

Algorithms

Regular multiplication

- $O(n^2)$
- Distribute each term of the first polynomial to every term of the second polynomial. When multiplying two terms, multiply their coefficients (numbers) and add their exponents. Add up the terms resulting from multiplications with the same exponent.

Karatsuba mutiplication

- $O(n^{\log 3})$
- The Karatsuba algorithm is a fast multiplication algorithm that uses a divide and conquer approach to multiply two numbers. The point of this algorithm is to break large numbers down into smaller numbers so that any multiplications that occur happen on smaller numbers.

Experiments

| Polynomial order | Approach | Nb. of Threads | Time (ms) |
|------------------|------------------------|----------------|-----------|
| 5 | Simple Sequential | - | 1 |
| 5 | Karatsuba Sequential | - | 2 |
| 5 | Simple Parallelized | 1 | 4 |
| 5 | Karatsuba Parallelized | 1 | 9 |
| 5 | Simple Parallelized | 2 | 0 |
| 5 | Karatsuba Parallelized | 2 | 4 |
| 5 | Simple Parallelized | 3 | 2 |
| 5 | Karatsuba Parallelized | 3 | 3 |
| 5 | Simple Parallelized | 4 | 1 |
| 5 | Karatsuba Parallelized | 4 | 7 |
| 5 | Simple Parallelized | 5 | 0 |
| 5 | Karatsuba Parallelized | 5 | 4 |
| 5 | Simple Parallelized | 10 | 2 |
| 5 | Karatsuba Parallelized | 10 | 3 |
| 5 | Simple Parallelized | 15 | 1 |
| 5 | Karatsuba Parallelized | 15 | 2 |
| 5 | Simple Parallelized | 30 | 2 |
| 5 | Karatsuba Parallelized | 30 | 2 |
| 10 | Simple Sequential | - | 0 |
| 10 | Karatsuba Sequential | - | 1 |

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|-----|------------------------|----|----|
| 10 | Simple Parallelized | 1 | 0 |
| 10 | Karatsuba Parallelized | 1 | 4 |
| 10 | Simple Parallelized | 2 | 0 |
| 10 | Karatsuba Parallelized | 2 | 3 |
| 10 | Simple Parallelized | 3 | 0 |
| 10 | Karatsuba Parallelized | 3 | 6 |
| 10 | Simple Parallelized | 4 | 0 |
| 10 | Karatsuba Parallelized | 4 | 5 |
| 10 | Simple Parallelized | 5 | 1 |
| 10 | Karatsuba Parallelized | 5 | 4 |
| 10 | Simple Parallelized | 10 | 2 |
| 10 | Karatsuba Parallelized | 10 | 4 |
| 10 | Simple Parallelized | 15 | 2 |
| 10 | Karatsuba Parallelized | 15 | 5 |
| 10 | Simple Parallelized | 30 | 2 |
| 10 | Karatsuba Parallelized | 30 | 7 |
| 50 | Simple Sequential | - | 0 |
| 50 | Karatsuba Sequential | - | 2 |
| 50 | Simple Parallelized | 1 | 1 |
| 50 | Karatsuba Parallelized | 1 | 16 |
| 50 | Simple Parallelized | 2 | 1 |
| 50 | Karatsuba Parallelized | 2 | 16 |
| 50 | Simple Parallelized | 3 | 1 |
| 50 | Karatsuba Parallelized | 3 | 29 |
| 50 | Simple Parallelized | 4 | 0 |
| 50 | Karatsuba Parallelized | 4 | 34 |
| 50 | Simple Parallelized | 5 | 0 |
| 50 | Karatsuba Parallelized | 5 | 27 |
| 50 | Simple Parallelized | 10 | 2 |
| 50 | Karatsuba Parallelized | 10 | 22 |
| 50 | Simple Parallelized | 15 | 1 |
| 50 | Karatsuba Parallelized | 15 | 21 |
| 50 | Simple Parallelized | 30 | 3 |
| 50 | Karatsuba Parallelized | 30 | 27 |
| 100 | Simple Sequential | - | 0 |
| 100 | Karatsuba Sequential | - | 2 |
| 100 | Simple Parallelized | 1 | 0 |
| 100 | Karatsuba Parallelized | 1 | 14 |
| 100 | Simple Parallelized | 2 | 2 |
| 100 | Karatsuba Parallelized | 2 | 14 |
| 100 | Simple Parallelized | 3 | 2 |
| 100 | Karatsuba Parallelized | 3 | 22 |

