University of Glasgow | School of Computing Science

CSC1103 Tutorial 10 : File Operations and Matrices

1. Create header file and link all programs

Problem definition:

Design a main program that call three other programs that perform the following

1. a program that contains a function that read matrix
2. a program that contains a function that print matrix
3. a program that does following a function that performs matrix operation
   a) add two matrices
   b) subtract two matrices
   c) multiply two matrices

and use a header file to link all the four programs including main program together

Problem Analysis

1. The addition of two matrices is given by

$$\mathbf{C} = \mathbf{A} + \mathbf{B}$$

The elements of matrix $\mathbf{C}$ are obtained as follows:

$c_{ij=} a_{ij} + b_{ij}$ for all i, j . For example,

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \end{bmatrix}, \mathbf{B} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \end{bmatrix}$$

$$\mathbf{C} = \begin{bmatrix} a_{11} + b_{11} & a_{12} + b_{12} & a_{13} + b_{13} & a_{14} + b_{14} \\ a_{21} + b_{21} & a_{22} + b_{22} & a_{23} + b_{23} & a_{24} + b_{24} \\ a_{31} + b_{31} & a_{32} + b_{32} & a_{33} + b_{33} & a_{34} + b_{34} \end{bmatrix}$$

2. For subtraction operation

$$\mathbf{C} = \mathbf{A} - \mathbf{B}$$

The elements of matrix $\mathbf{C}$ are obtained as follows:

$c_{ij=} a_{ij} - b_{ij}$ for all i, j where

$$\mathbf{C} = \begin{bmatrix} a_{11}-b_{11} & a_{12}-b_{12} & a_{13}-b_{13} & a_{14}-b_{14} \\ a_{21}-b_{21} & a_{22}-b_{22} & a_{23}-b_{23} & a_{24}-b_{24} \\ a_{31}-b_{31} & a_{32}-b_{32} & a_{33}-b_{33} & a_{34}-b_{34} \end{bmatrix}$$

3. For multiplication operation assuming matrix $\mathbf{A}$ of dimension 3x4 and matrix **B** of dimension 4x4

$$\mathbf{C} = \mathbf{A}.\mathbf{B}$$

assuming

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix}$$

The elements of matrix $\mathbf{C}$ are obtained as follows where p is number of columns in matrix **A** and number of rows in matrix **B**

$$c_{ij=} \sum_{k=1}^{P} a_{ik}\, b_{kj} = a_{i1}b_{1j} + a_{i2}b_{2j} + \cdots a_{iP}b_{Pj}$$ where

$$\mathbf{C} = \begin{bmatrix} a_{11}b_{11}+a_{12}b_{21}+a_{13}b_{31}+a_{14}b_{41} & a_{11}b_{12}+a_{12}b_{22}+a_{13}b_{32}+a_{14}b_{42} & a_{11}b_{13}+a_{12}b_{23}+a_{13}b_{33}+a_{14}b_{43} & a_{11}b_{14}+a_{12}b_{24}+a_{13}b_{34}+a_{14}b_{44} \\ a_{21}b_{11}+a_{22}b_{21}+a_{23}b_{31}+a_{24}b_{41} & a_{21}b_{12}+a_{22}b_{22}+a_{23}b_{32}+a_{24}b_{42} & a_{21}b_{13}+a_{22}b_{23}+a_{23}b_{33}+a_{24}b_{43} & a_{21}b_{14}+a_{22}b_{24}+a_{23}b_{34}+a_{24}b_{44} \\ a_{31}b_{11}+a_{32}b_{21}+a_{33}b_{31}+a_{34}b_{41} & a_{31}b_{12}+a_{32}b_{22}+a_{33}b_{32}+a_{34}b_{42} & a_{31}b_{13}+a_{32}b_{23}+a_{33}b_{33}+a_{34}b_{43} & a_{31}b_{14}+a_{32}b_{24}+a_{33}b_{34}+a_{34}b_{44} \end{bmatrix}$$

