[QI;MP]

Thomas Busch

BASIC INTRODUCTION

OIST

What is Matlab?

[QI;MP]

- A high level programming language with a large number of specialised toolboxes for different areas

- it *solves* complicated mathematical equations for you and *visualizes* the results

$$\begin{aligned} 2x + y &= 4 \\ x - y &= -1 \end{aligned} \xrightarrow{\text{by hand}} \begin{aligned} x &= 1 \\ y &= 2 \end{aligned}$$

but for complicated systems with lots of equations a computer is a great help

- complicated and coupled equation appear in all kinds of areas: physics, neuroscience, biology, financial mathematics, engineering,...

Toolboxes

[QI;MP]

MATLAB® プロダクトファミリ

MATLAB

並列処理

Parallel Computing Toolbox
MATLAB Distributed Computing Server

数学、統計および最適化

Symbolic Math Toolbox
Partial Differential Equation Toolbox （英語）
Statistics Toolbox
Curve Fitting Toolbox
Optimization Toolbox
Global Optimization Toolbox
Neural Network Toolbox （英語）
Model-Based Calibration Toolbox （英語）

制御システム設計および解析

Control System Toolbox
System Identification Toolbox
Fuzzy Logic Toolbox （英語）
Robust Control Toolbox （英語）
Model Predictive Control Toolbox （英語）
Aerospace Toolbox （英語）

信号処理および通信

Signal Processing Toolbox
DSP System Toolbox
Communications System Toolbox
Wavelet Toolbox （英語）
RF Toolbox （英語）
Phased Array System Toolbox （英語）

画像処理とコンピューター ビジョン

Image Processing Toolbox
Computer Vision System Toolbox
Image Acquisition Toolbox （英語）
Mapping Toolbox （英語）

実験、計測

Data Acquisition Toolbox （英語）
Instrument Control Toolbox （英語）
Image Acquisition Toolbox （英語）
OPC Toolbox （英語）
Vehicle Network Toolbox （英語）

Simulink® プロダクトファミリ

Simulink

イベントベース モデリング

Stateflow
SimEvents （英語）

物理モデリング

Simscape
SimMechanics （英語）
SimDriveline （英語）
SimHydraulics （英語）
SimRF （英語）
SimElectronics （英語）
SimPowerSystems

制御システム設計および解析

Simulink Control Design
Simulink Design Optimization （英語）
Aerospace Blockset （英語）

信号処理および通信

DSP System Toolbox
Communications System Toolbox
SimRF （英語）
Computer Vision System Toolbox

コード生成

Simulink Coder
Embedded Coder
HDL Coder （英語）
Simulink PLC Coder （英語）
Fixed-Point Designer
DO Qualification Kit *(for DO-178)* （英語）
IEC Certification Kit *(for ISO 26262 and IEC 61508)* （英語）

...and many in-official toolboxes.

ラピッドプロトタイピングおよびHILシミュレーション

xPC Target （英語）
xPC Target Embedded Option （英語）
Real-Time Windows Target （英語）

確認、検証およびテスト

Simulink Verification and Validation （英語）

Polyspace® プロダクトファミリ

Polyspace Bug Finder
Polyspace Code Prover （英語）
DO Qualification Kit *(for DO-178)* （英語）
IEC Certification Kit *(for ISO 26262 and IEC 61508)* （英語）

追加製品およびサービス

Connections パートナー ディレクトリ
ハードウェア サポート カタログ

MathWorks サービス

MathWorks ソフトウェア保守サービス
トレーニング
技術コンサルティング

R2013b

2つの新製品と、MATLAB、Simulink および 他 79 製品のアップデート

» ビデオを見る
» ダウンロード（英語）

適用分野

- 技術計算
- 組込みシステム
- 制御システム
- デジタル信号処理

Today and Tomorrow

[QI;MP]

	Sunday, Oct 13
9.00 - 11.00	Introduction to Matlab (Thomas)
11.00 - 11.30	Coffee Break
11.30 - 12.30	Basic Numerical Structures (Lee)
12.30 - 14.00	Lunch Break
14.00 - 16.00	Basic Numerical Structures - Applications (Jeremie)
16.00 - 16.30	Coffee Break
16.30 - 18.00	Differential Equations (Yongping)
20.00 ~	The Matrix (Auditorium)
	Monday, Oct 14
9.00 - 10.30	Matlab Graphics (Tara)
10.30 - 11.00	Coffee Break
11.00 - 12.30	Image Processing (Chandru)
12.30 - 14.00	Lunch Break (Kaito+ is open!)
14.00 - 17.00	Conway's Game of Life (Jeremie)
17.00 - 17.30	Matlab and Computing @ OIST (Lee)

Matlab

Matlab: **Ma**trix **Lab**oratory

→ can be used as advanced calculator
→ can be used as advanced graphics tool
→ can be used as programming language

Why use Matlab?

