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# Lab 2A: Magic

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# Magic Square

- A  $n \times n$  Matrix whose entries are the integers from 1 to  $n^2$ .
- The sum of every row, every column, diagonal and anti-diagonal is the magic number  $n(n^2+1)/2$ .
- Example:

Durer's magic square

$$\begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$

# Review

- Inner product:  $\begin{bmatrix} a & b & c & d \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = a+b+c+d$

$$M \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} m_1 & m_2 & m_3 & m_4 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = m_1+m_2+m_3+m_4$$

# Review

- In the following parts, we will use this formula

$$\mathbf{x} = \begin{bmatrix} 1 \\ 1 \\ \cdot \\ \cdot \\ \cdot \\ 1 \end{bmatrix}, \quad \mathbf{x}^T \mathbf{A} \mathbf{x} = \mathbf{x}^T (a_1 + \dots + a_n) = \sum_{i=1}^n \sum_{j=1}^n A_{ij}$$

# Hands on

# Hands on: Lab 2A Magic

- Mathworks Grader Lab 2A: Magic

- Goal:

Using MATLAB and some techniques in Linear Algebra to check the special properties of Durer's magic square.

$$\begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$

# Problem 1

- Construct the matrix  $M$  be the Durer's magic square.

$$M = \begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$

## Problem 2

- Use the matrix-vector multiplication to compute the row sums of the matrix  $M$ .



## Problem 3

- Use a transpose and the matrix-vector multiplication to compute the column sums of the matrix  $M$ .

## Problem 4

- Compute the sum of the four 2x2 submatrices made by drawing two lines horizontally and vertically through the center of the matrix  $M$ .

$$M = \begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$

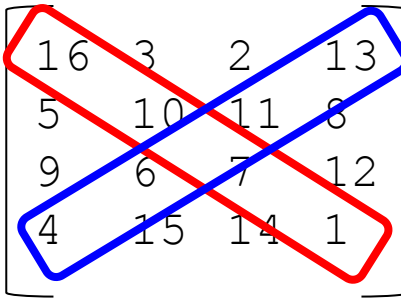
# Problem 5

- The sum of another 2x2 submatrix made by four interior elements of the matrix M.

$$M = \begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$

# Problem 6

- Compute the sum of the **diagonal** elements and the **anti-diagonal** elements of the matrix M.

$$M = \begin{bmatrix} 16 & 3 & 2 & 13 \\ 5 & 10 & 11 & 8 \\ 9 & 6 & 7 & 12 \\ 4 & 15 & 14 & 1 \end{bmatrix}$$


# What We Learned

# Advantage

- MATLAB optimizes on the matrix-matrix multiplication and the matrix-vector multiplication.

Questions  
Or  
Comments?