Input variable

1. The matrix A elements, $A \ \ (double\ A[\ ]\ )$
2. The matrix B elements, $B \ \ (double\ B[\ ]\ )$
3. The size of the row and column for the matrices, num_row, num_col $(int\ num\_row, int\ num\_col\ )$
4. The choice of operation, $choice$ $(int\ choice\ )$

Output variable

1. The matrix A elements, $C \ \ (double\ C[\ ]\ )$

1. Algorithm

The program is divided into following functions

a) **main ()** :

i. call the function **matrix_read ()** through array and pointer variable to read matrix A and matrix B of size $num\_row \times num\_col$

ii. call the function **matrix_print ()** to print matrix A and matrix B of size $num\_row \times num\_col$ or the calculated matrix C

iii. call the function **matrix_ops ()** to perform operation on matrix A and matrix B of size $num\_row \times num\_col$ according to the choice, $choice$

b) **matrix_read** ():

i. read the number of row and col, num_col , num_col for matrix

ii. read in the elements for the matrix with size $num\_row \times num\_col$

c) **matrix_print** ():

i. print the elements on the inputted matrix A and B or the calculated matrix C according to the choice, $choice$

Algorithm for **main ()**

```
1.  Set $choice = 0$
2.  Call matrix_read ($A, \&num\_row, \&num\_col$)
3.  Call matrix_print ($A, num\_row, num\_col, choice$)
4.  Call matrix_read ($B, \&num\_row, \&num\_col$)
5.  Call matrix_print ($B, num\_row, num\_col, choice$)
6.  Set $choice = 1$
7.  Call matrix_ops ($A, B, C\ num\_row, num\_col, choice$)
8.  Call matrix_print ($C, num\_row, num\_col, choice$)
9.  Set $choice = 2$
10. Call matrix_ops ($A, B, C\ num\_row, num\_col, choice$)
11. Call matrix_print ($C, num\_row, num\_col, choice$)
12. Set $choice = 3$
13. Call matrix_ops ($A, B, C\ num\_row, num\_col, choice$)
14. Call matrix_print ($C, num\_row, num\_col, choice$)
```

Algorithm for **matrix_read (X** , $\&num\_row, \&num\_col$)

```
1. Read the number of row for matrix $\mathbf{X}$ and store in the address indicated by pointer $ptr\_row$ where $ptr\_row$ pointed to the address of $num\_row$
2. Read the number of col for matrix $\mathbf{X}$ and store in the address indicated by pointer $ptr\_col$ where $ptr\_col$ pointed to the address of $num\_col$
3. For $i = 0\ to\ (value\ in\ the\ address\ pointed\ by\ ptr\_row - 1)$ do the following
    3.1. For $j = 0\ to\ (value\ in\ the\ address\ pointed\ by\ ptr\_col - 1)$ do the following
        3.1.1 Read $X[i][j]$
```

Algorithm for **matrix_print(**$\mathbf{X}$, $num\_row, num\_col, choice$)

```
1. IF $(choice = 0)$
   1.1.    Print the string “Matrix Entered”
2. IF $(choice = 1)$
   2.1.  Print the string “Addition of two matrices”
3. IF $(choice = 2)$
   3.1   Print the string “Subtraction of two matrices”
4. IF $(choice = 3)$
   4.1   Print the string “Multiplication of two matrices”
5. For $i = 0\ to\ num\_row$ do the following
         4.1 For $j = 0\ to\ num\_col$ do the following
                 4.1.1   Print $X[i][j]$
```

