CS368 MATLAB Programming

Lecture 1

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Based on lecture slides by Michael O'Neill and Beck Hasti

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Socrative

Admin

- Download the Socrative App or go to the Socrative website.
- Use Room CS368, and log in with wisc ID.
- Choose "B" for the first question $Q1$.

Lecture Format

Admin

- In person and/or on Zoom.
- $\sim$ 20 minutes introduction of the problem.
- $\sim$ 30 minutes examples and quizzes.

Grading

Admin

- Quizzes (Q): weekly, 2 points each.
- Programming homework (P): biweekly, 10 points each.
- Credit if $Q + P \geqslant 75$.

Quizzes

Admin

- Obviously incorrect answers will lose points.
- Otherwise not graded for correctness.

Example Quiz Type 1

Quiz

Q 1

- (Guess the output.)
- *1 + 1*
- *A* : Don't choose this.
- *B* : **2**
- *C* : **2.0000**
- *D* : **10**
- *E* : Don't choose this.

Example Quiz Type 2

Quiz

Q 2

- (Guess the code that produces the output.)
- **2**
- $A: 1 * 1$
- $C: 1 + 1$
- $E: 1 \hat{} 1$

B. D.

Programming Homework

Admin

- Please do not start before announcement on Canvas and Piazza.
- Due dates: biweekly on Wednesday.
- No penalty for late submissions within a week, except you have to submit a regrade request form.
- Submit output on course website.
- Submit code on Canvas.

+2, 3 days

Programming Homework Due Dates

Admin

- Example solutions will be posted around the due date.
- If you are unable to solve some of the questions correctly before the due date, you can look at the solutions, fix your code and resubmit without penalty.
- Example solutions should not be used as starter code.

Office Hours

Admin

- Daily from 4 : 35 to 5 : 25, either in-person or on Zoom, see schedule on course website.
- If you don't have specific questions, you are welcome to join and work with other students on programming homework.
- If you have personal issues to discuss, private message me on Piazza or email me to set up an appointment.

What is MATLAB

Math

- MATrix LABoratory.
- Mainly used for numerical matrix computations.

1. Numerical: approximation of continuous functions.
2. Matrix: rectangular 2D array of numbers.

Why MATLAB

Math

- Matrix operations are simple to code.
- Matrix operations are very fast.

How to Open MATLAB

Code

- Download MATLAB or use the online version. There is a mobile app too.
- Command Window executes commands line by line.
- Text Editor creates an m-file script used to store a series of commands or to define functions.
- Current Folder lists the files in the working directory.
- Workspace lists the variables defined in the current session.

MATLAB Variables

Code

- Every variable in MATLAB is a matrix.
- A scalar is a 1×1 matrix.
- A column vector is an $N \times 1$ matrix.
- A row vector is a $1 \times N$ matrix.

Matrix Creation

Code

- `[a; b]` creates the matrix (column vector) $\begin{bmatrix} a \\ b \end{bmatrix}$.
- `[a b]` or `[a, b]` creates the matrix (row vector) $\begin{bmatrix} a & b \end{bmatrix}$.
- `[a b; c d]` creates the matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$.
- a, b, c, d can be (sub)matrices themselves.

Vector Creation Shortcuts

Code

- $a{:}b$ creates the matrix (row vector) $\begin{bmatrix} a & a+1 & a+2 & \dots & b \end{bmatrix}$
- $a{:}d{:}b$ creates the matrix (row vector) $\begin{bmatrix} a & a+d & a+2d & \dots & b \end{bmatrix}$.
- If $b \neq a + dn$ for some n, then the list stops at the largest value of $a + dn$ that is less than b.

1:2:6

1:2:5

[1 3 5]

Matrix Creation Shortcuts

Code

- *zeros(n, m)* creates an $n \times m$ matrix of 0s (n rows and m columns).
- *ones(n, m)* creates an $n \times m$ matrix of 1s (n rows and m columns).
- *repmat(x, n, m)* repeats the scalar or matrix x, $n \times m$ times.
- *eye(n)* creates an $n \times n$ identity matrix, for example,

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$ when $n = 3$.

