MATRIX MANIPULATOR

Laboratory Project Report submitted for

Computer Organisation and Architecture

(CSE2011)

Submitted by

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(CSE 'F' 4th SEMESTER)

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1. Declaration

We, the undersigned students of B. Tech. of ComputerScience and Engineering Department hereby declare that we own the full responsibility for the information, results etc. provided in this PROJECT titled "**MATRIX MANIPULATOR**" submitted to **Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar** for the partial fulfillment of the subject **Computer Organization and Architecture (CSE2011)**. We have taken care in all respect to honor the intellectual property right and have acknowledged the contribution of others for using them in academic purpose and further declare that in case of any violation of intellectual property right or copyright we, as the candidate(s), will be fully responsible for the same.

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2. Abstract

In computation involving matrices it is frequently necessary to interchange or rearrange rows or columns of a matrix. If the work is being done longhand or with a desk calculator, it is desirable to be able to perform the rearrangement without having to erase or rewrite numbers. In mathematics, matrix addition or subtraction, multiplication or the matrix product or any other arithmetic operation is a binary operation that produces a matrix from two matrices.

The matrix manipulator was devised for the use in the Bureau's statistical Engineering Laboratory for calculation with incidence matrices, i.e., matrices whose element are all 0's or 1's. So, through this project we will show how the matrix manipulation is taking place using MIPS programming language. MIPS is a reduced instruction set computer set architecture developed by MIPS Technologies. The early MIPS architecture was 32-bit with 64-bit versions added later. Also, the project is compiled to show Matrix addition of two different matrices, subtraction of two different matrices, multiplication, transpose, determinant, scaling of matrix.

3. Contents

1. Introduction

This project has been done keeping in mind all the basic concepts taught in Computer Organization and Architecture. This project deals with the matrix manipulation of two matrices. It is well known that matrices can be used in several key areas of science to provide meaning to data. Often these matrices can be manipulated to provide a solution based on the important properties of the matrices like Matrix addition, subtraction of two different matrices, also scaling up with a constant multiplication and transpose of matrix.

The user is prompted to enter two 3X3 matrixes. The user is also asked to enter the choice of operation to be done with the inputted matrices i.e.

a) Matrix Addition

b) Matrix Subtraction

c) Multiplication

d) Transpose

e) Determinant

f) Scaling

using user defined functions, and the output is displayed. If user enters invalid option, then an error message is displayed.

2. 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. Matrix addition is used to add up the respective elements present in two different matrices and store it into another matrix to show the addition property of the matrix. Similarly, Matrix subtraction is to subtract the respective elements present in two different matrices and store it in another matrix to show the subtraction property of the matrix. Scaling is the transformation, when applied to an object multiplies each of the local coordinates. Here Scaling is used to scale up/down the matrix with a constant using scalar multiplication. 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. 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.

3. Brief Description

As already mentioned in the introduction, matrix manipulator system will be required to carry out various operations and provide meaning to these combined structures. This section will outline the various features, implementations and user interactions provided by the system. During this project the basic matrix operations such as matrix, addition, subtraction, scaling, multiplication and transpose. 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. To find determinant we use the formula A[0][0] x ((A[1][1]xA[2][2])-(A[2][1]xA[1][2]))-A[0][1]x((A[1][0]xA[2][2])-(A[2][0]xA[1][2]))+A[0][2]x((A[1][0]xA[2][1])-(A[2][0]xA[1][1])) as we have considered a 3x3 squared matrix. 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. The last operation is multiplication of the matrix. If the user enters an invalid option then an error message is displayed.

