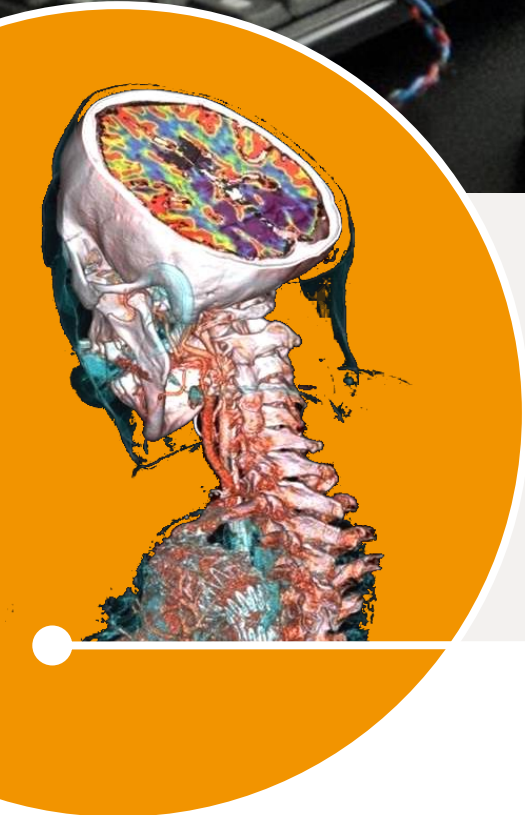
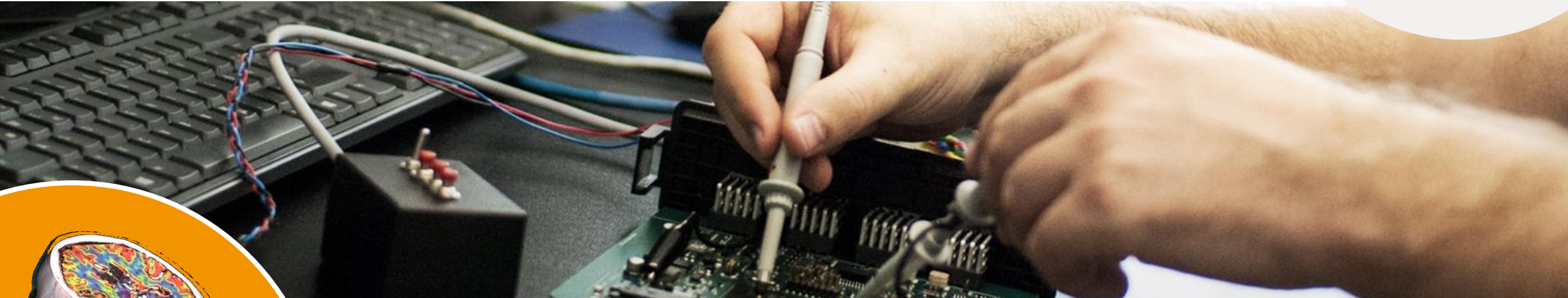


fördern • führen • inspirieren



MATLAB EXPO 2018



MATLAB Expo 2018 – Munich

MATLAB for Engineers @ Universities

From the Basics to the Professionalized Use in Research & Industry

Manuel Stich

Goal of the MATLAB Course

“Develop a 3 days course for engineering studies which should support the content of lectures in the fields of science, research and (medical) engineering.”
(as an introduction and as further preparation)



