



# MATRIX MANIPULATOR

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(CSE 'F' 4<sup>th</sup> SEMESTER)

# Problem Statement

To develop matrix operation calculator using MIPS.

It consists of basic operation like addition, subtraction, scaling and transpose and multiplication.

- Addition or subtraction is accomplished by adding or subtracting corresponding elements.
- Scaling is used to scale up/down the matrix with a constant using scalar multiplication.
- Transpose of matrix is that in which all the rows of a given matrix is transformed into columns and vice-versa.
- Multiplication of matrices is also done using MIPS code by rows of first matrix with the columns of second matrix.
- The determinant of a matrix is a scalar property of that matrix, which can be thought of physically as the volume enclosed by the row vectors of the matrix. Only square matrices have determinants.

# Brief Description

Manipulator system will be required to carry out various operations and provide meaning to these combined structures.

- In Matrix Addition and subtraction, we assume the two matrices given in the data segment. All we have to do is to start with the base address, add the respective elements of the two matrices, increment the address by four and do the same till the length is reached.
- While approaching for the Scaling of matrices there are many prospects to show scaling. We chose the one with scalar multiplication of the matrix with a constant.
- The next operation assigned to us is transpose in which we just have to reverse the rows with the columns and the columns with the rows simultaneously.
- To find determinant we use the formula  $A[0][0] \times ((A[1][1] \times A[2][2]) - (A[2][1] \times A[1][2])) - A[0][1] \times ((A[1][0] \times A[2][2]) - (A[2][0] \times A[1][2])) + A[0][2] \times ((A[1][0] \times A[2][1]) - (A[2][0] \times A[1][1]))$  as we have considered a 3x3 squared matrix.
- The last operation is multiplication of the matrix which is done multiplying the rows of first matrix with the columns of second matrix.
- If the user enters invalid option then error message is displayed.

# Algorithm

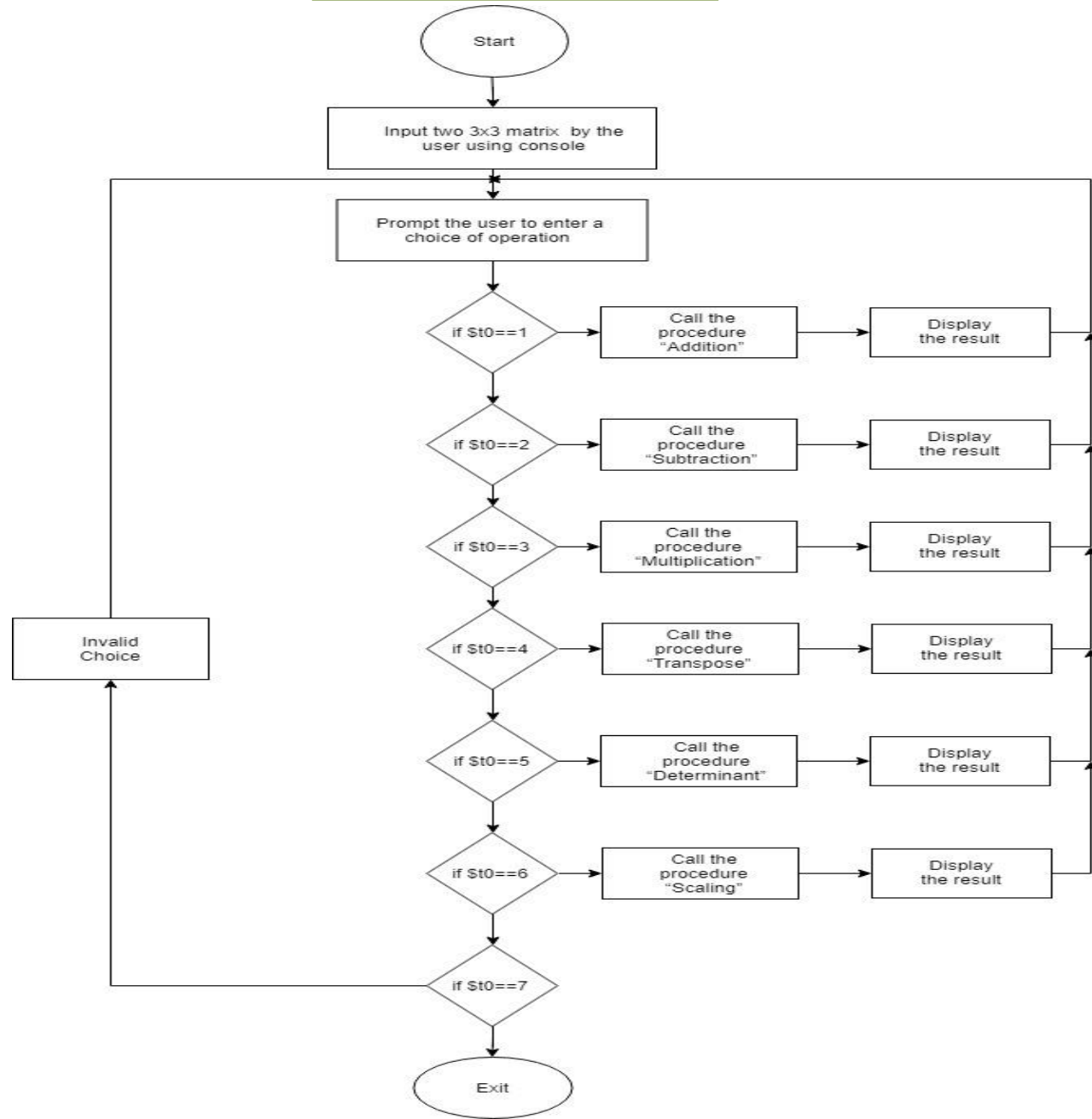
Step 1. Input the two matrixes each of size 3x3 from the user in the console using various syscall services.

