Introduction to programming in MATLAB

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Lecture 5

Outline

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1. Basic Data Structures
   - Arrays

2. MATLAB Functions
   - Inline Functions
   - Recursive Functions

Arrays

- An array refers to a set of numbers or objects that will follow a specific pattern usually in rows and columns
- Each element of a array has an index
- Elements can be directly accessed using the index of the element

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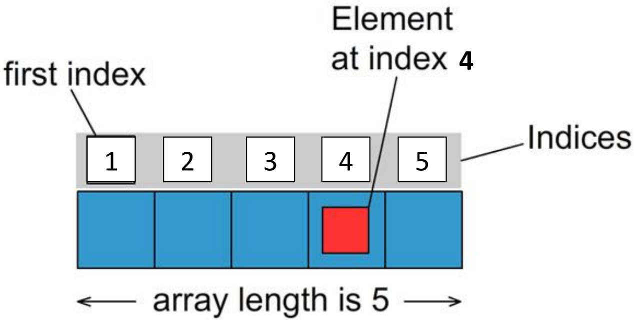

Vectors and Matrices

- An array of dimension $1 \times n$ is called a **row vector**, whereas an array of dimension $m \times 1$ is called a **column vector.**
- A **matrix** is a two-dimensional array consisting of **m rows** and **n columns.**
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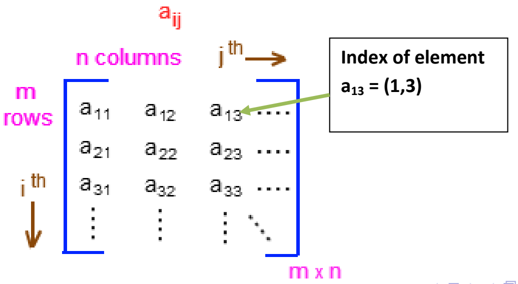

Basic Operations on Arrays

- **Defining an array** : vectors or matrices can be defined as follows
  - » A = [5 7 2 1] or A = [1,2,3,4] % Defining a row vector
  - » B = [3;6;2;9] % Defining a column vector
  - » C = [7 5; 8 9] % Defining 2×2 dimensional matrix
- **Access elements in arrays** :
  - » A(3) % 3 rd element of the vector A
  - » B(2,1) % index (2,1) element of the matrix B
  - » B(1,:) % All elements of the 1st row in matrix B
  - » B(:,2) % All elements of the 2nd column in matrix B
- Rows of a matrix can also be entered as vectors using the notation for creating vectors with **constant spacing**, or the **linspace** command.
  - » D = [1:2:11 ; 0:5:25 ; linspace(10,60,6) ; 67 32 4 58 9 18]

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- **Deleting and inserting Elements** :
  - » B = [2 8 7 9 11 23 56 4 89 6];
  - » B(4) = 21; % insert 21 as 4th element
  - » B(3:6) = []; % remove elements from index 3 to 6
  - » B
- **Subset of an array** : subset of a vector or matrix can be obtained as follows
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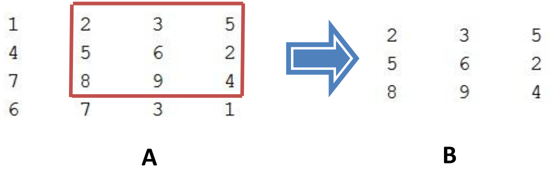

There are some useful elementary matrices in MATLAB

Elementary matrices

`eye(m,n)`	Returns an m-by-n matrix with 1 on the main diagonal
`eye(n)`	Returns an n-by-n square identity matrix
`zeros(m,n)`	Returns an m-by-n matrix of zeros
`ones(m,n)`	Returns an m-by-n matrix of ones
`diag(A)`	Extracts the diagonal of matrix A
`rand(m,n)`	Returns an m-by-n matrix of random numbers

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Summary of Array and Matrix operators

Character	Description
+ or -	Array **and** Matrix addition or subtraction of arrays
.*	Element-by-element multiplication of arrays
./	Element-by-element right division : a/b = a(i,j)/b(i,j)
.\	Element-by-element left division : a\b = b(i,j)/a(i,j)
.^	Element-by-element exponentiation
*	Matrix multiplication
/	Matrix right divide : a/b = a*(b)$^{-1}$
\	Matrix left divide (equation solve) : a\b = (a)$^{-1}$ * b
^	Matrix exponentiation

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Functions

- Using functions to break down a large program to smaller and more manageable units is the heart of modular programming.
- In general, an m-file containing a Matlab function begins with the keyword **function** in the function header we specify the **name of the function** and the **input** and **output** parameters.