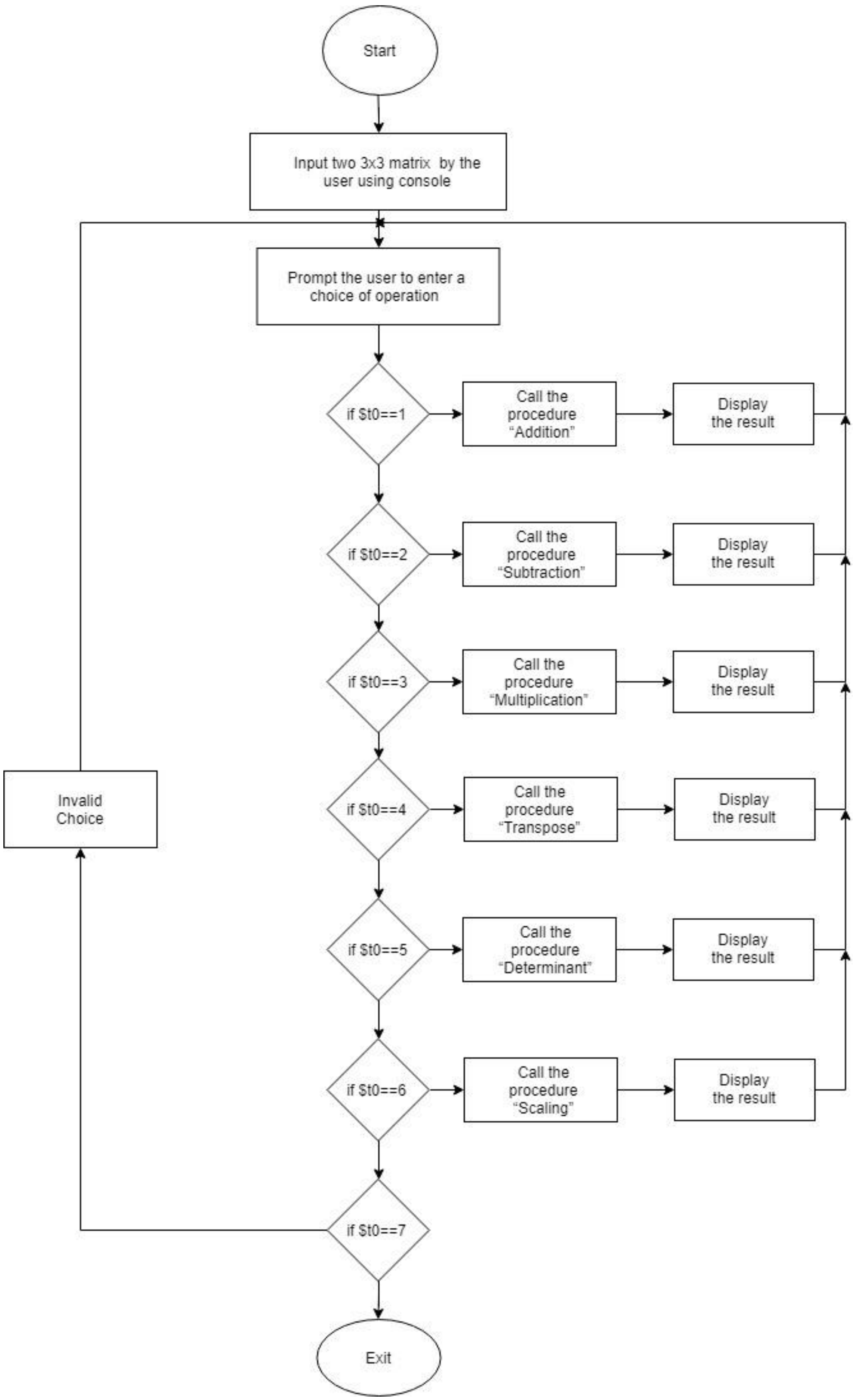
4. Steps of the Algorithms/Flow Diagram

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

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

3)

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


Start
Input two 3x3 matrix by the user using console
Prompt the user to enter a choice of operation
if $t0==1
Call the procedure "Addition"
Display the result
if $t0==2
Call the procedure "Subtraction"
Display the result
if $t0==3
Call the procedure "Multiplication"
Display the result
if $t0==4
Call the procedure "Transpose"
Display the result
if $t0==5
Call the procedure "Determinant"
Display the result
if $t0==6
Call the procedure "Scaling"
Display the result
if $t0==7
Invalid Choice
Exit