Goal of the MATLAB Course

MATLAB Course

MATLAB Basics + MATLAB Applications in Engineering

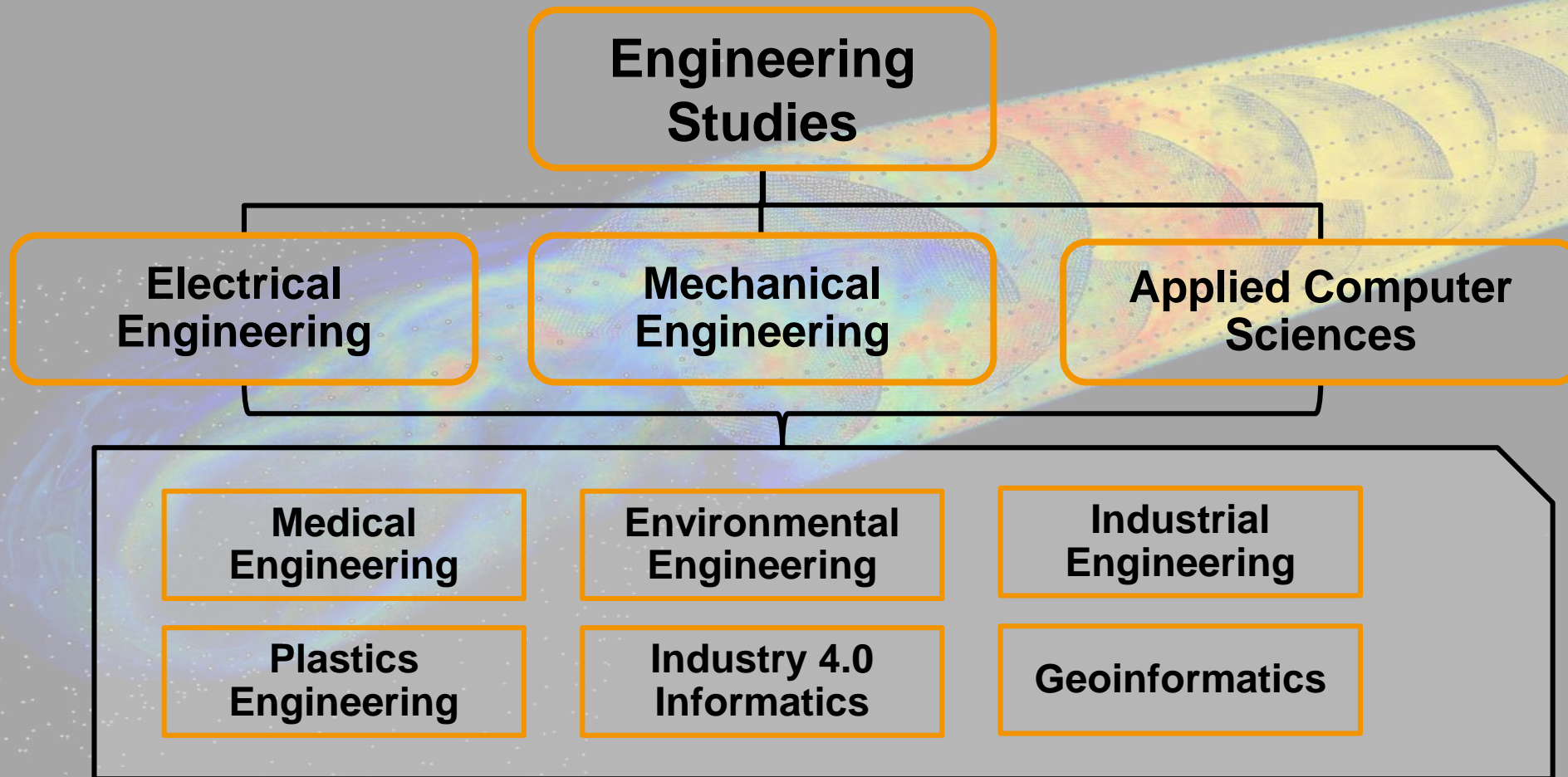


Key Features

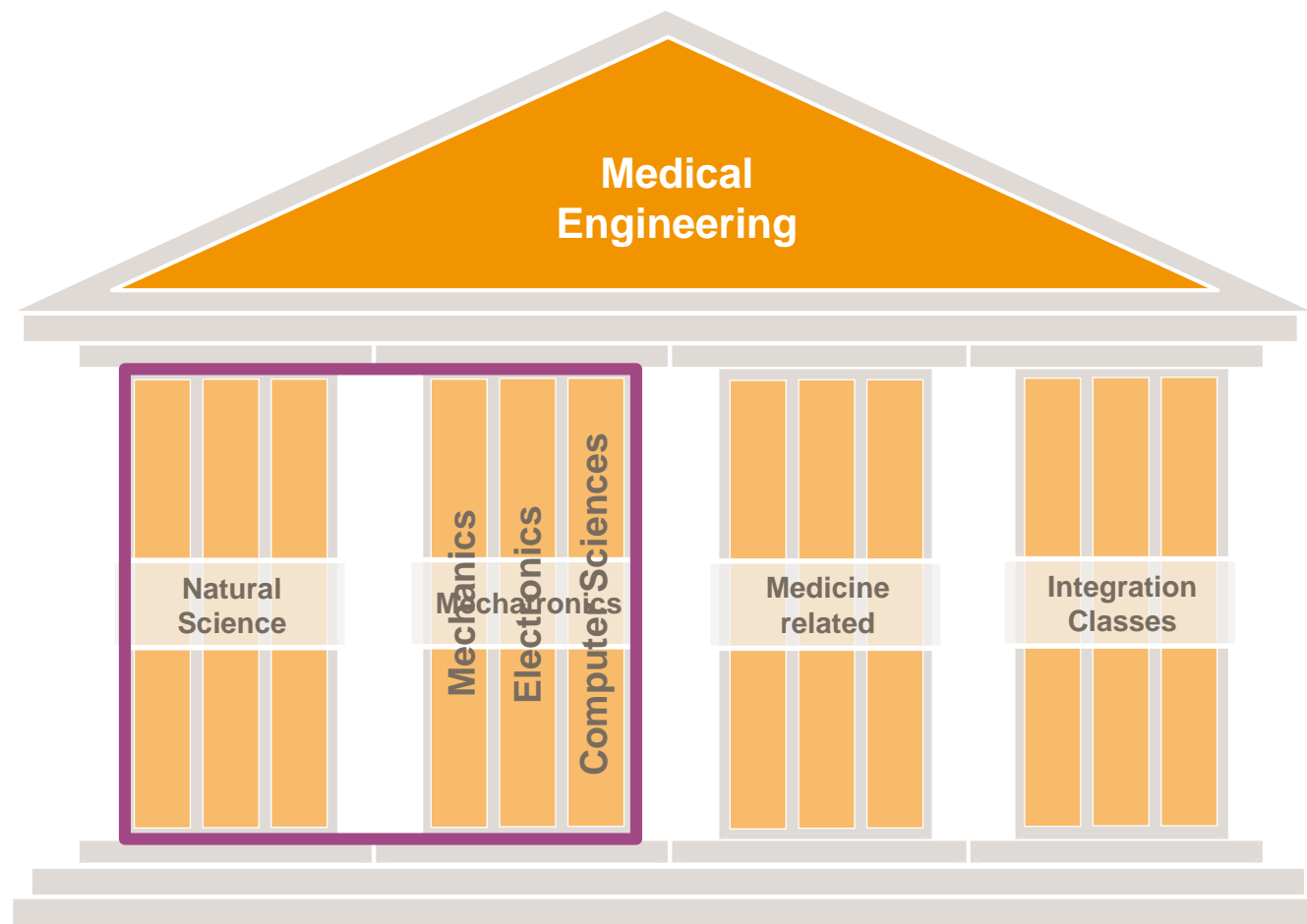
- a) Applications: Exercises, integration in research projects
- b) Interdisciplinarity: Eligible to a broad spectrum of studies
- c) Future potential: Online learning!



