

Data Structures & Algorithms Coursework

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Declaration

I confirm that the submitted coursework is my own work and that all material attributed to others (whether published or unpublished) has been clearly identified and fully acknowledged and referred to original sources. I agree that the College has the right to submit my work to the plagiarism detection service. TurnitinUK for originality checks.

Acknowledgements

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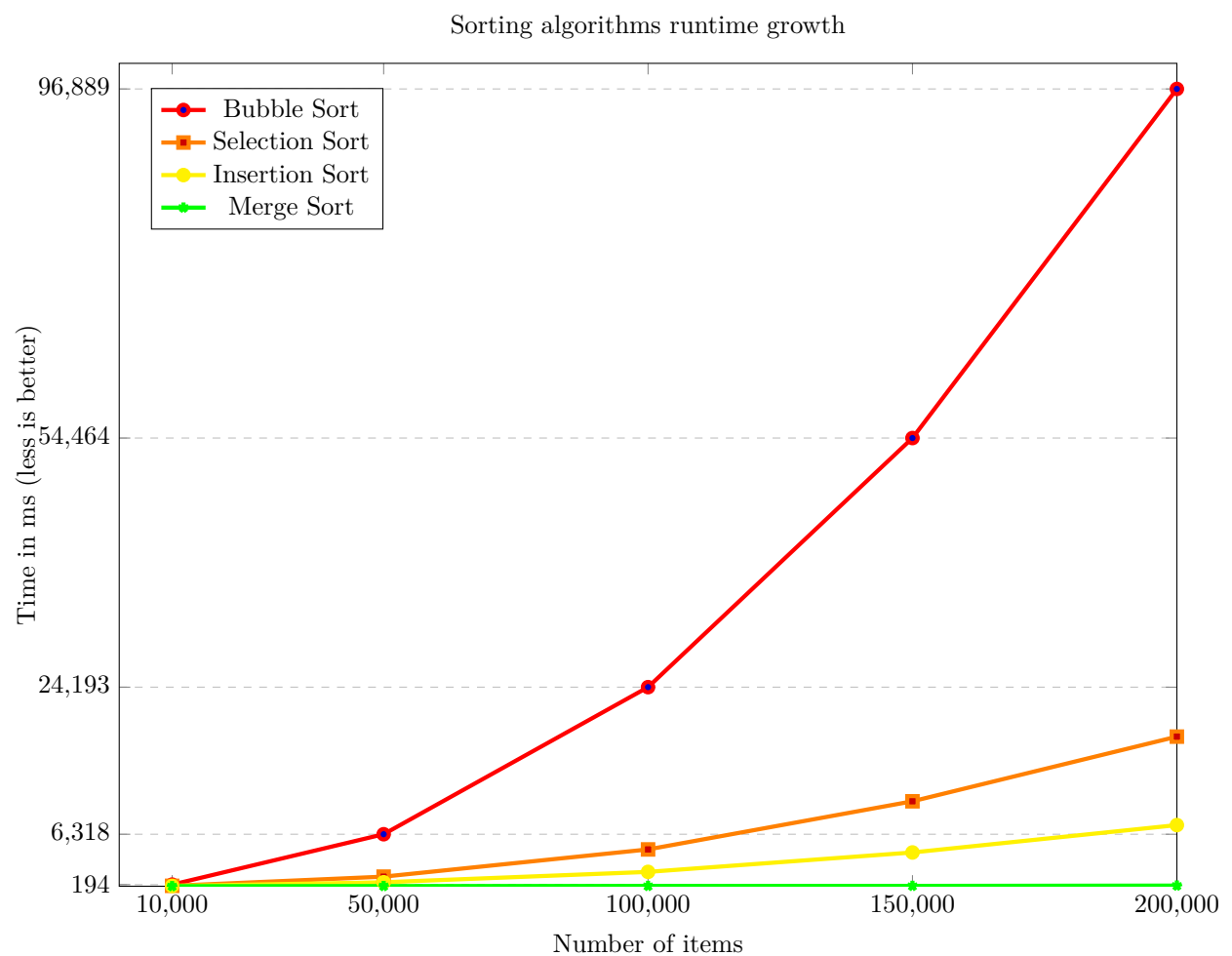
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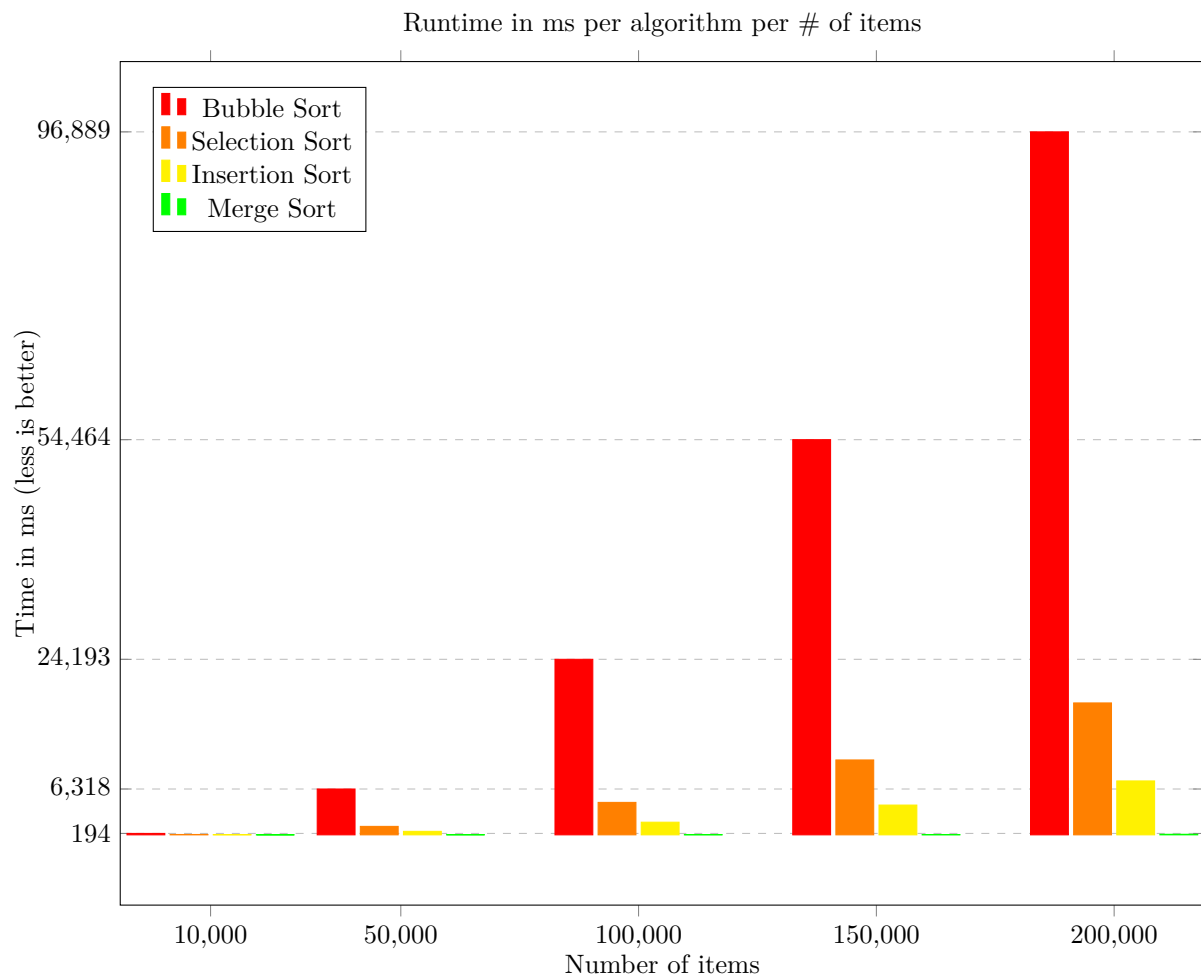
Chapter 1

Analysis of Sorting Algorithms

1.1 Sort time growth



1.2 Runtime Comparison



1.3 Reflection¹

We know that the complexity for the algorithms benchmarked above — $O(n^2)$, $O(n^2)$, $O(n^2)$ and $O(n \log_2(n))$ respectively—, and we can see that mapped accurately in the plots above.