5. Source Code using MIPS

```
.data
	dimension: .asciiz "Enter dimension of the matrix: "

	enter_first: .asciiz "Enter first matrix:\n"
	enter_second: .asciiz "Enter second matrix:\n"

	show_first: .asciiz "First matrix:\n"
	show_second: .asciiz "Second matrix:\n"

	menu: .asciiz "\n1.Addition\n2.Subtraction\n3.Multiplication\n\nThe Following
operations are for the first matrix\n4.Transpose\n5.Determinant\n6.Scaling\n7.Exit"

	choice: .asciiz "\nEnter your choice :"

	num_scale:.asciiz "\nEnter a number for scaling:"

	wrongchoice: .asciiz "\nInvalid Choice!"
	exiting: .asciiz "\n\tExiting."
	show_result: .asciiz "Result:\n"

	space: .asciiz " "
	newline: .asciiz "\n"

.text
.globl main
main:

# Prompt and take dimension input
	li $v0, 4
	la $a0, dimension
	syscall

	li $v0, 5
	syscall
	addu $s0, $zero, $v0		# $s0 == N

# Size of the 2d array stored in $a0 for next three steps
	mul $a0, $s0, $s0
	mul $a0, $a0, 4

# Declaring matrix A in $s1
	li $v0, 9
	syscall
	addu $s1, $zero, $v0

# Declaring matrix B in $s2
```

```
        li $v0, 9
        syscall
        addu $s2, $zero, $v0

# Declaring resultant matrix in $s3
        li $v0, 9
        syscall
        addu $s3, $zero, $v0

# $s4 = N^2
        mul $s4, $s0, $s0

# Take input in matrix A
        li $v0, 4
        la $a0, enter_first
        syscall

        xor $t1, $t1, $t1               # loop variable
        move $t2, $s1                   # pointer

loop1:

        slt $t0, $t1, $s4
        beq $t0, $zero, exit1

        li $v0, 5
        syscall
        sw $v0, 0($t2)

        addiu $t1, $t1, 1
        addiu $t2, $t2, 4

        j loop1

exit1:

# Take input in matrix B
        li $v0, 4
        la $a0, enter_second
        syscall

        xor $t1, $t1, $t1               # loop variable
        move $t2, $s2                   # pointer

loop2:

        slt $t0, $t1, $s4
        beq $t0, $zero, exit2

        li $v0, 5
```

```
        syscall
        sw $v0, 0($t2)

        addiu $t1, $t1, 1
        addiu $t2, $t2, 4

        j loop2

exit2:

  # Print matrix A
        li $v0, 4
        la $a0, show_first
        syscall

        move $a1, $s1
        jalprintMatrix

# Print matrix B
        li $v0, 4
        la $a0, show_second
        syscall

        move $a1, $s2
        jalprintMatrix

        li $v0,4
        la $a0, menu
        syscall

INPUT:
  li $v0,4
        la $a0, choice
        syscall

        li $v0,5
        syscall

        move $t0, $v0

        li $t1, 1
        li $t2, 2
        li $t3, 3
        li $t4, 4
        li $t5, 5
        li $t6, 6
        li $t7, 7

  move $a0,$s0
  move $a1,$s1
```

```
    move $a2,$s2
    move $a3,$s3

        blez $t0, Label0
        bgt $t0, $t7, Label0
        beq $t0, $t1, Label1
        beq $t0, $t2, Label2
        beq $t0, $t3, Label3
        beq $t0, $t4, Label4
        beq $t0, $t5, Label5
        beq $t0, $t6, Label6
        beq $t0, $t7, Label7

        Label0:
      li $v0,4
      la $a0,wrongchoice
syscall
      j INPUT
    Label1:
jal addition
      j INPUT
    Label2:
jal subtraction
      j INPUT
    Label3:
jal multiplication
      j INPUT
    Label4:
jal transpose
      j INPUT
    Label5:
jal determinant
      j INPUT
    Label6:
jal scaling
      j INPUT
    Label7:
      li $v0,4
      la $a0,exiting
syscall

      li $v0,10
syscall
.end main

.globl addition
.ent addition
addition:
    move $s0,$a0
    move $s1,$a1
```

```
    move $s2,$a2
xor $t1, $t1, $t1

    L1:
slt $t0, $t1, $s0
beq $t0, $zero, endL1
xor $t2, $t2, $t2

        L2:
slt $t0, $t2, $s0
beq $t0, $zero, endL2

mul $t4, $t1, $s0
addu $t4, $t4, $t2
sll $t4, $t4, 2
addu $t4, $t4, $s1

mul $t5, $t1, $s0
addu $t5, $t5, $t2
sll $t5, $t5, 2
addu $t5, $t5, $s2

lw $t6, 0($t4)
lw $t7, 0($t5)

            add $t8, $t6, $t7

            li $v0,1
            move $a0, $t8
syscall

            li $v0,4
            la $a0,space
syscall

addiu $t2, $t2, 1
            j L2
    endL2:
addiu $t1, $t1, 1

        li $v0,4
        la $a0, newline
syscall

        j L1
endL1:

jr $ra
.end addition
```

```
.globl subtraction
.ent subtraction
subtraction:
   move $s0,$a0
   move $s1,$a1
   move $s2,$a2
xor $t1, $t1, $t1

   L3:
slt $t0, $t1, $s0
beq $t0, $zero, endL3
xor $t2, $t2, $t2

      L4:
slt $t0, $t2, $s0
beq $t0, $zero, endL4

mul $t4, $t1, $s0
addu $t4, $t4, $t2
sll $t4, $t4, 2
addu $t4, $t4, $s1

mul $t5, $t1, $s0
addu $t5, $t5, $t2
sll $t5, $t5, 2
addu $t5, $t5, $s2

lw $t6, 0($t4)
lw $t7, 0($t5)

         sub $t8, $t6, $t7

         li $v0,1
         move $a0,$t8
syscall

         li $v0,4
         la $a0,space
syscall

addiu $t2, $t2, 1
         j L4

   endL4:
      li $v0,4
      la $a0,newline
syscall

addiu $t1, $t1, 1
      j L3
```

```
endL3:
jr $ra
.end subtraction

.globl multiplication
.ent multiplication
multiplication:
    move $s0,$a0
    move $s1,$a1
    move $s2,$a2
    move $s3,$a3

xor $t1, $t1, $t1                                   # loop 1 variable

    L5:
slt $t0, $t1, $s0
beq $t0, $zero, endL5

xor $t2, $t2, $t2                # loop 2 variable

        L6:
slt $t0, $t2, $s0
beq $t0, $zero, endL6

mul $t4, $t1, $s0                          # address of resultant[i][j]
addu $t4, $t4, $t2
sll $t4, $t4, 2
addu $t4, $t4, $s3

xor $t3, $t3, $t3                          # loop 3 variable

            L7:
slt $t0, $t3, $s0
beq $t0, $zero, endL7

mul $t5, $t1, $s0                # address of matA[i][k]
addu $t5, $t5, $t3
sll $t5, $t5, 2
addu $t5, $t5, $s1

mul $t6, $t3, $s0                # address of matB[k][j]
addu $t6, $t6, $t2
sll $t6, $t6, 2
addu $t6, $t6, $s2

lw $t7, 0($t5)                   # loading matA[i][k]
lw $t8, 0($t6)                   # loading matB[k][j]

mul $t9, $t7, $t8                # matA[i][k] * matB[k][j]
```

```
lw $t8, 0($t4)
addu $t9, $t9, $t8                    # resultant += matA[i][k] * matB[k][j]

sw $t9,0($t4)
addiu $t3, $t3, 1

            j L7

                  endL7:
         li $v0,1
         move $a0,$t9
syscall

         li $v0,4
         la $a0,space
syscall

addiu $t2, $t2, 1
         j L6

         endL6:
      li $v0,4
      la $a0,newline
syscall

addiu $t1, $t1, 1
      j L5

endL5:
jr $ra
.end multiplication

.globl transpose
.ent transpose
transpose:
   move $s0,$a0
   move $s1,$a1

xor $t1, $t1, $t1

         L8:
                  slt $t0, $t1, $s0
                  beq $t0, $zero, endL8
                  xor $t2, $t2, $t2

                  L9:
                           slt $t0, $t2, $s0
                           beq $t0, $zero, endL9

                           mul $t4, $t2, $s0
```

```
                        addu $t4, $t4, $t1
                        sll $t4, $t4, 2
                        addu $t4, $t4, $s1

                        lw $t5, 0($t4)

                        li $v0,1
                        move $a0,$t5
                        syscall

                        li $v0,4
                        la $a0,space
                        syscall

                        addiu $t2, $t2, 1
                        j L9
        endL9:
          li $v0,4
          la $a0,newline
syscall

addiu $t1, $t1, 1
          j L8
   endL8:
jr $ra
.end transpose

.globl determinant
.ent determinant
determinant:
   move $s0,$a0
   move $s1,$a1
   li $t0,0
          li $t1,1
          li $t2,2

          mul $t3,$t0,$s0
          addu $t3,$t3,$t0
          sll $t3,$t3,2
          addu $t3,$t3,$s1

          lw $t4,0($t3)          # A[0][0]

          mul $t3,$t1,$s0
          addu $t3,$t3,$t1
          sll $t3,$t3,2
          addu $t3,$t3,$s1

          lw $t5,0($t3)          # A[1][1]
```

```
mul $t3,$t2,$s0
addu $t3,$t3,$t2
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t6,0($t3)          # A[2][2]

mul $t5,$t5,$t6         #A[1][1]*A[2][2]

mul $t3,$t2,$s0
addu $t3,$t3,$t1
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t6,0($t3)          # A[2][1]

mul $t3,$t1,$s0
addu $t3,$t3,$t2
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t7,0($t3)          # A[1][2]

mul $t6,$t6,$t7        #A[2][1]*A[1][2]
sub $t5,$t5,$t6
mul $s7,$t4,$t5

mul $t3,$t0,$s0
addu $t3,$t3,$t1
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t4,0($t3)          # A[0][1]

mul $t3,$t1,$s0
addu $t3,$t3,$t0
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t5,0($t3)          # A[1][0]

mul $t3,$t2,$s0
addu $t3,$t3,$t2
sll $t3,$t3,2
addu $t3,$t3,$s1

lw $t6,0($t3)          # A[2][2]

mul $t5,$t5,$t6         #A[1][0]*A[2][2]
```

```
        mul $t3,$t2,$s0
        addu $t3,$t3,$t0
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t6,0($t3)           # A[2][0]

        mul $t3,$t1,$s0
        addu $t3,$t3,$t2
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t7,0($t3)           # A[1][2]

        mul $t6,$t6,$t7         #A[2][0]*A[1][2]
        sub $t5,$t5,$t6
        mul $s6,$t4,$t5

   sub $s7,$s7,$s6

mul $t3,$t0,$s0
        addu $t3,$t3,$t2
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t4,0($t3)           # A[0][2]

        mul $t3,$t1,$s0
        addu $t3,$t3,$t0
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t5,0($t3)           # A[1][0]

        mul $t3,$t2,$s0
        addu $t3,$t3,$t1
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t6,0($t3)           # A[2][1]

        mul $t5,$t5,$t6         #A[1][0]*A[2][1]

        mul $t3,$t2,$s0
        addu $t3,$t3,$t0
        sll $t3,$t3,2
        addu $t3,$t3,$s1

        lw $t6,0($t3)           # A[2][0]
```