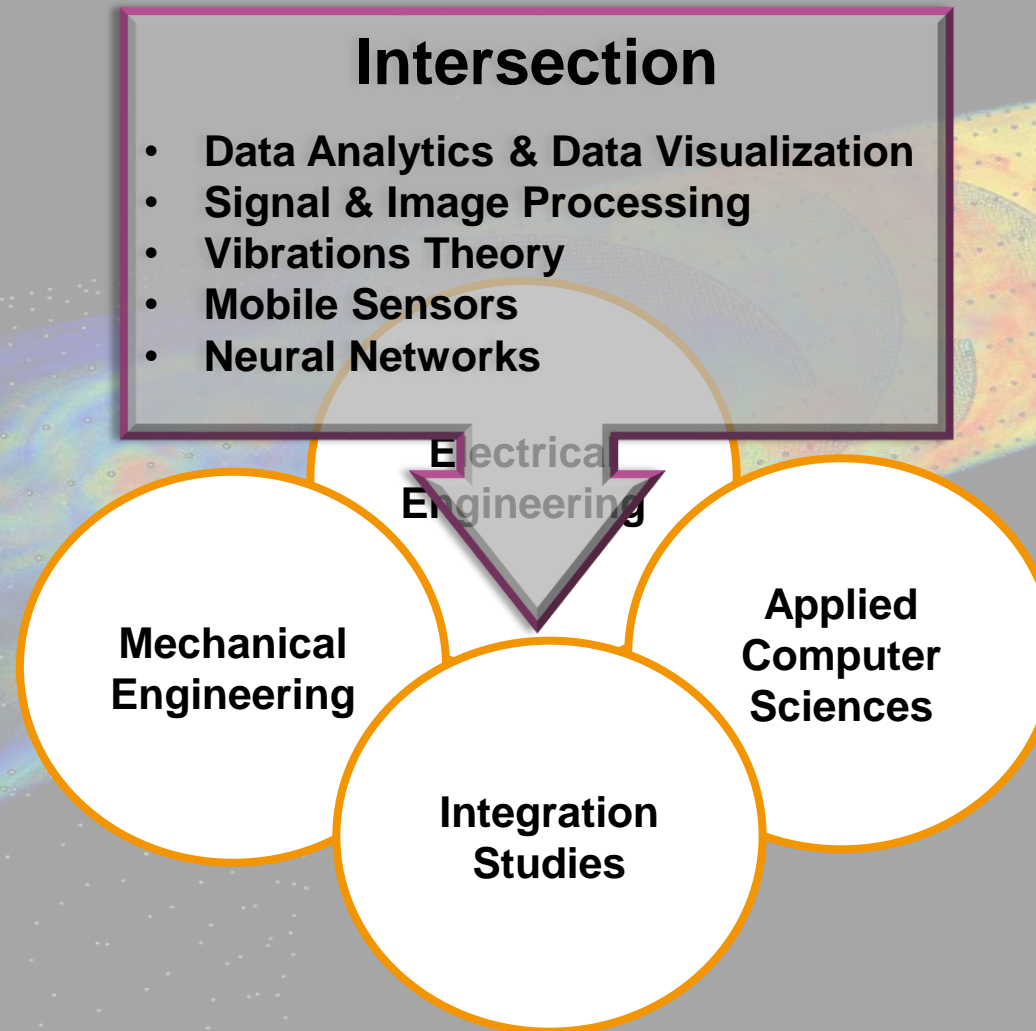
Interdisciplinarity



Interdisciplinarity

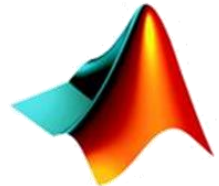


Interdisciplinarity

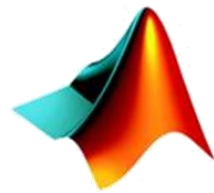


Programming Language

Which programming language
should we choose?



Programming Language



MATLAB



python™



WOLFRAM
MATHEMATICA



Widely used in research and industry



Provides very cool and useful toolboxes



Best documentation ever!



\$\$\$



Widely used programming language



Inexpensive, free



Lame documentation



Version divergence



Good documentation



Only used in academic – week usage in industry

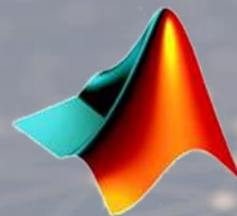


\$\$\$, no licenses available



Not a gold standard in numerical computing

Programming Language



MATLAB



Heavily used in research and industry



Powerful in numerical computing + MuPAD®



Provides cool and useful toolboxes



Mathematical syntax, easy for non-programmers



Best documentation ever!



