Define a Variable

- The 1st character must be a letter.
- The variable name is composed of...
  - Letters (a,b,...,y,z,A,B,...,Z)
  - Numbers (0,1,2,...,9)
  - Underscore (_)
- At most 63 characters (or be automatically truncated)
- Use "=" to assign right-hand side value to the left-hand side variable
Data type of Variable
• Numbers
  • A=18
• Character/String
  • A='a'
  • A='This is a test.'
• Array/Matrix
  • A=[1 2 3 4 5 6 7 8]
  • A=[1 2 3 4; 5 6 7 8]
  • A=[1:4; 5:8]
  • A=[1:2:7; 2:2:8]

Memory Demands
• Minimal unit: bit (位元)
• Binary format (0 or 1 in a bit)
• Common unit: byte (位元組), 1 byte = 8 bits

  • 1 byte = 8 bits \( \rightarrow \) 可儲存\(2^8=256\)個數字
  • 2 bytes = 16 bits \( \rightarrow \) 可儲存\(2^{16}=65536\)個數字
  • 4 bytes = 32 bits \( \rightarrow \) 可儲存\(2^{32}=4.2950e9\)個數字
  • 8 bytes = 64 bits \( \rightarrow \) 可儲存\(2^{64}=1.8447e19\)個數字

Data precision
• double - Convert to 64-bit floating point.
• single - Convert to 32-bit floating point.
• uint8 - Convert to unsigned 8-bit integer.
• uint16 - Convert to unsigned 16-bit integer.
• uint32 - Convert to unsigned 32-bit integer.
• uint64 - Convert to unsigned 64-bit integer.
• int8 - Convert to signed 8-bit integer.
• int16 - Convert to signed 16-bit integer.
• int32 - Convert to signed 32-bit integer.
• int64 - Convert to signed 64-bit integer.
• logical - Convert numeric values to logical (8-bit).
• char - Converts nonnegative integer array into a character array (16-bit).

Useful Function – check memory usage
• whos
  • List current variables in the workspace, long form.

  ![Command Window]

  \[
  \begin{array}{|c|c|c|c|}
  \hline
  \text{Name} & \text{Size} & \text{Bytes} & \text{Class} & \text{Attributes} \\
  \hline
  A & 20000\times 10000 & 1600000000 & \text{double} & \\
  a & 1x1 & 2 & \text{char} & \\
  ans & 1x1 & 8 & \text{uint64} & \\
  \hline
  \end{array}
  \]\n
  • 20000*10000*(64/8)bytes = 1.6e+09 bytes = 1.6 Giga bytes (Gb)
Check the capacity of data type

< Integer >
- intmax
  - Largest positive integer value.
- intmin
  - Smallest integer value.

< double or single >
- realmax
  - Largest finite floating point number.
- realmin
  - Smallest positive normalized floating point number.

If out of range → reset to maximal or minimal values

Numbers vs. Characters

- Character is recognized as numbers by computers
- ASCII code chart (0~127), UNICODE (128~65535)

Try it!
char([54 58 48 48 32 112 109 46])
- abs('s')
- char(115)
  % 如 input数值介于127~65535则按照unicode编码
- abs('我很欣賞你')
- char([25105 24456 27427 36062 20320])

Useful Functions

- str2num
  - Convert string matrix to numeric array.
- num2str
  - Convert numbers to a string.
Index of Elements in Matrix

- An efficient way to deal with massive data~

Who forgets his tie?!

Format of Index

- Create matrix A.

A

1 223 344 6
3 7 4 6 5
4 6 64 6 84
6 5 6 7 37

(1) (6) (11) (16) (21)
(2) (7) (12) (17) (22)(3) (8) (13) (18) (23)
(4) (9) (14) (19) (24)
(5) (10) (15) (20) (25)

Column-wise index
Row-column index

Get Value

- A specific range of index
Get Value: Try it
• A specific range of index

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12</td>
<td>23</td>
<td>46</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<td>6</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

Column-wise index: 7 4 45 23 78
Row-column index: (1,1) (1,2) (1,3) (1,4) (1,5)
                  (2,1) (2,2) (2,3) (2,4) (2,5)
                  (3,1) (3,2) (3,3) (3,4) (3,5)
                  (4,1) (4,2) (4,3) (4,4) (4,5)
                  (5,1) (5,2) (5,3) (5,4) (5,5)