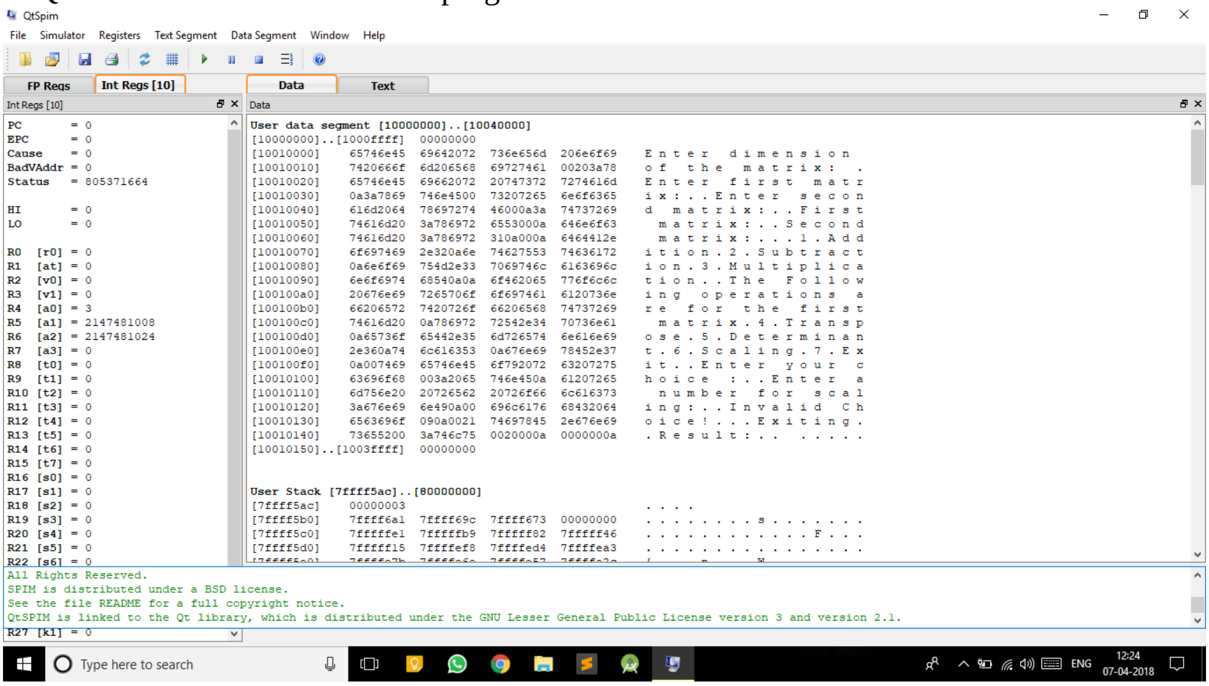
```
            mul $t3,$t1,$s0
            addu $t3,$t3,$t1
            sll $t3,$t3,2
            addu $t3,$t3,$s1

            lw $t7,0($t3)          # A[1][1]

            mul $t6,$t6,$t7        #A[2][0]*A[1][1]
            sub $t5,$t5,$t6
            mul $s6,$t4,$t5

    add $s7,$s7,$s6

    li $v0, 4
            la $a0, show_result
            syscall

    li $v0,1
            move $a0, $s7
            syscall

jr $ra
.end determinant

.globl scaling
.ent scaling
scaling:
    move $s0,$a0
    move $s1,$a1

    li $v0,4
    la $a0,num_scale
syscall

    li $v0,5
syscall

    move $s7,$v0
xor $t1, $t1, $t1

    L11:
slt $t0, $t1, $s0
beq $t0, $zero, endL11
xor $t2, $t2, $t2

        L12:
slt $t0, $t2, $s0
beq $t0, $zero, endL12

mul $t4, $t1, $s0
```

```
addu $t4, $t4, $t2
sll $t4, $t4, 2
addu $t4, $t4, $s1

lw $t5,0($t4)
mul $t5,$t5,$s7

        li $v0,1
        move $a0,$t5
syscall

        li $v0,4
        la $a0,space
syscall

addiu $t2, $t2, 1
        j L12
   endL12:
      li $v0,4
      la $a0,newline
syscall

addiu $t1, $t1, 1
      j L11

endL11:
jr $ra
.end scaling

.globlprintMatrix
.entprintMatrix
printMatrix:
        xor $t1, $t1, $t1                        # loop 1 variable

        print1:
                slt $t0, $t1, $s0
                beq $t0, $zero, end_print1
                addiu $t1, $t1, 1

                xor $t2, $t2, $t2                # loop 2 variable

                print2:
                        slt $t0, $t2, $s0
                        beq $t0, $zero, end_print2
                        addiu $t2, $t2, 1

                        li $v0, 1
                        lw $a0, 0($a1)
                        syscall
```