The first plot, the graph displayed on section 1.1, shows the increment in time for the *bubble*, *selection*, and *insertion* sort algorithms as exponential. Their curves vary greatly because **Big O** is not meant to give an accurate description of the time, just of how it'll scale. The point being, they all scale in a similar manner. The green line represents the *merge* sort algorithm which is, along with *quicksort*, considered to be the best algorithm overall. We can barely see it scale because the plot is drawn next to the quadratic plot of *bubble* sort. If we look closely, though, we can see it almost resembles a linear time complexity, but not quite.

The second plot, a bar graph displayed on section 1.2, uses the same colors and the same data to represent, perhaps more clearly, how each algorithm fares amongst each other using the same dataset.

¹Selection sort and benchmark utility code can be found Appendix A.

Chapter 2

Segregate Even and Odd numbers

2.1 Task

Given an array $A[]$, write an algorithm in pseudocode that segregates even and odd numbers. The algorithm should put all even numbers first, and then odd numbers.

2.2 Implementation

Chapter 3

Recursion

3.1 Tasks

Design a recursive method for each of the following problems:

1. When you cut a pizza, you cut along a diameter of the pizza. Let `pizza(n)` be the number of slices of pizza that exist after you have made `n` cuts, where $n \geq 1$. For example, `pizza(2) = 4` because there are four slices after two diagonal cuts. Write a recursive method `pizza(n)` to return the number of slices and verify the correctness of your method when the pizza is cut 4 times (*3 points*).
2. A bunch of motorcycles and cars want to parallel park on a street. The street can fit `n` motorcycles, but one car take up three motorcycle spaces. Let `a(n)` be the number of arrangements of cars and motorcycles on a street that fits `n` motorcycles (*7 points*).

Chapter 4

Appendix A

4.1 Benchmark.java

```
package me.rsole.util;

import java.util.ArrayList;
import java.util.List;
import java.util.concurrent.TimeUnit;

public class Benchmark {
    private List<Thread> threads = new ArrayList<>();

    public void add(String name, Runnable computation) {
        Thread t = new Thread(
            () -> System.out.printf("%s took %s.\n", name, run(computation))
        );
        threads.add(t);
    }

    public void run() {
        for (Thread t : threads) t.run();
    }

    private String run(Runnable computation) {
        long start = System.currentTimeMillis();
        computation.run();
        long end = System.currentTimeMillis();

        return format(end - start);
    }

    private String format(long time) {
        long minutes = TimeUnit.MILLISECONDS.toMinutes(time);
        long seconds =
            TimeUnit.MILLISECONDS.toSeconds(time) -
            TimeUnit.MINUTES.toSeconds(minutes);
        long milliseconds =
            time -
            (TimeUnit.SECONDS.toMillis(seconds) +
            TimeUnit.MINUTES.toMillis(minutes));
    }
}
```



```

    return String.format("%dm %ds %dms", minutes, seconds, milliseconds);
}
}

```

4.2 SelectionSort.java

```

package me.rsole.sort;

import org.jetbrains.annotations.Contract;

public class SelectionSort {
    @Contract(pure = true)
    public static int[] exec(int[] xs) {
        int[] ys = xs.clone();
        int minIdx = 0;

        for (int i = 0; i < ys.length; i++) {
            for (int j = i; j < ys.length; j++) {
                if (ys[j] < ys[minIdx]) minIdx = j;
            }

            int swap = ys[i];
            ys[i] = ys[minIdx];
            ys[minIdx] = swap;
            minIdx = i + 1;
        }

        return ys;
    }
}

```