- *diag([a b c])* creates a diagonal matrix $\begin{bmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & c \end{bmatrix}$.

Matrix Creation, Vector

Quiz

Q3

- *[1:2:4 4:2:1]*
- A: 1 3 4 2
- B: 1 3 / 4 2
- C: 1 3
- D: 1 3 4

[1:2:4 4:-2:1]

[1:2:4 ; 4:-2:1]

[1:2:4 4]

Matrix Creation, Block Matrix

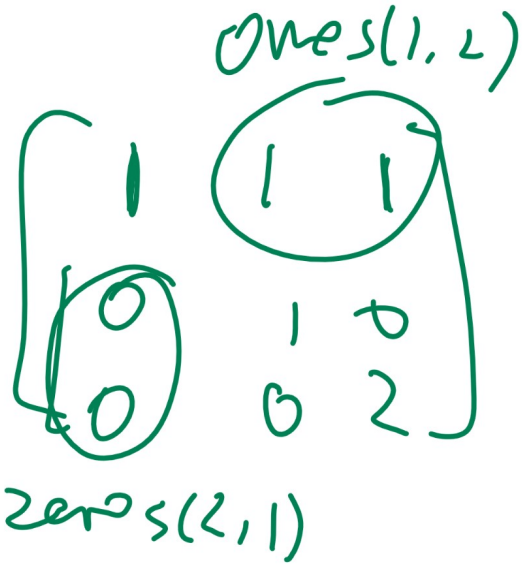
Quiz

Q4

- *[eye(1) ones(1, 2); zeros(2, 1) diag(1:2)]*

$$A: \begin{matrix} 0 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \end{matrix}, \quad B: \begin{matrix} 0 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \end{matrix}$$

$$C: \begin{matrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{matrix}, \quad D: \begin{matrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 2 \end{matrix}$$



[eye(1) ones(2,1)] → Error.

Matrix Creation, Repeat Matrix

Quiz

Q5

- repmat([1 2], 2, 1)

rows, columns

$\begin{bmatrix} 1 & 2 \\ 1 & 2 \end{bmatrix}$

- A: 1 2 1 2,

repmat([1 2], 1, 2)

B: 1 2 1 2

repmat([1;2], 2, 1)

- C: 1 2 1 2,

D: 1 1 2 2

repmat([1;2], 1, 2)

$\begin{bmatrix} 1 \\ 2 \end{bmatrix}$ $\begin{bmatrix} 1 \\ 2 \end{bmatrix}$

Transpose

Code

- Transposing a matrix rearranges the elements of the matrix so that columns become rows and rows become columns.

1. `[a b; c d]'` produces the transpose $\begin{bmatrix} a & b \\ c & d \end{bmatrix}^T = \begin{bmatrix} a & c \\ b & d \end{bmatrix}$.
2. `[a b]'` produces the column vector $\begin{bmatrix} a & b \end{bmatrix}^T = \begin{bmatrix} a \\ b \end{bmatrix}$.
3. `[a; b]'` produces the row vector $\begin{bmatrix} a \\ b \end{bmatrix}^T = \begin{bmatrix} a & b \end{bmatrix}$.

Matrix Scalar Operations

Code

- Suppose M is a matrix and c is a scalar.
- $M + c$ adds c to every element of M, for example, $zeros(n,\ m) + 1$ produces the same matrix as $ones(n,\ m)$.
- $M * c$ multiplies c to every element of M, for example, $ones(n,\ m) * 0$ produces the same matrix as $zeros(n,\ m)$.
- More details in the next lecture.

Vector Access

Code

- Suppose M is a row vector.
- If i is a scalar, $M(i)$ accesses the i-th element of M.
- If i is a row vector, $M(i)$ accesses the (sub)vector of M containing elements with indices in i.

M(1), M(2) ...

M(1:2)

M([1 2])

Matrix Access

Code

- Suppose M is a matrix.
- If i, j are scalars, $M(i, j)$ accesses row i column j of M.
- If i, j are vectors, $M(i, j)$ accesses the (sub)matrix of M containing rows with indices in i and columns with indices in j.