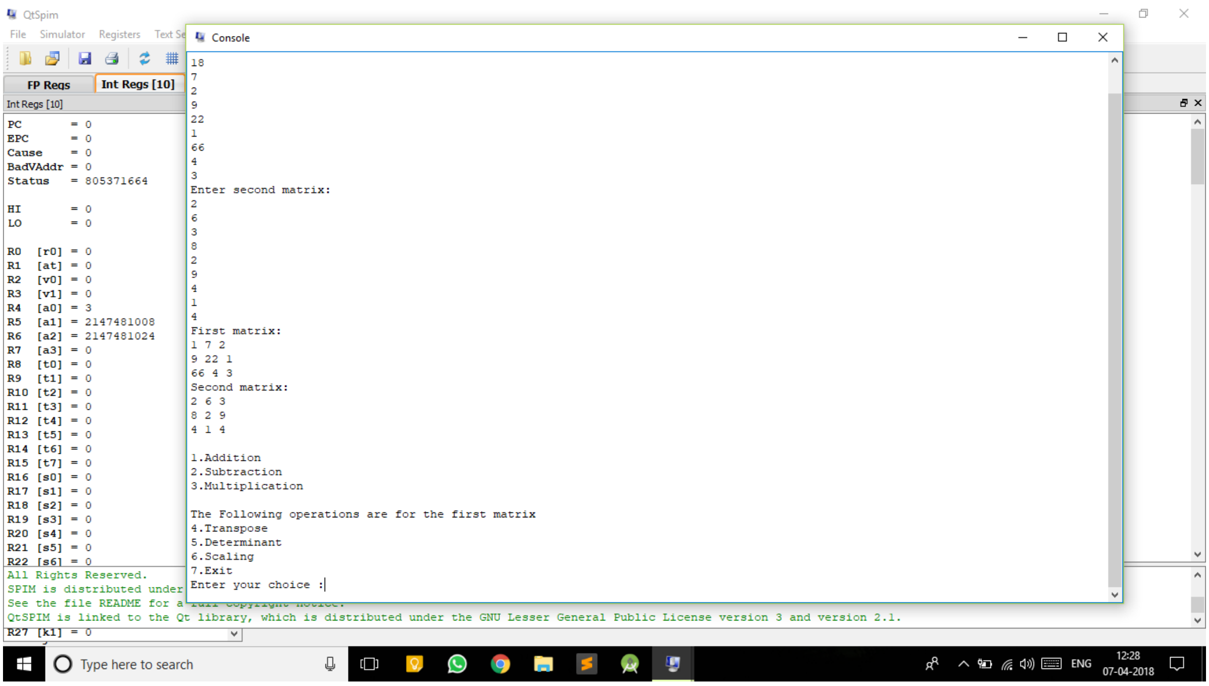
```
                addiu $a1, $a1, 4          # increment pointer

                li $v0, 4
                la $a0, space
                syscall

                j print2

    end_print2:

      li $v0, 4
      la $a0, newline
syscall

      j print1
  end_print1:
jr $ra
.endprintMatrix
```

6. Testing

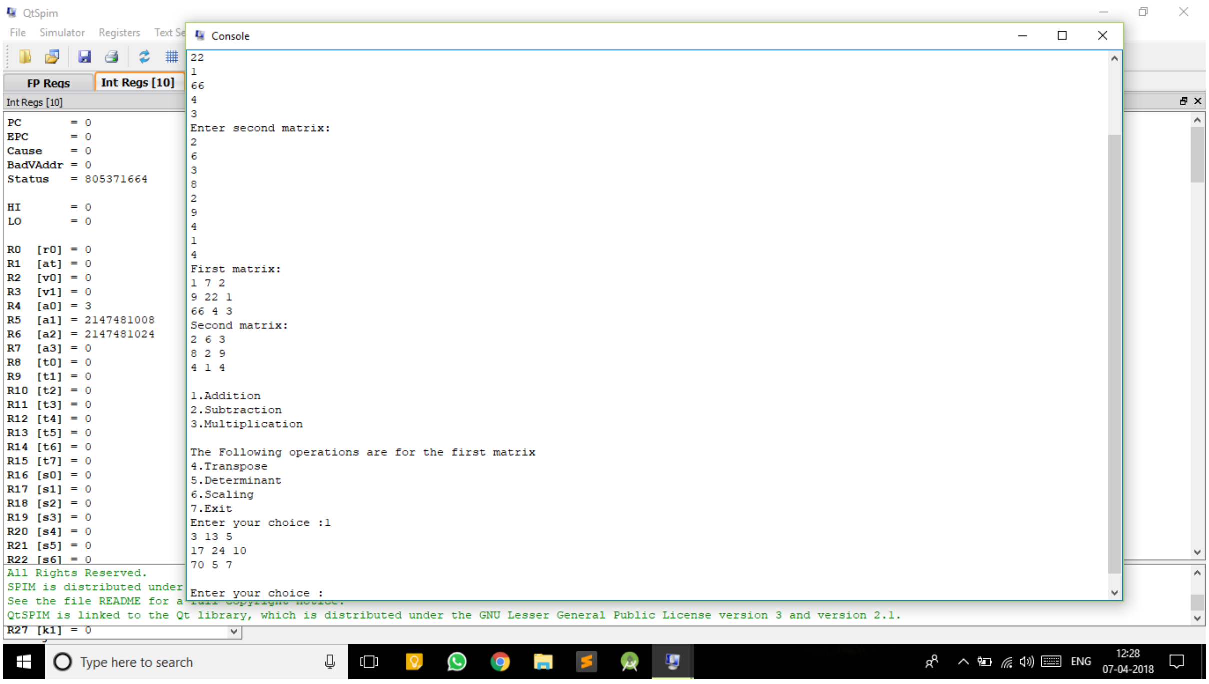
1. QtSPIM is reinitialized and the program is loaded.



