FUNDAMENTALS OF MATLAB

Or:

How Matlab made my life better.

Programming

- Different languages …
  … one basic skill.

- Key: Being as simple-minded as…
  … your computer.

Part I

- What is a computer?
- What is an algorhythm?
- What is a vector?
- Matrices and basic operations

Computers are

- Tame and stubborn.

- No matter how hard you try, you won’t BREAK it with your code.

Computers are

- Hardware + Software
- Hardware:
  - What you'll ruin with a brick, a hammer, a screwdriver (of both solid and liquid kind), or even a third-floor window …

Computers are

- Hardware + Software
- Hardware:
  - Memory:
    - dead (ROM, hard drive) or alive (RAM)
    - in a stick (flash) or in a disk (CD, DVD)
  - Monitor and graphics card (VRAM)
  - Speakers (and sound card, integrated)
  - Various peripherals:
    - Mouse, keyboard, eye tracker, EEG stuff.
  - ONE (or a few)
    ALL-MIGHTY microprocessor CPU
    - Central Processing Unit

(D)RAM and CACHE

- Dynamic Random Access Memory
  - Yummy.
  - Link.
- Get a TON!
- This will make you (and Matlab) happier.

So... software

- a.k.a. programs
  - Catalog of “behavioral” instructions.
- Programs are written in “programming languages”.
- CANNOT HARM your computer.
- So, feel free to crash your computer as much as you’d like!

Aha! Programming

- Tell the machine what to do.

- You'll need:
  - A language to communicate with the CPU's binary world (bits & bytes) and
  - Lots of patience.

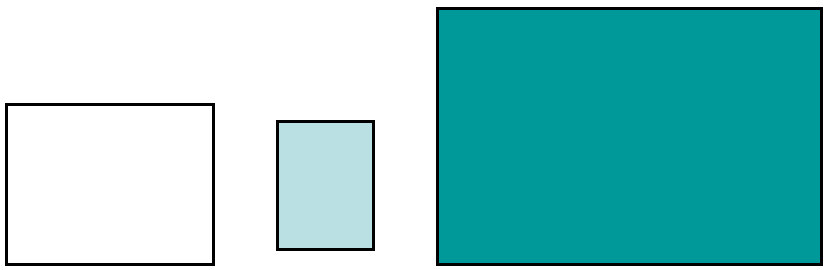
MATLAB

- MATrix LABoratory:
  - High-level language
    - slow to interpret by machine
    - easy to understand by humans
  - I will teach you “syntax”
    - Algorithm based
  - Our vocabulary will be MATRICES (and functions).

    MATLAB is optimized for **matrix-based** calculations

ALGORITHMS

- Describe in a piece of paper, the instructions required to achieve the following goal:
  - I want to stack these three boxes on top of each other.