M(3, 2)

M(2:3, [2, 4])

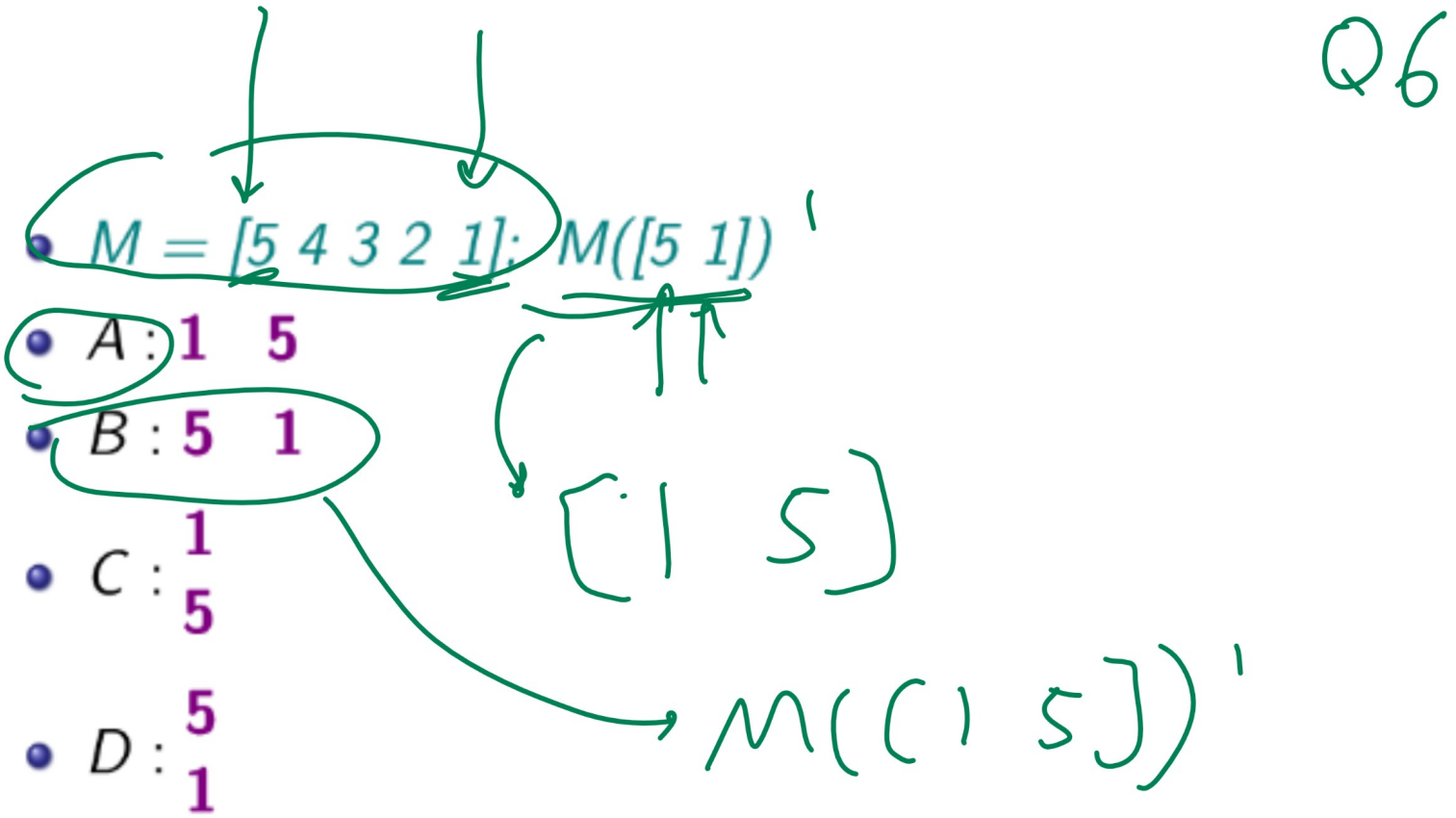
Matrix Access Shortcuts

Code

- Suppose M is a matrix.
- If i is a scalar, *M(i, :)* or *M(i, 1:end)* accesses row i of M.
- If i is a vector, *M(i, :)* or *M(i, 1:end)* accesses the (sub)matrix of M containing rows with indices in i.
- Suppose M is a matrix.
