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Name, SID, Date ....

In Class Assignment 17: Square Matrix Multiply

Benjamin Sanders, MS November 25, 2020

1 Introduction

You will need to work individually to complete this assignment. Write your name at the top of all pages for this assignment. Turn in all work to Blackboard on or before the deadline to receive credit.

You may use additional libraries and online resources, if you get them approved in writing, over email, from the instructor first. If you have received approval from the instructor, write the approved libraries and any references in the space below.

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2 Assignment Description

2.1 Big Picture

Square Matrix Multiply is a common function in Linear Algebra, and is used extensively in image processing to produce pixel-by-pixel transformations in an efficient fashion.

2.2 Algorithm Implementation

Implement the following algorithm in Java, using the Vector data structure for any 1-D array, 2-D array, or linear algebra purposes.

If you have seen matrices before, then you probably know how to multiply them. (Otherwise, you should read Section D.1 in Appendix D.) If $A = (a_{ij})$ and $B = (b_{ij})$ are square $n \times n$ matrices, then in the product $C = A \cdot B$, we define the entry c_{ij}, for $i, j = 1, 2, \ldots, n$, by

$$c_{ij} = \sum_{k=1}^{n} a_{ik} \cdot b_{kj} . \tag{4.8}$$

We must compute n^2 matrix entries, and each is the sum of n values. The following procedure takes $n \times n$ matrices A and B and multiplies them, returning their $n \times n$ product C. We assume that each matrix has an attribute *rows*, giving the number of rows in the matrix.

SQUARE-MATRIX-MULTIPLY(A, B)

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n = A.rows
let C be a new n × n matrix
for i = 1 to n
    for j = 1 to n
        c_ij = 0
        for k = 1 to n
            c_ij = c_ij + a_ik · b_kj
return C
```

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2.3 Time Complexity Analysis

Where n is the number of data points in A and B together, analyze the time complexity of the given algorithm with respect to n. Write the result of your analysis in big-O notation, i.e. $O(n^2)$ in the space below.

O(n^3)

2.4 Space Complexity Analysis

Where n is the number of data points in A and B together, analyze the space complexity of the given algorithm with respect to n. Write the result of your analysis in big-O notation, i.e. $O(n \cdot log(n))$ in the space below.

O(n^2)

2.5 Optimize the Algorithm for a Purpose

Choose an optimization, either in time or in space, for the given algorithm. Write your intended big-O notation, i.e. $O(1)$, $O(n)$, etc., in the space below, and write N/A in the other space.

- Time Complexity: O(n^2.8)
- Space Complexity: O(n^2)

What application would benefit from the purpose of the above optimization? Why? Write two sentences to answer these questions in the space below.

The Strassen's algorithm for matrix multiplication can benefit applications involving large-scale scientific computations or data processing where matrix multiplication is a fundamental operation. Its optimized time complexity can significantly improve the performance of algorithms reliant on matrix operations, such as machine learning algorithms or numerical simulations, leading to faster computation times and more efficient resource utilization.

2.6 New Algorithm Design and Implementation

In the space below, design an algorithm that achieves the same purpose of the given algorithm, but includes the optimization you have specified above. Use pseudocode written in a style similar to the given algorithm, and implement it in Java. You may use as many additional pages as necessary for this purpose.

3 What to Turn In

Turn in one PDF or Word document on Blackboard, containing the following items.

1. All pages scanned or photographed of the In Class Assignment completed document.
2. Any additional pages you used to complete the assignment.
3. All code created for the assignment, along with test cases.
4. One statement indicating which parts of your implementation(s) are working, and which parts are not.
5. Screenshots demonstrating the code working, if it is working.