Lab 5 Documentation

Statement

Perform the multiplication of 2 polynomials. Use both the regular $O(n^2)$ algorithm and the Karatsuba algorithm, and each in both the sequencial form and a parallelized form. Compare the 4 variants.

Sequential Classic:
The regular polynomial multiplication algorithm, where the 2 polynomials are parsed in 2 nested loops and the result is computes with the following formula coefficients[i + j] += coefficients[i] + coefficients[j].
Complexity: $O(n^2)$

Parallel Classic:
The same computations as above, but the range of elements in the result are distributed between threads and they are also disjoint, such that we do not need mutexes on polynomials.

Sequential Karatsuba:
The Karatsuba algorithm is a divide-and-conquer algorithm that is more efficient than the standard polynomial multiplication algorithm (like the one implemented in SequentialClassic) for large polynomials. The key idea behind the Karatsuba algorithm is to reduce the number of recursive multiplications by using fewer multiplications to compute intermediate results. It works by recursively splitting the input polynomials into smaller halves, computing three products using those halves, and combining the results using addition and subtraction operations.
Complexity: $O(n^{log_2 3})$

Parallel Karatsuba:
The key goal of the parallel version is to leverage multiple threads to concurrently compute subproblems of the Karatsuba multiplication, potentially reducing the overall computation time for large polynomials compared to the sequential version.

Testing

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Sequential classic duration (p1 degree = 1000, p2 degree = 1000): 33 milliseconds
Parallel classic duration (p1 degree = 1000, p2 degree = 1000): 83 milliseconds
Sequential Karatsuba duration (p1 degree = 1000, p2 degree = 1000): 61 milliseconds
Parallel Karatsuba duration (p1 degree = 1000, p2 degree = 1000): 99 milliseconds
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Sequential classic duration (p1 degree = 5000, p2 degree = 5000): 479 milliseconds
Parallel classic duration (p1 degree = 5000, p2 degree = 5000): 176 milliseconds
Sequential Karatsuba duration (p1 degree = 5000, p2 degree = 5000): 460 milliseconds
Parallel Karatsuba duration (p1 degree = 5000, p2 degree = 5000): 124 milliseconds
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Sequential classic duration (p1 degree = 20000, p2 degree = 15000): 4276 milliseconds
Parallel classic duration (p1 degree = 20000, p2 degree = 15000): 1379 milliseconds
Sequential Karatsuba duration (p1 degree = 20000, p2 degree = 15000): 2290 milliseconds
Parallel Karatsuba duration (p1 degree = 20000, p2 degree = 15000): 566 milliseconds
```