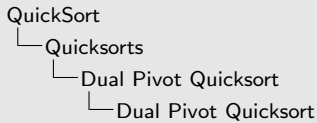
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- $2n \log n - 1.51n + O(\log(n))$ Comparisons
- $0.8n \log n - 0.3n + O(\log(n))$ Swaps
- Two Pivots
 - First and Last Element

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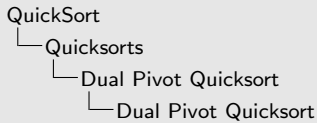
Dual Pivot Quicksort

- $2n \log n - 1.51n + O(\log(n))$ Comparisons
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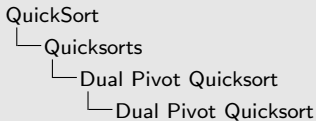
Dual Pivot Quicksort

- $2n \log n - 1.51n + O(\log n)$ Comparisons
- $0.8n \log n - 0.3n + O(\log n)$ Swaps
- Two Pivots
 - First and Last Element
 - Middle 2 of 5 elements (Evenly Spaced Out)
- Partitions Smalls then Bigs (Middle is automatic)

[7]

Tertile Elements = Middle 2 of 5 elements (Evenly Spaced Out)

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- $2n \log n - 1.51n + O(\log n)$ Comparisons
- $0.8n \log n - 0.3n + O(\log n)$ Swaps
- Two Pivots
 - First and Last Element
 - Middle 2 of 5 elements (Evenly Spaced Out)
- Partitions Smalls then Bigs (Middle is automatic)
- Three Recursive Calls

[7]

Tertile Elements = Middle 2 of 5 elements (Evenly Spaced Out)

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└─ Quicksorts
 └─ Three Pivot Quicksort
 └─ Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

■ $1.846n \log n + O(n)$ Comparisons

[7]

This algorithm had incomplete pseudo-code. Only the partition algorithm was specified.

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Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

- $1.846n \log n + O(n)$ Comparisons
- $0.615n \log n + O(n)$ Swaps

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Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

- $1.846n \log n + O(n)$ Comparisons
- $0.615n \log n + O(n)$ Swaps
- Three Pivots

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Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

- $1.846n \log n + O(n)$ Comparisons
- $0.615n \log n + O(n)$ Swaps
- Three Pivots
 - Middle 3 of 7 elements (Evenly Spaced Out)

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Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

- $1.846n \log n + O(n)$ Comparisons
- $0.615n \log n + O(n)$ Swaps
 - Three Pivots
 - Middle 3 of 7 elements (Evenly Spaced Out)
- Simultaneous Partition algorithm

[7]

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Kushagra-Ortiz-Qiao-Munro Tri-Pivot Quicksort

- $1.846n \log n + O(n)$ Comparisons
- $0.615n \log n + O(n)$ Swaps
 - Three Pivots
 - Middle 3 of 7 elements (Evenly Spaced Out)
- Simultaneous Partition algorithm
- Four Recursive Calls

[7]

This algorithm had incomplete pseudo-code. Only the partition algorithm was specified.

QuickSort

Quicksorts

Summary

Theoretical Average Case Run Time

Sort Method	Comparisons
Classic	$2n \log n - 1.51n + O(\log(n))$
Dual Pivot	$2.13n \log n - 2.57n + O(\log(n))$
Optimal Dual Pivot	$1.8n \log n + O(n)$
Three Pivot	$1.846n \log n + O(n)$
Yaroslavskiy	$1.9n \log n - 2.46n + O(\log(n))$
M Pivot	$O(n \log n)$

[7]

[7]

[7]

These are average case run times. The M-Pivot quicksort is not studied very well. As you see, people study each quicksort with a fixed number of pivots.

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QuickSorts

Summary

Theoretical Average Case Run Time

Sort Method	Swaps
Classic	$0.33n \log n - 0.58n + O(\log(n))$
Dual Pivot	$0.8n \log n - 0.3n + O(\log(n))$
Optimal Dual Pivot	$0.22n \log n + O(n)$
Three Pivot	$0.615n \log n + O(n)$
Yaroslavskiy	$0.6n \log n + 0.08n + O(\log(n))$
M Pivot	$O(n \log n)$

[7]

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These are average case run times. The M-Pivot quicksort is not studied very well. As you see, people study each quicksort with a fixed number of pivots.

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Will add slides to answer potential questions