1. allows for quick and easy introduction to programming
2. provides a quick and intuitive development environment
3. useful in many areas
4. basic program can be extended using specialised toolboxes
5. used in academia and industry
6. is platform independent (write once, run under all operating systems)
7. can be linked to other software (C/C++, Fortran, Java,...)

→ All skills learned programming with Matlab can be easily transferred to other programming languages.

Using Matlab

[QI;MP]

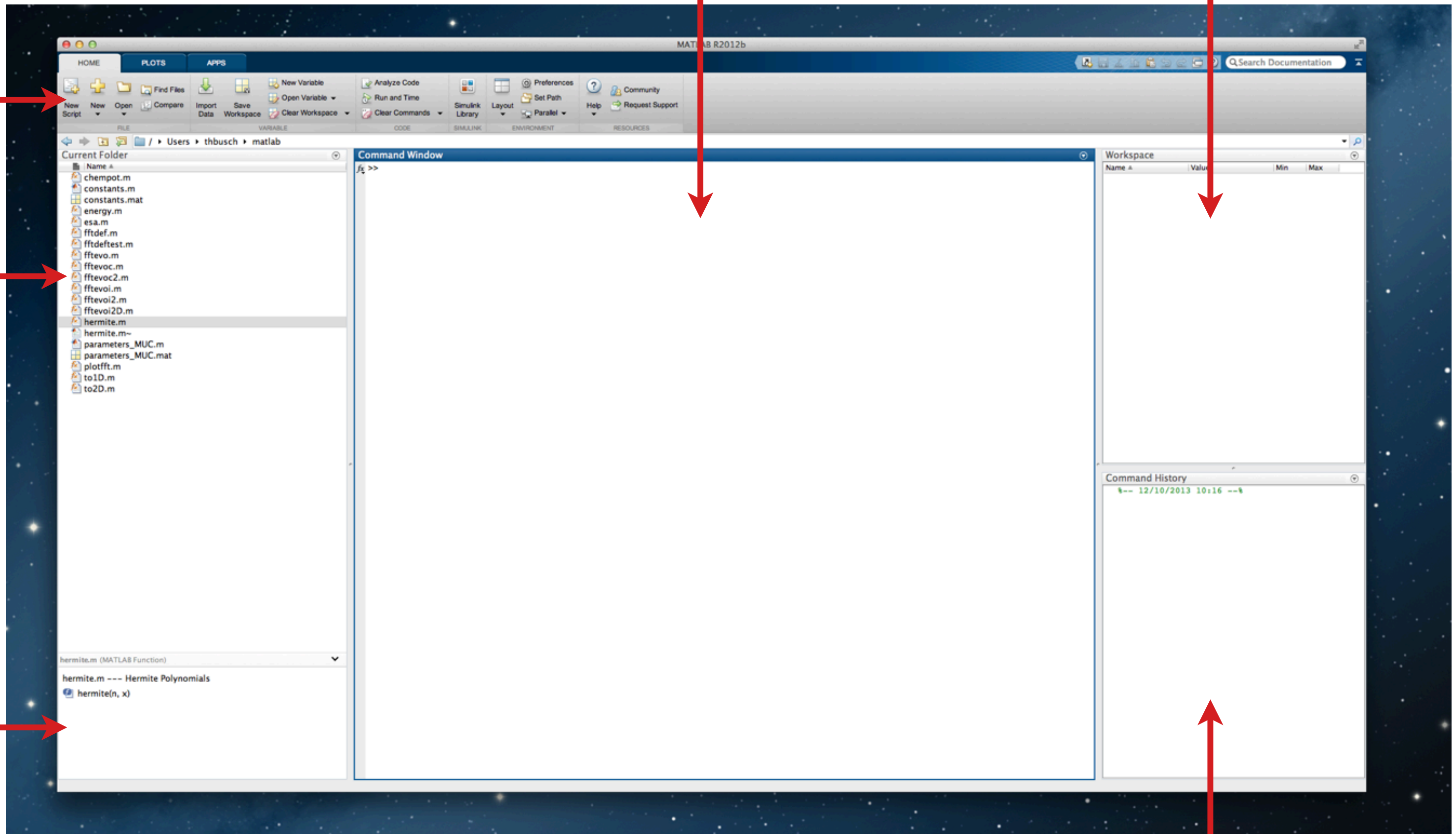
command window

variables defined

menu bar

current folder

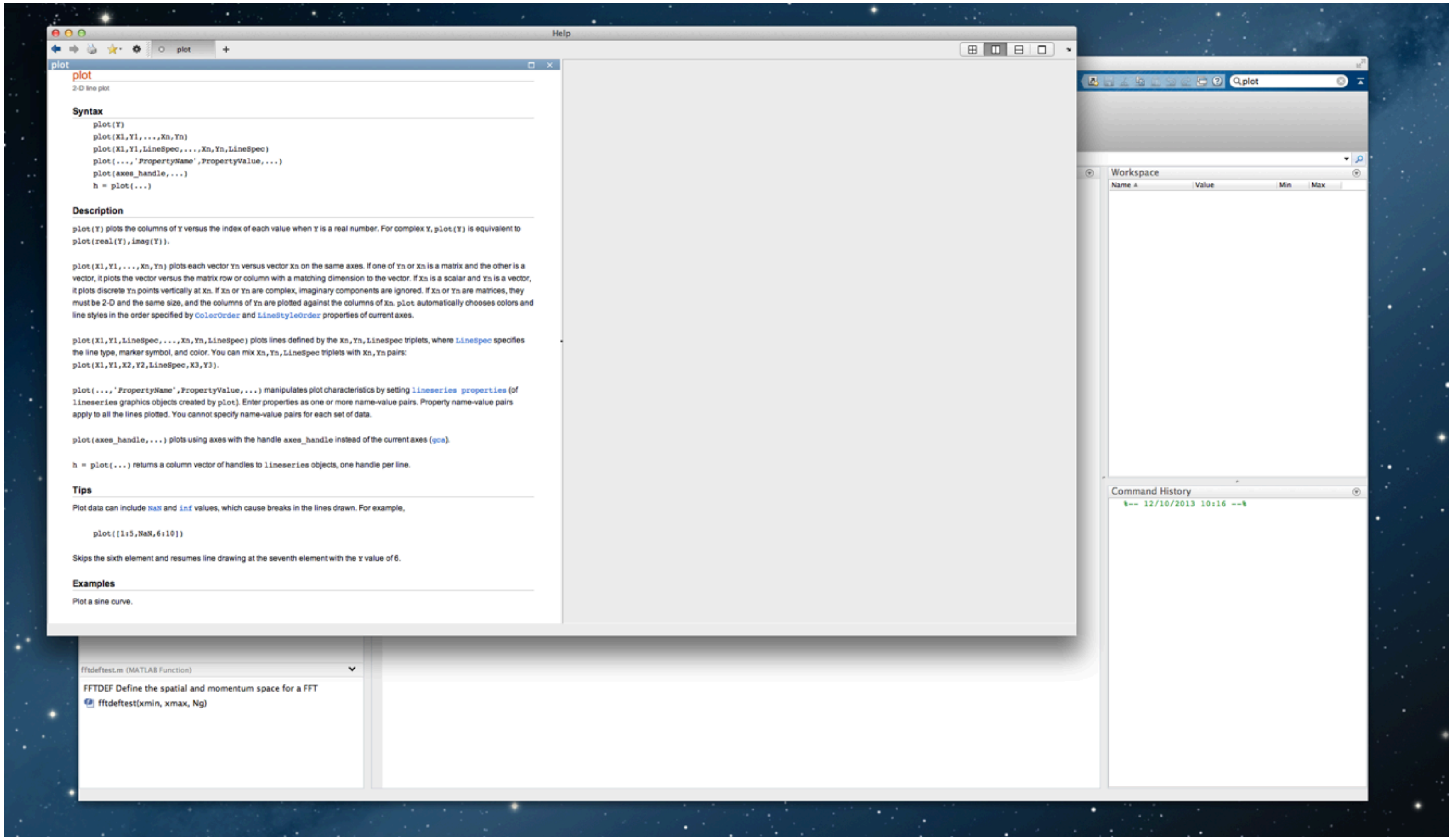
info about current file



command history

Matlab Help

- Matlab has a very helpful *help* system



- faster: type **help** or **help <command>** at the command line

Calculating in Matlab

[QI;MP]

