Experiment-1
Fundamental Matrix Operations

(Duration: 105 mins)

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Purpose: A matrix represents a collection of numbers arranged in an order of rows and columns. Matrices are rectangular arrays of numbers or other mathematical objects and are fundamental to engineering mathematics. We use matrices in mathematics and engineering because often we need to deal with several variables at once. Matrices are vital tools in some fields such as control systems, electrical machines, artificial intelligence (Figure 1) and circuit analysis (Figure 2). This experiment aims to equip you with a simple set of functions that help you in your future work on linear systems.

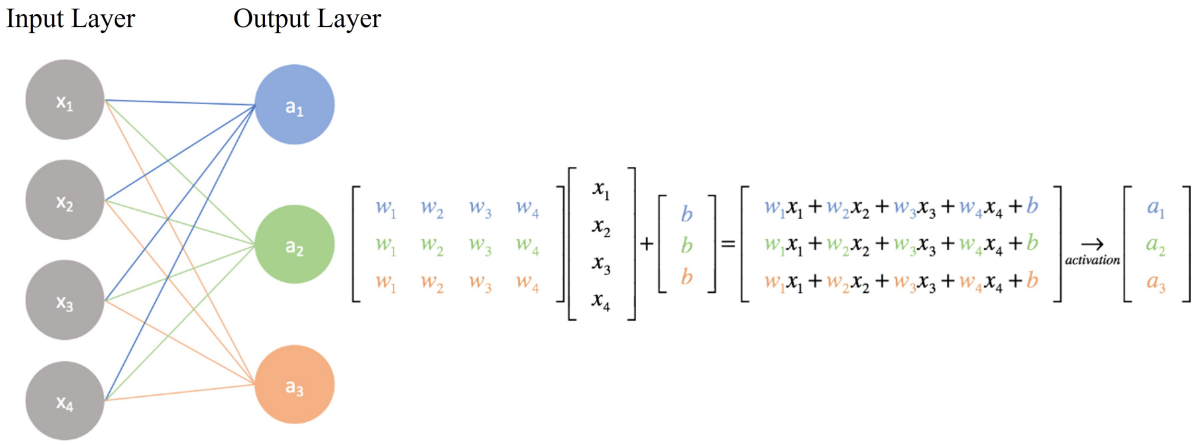

Figure 1: Matrix Representation of a Simple Neural Network

$$\begin{bmatrix} 112 & -90 & -10 \\ -90 & 100 & 0 \\ -10 & 0 & 100 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 18 \\ -6 \\ 6 \end{bmatrix}$$

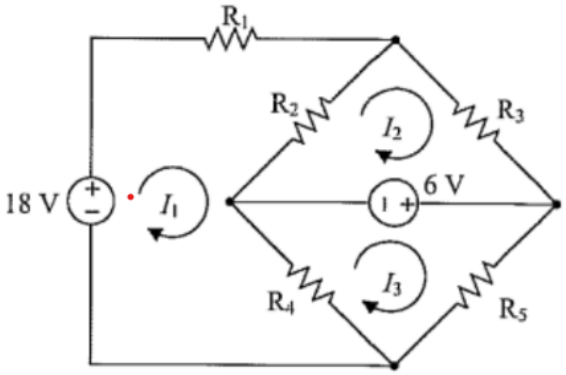

Figure 2: Matrix Representation of Circuit Equation

Introduction

In this experiment, you realize its fundamental applications of Linear Algebra (Matrix Addition, Matrix Multiplication, Matrix Transpose, Matrix Determinant) in C programming language. The aims of the experiment:

- Implement matrix operations in C programming.
- Define matrix.
- Get the input from the user and place it in the correct locations of the matrix.
- How to pass your matrix to a function?
- Create and print matrix.
- Create user-defined functions and call in the main function.