Step 2. Prompt the user to enter the choice of the operation and store it in \$t0 register.

Step 3.

- I. If the content of \$t0 register=1 then perform addition of the two matrices (using addition function).
- II. Else If the content of \$t0 register=2 then perform subtraction of the two matrices (using subtraction function).
- III. Else If the content of \$t0 register=3 then perform multiplication of two matrices (using multiplication function).
- IV. Else If the content of \$t0 register=4 then perform transpose of first matrix (using transpose function).
- V. Else If the content of \$t0 register= 5 then find determinant of first matrix (using determinant function).
- VI. Else If the content of \$t0 register= 6 then perform scaling for first matrix by taking a scaling element(using scaling function).
- VII. Else If the content of \$t0 register= 7 then exit.
- VIII. Else For any other choice, display the error message.

# Flow Chart



# C Implementation

```
#include<stdio.h>
void addition(int A[][3],int B[][3],int n);
void subtraction(int A[][3],int B[][3],int n);
void multiplication(int A[][3],int B[][3],int n);
void transpose(int A[][3],int n);
void determinant(int A[][3]);
void scaling(int A[][3],int n);
void print_matrix(int A[][3],int n);
int main()
{
    int n,i,j,choice;
    printf("Enter dimension of array=> ");
    scanf("%d",&n);
    int A[3][3],B[3][3];
    printf("Enter elements in first array\n");
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
```

```
        for(j=0;j<n;j++){
                                scanf("%d",&A[i][j]));
        }
    }
    printf("Enter elements in second
array\n");
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
                                scanf("%d",&B[i][j]));
        }
    }
    printf("\nFirst entered matrix is as
follows:\n");
    print_matrix(A,n);
    printf("\nSecond entered matrix is as
follows:\n");
    print_matrix(B,n);
    printf("\nMENU\n");
    printf("1.ADDITION\n");
    printf("2.SUBTRACTION\n");
    printf("3.MULTIPLICATION\n");
    printf("4.TRANSPOSE\n");
    printf("5.DETERMINANT\n");
    printf("6.SCALING\n");
```

```
printf("7.EXIT\n");
printf("Enter your choice=> ");
scanf("%d",&choice);
while(choice!=7){
    switch(choice){
        case 1:
            addition(A,B,n);
            break;
        case 2:
            subtraction(A,B,n);
            break;
        case 3:
            multiplication(A,B,n);
            break;
        case 4:
            transpose(A,n);
            break;
        case 5:
            determinant(A);
            break;
```



```

        case 6:
            scaling(A,n);
            break;
        default:
            printf("\nINVALID CHOICE!");
    }
    printf("\nEnter your choice=> ");
    scanf("%d",&choice);
}
printf("\nEXITING");
return 0;
}
void addition(int A[][3],int B[][3],int n)
{
    int i,j,sum=0;
    printf("\nResultant matrix:\n");
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
            sum=A[i][j]+B[i][j];
            printf("%d ",sum);
        }
        printf("\n");
    }
}