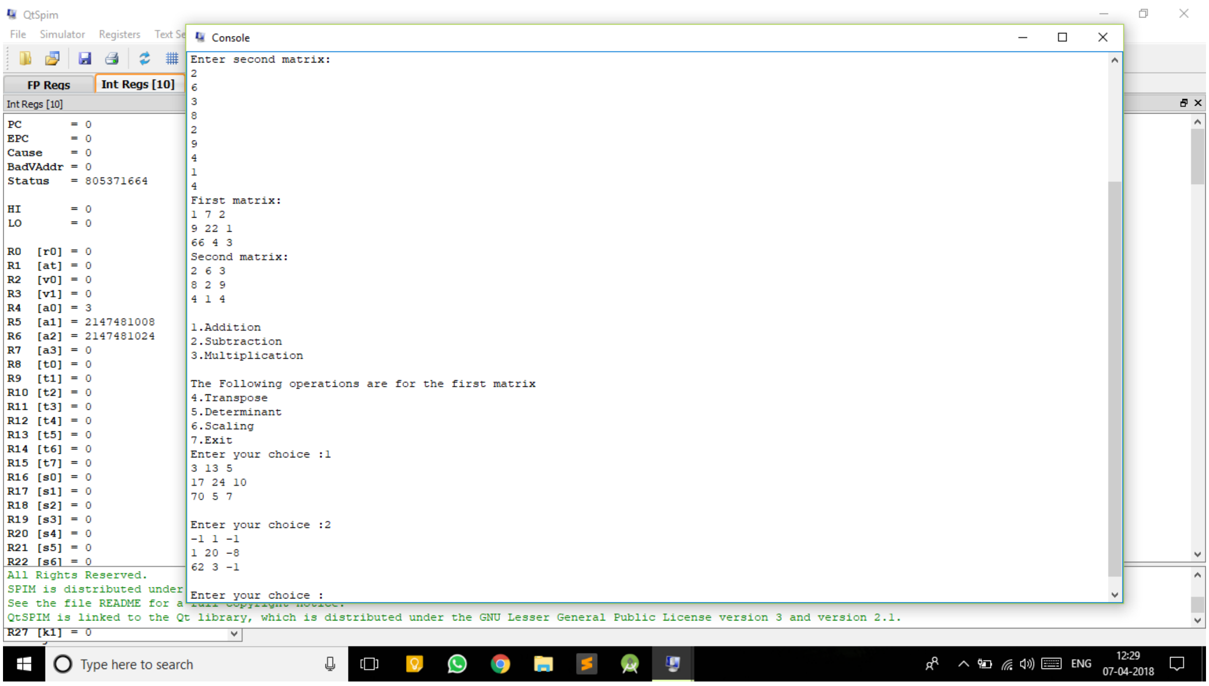
2. Two matrices are taken as input.



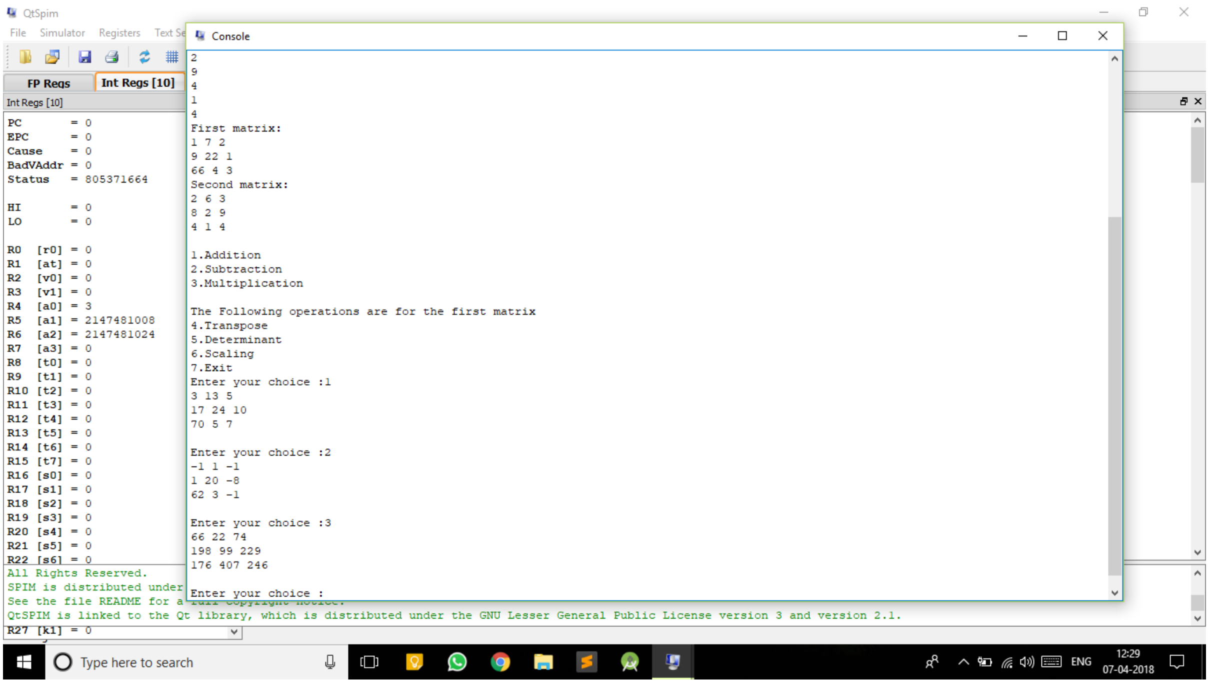
3. Addition is performed.



