Computing Methods for Experimental Physics and Data Analysis

Data Analysis in Medical Physics

Lecture 2: intro to MATLAB

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Course Calendar

- **1. Thursday, November 19 9->11**

- **2. Monday, November 23 9->11**
- **3. Monday, November 23 16->18**
- **4. Thursday, November 26 9->11**

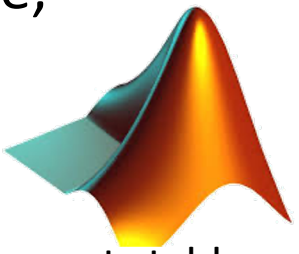
- **5. (Monday, November 30 9->11) → Friday, November 27 9->11**
- **6. Monday, November 30 16->18 – MedPhys + HEP**
- **7. Thursday, December 3 9->11**

- **8. Monday, December 7 9->11**
- **9. Monday, December 7 16->18**
- **10. Thursday, December 10 9->11**

- **11. Monday, December 14 9->11**
- **12. Monday, December 14 16->18**
- **13. Monday, December 17 9->11**

Brief introduction to MATLAB

- MATLAB (MATrix LABoratory) integrates computation, visualization, and programming in an easy-to-use environment.
- MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages,
  including C, C++, C#, Java, Fortran and Python.
- MATLAB users come from various backgrounds of engineering, science, and economics.



Current stable release is R2020b

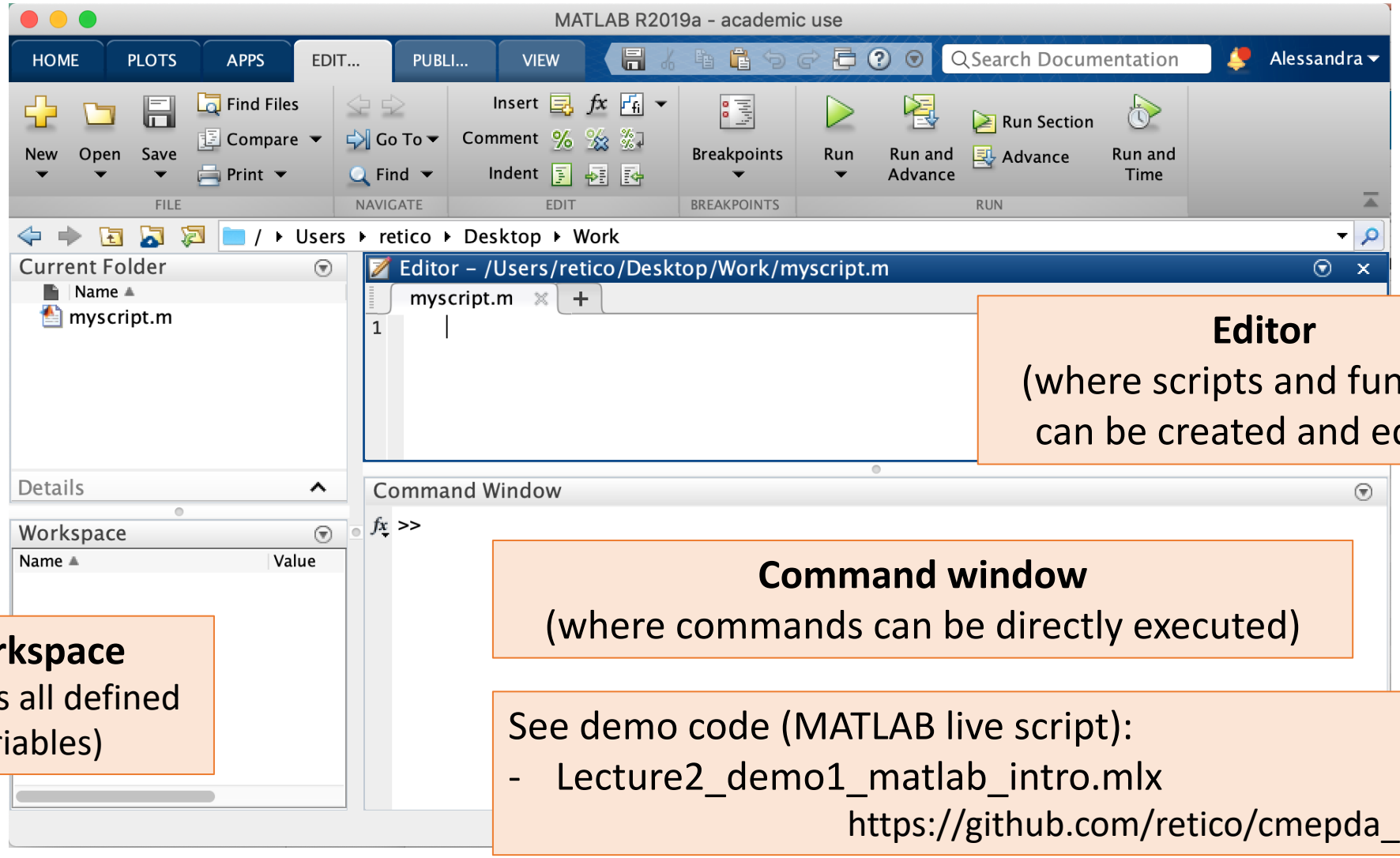
- First of all: download and install on your laptop:
  https://start.unipi.it/personale-t-a/strumenti-di-lavoro/strumenti-informatici/software-e-servizi-cloud/software-matlab/