Submission format = **namesurname_labnumber.c** →(mehmetsergencatal_Lab1.c)

Problem Statement

You are asked to write four functions to carry out fundamental matrix operations:

- Matrix addition (Add two matrices, dimensions must match)
- Matrix multiplication (Multiply two matrices, dimensions must match)
- Matrix Transpose
- Matrix Determinant (Max. dimension of the matrix is 3x3)

You can verify your functions by comparing the results to the examples given in the last section of the lab procedure. The running program in the bash shell should look in Figure 5, Figure 6, Figure 7 and Figure 8. An ideal program should;

- Your program should work infinite loop and the user can choose which operation will take place.**(15p)**
- Get the matrix dimensions from the user.**(10p)**
- Get the array content inputs from the user and assign them to the correct locations of the matrix. (You have to use **void create_matrix(int r,int c,int M[n][n])** function shown in **Lab Procedure** section.)
- Prompt an error message when dimensions of the matrix do not match (**row and column sizes must be equal for matrix addition, column size and row size must match for matrix multiplication, the matrix must be square and maximum dimension is 3x3 for determinant operation.**)**(10p)**

Lab Procedure

Include these libraries in your code.

```
#include <stdio.h>
#include <stdlib.h>
```

Write a function to create matrix.**(10p)**

```
void create_matrix(int r,       //number of row
                   int c,       //number of column
                   int M[n][n]); //input matrix
```

Write a function to print matrix.**(10p)**

```
void print_matrix(int r,int c,int M[n][n])
```

Write a function to add two matrices.**(10p)**

```
void add_matrix(int r,int c,int A[n][n],int B[n][n],int C[n][n])
```

Write a function to multiply two matrices.**(15p)**

```
void multiply_matrix(int r1,int c1, int c2, int A[n][n],int B[n][n],int C[n][n])
```

Write a function to find the transpose of a matrix.**(10p)**

```
void transpose_matrix(int r,int c,int A[n][n],int C[n][n])
```

Write a function to find the determinant of a matrix (See Figure 3 and Figure 4).**(10p)**

```
int determinant_matrix(int r,int c,int A[n][n])
```

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

Figure 3: 2x2 Matrix Determinant Formula

$$A = \begin{vmatrix} a & b & c \\ d & e & f \\ g & h & i \end{vmatrix} = a\begin{vmatrix} e & f \\ h & i \end{vmatrix} - b\begin{vmatrix} d & f \\ g & i \end{vmatrix} + c\begin{vmatrix} d & e \\ g & h \end{vmatrix}$$

Figure 4: 3x3 Matrix Determinant Formula

You can check your code with these matrices.

$$\begin{bmatrix} 5 & -8 & 4 \\ 3 & 6 & 1 \\ 13 & 41 & -19 \end{bmatrix} + \begin{bmatrix} 11 & 7 & 9 \\ -5 & 3 & 25 \\ -5 & -9 & 30 \end{bmatrix} = \begin{bmatrix} 16 & -1 & 13 \\ -2 & 9 & 26 \\ 8 & 32 & 11 \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} 8 & -2 & 3 & 9 \end{bmatrix} . \begin{bmatrix} 5 & -3 & 14 \\ 0 & 1 & -8 \\ -6 & 0 & 3 \\ -7 & 5 & 1 \end{bmatrix} = \begin{bmatrix} -41 & 19 & 146 \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} 45 & -16 & 3 & 22 \\ 88 & -12 & 35 & 66 \end{bmatrix}^{\top} = \begin{bmatrix} 45 & 88 \\ -16 & -12 \\ 3 & 35 \\ 22 & 66 \end{bmatrix} \tag{3}$$

