Unit 6:
Data Structures

Objectives

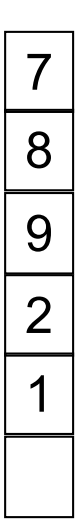
- Understanding different ways in which data can be organized and stored in memory
  - Vectors
  - Strings
  - Matrices
  - Cells
  - Structs

Vectors

- What is a vector?
- How can we create a vector?
- What type of information can we store in a vector?
- How can we modify the data in a vector?
- How can we retrieve data stored in a vector?
- How can we increment the size of a vector?
- How can we concatenate vectors?
- How can we delete an element in a vector?

Vectors

- One dimension matrices
- They are used as containers for storing **data of the same type**: integers, floats, char, ..
- Vector can dynamically change their size
- Vector elements can be accessed via their position within the vector itself
  - Example: vect(4) to obtain the element in the 4th position
- *Some useful functions*
  - *length (vector)* return the number of elements stored in a vector
  - *isempty (vector)* return 1 if the vector is empty and 0 otherwise



Vectors

1. Creation

```
varVector = [];
varVector = [1,2,3,4];
varVector = [0.0454, 3.56];
varVector = zeros(1,4);
…
```

```
varVector = 1;
varVector = 1:4;
varVector = [ ‘a’ , ‘b’ , ‘c’ ];
```

2. Use
   - Retrieve an element: *varVector(position);*
   - Retrieve a portion: *varVector(position_ini : position_fin);*
   - Modify an element: *varVector(position) = value;*
   - Delete an element: *varVector(position) = [];*
   - Concat a new element: *varVector = [varVector value];*
   - Join two vectors: *varVector3 = [varVector1 varVector2];*

Strings

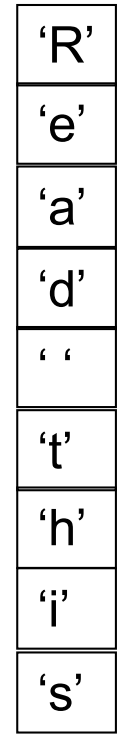
- A string is a **vector of characters**
- Two options for creating a String:

  1.- Create it the same way as we create a vector

  ```
  varSt = ['R','e','a','d',' ','t','h','i','s'];
  ```

  2.- Write the content of the string within quotes

  ```
  varSt = 'Read this';
  ```



- Once you created the String you can use it in the same way as any other vector

Retrieve a character: `varSt(pos)`

Save/Modify a character: `varSt(pos)= value` where value is a char

Delete a character: `varSt(pos)= []`

Concat two strings: `varSt1 = [varSt1  varSt2]`

Join two strings: `varSt3 = [varSt1 varSt2]`

Strings

- To print the content of a string
  - You can print the characters one by one (in the same way as when you print the content of a vector of numbers)
  - You can print all its content at once with *fprintf* and the control character %s
    - *Example:*

>>var = 'Biomedical Engineering'

>>fprintf('\n %s', var);

Biomedical Engineering

Strings

- Matlab provides many functions to work with Strings:

strcmp (s1, s2)	Compares the two strings and returns 1 if they are the same and 0 if they are different
strcmpi (s1, s2)	Works the same way as strcmp but ignoring the case (lowercase/uppercase)
s1 == s2	Return a vector containing 1s and 0s for each position in which the characters of the string are equal or different
s1=[s1, s2]	Concatenate the second string to the first one
strfind(s1, s2)	Returns the starting index of any occurrences of the string s2 in the string s1
isempty(s)	Returns 1 if the string is the string is empty, 0 otherwise
[t, r] = strtok(s1, delim)	Returns the first token in the string s1 delimited by the characters of delim. The remainder of the original string is returned in r.

Check out the pdf in Aula Global with the descriptions of the functions we will use more often during the course

Exercise

- What is the value of *var* after executing the following code lines?

```
s1 = 'University';
var = s1(5);
```

Exercise

- What is the value of *var* after executing the following code lines?

```
s1 = 'University';
var = s1(5);
```

Solution:
The value of var will be 'e'

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Engineering';
var = strfind(s1,'in');
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Engineering';
var = strfind(s1,'in');
```

Solution:
The value of var will be [4 9]

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'cat';
s2 = 'car';
var = strcmp(s1, s2)
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'cat';
s2 = 'car';
var = strcmp(s1, s2)
```

Solution:
The value of var will be 0

Exercise

- What MATALB will print in screen after executing these lines?

```
s1 = 'cat';
s2 = 'car';
(s1 == s2)
```

Exercise

- What MATALB will print in screen after executing these lines?

```
s1 = 'cat';
s2 = 'car';
(s1 == s2)
```

REMEMBER:
If you want to compare two strings use the function **strcmp** instead

Solution:
[1 1 0]

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Bio';
s2 = 'medical';
var = [s1 s2]
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Bio';
s2 = 'medical';
var = [s1 s2]
```

Solution:
The value of var will be 'Biomedical'

Exercise

- What is the value of *var1 and var2* after executing these lines?

```
s1 = 'Computer*Programming';
[var1 var2] = strtok(s1, '*')
```

Exercise

- What is the value of *var1 and var2* after executing these lines?