Embedded code generation possible

Programming Language

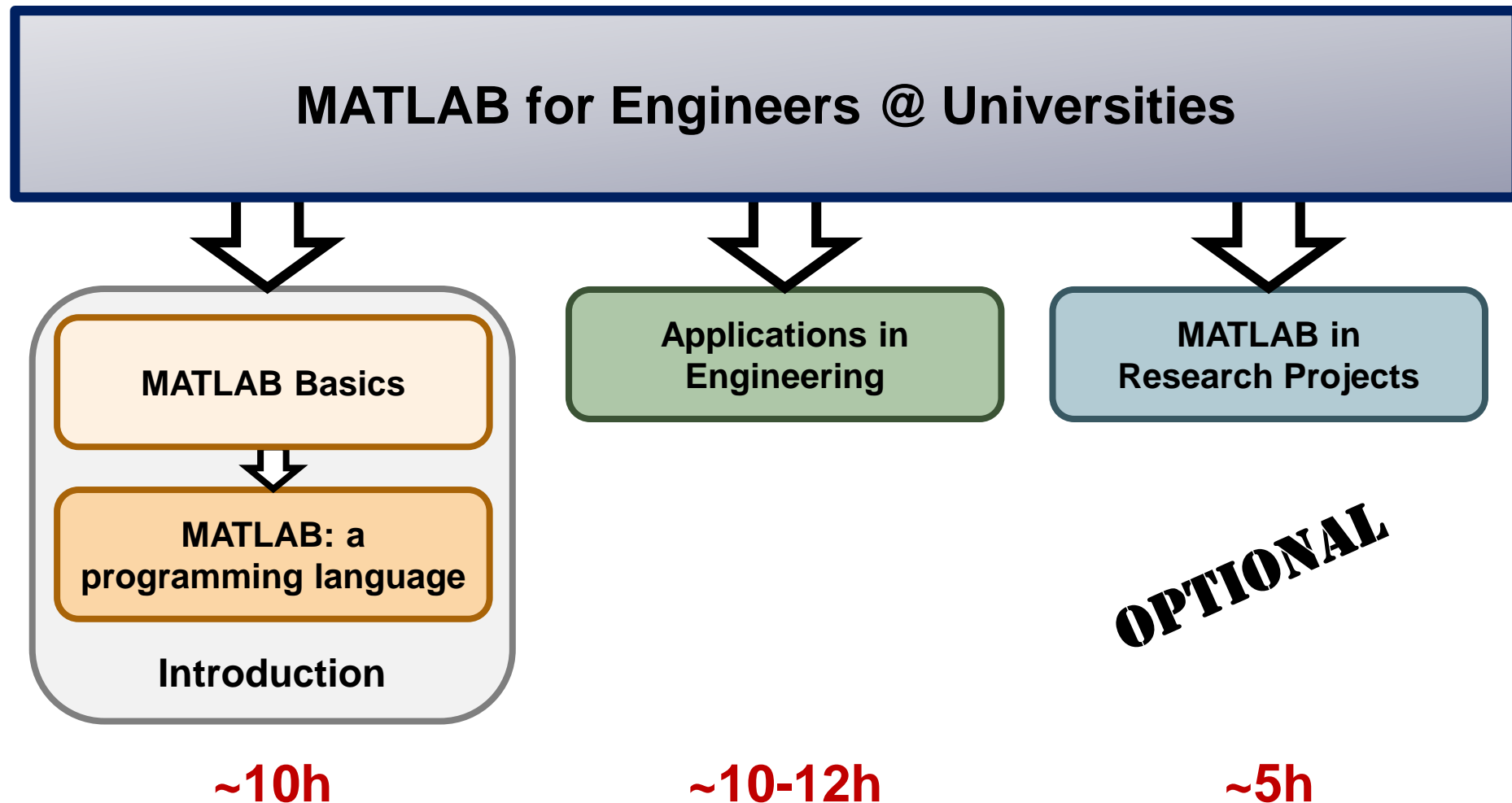


“As a process engineer I had no experience with neural networks or machine learning. I worked through the MATLAB examples to find the best machine learning functions for our predictive metrology use case. I couldn’t have done this in C or Python—it would’ve taken too long to find, validate, and integrate the right packages.”

— Emil Schmitt-Weaver, ASML

„Easy and straightforward introduction in Neural Networks for unexperienced users who want to apply Neural Networks to certain problems in engineering“

MATLAB Course



MATLAB Course: MATLAB Introduction

MATLAB Basics

- First launch: MATLAB IDE and GUI
- Variables and value assignment
- MATLAB – MATrix LABoratory: Vectors and matrices
 - ❖ Examples from linear algebra
 - ❖ From command window to MATLAB scripts
- Data visualization
 - ❖ Data and function plotting
 - ❖ Ways to visualize data and create a nice figure for publication
- MATLAB Documentation
- **MATLAB Onramp Course part 1: Ch. 1-7 (in lecture or at home)**