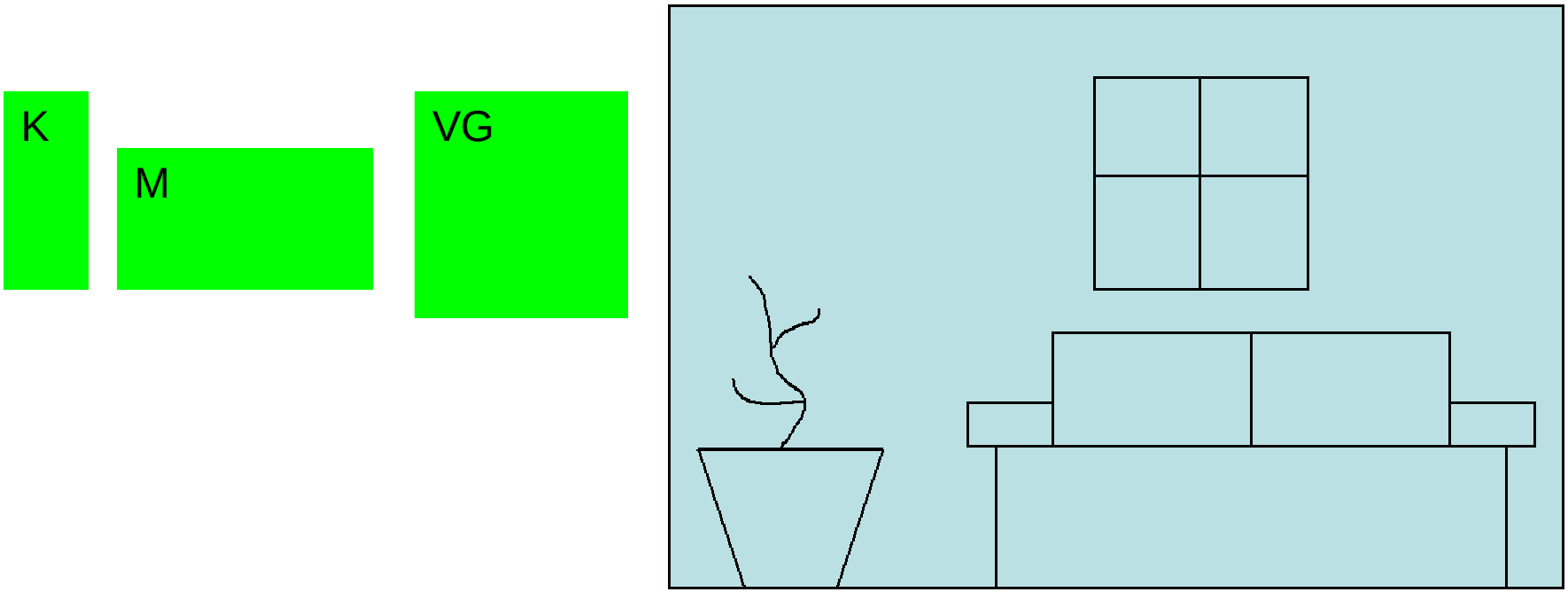


How would these instructions change if we wanted a stable structure?

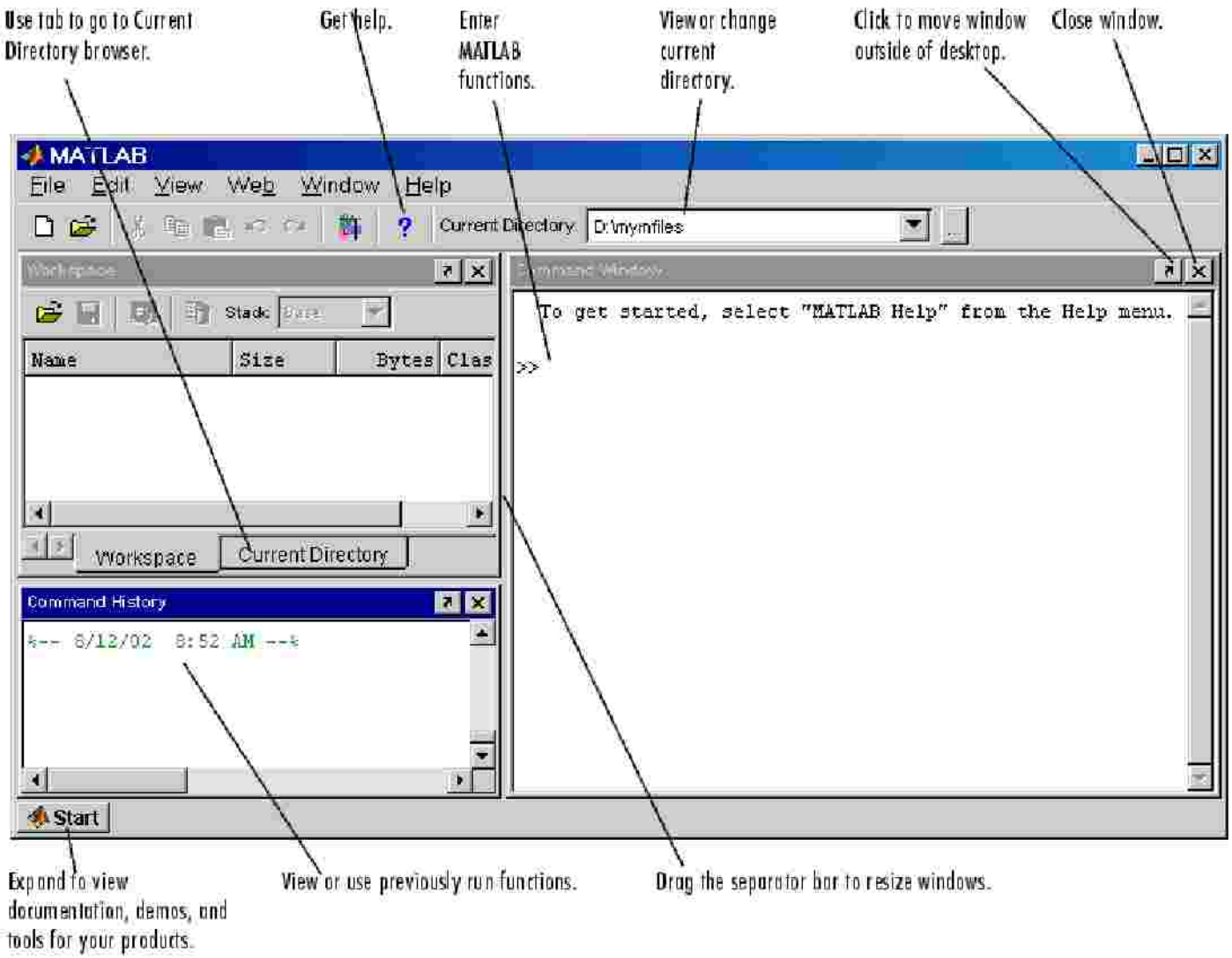
How would these instructions change if we had an indeterminate amount of boxes of different sizes?