```
s1 = 'Computer*Programming';
[var1 var2] = strtok(s1, '*')
```

Solution:
The value of var1 will be 'Computer'
The value of var2 will be '*Programming'

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Bio';
var = isempty(s1);
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 'Bio';
var = isempty(s1);
```

Solution:
The value of var will be 0

Exercise

- What is the value of *var* after executing these lines?

```
s1 = '';
var = isempty(s1);
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = '';
var = isempty(s1);
```

Solution:
The value of var will be 1

Exercise

- What is the value of *var* after executing these lines?

```
s1 = '9';
var = s1 + 2;
```

Exercise

- What is the value of *var* after executing these lines?

```
s1 = '9';
var = s1 + 2;
```

You are trying to sum a character and a number. MATLAB will convert the character to its corresponding ASCII code, and then performs the operation.

Solution:
The value of var will be 59

Exercise

- What is the value of *var* after executing these lines?

```
s1 = 9;
var = s1 + 2;
```

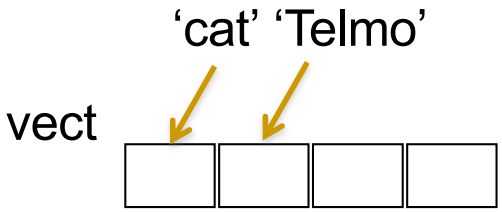
To know the ascii value of a character you can use the function double.
Example: the command *double('9')* returns the value 57

Vectors/Matrices of Strings

- Sometimes you try to store Strings in a vector.. in the same way as you work with vectors. This is tricky. Be aware of this:

If you try to do

vect(1) = ‘cat’;



You are trying to store an String containing 3 characters in one single position of a vector. You will get an error

Vectors/Matrices of Strings

- Sometimes you try to store Strings in a vector.. in the same way as you work with vectors. This is tricky. Be aware of this:

If you have a 3x3 matrix you could do

mat(1,:) = ‘cat’;

mat(2,:)= ‘dog’;

mat

c	a	t
d	o	g

This is fine. You put one character in each cell of the matrix

Vectors/Matrices of Strings

- Sometimes you try to store Strings in a vector.. in the same way as you work with vectors. This is tricky. Be aware of this:

However, if you try to do something like

```
mat(1,:) = 'cat';
mat(2,: )= 'dog';
mat(3,: )='squirrel';
```

mat

c	a	t					
d	o	g					
s	q	u	i	r	r	e	l

This is not a matrix anymore! The third row is longer than the other 2…. You will get an error.

Vectors/Matrices of Strings

- Conclusion:
  - You can save strings together putting each of them in a different row of matrix… but **only** when all the strings have **the same length**.
    - In the next week we will learn to overcome the problem of storing together strings with different lenghts.

Exercise

- Write a program that asks the user to introduce his/her name and surname and it prints the user initials as in the example:

Example:

Introduce your name: Bill

Introduce your surname: Gates

Your initials are B. G.

Exercise

```
name = input('Introduce your name:','s');
surename = input('Introduce your surname:','s');
initials = [name(1) '.' ' ' surname(1) '.'];
fprintf('\nYour initials are %s',initials);
```

Example

- Write a program that asks the user to introduce word/sentences and it prints how many times the user introduces the word ‘cat’. The program ends the execution when the user introduces a blank word (empty).

Example:

Introduce a word: House
Introduce a word: Cat
Introduce a word: Programming
Introduce a word: cat
Introduce a word: Table
Introduce a word:
You introduce the word cat 2 times
Bye!

Example

```
count = 0;
word = input('Introduce a word:','s');
while (isempty(word) == 0)
    if strcmpi(word, 'cat')
            count = count + 1;
    end
    word = input('Introduce a word:','s');
end
fprintf('\n You introduced the word cat %d times', count);
disp('bye!');
```

Example

- Write a program that asks the user to introduce word/sentences and prints those that end in a vowel. The program ends the execution when the user introduces a blank word (empty).

Example:

Introduce a word: House

House

Introduce a word: Programming

Introduce a word: Table

Table

Introduce a word:

Bye!

Example

```
word = input('Introduce a word:','s');
while (isempty(word) == 0)
        maxpos = length(word);
        finalchar = word(maxpos);
        switch finalchar
          case {'a','e','i','o','u', 'A','E','I','O','U'}
                        fprintf('%s\n', word);
        end
        word = input('\nIntroduce a word:','s');
end
disp('bye!');
```

Example

- Write a program that asks the user to introduce a character. Then it asks to introduce word/sentences and prints those that contains the character. The program ends the execution when the user introduces a blank word.

Example:

Introduce a character: a
Introduce a word: House
Introduce a word: Programming
Programming
Introduce a word: Table
Table
Introduce a word:
Bye!

Example

```
vchar = input('Introduce a character: ','s');
word = input('Introduce a word: ','s');
while (isempty(word) ==0)
        vpos = strfind (word, vchar);
        if  isempty(vpos) == 0
            fprintf('%s\n', word);
        end
        word = input('Introduce a word: ','s');
end
disp('Bye!');
```

Example

- Write a program that asks the user to introduce a word. Then it asks to introduce sentences and prints those that contains the word. The program ends the execution when the user introduces a blank word.

Example:

Introduce a word: cat

Introduce a sentence: Programming MATLAB

Introduce a sentence: The cat is black

The cat is black

Introduce a sentence: The cat is on the table

The cat is on the table

Introduce a sentence:

Bye!

Example

EXACTLY THE SAME PROGRAM
AS THE PREVIOUS EXERCISE

```
word = input('Introduce a word: ','s');
sentence = input('Introduce a sentence: ','s');
while (isempty(sentence) ==0)
        vpos = findstr(sentence, word);
        if isempty(vpos) == 0
            fprintf('%s\n', sentence);
        end
        sentence = input('Introduce a sentence: ','s');
end
disp('Bye!');
```