Useful Function - Find
• Find
  • Find indices of matched elements.
    ind = find(A==8)
  • % get column-wise index
    [row, col] = find(A==8)
  • % get row-column index

Try to find the indices of value 6~

Delete Rows or Columns

<table>
<thead>
<tr>
<th></th>
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Relation and Logical Operators
% Relation operators

- Equal: ==
- Not equal: ~=
- Less than: <
- Greater than: >
- Less than or equal: <=
- Greater than or equal: =>

% Logical operators

- And: &
- Or: |
Set Value
• Rewrite values at specific locations

Column-wise index
Row-column index

Set Value
• Rewrite values at specific locations

Column-wise index
Row-column index

Set Value
• Replace value of 6 by 100

ind = find(A==6);
A(ind) = 100;

[rows,cols] = find(A==6);

Set Value
• Rewrite values at specific locations

Column-wise index
Row-column index

Set Value
• Rewrite values at specific locations

Column-wise index
Row-column index
Matrix generator
• Ones
  • Create a Ones array
• Zeros
  • Create a Zeros array
• rand
  • Create an array with uniformly distributed pseudorandom numbers.
• randn
  • Create an array with normally distributed pseudorandom numbers

More Elegant way to Define Matrix
• Define a 5x7x3 matrix with values from 1 to 105.
  • A=zeros(5,7,3);
  • A(:)=1:105

Useful Functions
• size
  • Size of array.
• length
  • Length of vector.
Top Rule: Matrix Dimension

- Common errors in matrix operation

<table>
<thead>
<tr>
<th>Command Window</th>
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<tbody>
<tr>
<td>&gt;&gt; A(100)</td>
</tr>
<tr>
<td>Index exceeds matrix dimensions.</td>
</tr>
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</table>

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<td>&gt;&gt; A+B</td>
</tr>
<tr>
<td>Error using +</td>
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<tr>
<td>Matrix dimensions must agree.</td>
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<td>&gt;&gt; A*B</td>
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<tr>
<td>Error using *</td>
</tr>
<tr>
<td>Inner matrix dimensions must agree.</td>
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- A+B or A–B
  - Matrix A and matrix B must have same matrix dimension.

- A*B
  - Inner matrix dimension must agree.
  - Ex: A is M x N and B is N x P

- A.*B or A./B
  - Matrix A and matrix B must have same matrix dimension.
  - The matrix operation was conducted element-by-element.

- A^k
  - Matrix A must be a square matrix.

- A.^k
  - No specific requirement for matrix dimension.
Top Rule: Matrix Dimension
• A/B
  • A'inv(B)
  • Inner matrix dimensions of A and inverse matrix of B must agree.
• A\B
  • Inv(A)*B
  • Inner matrix dimensions of inverse matrix of A and B must agree.

Matrix Transpose
• A'

Try it~
• Create matrix A and matrix B.
• Set matrix C to be the blue part of A.
• Multiply B by C' element-by-element to get matrix D

Useful Functions
• permute
  • Permute array dimensions.
• reshape
  • Reshape array.
• repmat
  • Replicate and tile an array.
Exercise

• $X = [3 \ 1 \ 8 \ 6 \ 5 \ 4 \ 3 \ 5 \ 4 \ 1 \ 6 \ 8 \ 7 \ 9 \ 6]$

• 計算 sample mean
  \[ \mu_X = \frac{\sum_{k=1}^{N} x_k}{N} \] (where $N=15$)
  \[ \mu_X = 5.067 \]

• 計算 sample variance
  \[ S_X^2 = \frac{\sum_{k=1}^{N} (x_k - \mu_X)^2}{N - 1} \]
  \[ S_X^2 = 5.9238 \]

• 計算每個 $x$ 的 z score
  \[ z_x = \frac{x_k - \mu_X}{S_X} \]
  \[ z_x = [-0.84 \ -1.67 \ 1.20 \ 0.38 \ -0.02 \ -0.43 \ -0.84 \ -0.02 \ -0.43 \ -1.67 \ 0.38 \ 1.20 \ 0.79 \ 1.61 \ 0.38] \]