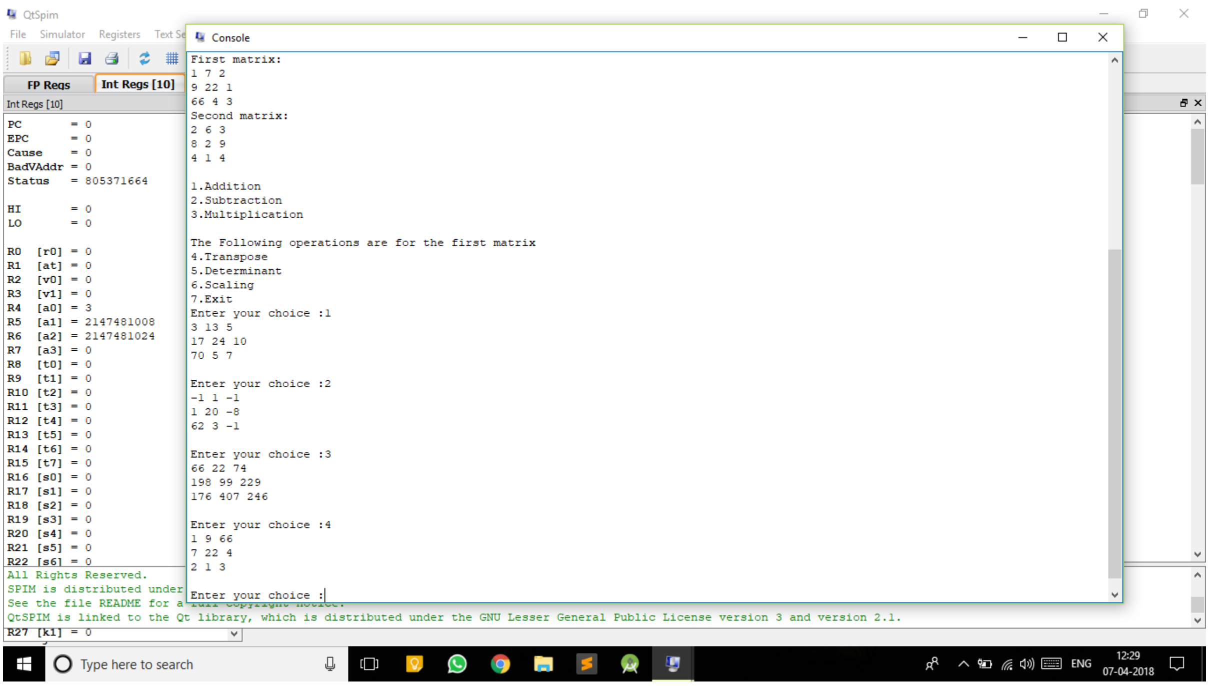
4. Subtraction is performed.



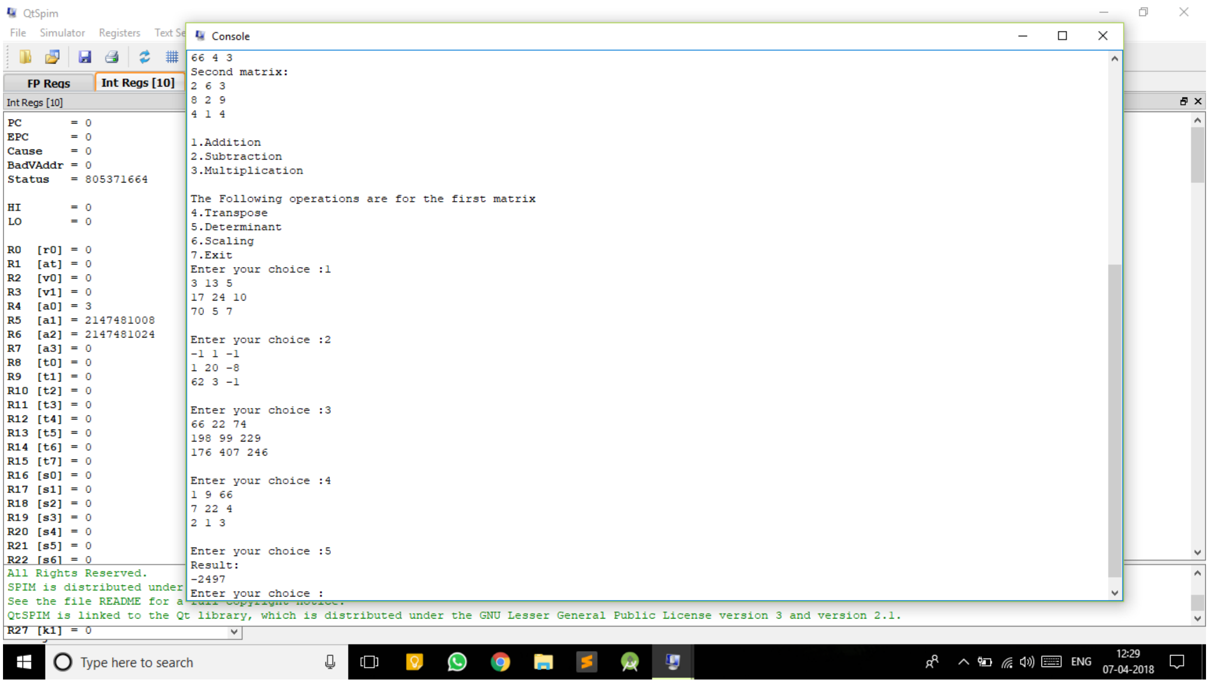
5. Multiplication is performed.