ALGORITHMS

- Describe in a piece of paper, the instructions required to achieve the following goal:
  - I want to hang my Klimt, Monet, and VanGogh paintings on my wall.



START MATLAB!



A few important things

- **Create a directory where you will save your Matlab work**

- **SET PATH!**
  - **Window or in command line:**
  - **Setting the path in your code:**

```
>p=path;
>path(p,'c:\MatlabCourse');
```

A few important commands

- **pwd: Where are you?**
- **cd: Change Directory**
- **dir: lists contents of folder**
- **mkdir: makes a new directory**

- **who: lists of variables in workspace**
- **whos: who + size of variables**
- **clear X: erases X**
- **clear all: erases all.**

The most important commands

- **help *topic***
- **lookfor *string***
- **edit *nameoffile***

Intro to Matrices

- **Vector**:
  - Orderly array of stuff
  - Stuff = numbers, letters, words, bits

[1 2 3 4 5 6] is a 6 element vector of digits

[‘cat’ ‘dog’] is a 2 element vector of words (strings)

[c a t d o g] is a 6 element vector of characters

[0 1 0 1 1 1] is a 6 element vector of bits (binary digit)

MATRIX = “VECTOR” Of Vectors

Matrices

- Simple matrices will look like this: (horizontally stacked vectors)

```
[1 1 1 1
 2 2 2 2
 3 4 5 6]
```

What is the (2,3) element in the matrix?

This is a 3 rows by 4 column matrix referred to as a 3-by-4 matrix.

First mentioned dimension is **ALWAYS the number of rows**
Second dimension = number of columns

Matrices

- Matrices can have as many **dimensions** as you'd like.
  - Vectors have 1 dimension
    - Third element in vector V: V(3)
  - Most algebraic Matrices have 2 (one for the rows, and for the columns)
    - Third row, fourth column of M: M(3,4).
  - Matrices can be (m-by-n-by-o-by-p)
    - Elements are then referenced (i,j,k,l), One index for each dimension.

What can I put in a matrix?

- A note on memory allocation and types of values: link
  - numbers (int, double)
  - or letters (char)
  - or strings of letters (strings)
  - A matrix with a combination of different kinds of values is called a STRUCTURE (later in the semester).

- A **variable** is a piece of memory that holds whichever value you specify. In Matlab, a variable will hold the values of an entire matrix or structure. Size.

- A **pointer** is the address in memory of a piece of memory holding whichever value you specified.

