实验目的

通用矩阵乘法的实现与优化

实验代码及过程

首先，给出C代码和python代码

C++

```
#include <iostream>
#include <ctime>
#include <cstdlib>

using namespace std;

// 生成随机矩阵
void generateRandomMatrix(float** matrix, int rows, int cols) {
    for (int i = 0; i < rows; ++i) {
        for (int j = 0; j < cols; ++j) {
            matrix[i][j] = static_cast<float>(rand()) / RAND_MAX;
        }
    }
}

// 矩阵乘法
void matrixMultiplication(float** A, float** B, float** C, int M, int N, int
    for (int i = 0; i < M; ++i) {
        for (int j = 0; j < K; ++j) {
            C[i][j] = 0.0;
            for (int k = 0; k < N; ++k) {
                C[i][j] += A[i][k] * B[k][j];
            }
        }
    }
}

int main() {
    int M, N, K;
    cout << "Enter values for M, N, and K (512-2048): ";
    cin >> M >> N >> K;

    if (M < 512 || M > 2048 || N < 512 || N > 2048 || K < 512 || K > 2048)
```

```
        cout << "Invalid input. All values must be between 512 and 2048." <<
        return 1;
    }

    // 分配内存并初始化矩阵
    float** A = new float*[M];
    float** B = new float*[N];
    float** C = new float*[M];

    for (int i = 0; i < M; ++i) {
        A[i] = new float[N];
        C[i] = new float[K];
    }

    for (int i = 0; i < N; ++i) {
        B[i] = new float[K];
    }

    // 生成随机矩阵
    srand(static_cast<unsigned>(time(nullptr)));
    generateRandomMatrix(A, M, N);
    generateRandomMatrix(B, N, K);

    // 计算矩阵乘法的时间
    clock_t startTime = clock();
    matrixMultiplication(A, B, C, M, N, K);
    clock_t endTime = clock();
    double elapsedTime = static_cast<double>(endTime - startTime) / CLOCKS_

    cout << "Matrix A:" << endl;
    // 输出矩阵A的内容

    cout << "Matrix B:" << endl;
    // 输出矩阵B的内容

    cout << "Matrix C:" << endl;
    // 输出矩阵C的内容

    cout << "Matrix multiplication took " << elapsedTime << " seconds." <<

    // 释放分配的内存
    for (int i = 0; i < M; ++i) {
        delete[] A[i];
        delete[] C[i];
    }
    for (int i = 0; i < N; ++i) {
        delete[] B[i];
    }

    delete[] A;
    delete[] B;
    delete[] C;

    return 0;
}
```

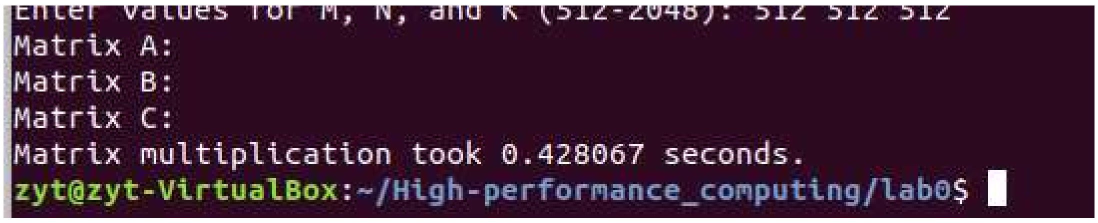
python

```
import random
import time

# 生成随机矩阵
def generate_random_matrix(rows, cols):
    matrix = []
    for i in range(rows):
        row = [random.random() for _ in range(cols)]
        matrix.append(row)
    return matrix

# 矩阵乘法
def matrix_multiplication(A, B):
    M = len(A)
    N = len(A[0])
    K = len(B[0])
    C = [[0.0 for _ in range(K)] for _ in range(M)]

    for i in range(M):
        for j in range(K):
            for k in range(N):
                C[i][j] += A[i][k] * B[k][j]

    return C

def main():
    M, N, K = map(int, input("Enter values for M, N, and K (512-2048): ").sp

    if M < 512 or M > 2048 or N < 512 or N > 2048 or K < 512 or K > 2048:
        print("Invalid input. All values must be between 512 and 2048.")
        return 1
```

```python
    # 生成随机矩阵
    random.seed(time.time())
    A = generate_random_matrix(M, N)
    B = generate_random_matrix(N, K)

    # 计算矩阵乘法的时间
    start_time = time.time()
    C = matrix_multiplication(A, B)
    end_time = time.time()
    elapsed_time = end_time - start_time

    # print("Matrix A:")
    # for row in A:
    #     print(row)

    # print("Matrix B:")
    # for row in B:512
    #     print(row)

    # print("Matrix C:")
    # for row in C:
    #     print(row)

    print(f"Matrix multiplication took {elapsed_time:.4f} seconds.")

if __name__ == "__main__":
    main()
```