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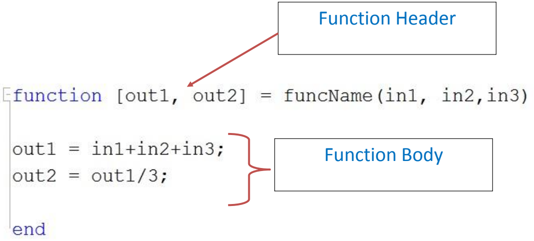

- Functions can have multiple inputs and multiple outputs

Example of input and output arguments

`function C=FtoC(F)`	One input argument and one output argument
`function area=TrapArea(a,b,h)`	Three inputs and one output
`function [h,d]=motion(v,angle)`	Two inputs and two outputs

- function file must be saved by the function name
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Sub Functions and Main Function

- Defining a main function and sub functions is important in divide and conquer approach
- Main function and sub functions can be implemented on separate M-files. But they should be saved in the same directory
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```
function [sm,avg] = addavg(x,y)   % Main Function

sm = addition(x,y);
avg = aver(x,y);
end

function a = aver(x,y)            % Sub Function 01

a = addition(x,y)/2;
end

function s = addition(x,y)        % Sub Function 02

s = x+y;
end
```

Local and Global variables

- The variables defined in a function are recognized only inside the function file.
- It is possible, however , to make a variable to be recognized in different function files. In other words to make the variables are **global**.
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Inline Function

- Using inline function we can create a function without getting into edit window.
- Inline functions are created with the inline command in the following format.

  Name = inline('math expression typed as a string')

Examples

» FA = inline('$exp(x^2)/sqrt(x^2+5)$');

» FA

» FA(2)

» f = inline('$exp(x^2)/sqrt(x^2+y^2)$', 'x', 'y');

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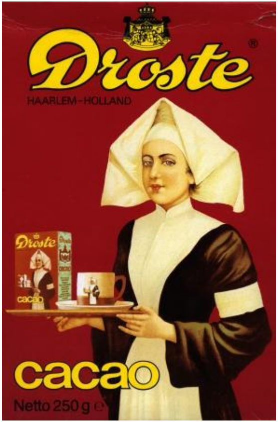
Recursion



Recursion is the process of repeating items in a self-similar way. The most common application of recursion is in mathematics and computer science, in which it refers to a method of defining functions in which the function being defined is applied within its own definition

Recursive Function

- An important class of functions are Recursive functions, function is said to be recursive if it calls itself in its own definition.
- Recursion is useful for computing the result of a function which can be expressed in terms of an integer (n) number of repetitive operations.
- For example, the sum of first n integers can be written as:

$$S(n) = 1 + 2 + 3 + ... + n \tag{1}$$

$$S(n) = S(n-1) + n \tag{2}$$

- The first equation shows a non-recursive way of calculating the sum of first (n) integers. This equation can be implemented using the familiar loops.
- The second equation defines a recursive formula for calculating the sum.

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Example

Develop MATLAB function to calculate the sum of the first n integers using recursive formula

```
function [outsum] = sumrec(n)
if n<1
    error('Error : n must be positive\n');
elseif n==1
    outsum = 1;
else
    outsum = sumrec(n-1) + n; % recursive formula
end
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Generating Fibonacci numbers : 0 1 1 2 3 5 8 13 21 ...
using recursive formula F(n) = F(n -1) + F(n - 2) ; F(0) = 0 and F(1) = 1

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function [outfn] = fiborec(n)
if n<1
    error('Error : n must be positive\n');
elseif n==1
    outfn = 0;
elseif n==2
    outfn = [0 1];
else
    fnm1 = fiborec(n-1);
    outfn = fnm1(n-1) + fnm1(n-2);
    outfn = [fnm1 outfn];
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- Every recursive function must have a **terminating condition.** If the terminating condition is missing, then the recursive function would keep calling itself an infinite number of times.
- Recursive definitions are some times more important in programming than iterative definition since it is easier to write and debug complex problems.
- However if recursive algorithm is not much shorter than the non-recursive one, you should always go for the non-recursive(iterative) one.
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