```

```
void subtraction(int A[][3],int B[][3],int n)
{
    printf("\nResultant matrix:\n");
    int i,j,diff=0;
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
            diff=A[i][j]-B[i][j];
            printf("%d ",diff);
        }
        printf("\n");
    }
}
```

```
void multiplication(int A[][3],int B[][3],int n)
{
    int i,j,k,sum;
    printf("\nResultant matrix:\n");
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
            sum=0;
            for(k=0;k<n;k++){
                sum+=A[i][k]*B[k][j];
            }
            printf("%d ",sum);
        }
    }
}
```

```

    }

        printf("\n");

    }

}

void transpose(int A[][3],int n)
{
    int i,j,t;
    printf("\nResultant matrix:\n");
    for(i=0;i<n;i++){
        for(j=0;j<n;j++){
            t=A[j][i];
            printf("%d ",t);

        }
        printf("\n");
    }

}

void determinant(int A[][3])
{
    int d=A[0][0]*((A[1][1]*A[2][2])-(A[2][1]*A[1][2]))-A[0][1]*((A[1][0]*A[2][2])-(A[2][0]*A[1][2]))+A[0][2]*((A[1][0]*A[2][1])-(A[2][0]*A[1][1]));
    printf("\nDeterminant result= %d",d);

}

void scaling(int A[][3],int n)

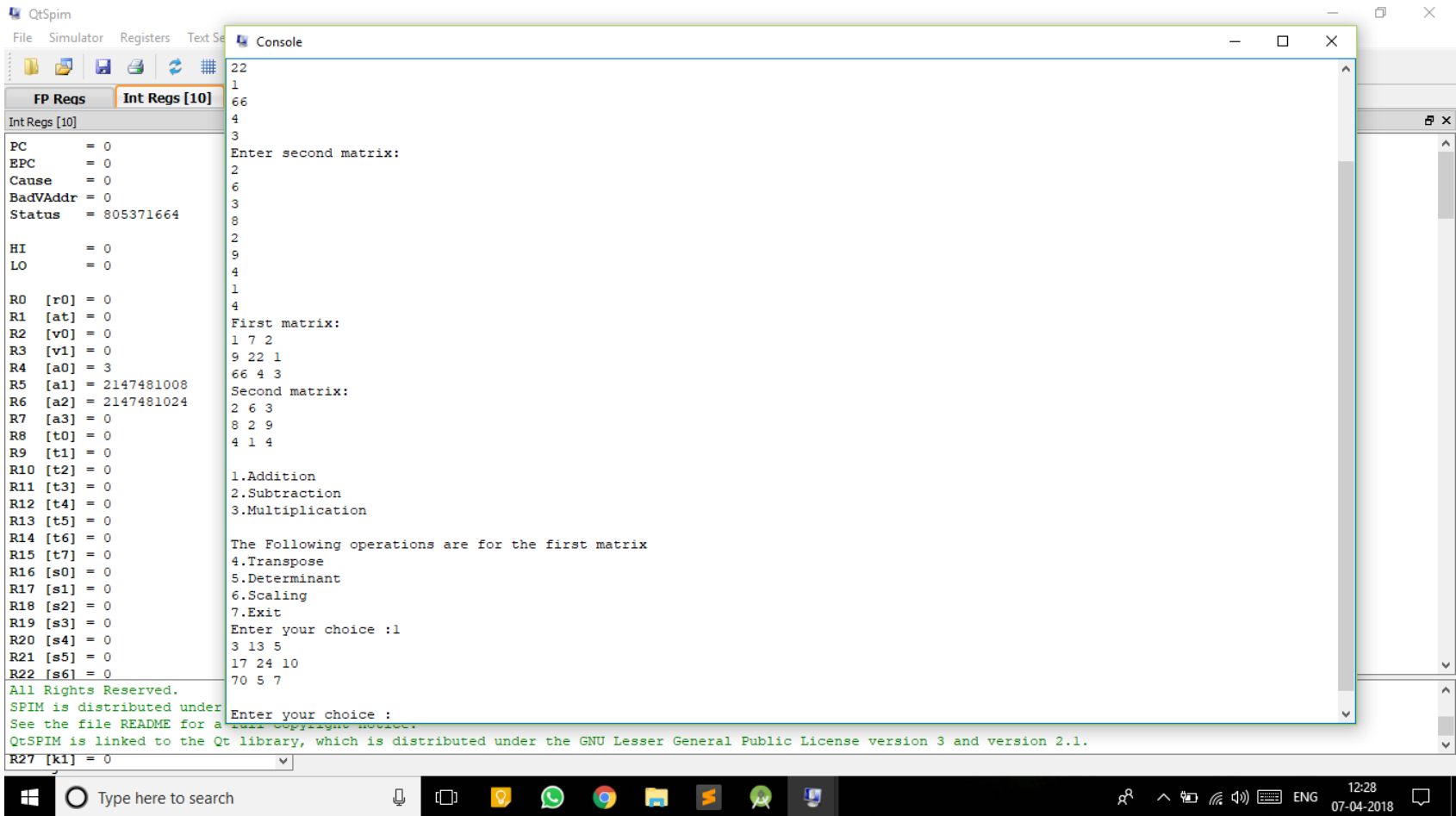
```

```
{  
    int scaling_factor, scale, i, j;  
    printf("Enter a number for performing scaling=> ");  
    scanf("%d", &scaling_factor);  
    printf("\nResultant matrix:\n");  
    for(i=0; i<n; i++){  
        for(j=0; j<n; j++){  
            scale = A[i][j] * scaling_factor;  
            printf("%d ", scale);  
        }  
        printf("\n");  
    }  
}
```

```
}  
void print_matrix(int A[][3], int n)  
{  
    int i, j;  
    for(i=0; i<n; i++){  
        for(j=0; j<n; j++){  
            printf("%d ", A[i][j]);  
        }  
        printf("\n");  
    }  
}
```