System requirements and useful MATLAB toolboxes

- System requirements for installation:
  - Administrative rights
  - **Processors – Minimum**: any Intel or AMD x86-64 processor
  - **RAM – Minimum:** 3.3 GB. **Recommended:** 8 GB
  - **DISK – Minimum**: 3.3 GB of HDD space for **MATLAB** only, 5-8 GB for a typical installation. **Recommended**: An SSD is recommended

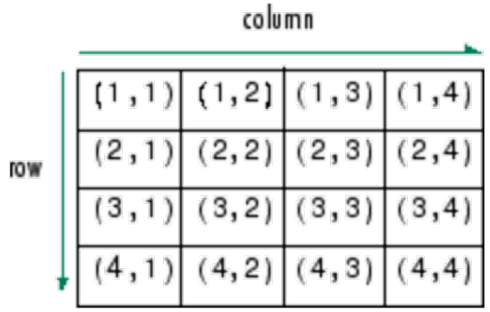
- During the installation you have to specify the products to be installed, i.e. the MATLAB toolboxes.
- You may add some toolboxes you like to the suggested ones (e.g. the Image Processing, Curve Fitting, Wavelet and Deep Learning toolboxes we will use in the exercises)
- You can add more toolboxes, whenever you need, from the Add-Ons drop down menu from the MATLAB desktop HOME tab.