Quick word on variables

A variable NAME has at least one letter + any number of letters, digits and underscores.

```
myage = [29]

myname  = ‘alejo’
```

What happens when I do?

```
myname = alejo
```

A WARNING on variables

Matlab is smart

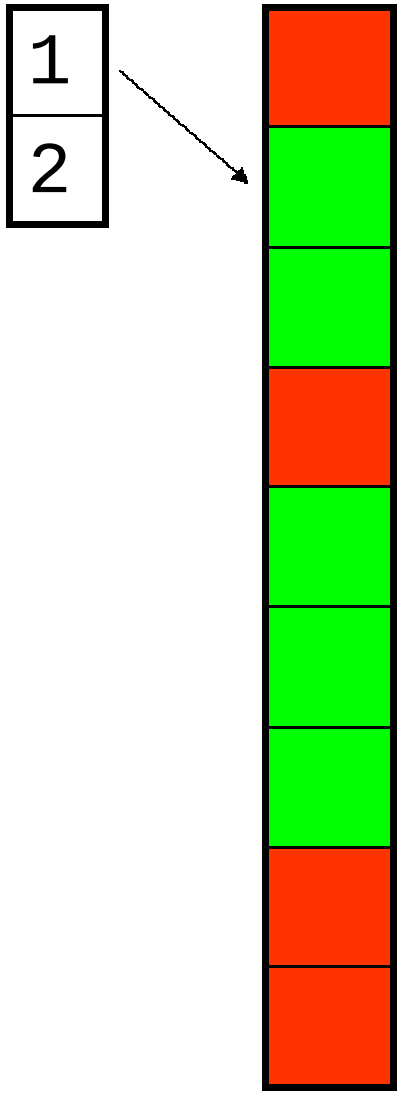
--> no preallocation necessary

Dangerous!

Besides, it is slow:

The #1 slow-down factor of Matlab code is dynamic preallocation.

How does Matlab put information in memory?



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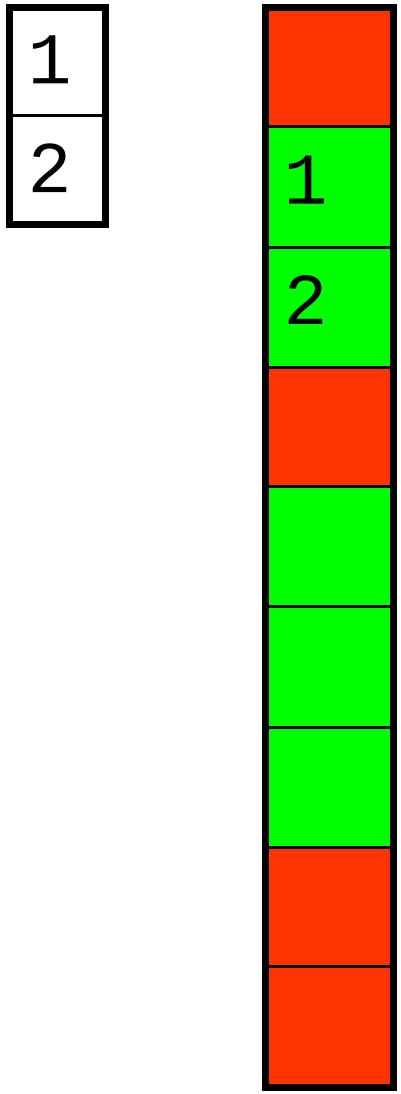

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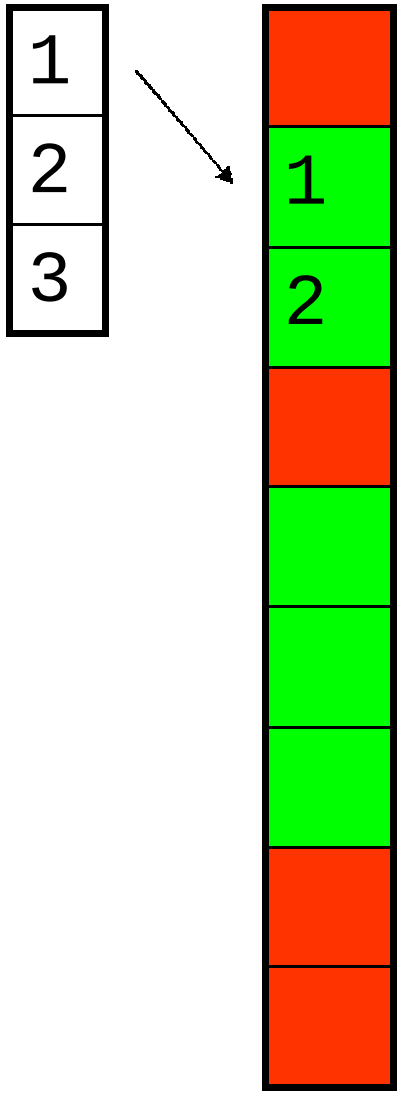