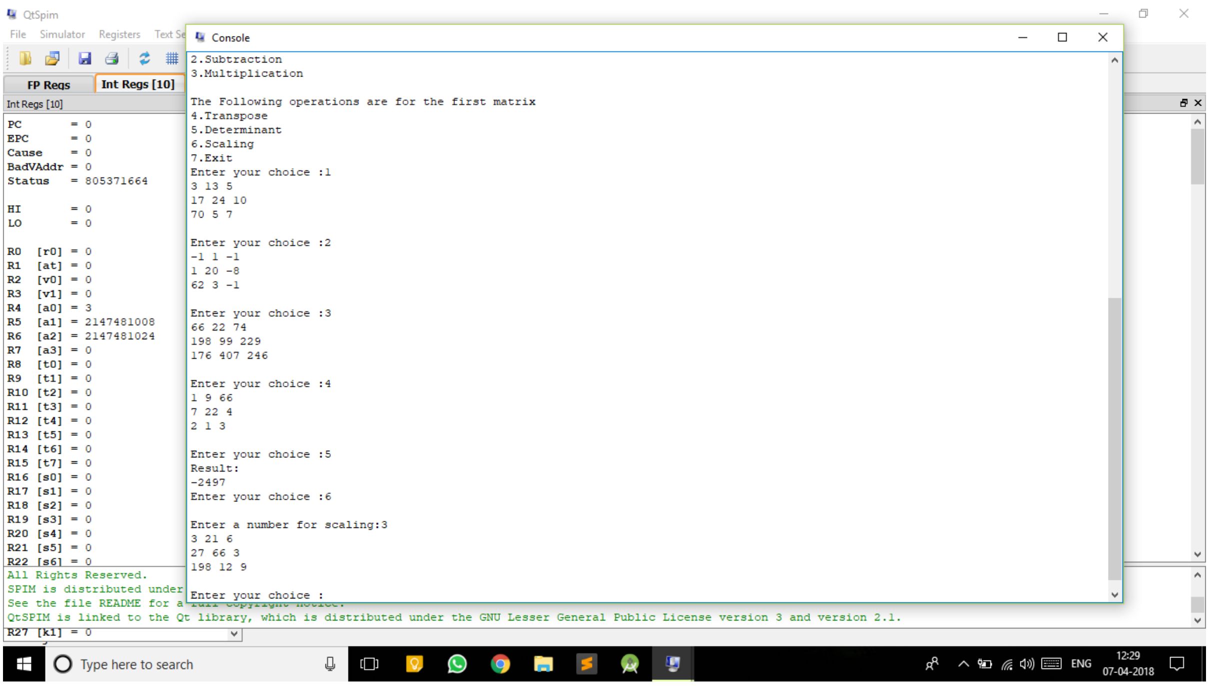
6. The transpose of the first matrix is found out.



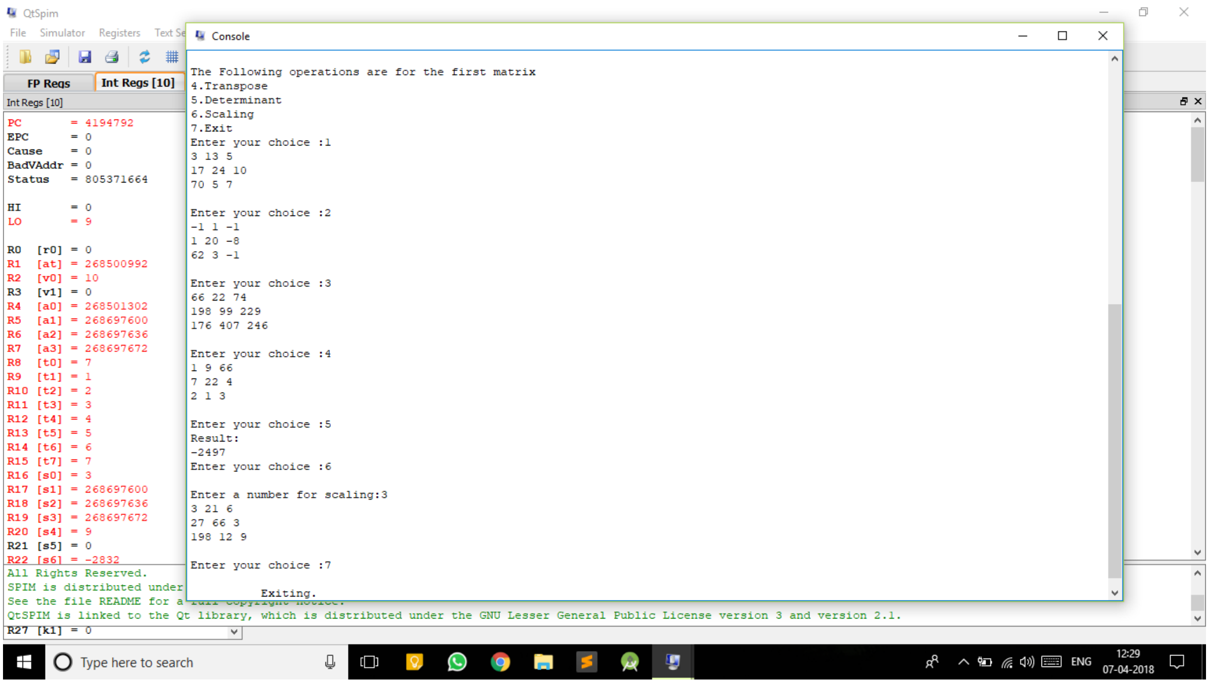
7. The determinant is found of the first matrix.



8. The first matrix is scaled by taking a number to for scaling.



9. The program is terminated.



7. Conclusion

In order to simplify matrix manipulation, we designed a MIPS code for Matrix Manipulator to test and implement different arithmetic operations like Matrix Addition, Matrix Subtraction, matrix scaling and matrix transpose and matrix multiplication. This project comprises of all the arithmetic operations of the matrix assigned to us.

The limitations that came across while designing the project was

1. The matrices must be a square matrix.

2. For scaling and transposing, and determinant two matrixes are needed to be taken as input, but the operations are performed on first matrix.

8. References

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  - Online diagram software for making flowcharts.