Getting started with matlab

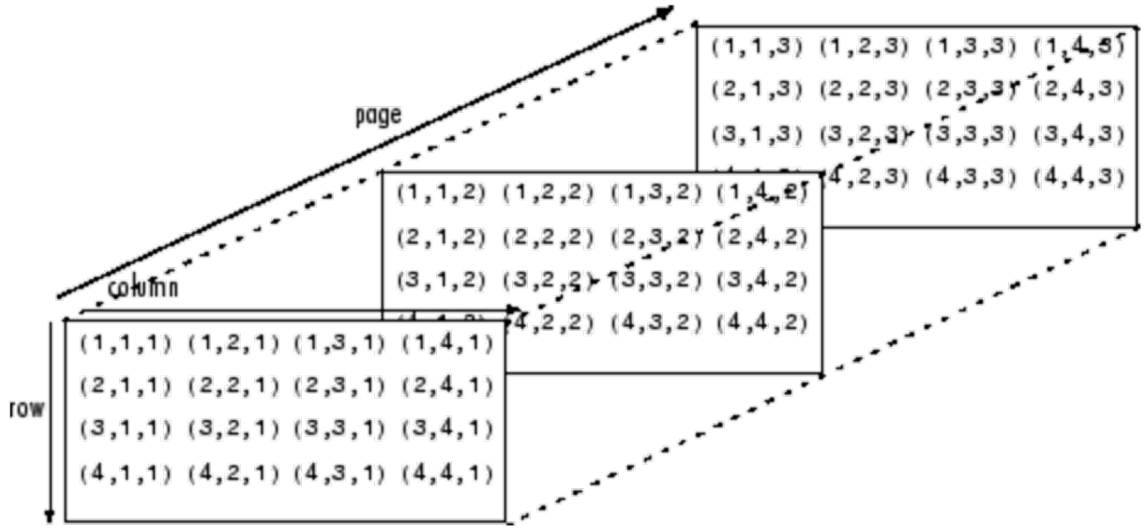


Multidimensional Matlab arrays

A multidimensional array in MATLAB® is an array with more than two dimensions. In a matrix, the two dimensions are represented by rows and columns.



Each element is defined by two subscripts, the row index and the column index. Multidimensional arrays are an extension of 2-D matrices and use additional subscripts for indexing. A 3-D array, for example, uses three subscripts. The first two are just like a matrix but the third dimension represents *pages* or *sheets* of elements.