- If j is a scalar, *M(:, j)* or *M(1:end, j)* accesses column j of M.
- If j is a vector, *M(:, j)* or *M(1:end, j)* accesses the (sub)matrix of M containing columns with indices in j.

Matrix Access, Vector

Quiz



Matrix Access, Vector Sequence

Quiz

Q7

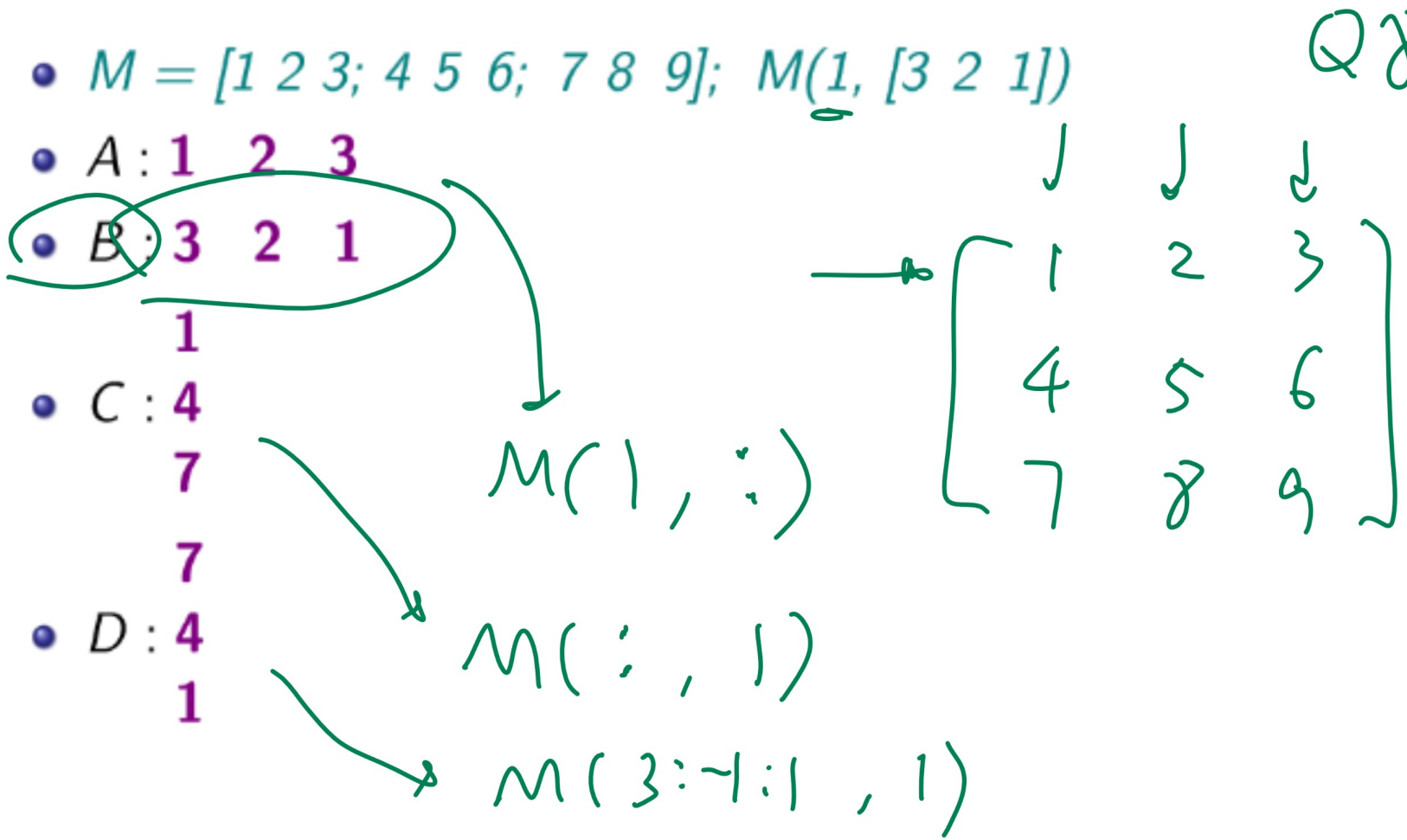
- `M = [1 2 3 4 5]; M([1:2 5:-1:4])`
- A: 1 2
- B: 1 2 5
- C: 1 2 5 4