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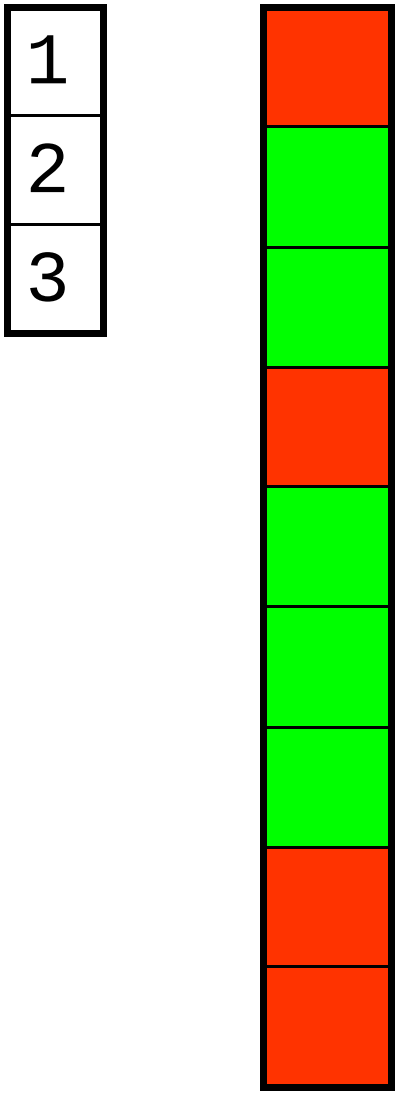

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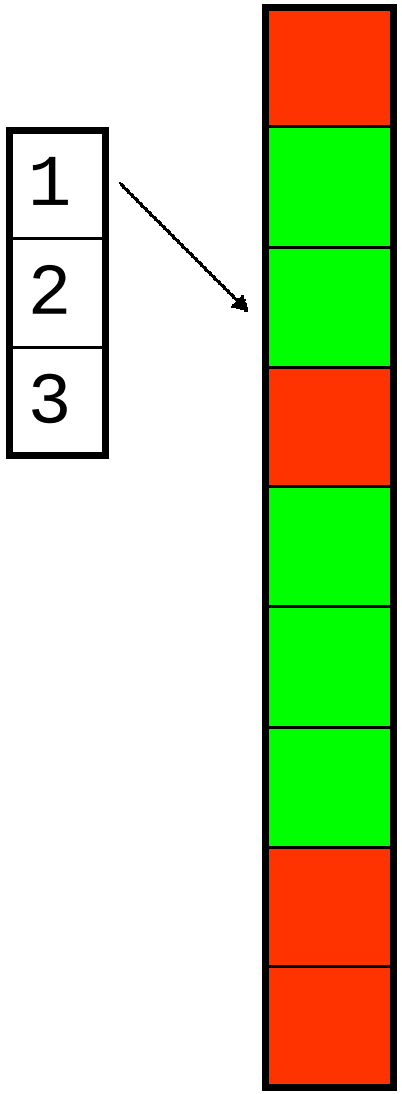

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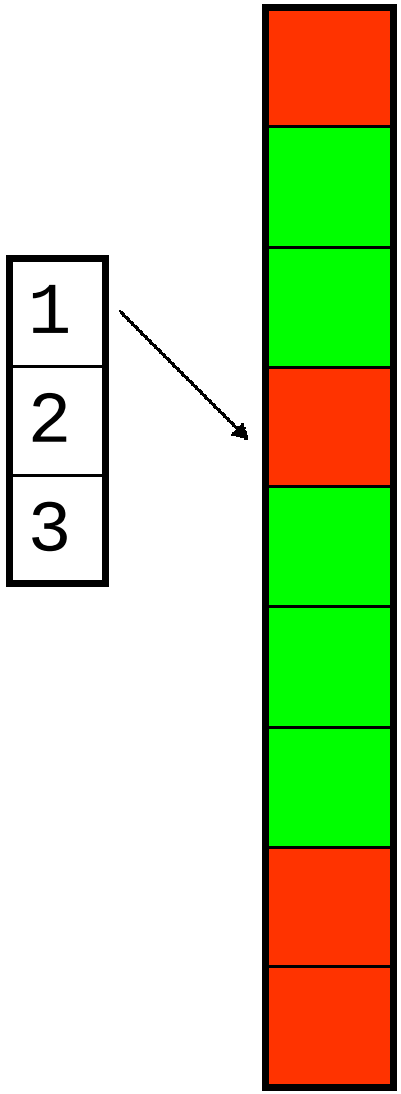