Algorithm for **matrix_ops(**$\mathbf{A}$, $\mathbf{B}$, $\mathbf{C}$, $num\_row, num\_col, choice$)

```
1. Set $p = num\_col$
2. Switch $(choice)$
   2.1.    $choice$ is addition
           2.1.1   For $i = 0\ to\ num\_row$ do the following
                   2.1.1.1   For $j = 0\ to\ num\_col$ do the following
                             2.1.1.1.1   $C[i][j] = A[i][j] + B[i][j]$
           2.1.2   Break from the $choice$ is addition
   2.2.    $choice$ is subtraction
           2.2.1   For $i = 0\ to\ num\_row$ do the following
                   2.2.1.1   For $j = 0\ to\ num\_col$ do the following
                             2.2.1.1.1   $C[i][j] = A[i][j] - B[i][j]$
           2.2.2   Break from the $choice$ is subtraction
   2.3     $choice$ is multiplication
           2.3.1   For $i = 0\ to\ num\_row$ do the following
                   2.3.1.1   For $j = 0\ to\ num\_col$ do the following
                             2.3.1.1.1   $C[i][j] = 0$
                             2.3.1.1.2   For $k = 0\ to\ p - 1$ do the
                                         following
                                         2.3.1.1.2.1
                                 $C[i][j] = C[i][j] + A[i][k] * B[k][j]$
           2.3.2   Break from the $choice$ is multiplication
```

Pseudocode

```
BEGIN
    $choice \leftarrow 0$
    $matrix\_read(A, \&num\_row, \&num\_col)$
    $matrix\_print(A, num\_row, num\_col, choice)$
    $matrix\_read(B, \&num\_row, \&num\_col)$
    $matrix\_print(B, num\_row, num\_col, choice)$
    $choice \leftarrow 1$
    $matrix\_ops(A, B, C, num\_row, num\_col, choice)$
    $matrix\_print(C, num\_row, num\_col, choice)$
    $choice \leftarrow 2$
    $matrix\_ops(A, B, C, num\_row, num\_col, choice)$
    $matrix\_print(C, num\_row, num\_col, choice)$
    $choice \leftarrow 3$
    $matrix\_ops(A, B, C, num\_row, num\_col, choice)$
    $matrix\_print(C, num\_row, num\_col, choice)$
END
```

```
FUNCTION $matrix\_read(x, ptr\_row, ptr\_col)$
        $ptr\_row$        $refToInt \rightarrow \&num\_row$
        $ptr\_col$        $refToInt \rightarrow \&num\_col$
        READ (*$ptr\_row$)
        READ (*$ptr\_col$)
        FOR $i = 0\ to * ptr\_row - 1$ do
                FOR $j = 0\ to * ptr\_col - 1$ do
                        READ $x[i][j]$
                END FOR
        END FOR
ENDFUNCTION

FUNCTION $matrix\_print(x, num\_row, num\_col, choice)$
        IF ($choice = 0$)
                PRINT "Following is matrix entered"
        ENDIF
        IF ($choice = 1$)
                PRINT "Addition of two matrix A and B"
        ENDIF
```

```
    IF $(choice = 2)$
        PRINT “Subtraction of two matrix A and B”
    ENDIF
    IF $(choice = 3)$
        PRINT “Multiplication of two matrix A and B”
    ENDIF
    FOR $i = 0\ to\ num\_row - 1$ do
        FOR $j = 0\ to\ num\_col - 1$ do
            PRINT $x[i][j]$
        END FOR
    END FOR
ENDFUNCTION

FUNCTION $matrix\_ops(A, B, C\ , num\_row, num\_col, choice)$
    $p \leftarrow num\_col$
    SWITCH $(choice)$
        CASE 1
            FOR $i = 0\ to\ num\_row - 1$ do
                FOR $j = 0\ to\ num\_col - 1$ do
                    $C[i][j] = A[i][j] + B[i][j]$
                ENDFOR
            ENDFOR
            BREAK
            CASE 2
                FOR $i = 0\ to\ num\_row - 1$ do
                    FOR $j = 0\ to\ num\_col - 1$ do
                        $C[i][j] = A[i][j] - B[i][j]$
                    ENDFOR
                ENDFOR
            BREAK
            CASE 3
                FOR $i = 0\ to\ num\_row - 1$ do
                    FOR $j = 0\ to\ num\_col - 1$ do
                        $C[i][j] = 0$
                        FOR $k = 0\ to\ p - 1$ do
                          $C[i][j] = C[i][j] + A[i][k] * B[k][j]$
                        ENDFOR
                    ENDFOR
                ENDFOR
            BREAK
ENDFUNCTION
```