| | | | |
|------|------------------------|----|----|
| 100 | Simple Parallelized | 4 | 2 |
| 100 | Karatsuba Parallelized | 4 | 23 |
| 100 | Simple Parallelized | 5 | 0 |
| 100 | Karatsuba Parallelized | 5 | 21 |
| 100 | Simple Parallelized | 10 | 1 |
| 100 | Karatsuba Parallelized | 10 | 24 |
| 100 | Simple Parallelized | 15 | 1 |
| 100 | Karatsuba Parallelized | 15 | 21 |
| 100 | Simple Parallelized | 30 | 2 |
| 100 | Karatsuba Parallelized | 30 | 21 |
| 500 | Simple Sequential | - | 3 |
| 500 | Karatsuba Sequential | - | 9 |
| 500 | Simple Parallelized | 1 | 5 |
| 500 | Karatsuba Parallelized | 1 | 20 |
| 500 | Simple Parallelized | 2 | 3 |
| 500 | Karatsuba Parallelized | 2 | 14 |
| 500 | Simple Parallelized | 3 | 2 |
| 500 | Karatsuba Parallelized | 3 | 22 |
| 500 | Simple Parallelized | 4 | 2 |
| 500 | Karatsuba Parallelized | 4 | 21 |
| 500 | Simple Parallelized | 5 | 2 |
| 500 | Karatsuba Parallelized | 5 | 20 |
| 500 | Simple Parallelized | 10 | 2 |
| 500 | Karatsuba Parallelized | 10 | 21 |
| 500 | Simple Parallelized | 15 | 2 |
| 500 | Karatsuba Parallelized | 15 | 23 |
| 500 | Simple Parallelized | 30 | 2 |
| 500 | Karatsuba Parallelized | 30 | 20 |
| 1000 | Simple Sequential | - | 13 |
| 1000 | Karatsuba Sequential | - | 32 |
| 1000 | Simple Parallelized | 1 | 15 |
| 1000 | Karatsuba Parallelized | 1 | 37 |
| 1000 | Simple Parallelized | 2 | 8 |
| 1000 | Karatsuba Parallelized | 2 | 32 |
| 1000 | Simple Parallelized | 3 | 9 |
| 1000 | Karatsuba Parallelized | 3 | 31 |
| 1000 | Simple Parallelized | 4 | 6 |
| 1000 | Karatsuba Parallelized | 4 | 33 |
| 1000 | Simple Parallelized | 5 | 6 |
| 1000 | Karatsuba Parallelized | 5 | 33 |
| 1000 | Simple Parallelized | 10 | 5 |
| 1000 | Karatsuba Parallelized | 10 | 32 |

| | | | |
|-------|------------------------|----|-----|
| 1000 | Simple Parallelized | 15 | 3 |
| 1000 | Karatsuba Parallelized | 15 | 29 |
| 1000 | Simple Parallelized | 30 | 4 |
| 1000 | Karatsuba Parallelized | 30 | 31 |
| 2500 | Simple Sequential | - | 61 |
| 2500 | Karatsuba Sequential | - | 126 |
| 2500 | Simple Parallelized | 1 | 100 |
| 2500 | Karatsuba Parallelized | 1 | 111 |
| 2500 | Simple Parallelized | 2 | 40 |
| 2500 | Karatsuba Parallelized | 2 | 24 |
| 2500 | Simple Parallelized | 3 | 37 |
| 2500 | Karatsuba Parallelized | 3 | 25 |
| 2500 | Simple Parallelized | 4 | 26 |
| 2500 | Karatsuba Parallelized | 4 | 29 |
| 2500 | Simple Parallelized | 5 | 23 |
| 2500 | Karatsuba Parallelized | 5 | 24 |
| 2500 | Simple Parallelized | 10 | 14 |
| 2500 | Karatsuba Parallelized | 10 | 29 |
| 2500 | Simple Parallelized | 15 | 15 |
| 2500 | Karatsuba Parallelized | 15 | 24 |
| 2500 | Simple Parallelized | 30 | 13 |
| 2500 | Karatsuba Parallelized | 30 | 27 |
| 5000 | Simple Sequential | - | 188 |
| 5000 | Karatsuba Sequential | - | 197 |
| 5000 | Simple Parallelized | 1 | 282 |
| 5000 | Karatsuba Parallelized | 1 | 212 |
| 5000 | Simple Parallelized | 2 | 160 |
| 5000 | Karatsuba Parallelized | 2 | 56 |
| 5000 | Simple Parallelized | 3 | 144 |
| 5000 | Karatsuba Parallelized | 3 | 348 |
| 5000 | Simple Parallelized | 4 | 110 |
| 5000 | Karatsuba Parallelized | 4 | 57 |
| 5000 | Simple Parallelized | 5 | 92 |
| 5000 | Karatsuba Parallelized | 5 | 60 |
| 5000 | Simple Parallelized | 10 | 58 |
| 5000 | Karatsuba Parallelized | 10 | 57 |
| 5000 | Simple Parallelized | 15 | 53 |
| 5000 | Karatsuba Parallelized | 15 | 59 |
| 5000 | Simple Parallelized | 30 | 53 |
| 5000 | Karatsuba Parallelized | 30 | 58 |
| 10000 | Simple Sequential | - | 765 |
| 10000 | Karatsuba Sequential | - | 659 |

| | | | |
|-------|------------------------|----|------|
| 10000 | Simple Parallelized | 1 | 1128 |
| 10000 | Karatsuba Parallelized | 1 | 657 |
| 10000 | Simple Parallelized | 2 | 646 |
| 10000 | Karatsuba Parallelized | 2 | 165 |
| 10000 | Simple Parallelized | 3 | 573 |
| 10000 | Karatsuba Parallelized | 3 | 160 |
| 10000 | Simple Parallelized | 4 | 425 |
| 10000 | Karatsuba Parallelized | 4 | 157 |
| 10000 | Simple Parallelized | 5 | 373 |
| 10000 | Karatsuba Parallelized | 5 | 160 |
| 10000 | Simple Parallelized | 10 | 257 |
| 10000 | Karatsuba Parallelized | 10 | 156 |
| 10000 | Simple Parallelized | 15 | 231 |
| 10000 | Karatsuba Parallelized | 15 | 156 |
| 10000 | Simple Parallelized | 30 | 211 |
| 10000 | Karatsuba Parallelized | 30 | 160 |