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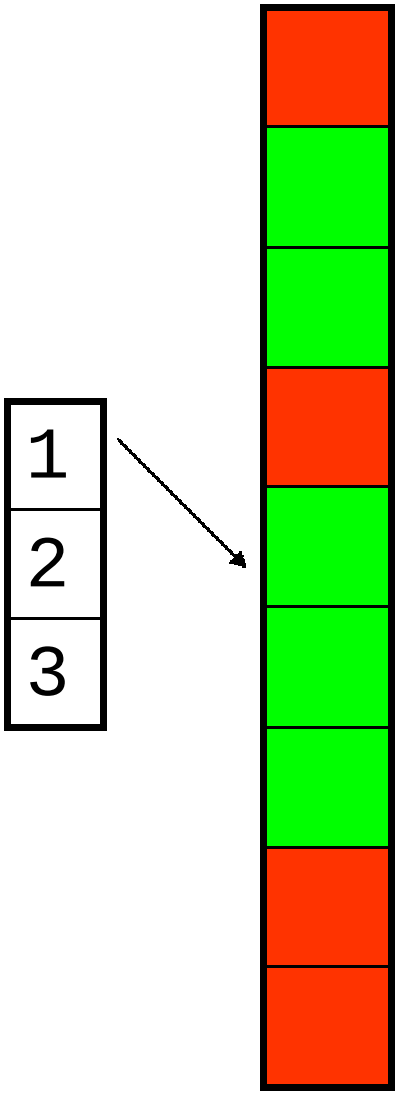

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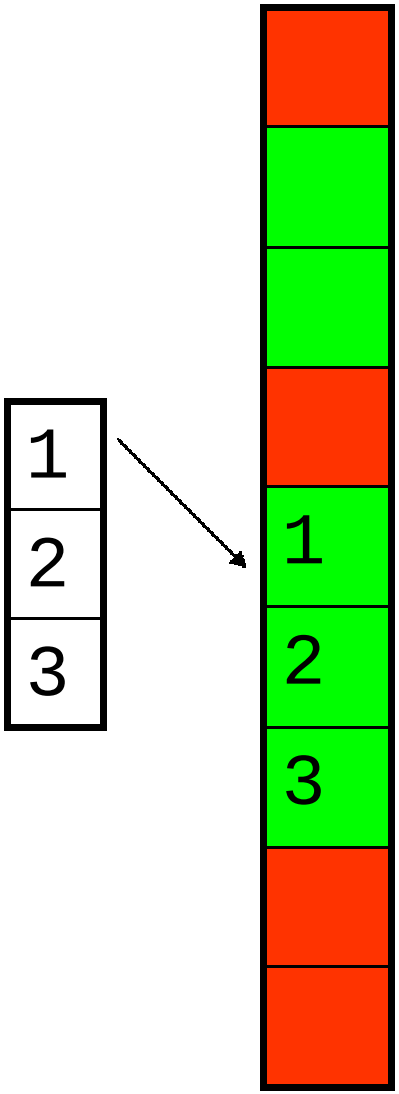

And this repeats EVERY time you modify the SIZE of a variable.

THE POWER OF MATLAB RESIDES IN THE SEQUENTIAL ADDRESS OF ORDERED INFORMATION IN MEMORY.

Back to Matlab!

- Name your matrices always lowercase (because…)
- Create variable a:

```
> a = [ 1 2 3 4];
```

, delimitates elements within a row

Create matrix b:

```
> b = [ 1 2 3
4 5 6];
```

; delimitates rows

Or:

```
> c = [1,2,3;4,5,6];
```

c(i,j) is element i,j of c

Back to Matlab!