→ we will start using Matlab as an advanced calculator

- express mathematics in form suitable for Matlab
- use build in mathematical functions in calculations
- use variables in calculations

→ simply enter an expression at the commend line and evaluate it right away (i.e. press enter)

```
>>  2 * 9 - 8
ans =
      10
>>
```

whenever >> appears, you can enter input

Mathematical Operators

Operator	Matlab	Example
+	+	7+4 = 11
-	-	7-4 = 3
$\times$	*	7*4 = 28
$\div$	/	7/4 = 1.75
a^b	a^b	7^4 =2401

→ Matlab uses *scientific notation* for very large and very small numbers, but has a special way to do so

$34^{16} = 3.1891 \times 10^{24}$ →

```
>> 34^16
ans=
   3.1891e+24
```

BEDMAS

[QI;MP]

→ Matlab evaluates expressions in the following (standard) order

1. brackets
2. exponentials
3. division/multiplication
4. addition/subtraction

```
>> 3*4+2
ans=
    14
>> 3*(4+2)
ans=
    18
>>
```

Build-In Functions

→ Matlab has many build-in functions to make your life easier

```
>> sqrt(4)
ans=
    2
>> abs(-3)
ans=
    3
>>
```

```
>> help elfun
Elementary math functions

Trigonometric.
sin      - Sin
...
```

Scrolling & Output Suppression

[QI;MP]

Scrolling

→ earlier commands can be repeated by using the up and down arrow keys

  → can save a lot of time and work

→ if you give the first letter, scrolling only scrolls commands that start with that letter

Suppression of output

→ the output to the screen can be suppressed using a semi-colon

  → useful when you don't need to see it, but can also be source of confusion

```
>> area=5
area=
    5
>> area=5;
>>
```

Variables

- variables help representing mathematical problems:

Change from Fahrenheit to Celsius

$$C = \frac{5}{9}(F - 32)$$

$$F = 100 \quad \Rightarrow \quad C = 37.8$$

$$F = 32 \quad \Rightarrow \quad C = 0$$

```
>> F=100
F =
    100
>> C=(F-32)*5/9
C =
    37.7778
>> F=32
F =
    32
>> C=(F-32)*5/9
C =
    0
>>
```

- one can think of variables as *named locations* in the computer memory in which a number can be stored

- variables can have (almost) any name and are case sensitive

Special Variables

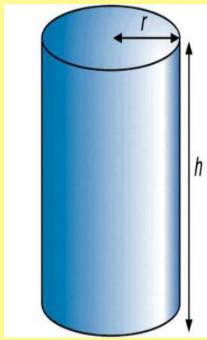
[QI;MP]

→ several variables names are special in Matlab and pre-assigned

ans	is the result of the last calculations
pi	represents 3.1415
Inf	represents infinity
i,j	represent the square root of -1 (complex numbers)
NaN	stands for *not-a-number* and occurs when an expression is undefined, e.g. division by zero

Task: calculate the volume of a cylinder

$$V = \pi r^2 h$$



$$r = 2cm$$

$$h = 15cm$$

Data Representation in Matlab

[QI;MP]

→ structure for storage of all data in Matab is the MATRIX

→ scalars are 1x1 matrices

Rules for variable names:

1. must start with a letter, followed by letters, digits or underscores
   e.g. x12, temp, temp_max are good, temp-A is bad
2. are case sensitive: TEMP, Temp, temp, tEMp are all different variable
3. must not be longer than 63 characters
4. must not contain punctuation characters

Creating variables:

Enter name at command line and assign a value

Deleting variables:

>> clear a → deletes variable a
>> clear → deletes all variables

Matrices

→ Special syntax is needed when defining and manipulating arrays

```
>> x=[1 2 5 8]
x =
   1   2   5   8
>> X=[1 2 3 ; 5 -3 7 ; 8 9 5]
X =
      1    5   8
      2   -3   9
      3    7   5
>> y=x'
y =
      1
      2
      5
      8
>>
```