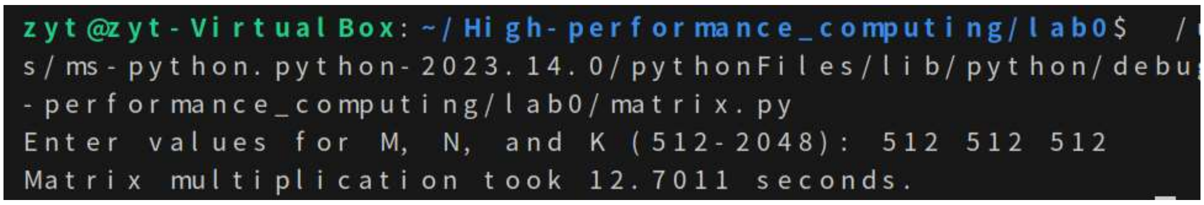
然后分别指定两个矩阵的行和列都是512

C++结果如下



```
Enter values for M, N, and K (512-2048): 512 512 512
Matrix A:
Matrix B:
Matrix C:
Matrix multiplication took 0.428067 seconds.
zyt@zyt-VirtualBox:~/High-performance_computing/lab0$
```

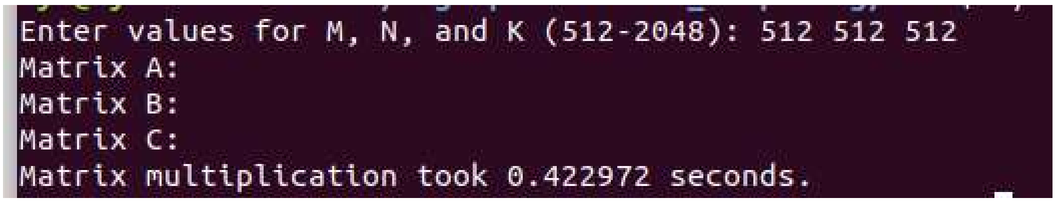
python结果如下



```
zyt@zyt-VirtualBox:~/High-performance_computing/lab0$  /
s/ms-python.python-2023.14.0/pythonFiles/lib/python/debu
-performance_computing/lab0/matrix.py
Enter values for M, N, and K (512-2048): 512 512 512
Matrix multiplication took 12.7011 seconds.
```

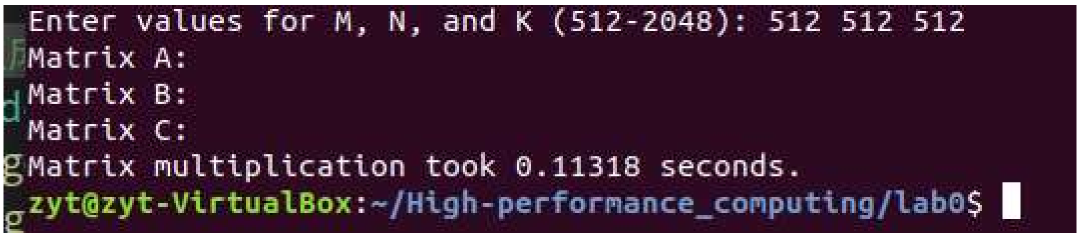
不难看出，python运算比C++慢得多，符合一般情况。

循环顺序优化


```
Enter values for M, N, and K (512-2048): 512 512 512
Matrix A:
Matrix B:
Matrix C:
Matrix multiplication took 0.422972 seconds.
```

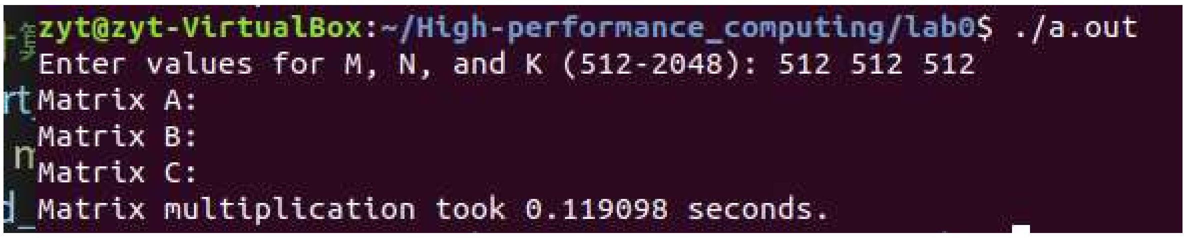
速度变快了

再进行编译优化，


```
Enter values for M, N, and K (512-2048): 512 512 512
Matrix A:
Matrix B:
Matrix C:
Matrix multiplication took 0.11318 seconds.
zyt@zyt-VirtualBox:~/High-performance_computing/lab0$
```

可以看出又快了许多。

再利用-O3编译


```
zyt@zyt-VirtualBox:~/High-performance_computing/lab0$ ./a.out
Enter values for M, N, and K (512-2048): 512 512 512
Matrix A:
Matrix B:
Matrix C:
Matrix multiplication took 0.119098 seconds.
```

变化的不是很明显。

实验结果

版本	实现	运行时间(s)	相对加速比(相对前一版本)	绝对加速比(相对版本1)	浮点性能(GFLOPS)	达到峰值性能的百分比
1	Python	12.7011	1	1	0.001	0.001
2	C	0.428067	29.67	29.67	0.114	0.012
3	+调整循环顺序	0.422972	1.012	30.09	0.686	0.085
4	+编译优化	0.11318	3.743	112.38	1.972	0.201

实验感想

1. 认识到了编译优化带来的好处。

2. 认识到C++的优越性。