# Screenshots

## ADDITION



# SUBTRACTION

The screenshot shows the QtSpim MIPS simulator interface. The 'Registers' window on the left displays the state of various registers, including PC, EPC, Cause, BadVAddr, Status, HI, LO, and R0 through R27. The 'Console' window on the right shows the execution of a program that prompts for two matrices and performs subtraction. The program prompts for the 'second matrix' and then the 'first matrix'. It then displays a menu of operations: 1.Addition, 2.Subtraction, 3.Multiplication, 4.Transpose, 5.Determinant, 6.Scaling, and 7.Exit. The user selects option 2 (Subtraction) for both matrices. The program then displays the result of the subtraction for the first matrix: -1 1 -1, 1 20 -8, 62 3 -1. The console also shows the copyright notice for SPIM and the license information for QtSPIM.

```
QtSpim
File Simulator Registers Text Se...
FP Regs Int Regs [10]
Int Regs [10]
PC = 0
EPC = 0
Cause = 0
BadVAddr = 0
Status = 805371664
HI = 0
LO = 0
R0 [r0] = 0
R1 [at] = 0
R2 [v0] = 0
R3 [v1] = 0
R4 [a0] = 3
R5 [a1] = 2147481008
R6 [a2] = 2147481024
R7 [a3] = 0
R8 [t0] = 0
R9 [t1] = 0
R10 [t2] = 0
R11 [t3] = 0
R12 [t4] = 0
R13 [t5] = 0
R14 [t6] = 0
R15 [t7] = 0
R16 [s0] = 0
R17 [s1] = 0
R18 [s2] = 0
R19 [s3] = 0
R20 [s4] = 0
R21 [s5] = 0
R22 [s6] = 0
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QtSPIM is linked to the Qt library, which is distributed under the GNU Lesser General Public License version 3 and version 2.1.
R27 [k1] = 0

Console
Enter second matrix:
2
6
3
8
2
9
4
1
4
First matrix:
1 7 2
9 22 1
66 4 3
Second matrix:
2 6 3
8 2 9
4 1 4
1.Addition
2.Subtraction
3.Multiplication
The Following operations are for the first matrix
4.Transpose
5.Determinant
6.Scaling
7.Exit
Enter your choice :1
3 13 5
17 24 10
70 5 7
Enter your choice :2
-1 1 -1
1 20 -8
62 3 -1
Enter your choice :
```