- Create a vector of characters:

```
> d = ‘Hello world’;
```

What is d(4)? d(5)? d(6)?

Create a matrix of characters:

```
> e = [‘Hello’;’world’]
```

Select some of the elements in the Matrix using ‘:’

```
> f = e(:,5)   %all elements of 5th column of e
> g = e(2,2:4) %elements 2, 3 and 4 of 2nd row.
```

Exploring…

- Question: what do empty brackets do in the expression?

```
> e(:,4)=[]
```

Exploring…

Question: without typing on Matlab, what happens in the next series of commands?

```
> m = e(2,:);
    % m is a vector = 2nd row of e
Øe(2,:) = e(1,:);
    % 2nd row of e = 1st row of e
> e(1,:) = m;
```

What we learned…

--> to swap the values of 2 variables…

…you need 3 variables.

Exploring…

- Question: can I simply use numbers, like in? (that is, without brackets)

```
> age = 29;

Type
> age
> age(1)
> age(2)
```

Anything bizarre?

Exploring…

- Question: what do you think would happen if I did the following?

```
> t = e(7);
```

Values are stacked!

e(1) = e(1,1)

e(2) = e(2,1)

e(7) = ‘o’

Stacking matrices...

e(k) = `e(1+mod(k-1,number of rows),ceil(k./y))`

mod(x,y): remainder of the division of x by y:

mod(10,3) = 1

mod(9,3) = 0

SUPER USEFUL COMMAND (counterbalancing conditions)

Huhhh…?

e(k) = `e(1+mod(k-1,number of rows),ceil(k./y))`

ceil.

Rounds towards plus infinity.

ceil(3.4) = 4

ceil(3.999) = 4

ceil(-3.4) = ?

Other useful functions.

Try:

round(3.4999)
round(3.5001)

round = nearest integer.

Without typing help… what does FLOOR round to?

minus infinity.

FIX?

Towards zero.

CLEAR ALL

How to **use** a matrix: sum.

- Add two vectors: C = A + B:

```
A = [ 1 0 3]
B = [-1 4 2]
C = [ 0 4 5]
```

Corresponding elements are added in each cell.

Therefore, you cannot add vectors (or matrices) of different dimensions!

How to **use** a matrix: sum.

Type:

```
D = A + 4        % what happened?
```

--> be sure you specify to which element of a you'd like to add 4.

```
a(1) = a(1) + 4
```

So, in

```
 q = a(1) + 4       What's q?
```

How to **use** a matrix: multiplication.

- There are two important forms of multiplication:

  .* which multiplies all the values of a matrix by the same number.

  Type:

  ```
  > clear all;
  > a = [ 1 1 2; 3 4 5]
  > 2as = a.*2;  % 2.*a also works
  ```

How to **use** a matrix: multiplication.

- There are two important forms of multiplication:

  * which multiplies two matrices together. Hard math. To multiply A times B (A*B), A needs to have the same number of columns as B has rows.

  Try:

  ```
  >C = A * A                %what happened?
  >B = A'                 %what happened?
  >D = A * B
  ```

Other stuff.

So, be careful how you multiply.

But you can also subtract, divide
(both ./ and /, though matrix
division is OUT of our league).
^ is expontential (for numbers)

What is a script file?

Files of the type “.m” are simply a collection of orderly command- line instructions
(scripting language)

type:

```
> edit moo.m
```

and save it in your working directory.

script files

Inside moo.m type the following sequence of commands:

```
>str=’this is my first program’;
```

Save your file, close it and on the command line, execute it by typing:

```
>moo
```

script files

What happened? Why?

Allow your program to show you its output and run it again.

script files

Erase everything on moo and type:

```
a=[…
1 2 3 6
4 5 6 7.811];
```

Save moo and execute it.

CHECK WORKSPACE

script files

Two types of m files:

- programs (aka scripts)
  - don’t take inputs.
  - don’t produce outputs.
  - but leave variables in workspace.

- functions (tomorrow).
  - can take input (passing variables)
  - can return outputs.
  - variables are internal.

BREAK!!

Be back in 10 minutes.

Part II

- What is a computer?
- What is an algorhythm?
- What is a vector?
- Matrices and basic operations