[1, 2, 5, 4]

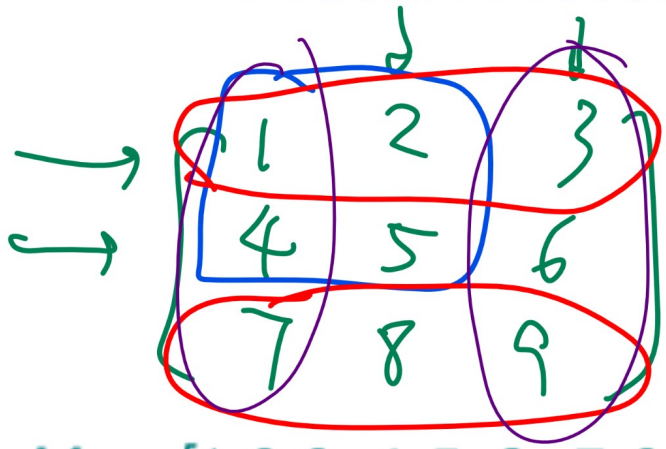
Matrix Access, Matrix

Quiz

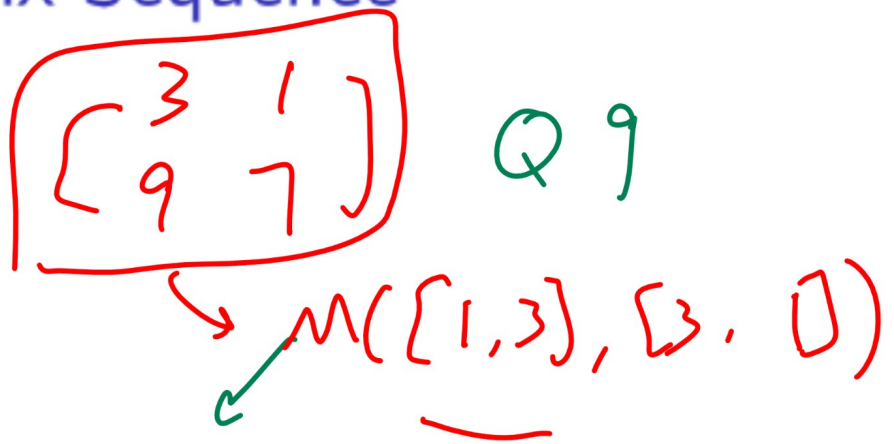
- *M = [1 2 3; 4 5 6; 7 8 9]; M(1, [3 2 1])*
- *A* : 1 2 3
- *B* : 3 2 1
- *C* : 4 7 7
- *D* : 4 1



Matrix Access, Matrix Sequence



Quiz



- $M = [1\ 2\ 3;\ 4\ 5\ 6;\ 7\ 8\ 9];\ M(1{:}2,\ 3{:}-1{:}2)$

- $A: \begin{matrix} 1 & 2 \\ 4 & 5 \end{matrix}$

$B: \begin{matrix} 2 & 3 \\ 5 & 6 \end{matrix}$

- $C: \begin{matrix} 3 & 2 \\ 6 & 5 \end{matrix}$

$D: \begin{matrix} 7 & 8 \\ 4 & 5 \end{matrix}$

[1,2] [3,2]

M(3:-1:2, 1:2)

M(1:2, 1:2) M(1:2, 2:3)

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