EE 2331 Data Structures and Algorithms, Semester B, 2009/10

Tutorial 2: Matrix

Week 2 (21st January, 2010)

The tasks of tutorial exercises are divided into three levels. Level 1 is the basic tasks. You should have enough knowledge to complete them after attending the lecture. Level 2 is the advanced tasks. You should able to tackle them after revision. Level 3 is the challenge tasks which may be out of the syllabus and is optional to answer. I expect you to complete at least task A in the tutorial.

Outcomes of this tutorial

1. Able to read inputs from file
2. Able to manipulate two-dimensional arrays
3. Able to manipulate C structures and pointers to C structures
4. Able to pass C structure arguments to functions using pass-by-reference
5. Able to distinguish between pass-by-value and pass-by-reference
6. Able to format printing floating point numbers

In this tutorial, you are asked to write a program to compute the addition and multiplication of two matrices. The matrices are stored in a text file with the following format:

Row	Content	Remark
1st	$row_a\ col_a$	The row and column of the 1st matrix
2nd	$a_{11}\ a_{12}\ a_{13}\ \ldots\ a_{1cola}$	The 1st row of the 1st matrix
…	…	…
$(row_a + 1)^{th}$	$a_{rowa1}\ a_{rowa2}\ a_{rowa3}\ \ldots a_{rowa\ cola}$	The last row of the 1st matrix
$(row_a + 2)^{th}$	$row_b\ col_b$	The row and column of the 2nd matrix
$(row_a + 3)^{th}$	$b_{11}\ b_{12}\ b_{13}\ \ldots\ b_{1colb}$	The 1st row of the 2nd matrix
…	…	…
$(row_a + row_b + 1)^{th}$	$b_{rowb1}\ b_{rowb2}\ b_{rowb3}\ \ldots\ b_{rowb\ colb}$	The last row of the 2nd matrix

The definition of Matrix is defined as follows:

```
struct _matrix {
  float element[MAXSIZE][MAXSIZE];
  int row;
  int col;
};

typedef struct _matrix Matrix;
```

The routine of reading the matrices from text file will be provided to you. You should concentrate on completing the following tasks only:

Task A (Level 1): Addition of two matrices, *S* = *A* + *B*

The sum *S* of two matrices *A* and *B* can be obtained by adding entries with the same indices:

$s_{ij} = a_{ij} + b_{ij}$ for all *i* and *j*.

Example 1: $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}$, $B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{bmatrix}$

$$S = A + B = \begin{bmatrix} a_{11} + b_{11} & a_{12} + b_{12} & a_{13} + b_{13} \\ a_{21} + b_{21} & a_{22} + b_{22} & a_{23} + b_{23} \end{bmatrix}$$

Precondition: Matrices A and B must be of the same dimensions, i.e. the numbers of rows of A and B must be equal, and same for the number of columns.

Example 2: $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}$, $B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$

A + *B* = error in dimension!

Complete the function add() that accepts two matrices and computes the corresponding sum. Return 1 for successful addition and return 0 for unsuccessful addition.

Expected Output Format:

```
Enter the file name for testing: test1.txt
Please enter your action ( 1) Task A, 2) Task B, 3) Task C ): 1
Matrix A is :
 -2.59   1.67   0.34
  2.00  -1.31   4.24

Matrix B is :
  1.78   0.58   6.62
  1.64   4.05  -1.55

The sum is:
 -0.81   2.25   6.96
  3.64   2.74   2.69
```

```
Enter the file name for testing: test2.txt

Please enter your action ( 1) Task A, 2) Task B, 3) Task C ): 1
Matrix A is :
 -2.59   1.67   0.34
  2.00  -1.31   4.24

Matrix B is :
  1.78   0.58   6.62
  1.64   4.05  -1.55
 -0.19   5.27   6.61

Cannot perform addition. Error in dimension!
```

Observation: How many for-loops are required in your function?

Task B (Level 2): Multiplication of two matrices, $P = A \times B$

The product P of two matrices A and B can be computed as

$$p_{ik} = \sum_j a_{ij} b_{jk} \quad \text{for all } i \text{ and } k$$

Example 3: $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}$, $B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}$

$$P = A \times B = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} + a_{13}b_{31} & a_{11}b_{12} + a_{12}b_{22} + a_{13}b_{32} & a_{11}b_{13} + a_{12}b_{23} + a_{13}b_{33} \\ a_{21}b_{11} + a_{22}b_{21} + a_{23}b_{31} & a_{21}b_{12} + a_{22}b_{22} + a_{23}b_{32} & a_{21}b_{13} + a_{22}b_{23} + a_{23}b_{33} \end{bmatrix}$$

Precondition: The number of columns of matrix A must be equal to the number of rows of matrix B.

Example 4: $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}$, $B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{bmatrix}$

A x B = error in dimension!

Complete the function multiply() that accepts two matrices and computes the corresponding product. Return 1 for successful multiplication and return 0 for unsuccessful multiplication.

Expected Output Format:

```
Enter the file name for testing: test1.txt
Please enter your action ( 1) Task A, 2) Task B, 3) Task C ): 1
Matrix A is :
 -2.59   1.67   0.34
  2.00  -1.31   4.24

Matrix B is :
  1.78   0.58   6.62
  1.64   4.05  -1.55

Cannot perform multiplication. Error in dimension!
```

```
Enter the file name for testing: test2.txt
Please enter your action ( 1) Task A, 2) Task B, 3) Task C ): 1
Matrix A is :
 -2.59   1.67   0.34
  2.00  -1.31   4.24

Matrix B is :
  1.78   0.58   6.62
  1.64   4.05  -1.55
 -0.19   5.27   6.61

The product is:
 -1.94   7.05 -17.49
  0.61  18.20  43.30
```

Observation: How many for-loops are required in your function?

Task C (Level 2): Pass-by-reference & pass-by-value

There are two provided functions to print out the content of a matrix. One is pass-by-value while another one is pass-by-reference. Complete the function printout2().

Observation: Which functions, printout() or printout2(), is pass-by-reference? Which functions, printout() or printout2(), would you prefer? Why?