← definition of a vector

← definition of a matrix

← transpose of a vector

Long Matrices

[QI;MP]

→ Matlab has many ways that help you define larger matrices

```
>> t = 1 : 10
t =
   1   2   3   4   5   6   7   8   9   10
>> s = 1 : 2 : 10
s =
   1   3   5   7   9
>> k = 2 : -0.5 : -1
k =
    2   1.5   1   0.5   0   -0.5   -1
>> B = [1:4 ; 6:9]
B =
    1   2   3   4
    6   7   8   9
>>
```

```
>> x = zeros(1,3)
x =
    0   0   0
>> h = ones(2,3)
h =
    1   1   1
    1   1   1
>> t = rand(2,2)
t =
     0.8145   0.4634
     0.2483   0.6302
>>
```

← zeros (M,N)
MxN matrix of zeros

← ones (M,N)
MxN matrix of ones

← rand (M,N)
MxN matrix of uniformly distributed random numbers from [0,1]

Matrix Indices

[QI;MP]

→ matrix indices begin from 1 (not 0)

```
>> A = [3 5 3 ; 6 8 2 ; 2 7 3]
A =
   3   5   3
   6   8   2
   2   7   3
>> A(3,2)
ans =
    ?????
>> A(6)
ans =
    ?????
>> A(2,:)
ans=
    6   8   2
```

```
>> A = (1:2,2)
A =
   5
   8
>> A(-2)
ans =
    ?????
>> A(0)
ans =
    ?????
>> A(4,2)
ans=
    ?????
```

Concatenation of Matrices

[QI;MP]

```
>> x = [1 2]; y = [3 4]; z = [0 0];
>> A = [x y]
A =
    1   2   3   4
>> B = [x; y]
B =
    1   2
    3   4
>> C = [x y ; z]
C=
    ?????
```

as long as done consistently, this works for matrices and arrays of any dimension!

Matrix Operations

[QI;MP]

```
>> A = [1 2 3 ; 4 5 6 ; 7 8 9]
A =
    1   2   3
    4   5   6
    7   8   9
```

```
>> B = [3 5 2 ; 5 2 8 ; 3 6 9]
B =
    3   5   2
    5   2   8
    3   6   9
```

Addition

```
>> X = A + B
X =
     4    7    5
     9    7   14
    10   14    9
```

Subtraction

```
>> X = A - B
X =
    -2   -3    1
    -1    3   -2
     4    2    0
```

Product

```
>> X = A * B
X =
    22   27   45
    55   66  102
    88  105  159
```

complex conjugate
Transpose

```
>> X = A'
X =
    1   4   7
    2   5   8
    3   6   9
```

Element by Element Operations

[QI;MP]

.*   element-by-element multiplication
./   element-by-element division
.^   element-by-element power

```
>> A = [1 2 3 ; 4 5 6 ; 7 8 9]
A =
    1   2   3
    4   5   6
    7   8  -9
>> x = A(1,:)
x =
    1   2   3
>> y = A(3,:)
y =
    7   8  -9
```

→

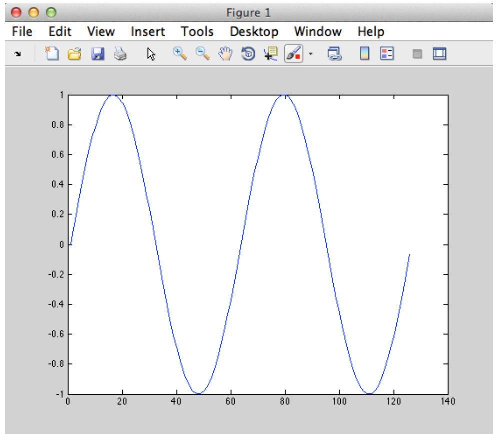
'dot' -operations

```
>> b = x .* y
b =
    7  16   -27
>> c = x ./ y
c =
    0.14   0.25   -0.33
>> d = x.^2
d =
    1   4   9
>> K = x^2
   ?????
>> B = x * y
   ?????
```

Basic Task

→ Plot the function $\sin(x)$ between $0 \le x \le 4\pi$

```
>> x = 0:0.1:4*pi;     ← create array
>> y = sin(x);         ← calculate sin of array
>> plot(y)             ← plot the result
>>
```



Task: plot the function $e^{-\frac{x}{3}} \sin x$ between $0 \le x \le 4\pi$