# MULTIPLICATION

The screenshot displays the QtSpim MIPS simulator interface. The main window is titled "Console" and shows the execution of a MIPS program. The program prompts the user to enter their choice, and the user has entered "3" for multiplication. The program then displays two 3x3 matrices and prompts the user to enter their choice for the first matrix operation. The user has entered "1" for addition. The program then displays the result of the addition of the two matrices.

**FP Reqs**

**Int Reqs [10]**

PC = 0  
EPC = 0  
Cause = 0  
BadVAddr = 0  
Status = 805371664  
HI = 0  
LO = 0  
R0 [r0] = 0  
R1 [at] = 0  
R2 [v0] = 0  
R3 [v1] = 0  
R4 [a0] = 3  
R5 [a1] = 2147481008  
R6 [a2] = 2147481024  
R7 [a3] = 0  
R8 [t0] = 0  
R9 [t1] = 0  
R10 [t2] = 0  
R11 [t3] = 0  
R12 [t4] = 0  
R13 [t5] = 0  
R14 [t6] = 0  
R15 [t7] = 0  
R16 [s0] = 0  
R17 [s1] = 0  
R18 [s2] = 0  
R19 [s3] = 0  
R20 [s4] = 0  
R21 [s5] = 0  
R22 [s6] = 0  
R27 [k1] = 0

First matrix:  
1 7 2  
9 22 1  
66 4 3  
Second matrix:  
2 6 3  
8 2 9  
4 1 4

1.Addition  
2.Subtraction  
3.Multiplication

The Following operations are for the first matrix  
4.Transpose  
5.Determinant  
6.Scaling  
7.Exit

