NSYSU-MATH Data Structure – Spring 2024

Homework 1

Design: Designing a Polynomial Class

Data Preparation

For this assignment, you will find a zip file named `HW1.zip` containing template files and public test data. Your task is to implement a `Polynomial` class in either Python or C++. The directory structure and contents are as follows:

1. Python Implementation (`Py`/ directory):
   - ✓ `Polynomial.py`: Implement your `Polynomial` class here.
   - ✓ `test.py`: Contains public test cases for your implementation.
   - ✓ `benchmark.py`: A template for conducting benchmark analysis.
2. C++ Implementation (`Cpp/` directory):
   - ✓ `Polynomial.cpp`: Implement your `Polynomial` class here.
   - ✓ `Polynomial.h`: The header file for your `Polynomial` class.
   - ✓ `main.cpp`: Contains public test cases for your implementation.
   - ✓ `benchmark.cpp`: A template for conducting benchmark analysis.

Description

This assignment is divided into three main parts:

1. Environment Setup:
   - ✓ Choose either C++ or Python as your programming language.
   - ✓ Set up your programming environment accordingly.
2. Class Implementation:
   - ✓ Implement a new class named `Polynomial` in the provided template file. For Python, use `Polynomial.py`. For C++, use `Polynomial.cpp`.
   - ✓ The specifications for the `Polynomial` class will be provided in the subsequent sections.
3. Time Complexity Analysis:
   - ✓ Analyze the time complexity for the following operations in your `Polynomial` class: **Addition, Subtraction and Multiplication**. Report the worst-case time complexity using Big O notation.
   - ✓ Use the benchmarking method introduced in class to validate your analysis. Implement your analysis in the provided template (`benchmark.py` for Python or `benchmark.cpp` for C++).

Note: You may assume that all basic operations on `lists` (or `vectors` in C++) have constant time complexity for the purpose of this analysis.

ADT

`Polynomial` **ADT**
Data: A list (vector) that stores coefficients stores in **descending order** from left to right. An integer that records the degree of polynomial
Operation: 1. **Initialize:** Creates a new polynomial that is constructed using the given coefficients. It needs a list of coefficients and returns the polynomial. **2. Addition:** Add two polynomials and return the resulting polynomial: $(x^2 + 3x + 2) + (x + 2) = x^2 + 4x + 4$ **3. Subtraction:** Subtract one polynomial from the other and return the resulting polynomial: $(x^2 + 3x + 2) - (x + 2) = x^2 + 2x$ **4. Multiplication:** Multiply two polynomials and return the resulting polynomial: $(x^2 + 3x + 2) \times (x + 2) = 2x^3 + 5x^2 + 8x + 4$ **5. Negation:** Negate the coefficient of a polynomial: $-(x^2 + 3x + 2) = -x^2 - 3x - 2$

Specifications

1. Class name: `Polynomial`
2. Attribute name: `_degree, _coeff` (They should be private)
3. Method: Constructor (list of coefficients), +, −, × and negation. You should implement them using operator overloading. Note a custom `print()` method for the class is already implemented. Do not modify this method.
4. **Use a `list` (in Python) or a `vector` (in C++) to store the coefficients.**
5. **Coefficients should be stored in descending order of power (from left to right). For a polynomial with highest power x^n it will contain $n+1$ terms (Input sequences may contain leading zeros; these should be removed).**

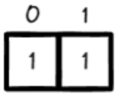
   Ex: $3x^4 + 2x^3 + x^2$ **(Input will be [3,2,1,0,0] or [0,3,2,1,0,0] …)**

0	1	2	3	4
3	2	1	0	0

$$-2x^4 + x^2 + 0.5$$

0	1	2	3	4
-2	0	1	0	0.5

$$x + 1$$



6. Please combine the terms that have the same powers.
7. The input coefficients can be integers or floating-point numbers.
8. You can only use standard Python or C++ library and do not use `reverse()` or `[::-1]` method for `list` and `vector`.

Deliverables

1. Deadline: 2024/3/17 (Sun.), 11:59 PM. Hand in the following two items to the cyber universities. Please see our Facebook group for the late policy and rules.
2. Report:
   - ✓ Describe your programming environment and provide instructions on how to set it up.
   - ✓ Explain the design of your program and the data structures used. Discuss what you have learned from completing this homework.
   - ✓ Provide a detailed analysis of the time complexity (Big O notation) and benchmark results for the Addition, Subtraction, and Multiplication operations in your implementation**.**
3. Program Source Files:
   - ✓ Submit your source files in a zip file. **Ensure that you follow the provided template files**.
   - ✓ Source File Comments: Each file must begin with three lines of comments indicating the Author, Date, and Purpose of the program. Include appropriate comments throughout your code for clarity.

Grading Policy

- Function Correctness: 60% (45% for public test cases and 15% for hidden test cases).
- Big O and Benchmark Analysis: 20%.
- Report: 20%.

Reference

1. https://python-course.eu/oop/polynomial-class.php
2. https://hplgit.github.io/primer.html/doc/pub/class/._class-readable003.html
3. https://web.ntnu.edu.tw/~algo/Polynomial.html
4. https://gist.github.com/birshert/8965693055464cb8b4e4cb16d6306fc8