

# Computer Programming

Dr. Deepak B Phatak  
Dr. Supratik Chakraborty  
Department of Computer Science and Engineering  
IIT Bombay

Session: More Matrix Applications

# Quick Recap

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- We have seen the use of matrices for
  - Representing a system of  $N$  simultaneous linear equations
  - Using Gaussian elimination to solve the system

# Overview

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- In this session, we will see two more applications of matrices
  - Matrix multiplication
  - Magic Squares

# Matrix Multiplication

$$A[3][4] \quad \times \quad B[4][2] \quad = \quad C[3][2]$$

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# Calculating one element of the resultant matrix



$$A[3][4] \quad \times \quad B[4][2] \quad = \quad C[3][2]$$

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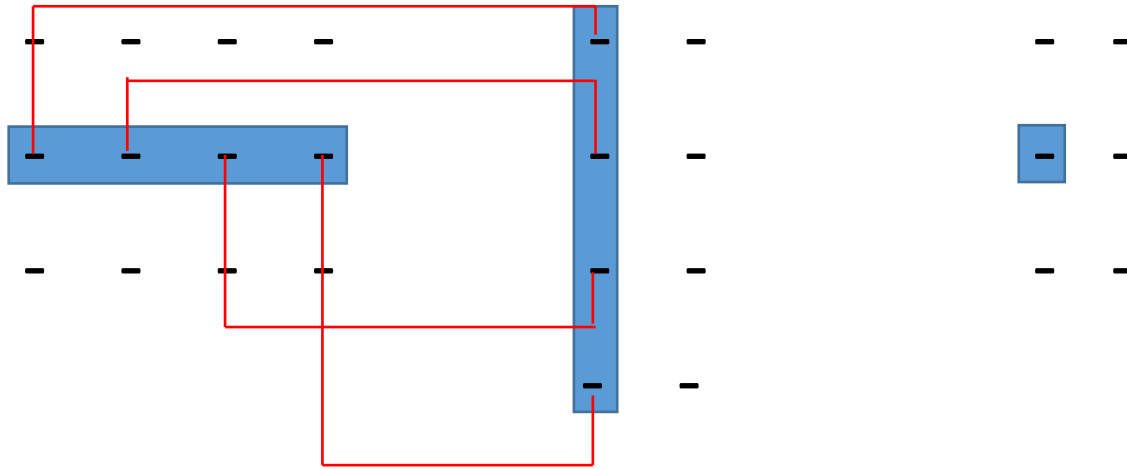
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$C[1][0]$

# Calculating one element of the resultant matrix

$$A[3][4] \times B[4][2] = C[3][2]$$



$$C[1][0] = A[1][0] \times B[0][0] + A[1][1] \times B[1][0] + A[1][2] \times B[2][0] + A[1][3] \times B[3][0]$$

# Matrix Multiplication



Given:  $m \times n$  matrix A;  $n \times p$  matrix B,  
The matrix product  $C = AB$  will be  $m \times p$  matrix.

$$C[i][j] = \sum_{k=0}^{n-1} A[i][k] * B[k][j]$$

# A segment of the program: matmult.cpp



```
// Read matrices A, and B
for (i=0; i<m; i=i+1) {
    for (j=0; j<p; j=j+1) {
        C[i][j]=0;
        for (k=0; k<n; k=k+1) {
            C[i][j]=C[i][j] + A[i][k]*B[k][j];
        }
    }
}
// Output result matrix C
```



# Magic Squares

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A magic square is an  $n \times n$  square matrix containing unique positive integers, where the sum of elements of every row and every column is same

8	1	6
3	5	7
4	9	2

# Magic Squares

- Additionally, sum of elements on each of the main diagonals is also the same as above

8	1	6	↗	
3	5	7	→	15
4	9	2	↖	
			→	15

- Known to Chinese (Lo Shu square)
- 3 x 3 magic squares were known to Indians since Vedic times

# Determine if the given matrix is a normal magic square



- We note the following:
  - Any  $n \times n$  matrix will have  $n$  rows,  $n$  columns and two diagonals
- To test a given matrix for being a magic square
  - First find out what should be the sum  
[sum for normal magic square =  $n * (n*n + 1) / 2$ ]
  - Then, calculate sums of rows and columns
  - Calculate the sums for two diagonals

# Determine if the given matrix is a normal magic square



- If any of these sums is not as desired
  - The given matrix is not magic square
- We will need arrays of size  $n$  for these sums
  - Calculate these sums
  - Now check if each of these sums is equal to the required sum

# Program: magic.cpp

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```
int main(){
    int square[20][20], N, i, j, sum;
    int  rsum[20], csum[20], d1sum =0, d2sum =0;

    /* Read N*/
    cout << " Give value of N " << endl;
    cin >> N;
```

# `magic.cpp` ...

```
cout << "Give elements of the matrix" << endl;
for (i=0; i<N; i++) {
    for (j=0; j< N; j++) {
        cin >> square[i][j];
    }
}
for (i=0; i < N; i++){
    rsum[i] = 0;
    jsum[i] = 0;
}
```

# magic.cpp ...

```
/* calculate the sum for this being N x N magic square */
sum = N * (N*N +1) /2;

/* find the row sums and check against required sum*/
for (i=0; i< N; i++){
    for (j=0; j < N; j++){
        rsum[i] += square[i][j];
    }
    if (rsum[i] != sum) {
        cout << " Not a magic square" << endl; return 1;
    }
}
```

# magic.cpp ...

```
/* find the column sums and check against required sum*/  
for (j=0; j< N; j++){  
    for (i=0; i < N; i++){  
        csum[j] += square[i][j];  
    }  
    if (csum[j] != sum) {  
        cout << " Not a magic square" << endl; return 1;  
    }  
}
```



# `magic.cpp` ...

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```
/* calculate the sums of two diagonals */  
for (i=0; i< N; i ++) d1sum += square[i][i];  
for (j=0; j < N; j ++) d2sum += square[j][N-j-1];
```

# magic.cpp ...

```
/* Now check if these diagonal sums are correct or not */
if (d1sum != sum) {
    cout << " Not a magic square" << endl;  return 1;
}
if (d2sum != sum) {
    cout << " Not a magic square" << endl;  return 1;
}
/* If we reach this point, then the square is a magic square */

cout << "Given matrix is a magic square" << endl;
return 0;
```

# Summary

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- In this session,
  - We studied matrix multiplication, and wrote a C++ program
  - We discussed normal magic squares, and wrote a C++ program to test if a given square matrix represents a magic square or not
- These programs are available in the files
  - `matmult.cpp`
  - `magic.cpp`
- Download, compile, and run these with your sample data