Enter your choice :1  
3 13 5  
17 24 10  
70 5 7

Enter your choice :2  
-1 1 -1  
1 20 -8  
62 3 -1

Enter your choice :3  
66 22 74  
198 99 229  
176 407 246

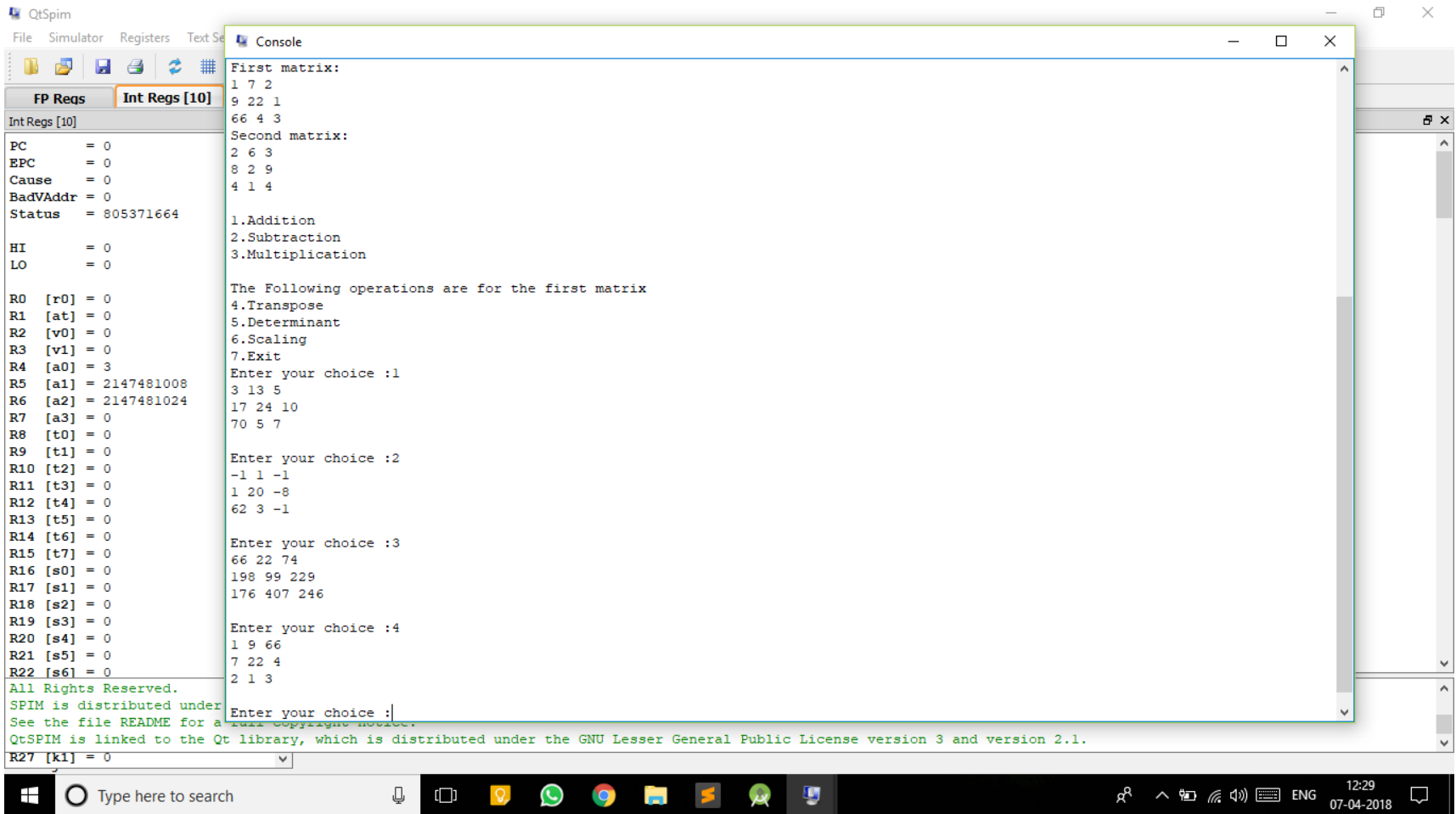
Enter your choice :

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Type here to search

12:29  
07-04-2018

# TRANSPOSE



The screenshot shows the QtSpim application interface. On the left, the 'Registers' panel displays the state of various registers. The 'Int Regs [10]' tab is selected, showing registers R0 through R27. R0-R4 contain zeros, R5-R6 contain specific memory addresses, and R7-R22 contain zeros. R27 contains the value 0. The 'Console' window on the right shows the execution of a program. It displays two 3x3 matrices: the first matrix is [[1, 7, 2], [9, 22, 1], [66, 4, 3]] and the second matrix is [[2, 6, 3], [8, 2, 9], [4, 1, 4]]. The program prompts the user to choose an operation: 1.Addition, 2.Subtraction, 3.Multiplication, 4.Transpose, 5.Determinant, 6.Scaling, 7.Exit. The user has entered '1' for Addition, '2' for Subtraction, and '3' for Multiplication. The results of these operations are displayed: Addition result is [[3, 13, 5], [17, 24, 10], [70, 5, 7]], Subtraction result is [[-1, 1, -1], [1, 20, -8], [62, 3, -1]], and Multiplication result is [[66, 22, 74], [198, 99, 229], [176, 407, 246]]. The program then prompts for choice 4, and the user has entered '4'. The console also displays copyright information for SPIM and QtSPIM.

```
QtSpim
File Simulator Registers Text Se Console
FP Regs Int Regs [10]
Int Regs [10]
PC = 0
EPC = 0
Cause = 0
BadVAddr = 0
Status = 805371664
HI = 0
LO = 0
R0 [r0] = 0
R1 [at] = 0
R2 [v0] = 0
R3 [v1] = 0
R4 [a0] = 3
R5 [a1] = 2147481008
R6 [a2] = 2147481024
R7 [a3] = 0
R8 [t0] = 0
R9 [t1] = 0
R10 [t2] = 0
R11 [t3] = 0
R12 [t4] = 0
R13 [t5] = 0
R14 [t6] = 0
R15 [t7] = 0
R16 [s0] = 0
R17 [s1] = 0
R18 [s2] = 0
R19 [s3] = 0
R20 [s4] = 0
R21 [s5] = 0
R22 [s6] = 0
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QtSPIM is linked to the Qt library, which is distributed under the GNU Lesser General Public License version 3 and version 2.1.
R27 [k1] = 0

First matrix:
1 7 2
9 22 1
66 4 3
Second matrix:
2 6 3
8 2 9
4 1 4
1.Addition
2.Subtraction
3.Multiplication
The Following operations are for the first matrix
4.Transpose
5.Determinant
6.Scaling
7.Exit
Enter your choice :1
3 13 5
17 24 10
70 5 7
Enter your choice :2
-1 1 -1
1 20 -8
62 3 -1
Enter your choice :3
66 22 74
198 99 229
176 407 246
Enter your choice :4
1 9 66
7 22 4
2 1 3
Enter your choice :
```