$$\begin{vmatrix} 1 & 15 & 36 \\ -16 & 5 & 81 \\ -2 & 11 & 15 \end{vmatrix} = -5622 \tag{4}$$

```
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
1
Matrix addition operation selected
(Dimension of two matrix must be same)
Enter the number of row:3
Enter the number of column:3
Write the matrix elements one by one
(0,0):5
(0,1):-8
(0,2):4
(1,0):3
(1,1):6
(1,2):1
(2,0):13
(2,1):41
(2,2):-19
-----------------------
 5  -8  4
 3  6  1
 13  41  -19
-----------------------
Enter the number of row:3
Enter the number of column:3
Write the matrix elements one by one
(0,0):11
(0,1):7
(0,2):9
(1,0):-5
(1,1):3
(1,2):25
(2,0):-5
(2,1):-9
(2,2):30
-----------------------
 11  7  9
 -5  3  25
 -5  -9  30
-----------------------
Result=
 16  -1  13
 -2  9  26
 8  32  11
-----------------------
```

(a)

```
-----------------------
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
2
Matrix multiplication operation selected
(1.Matrix column and 2. matrix row must be same)
Enter the number of row:1
Enter the number of column:4
Write the matrix elements one by one
(0,0):8
(0,1):-2
(0,2):3
(0,3):9
-----------------------
 8  -2  3  9
-----------------------
Enter the number of row:4
Enter the number of column:3
Write the matrix elements one by one
(0,0):5
(0,1):-3
(0,2):14
(1,0):0
(1,1):1
(1,2):-8
(2,0):-6
(2,1):0
(2,2):3
(3,0):-7
(3,1):5
(3,2):1
-----------------------
 5  -3  14
 0  1  -8
 -6  0  3
 -7  5  1
-----------------------
Result=
 -41  19  146
-----------------------
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
```

(b)

Figure 5: Example Outputs

```
Please Select Operation
----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
3
Matrix transpose operation selected
Enter the number of row:2
Enter the number of column:4
Write the matrix elements one by one
(0,0):45
(0,1):-16
(0,2):3
(0,3):22
(1,0):88
(1,1):-12
(1,2):35
(1,3):66
----------------------
 45  -16  3  22
 88  -12  35  66
----------------------
Result=
 45  88
 -16  -12
 3  35
 22  66
----------------------
Please Select Operation
----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(a)

```
----------------------
Please Select Operation
----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
4
Matrix determinant operation selected
(Matrix must be square and maximum dimension is 3)
Enter the number of row:3
Enter the number of column:3
Write the matrix elements one by one
(0,0):1
(0,1):15
(0,2):36
(1,0):-16
(1,1):5
(1,2):81
(2,0):-2
(2,1):11
(2,2):15
----------------------
 1  15  36
 -16  5  81
 -2  11  15
----------------------
Determinant= -5622
----------------------
Please Select Operation
----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(b)

Figure 6: Example Outputs

```
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
1
Matrix addition operation selected
(Dimension of two matrix must be same)
Enter the number of row:2
Enter the number of column:2
Write the matrix elements one by one
(0,0):1
(0,1):2
(1,0):3
(1,1):4
-----------------------
 1  2
 3  4
-----------------------
Enter the number of row:2
Enter the number of column:3
Invalid dimensions
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(a)

```
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
2
Matrix multiplication operation selected
(1.Matrix column and 2. matrix row must be same)
Enter the number of row:1
Enter the number of column:2
Write the matrix elements one by one
(0,0):1
(0,1):2
-----------------------
 1  2

Enter the number of row:4
Enter the number of column:2
Invalid dimensions
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(b)

Figure 7: Example Outputs with Error Message

```
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
4
Matrix determinant operation selected
(Matrix must be square and maximum dimension is 3)
Enter the number of row:2
Enter the number of column:3
Matrix is not square matrix

Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(a)

```
Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
4
Matrix determinant operation selected
(Matrix must be square and maximum dimension is 3)
Enter the number of row:4
Enter the number of column:4
Dimension is greater than 3

Please Select Operation
-----------------------
1-Matrix Addition
2-Matrix Multiplication
3-Matrix Transpose
4-Matrix Determinant
```

(b)

Figure 8: Example Outputs with Error Message