

PPD - Lab 5

1. $O(n^2)$ algorithm

Computes the basic multiplication algorithm, multiplying every coefficient of the first polynomial with every coefficient from the second polynomial.

2. $O(n^2)$ parallel

Performs the basic multiplication algorithm using a ThreadPoolExecutor to manage and execute tasks in parallel, ensuring tasks execute concurrently without interfering with each other. Each segment of a specified number of coefficients is assigned to a Task object.

3. Karatsuba algorithm

Each polynomial is recursively divided in 2 parts: the low part(lower degree coefficients) and the high part (higher degree coefficients). If we are in the best case where either of the two polynomials are of degree one, we will do the basic computation($O(n^2)$ algorithm, for efficiency. If not, compute recursively three key products:

- P1: product of the lower parts of the 2 polynomials ($lower1 * lower2$)
- P2: product of the sums of the higher part and lower part of each polynomial $((low1 + high1) * (low2 + high2))$
- P3: product of the higher parts of the 2 polynomials ($high1 * high2$).

After obtaining these 3 products, we combine them for the final result:

we shift the higher part to its place by adding n number of zeros, remove the overlapping terms (by computing $p2 - p3 - p1$) then shifting the result by $n/2$ number of zeros and adding the lower part. The final formula is:

$$p3 * (x^n) + (p2 - p3 - p1) * x^{(n/2)} + p1, \text{ where } n = \text{max degree}$$

4. Karatsuba parallel

We parallelize the algorithm described at 3 by using a fixed thread pool managed by ExecutorService. Each subproblem is submitted as a task, returning a Future to retrieve results after completion. To optimize performance, when recursion depth exceeds a threshold or polynomials' degree are small enough, the computation switches to sequential approach.

number_of_threads=10

Algorithm	Degree	Time
Regular Sequential	10.000	0.465s
Regular Parallel	10.000	0.199s
Karatsuba Sequential	10.000	0.371s
Karatsuba Parallel	10.000	0.092s
Regular Sequential	100.000	41.517s
Regular Parallel	100.000	13.855s
Karatsuba Sequential	100.000	11.854s
Karatsuba Parallel	100.000	3.11s