# DETERMINANT

The screenshot displays the QtSpim MIPS simulator interface. The 'Int Regs [10]' panel on the left shows the state of registers, with R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, and R27 all containing zero. The 'Console' window on the right shows the execution of a program that calculates the determinant of a 3x3 matrix. The program prompts the user to enter a choice (1, 2, 3, 4, or 5) and then displays the result of the operation. The console output shows the following sequence of events:

```
66 4 3
Second matrix:
2 6 3
8 2 9
4 1 4

1.Addition
2.Subtraction
3.Multiplication

The Following operations are for the first matrix
4.Transpose
5.Determinant
6.Scaling
7.Exit
Enter your choice :1
3 13 5
17 24 10
70 5 7

Enter your choice :2
-1 1 -1
1 20 -8
62 3 -1

Enter your choice :3
66 22 74
198 99 229
176 407 246

Enter your choice :4
1 9 66
7 22 4
2 1 3

Enter your choice :5
Result:
-2497
Enter your choice :
```

The bottom status bar of the QtSpim window shows the time as 12:29 on 07-04-2018, and the language is set to ENG.

# SCALING

QtSpim

File Simulator Registers Text Se

FP Regs Int Regs [10]

Int Regs [10]

PC = 0  
EPC = 0  
Cause = 0  
BadVAddr = 0  
Status = 805371664

HI = 0  
LO = 0

R0 [r0] = 0  
R1 [at] = 0  
R2 [v0] = 0  
R3 [v1] = 0  
R4 [a0] = 3  
R5 [a1] = 2147481008  
R6 [a2] = 2147481024  
R7 [a3] = 0  
R8 [t0] = 0  
R9 [t1] = 0  
R10 [t2] = 0  
R11 [t3] = 0  
R12 [t4] = 0  
R13 [t5] = 0  
R14 [t6] = 0  
R15 [t7] = 0  
R16 [s0] = 0  
R17 [s1] = 0  
R18 [s2] = 0  
R19 [s3] = 0  
R20 [s4] = 0  
R21 [s5] = 0  
R22 [s6] = 0

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R27 [k1] = 0

Console

2.Subtraction  
3.Multiplication

The Following operations are for the first matrix

4.Transpose  
5.Determinant  
6.Scaling  
7.Exit

Enter your choice :1  
3 13 5  
17 24 10  
70 5 7

Enter your choice :2  
-1 1 -1  
1 20 -8  
62 3 -1

Enter your choice :3  
66 22 74  
198 99 229  
176 407 246

Enter your choice :4  
1 9 66  
7 22 4  
2 1 3

Enter your choice :5  
Result:  
-2497

Enter your choice :6

Enter a number for scaling:3  
3 21 6  
27 66 3  
198 12 9

Enter your choice :

# Conclusion

From this project, we got an idea on how to perform different arithmetic operations on matrix like addition, subtraction, multiplication, transpose, determinant and scaling using MIPS code.

# References

- Computer Organization and Design
  - By David A Patterson and John L Hennessy.
- New Jersey Institute of Technology eLab
  - <http://ecelabs.njit.edu/ece459/lab1.php>
- University of Pittsburgh e-Library
  - <http://people.cs.pitt.edu/~xujie/cs447/AccessingArray>
- Draw.io
  - Online diagram software for making flowcharts