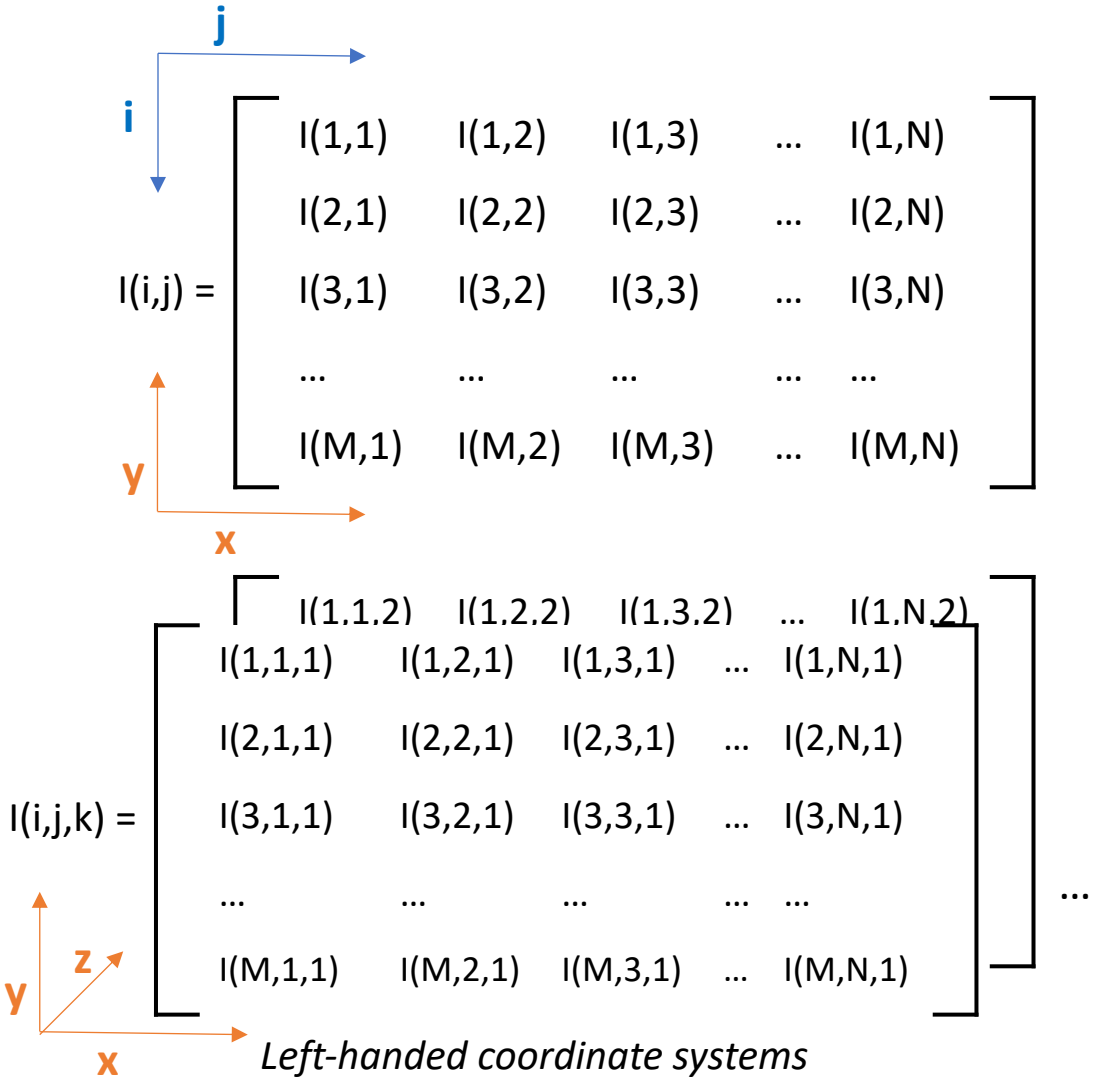


Basic image processing

- Basic operations with images:
  - imread(), imshow(), imwrite()
  - Histogram operations
  - Morphological Operations
  - Image filtering
  - Contrast (C), noise (N), signal-to-noise (SNR) and contrast-to-noise (CNR) ratio
  - …

- A large variety of functions for image processing are available in the MATLAB Image Processing toolbox

See demo code:
- Lecture2_demo2_image_read_display.mlx
- Lecture2_demo3_read_dicom.m



Matlab m-files and user-defined functions

- Matlab programs can be written with any ASCII text editor, using the *.m file extension.
- M-files can be executed from the matlab command line:

```
%  plot_sin.m
%  this script plots the sinus function
x=linspace(0,10*pi,200);
y=sin(x);
plot(y)
```

```
>> plot_sin          % it works both with and without specifying the .m extension
```

- User defined functions work just like commands in Matlab:

```
function [avg,st_dev]= show_stats(x)
% This function (show_stats.m) computes the basic statistics (average and standard deviation)
n = length(x);
avg = sum(x) / n;
st_dev = sqrt(sum((x - avg ).^2)/n);
```

```
>> v1 = randn(100,1)
>> [avg_v1,sd_v1]= show_stats(v1)
```

Matlab & git

- The best place to share your MATLAB projects is File Exchange because of its popularity with the MATLAB user community
- GitHub is one of the most popular websites that host Git repositories
- Since R2014b File Exchange is integrated with GitHub

- In addition to what you already know about GitHub usage, you have to follow the instructions to **Register Binary Files with Git**
  - **https://it.mathworks.com/help/matlab/matlab_prog/set-up-git-source-control.html**

You have to add some lines in the .gitattributes hidden file in your git repository

The .gitattributes file is already correctly set in the https://github.com/retico/cmepda_medphys repository

Add these lines to the .gitattributes file:

..
*.fig binary
*.mat binary
*.mlx binary
…

References and sources

- Books
  - Digital Image Processing for Medical Applications, Geoff Dougherty
  - Handbook of Medical Image Processing and Analysis, Isaac N. Bankman
  - Image Processing and Acquisition using Python, Ravishankar Chityala & Sridevi Pudipeddi

- Sources
  - https://start.unipi.it/personale-t-a/strumenti-di-lavoro/strumenti-informatici/software-e-servizi-cloud/software-matlab/
  - https://it.mathworks.com/help/matlab/getting-started-with-matlab.html
  - https://it.mathworks.com/videos/
  - https://it.mathworks.com/help/matlab/external-language-interfaces.html
  - https://it.mathworks.com/help/matlab/matlab_prog/set-up-git-source-control.html
  - https://blogs.mathworks.com/community/2014/10/20/matlab-and-git/