Day 1: ~4-5h

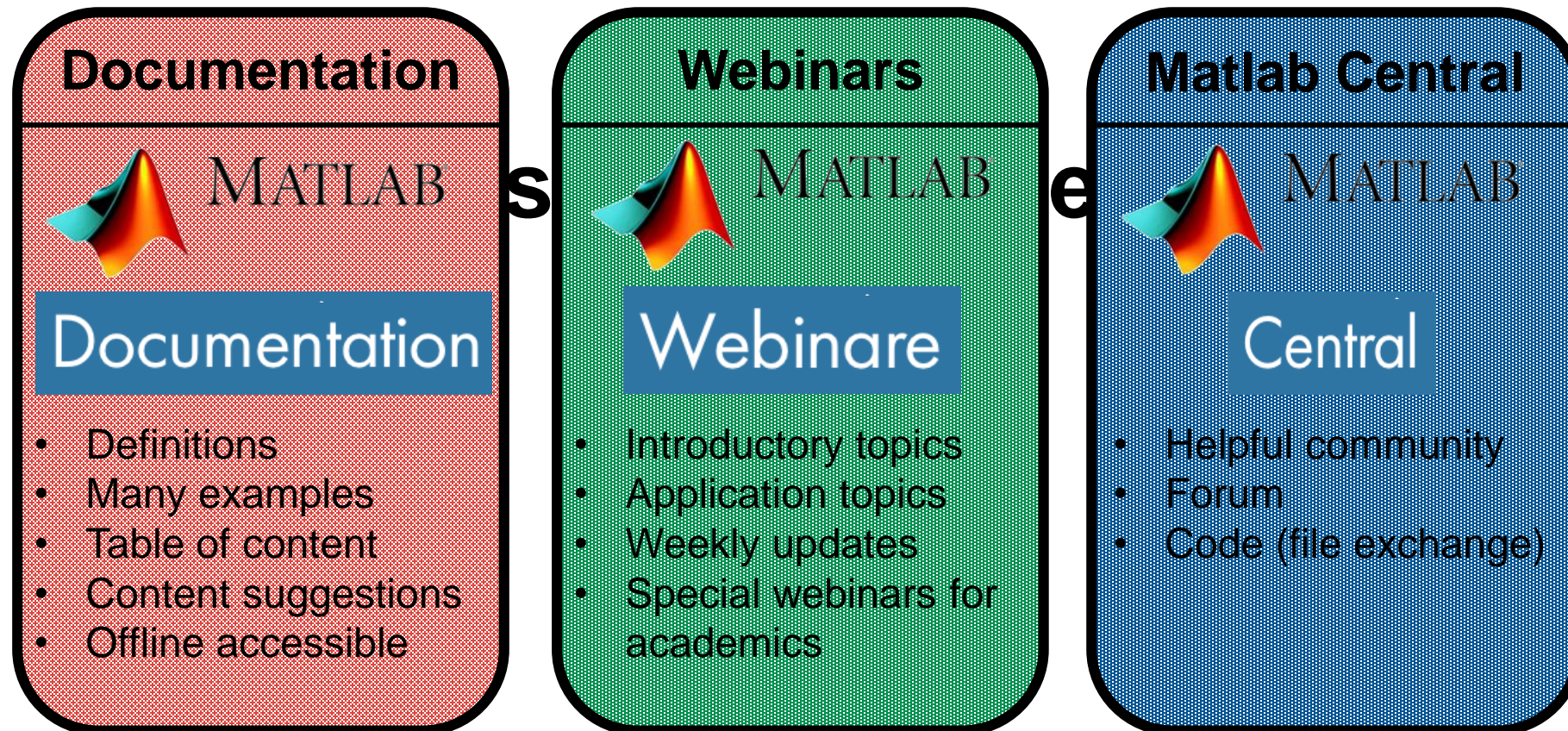
MATLAB Course: MATLAB Introduction

MATLAB: a programming language

- Questions concerning the last lecture
 - Branching
 - ❖ If-else
 - ❖ Switch-case
 - ❖ Try-catch
 - For- and while loops
 - MATLAB functions
 - ❖ Subfunctions
 - ❖ Nested Functions
 - ❖ Function Handles
 - Debugging
 - Exercise: Sinus series expansion
 - **MATLAB Onramp Course part 2: Ch. 9-12 (in lecture or at home)**
- Theory and comparison to other programming languages
 - One exercise together
 - One exercise alone

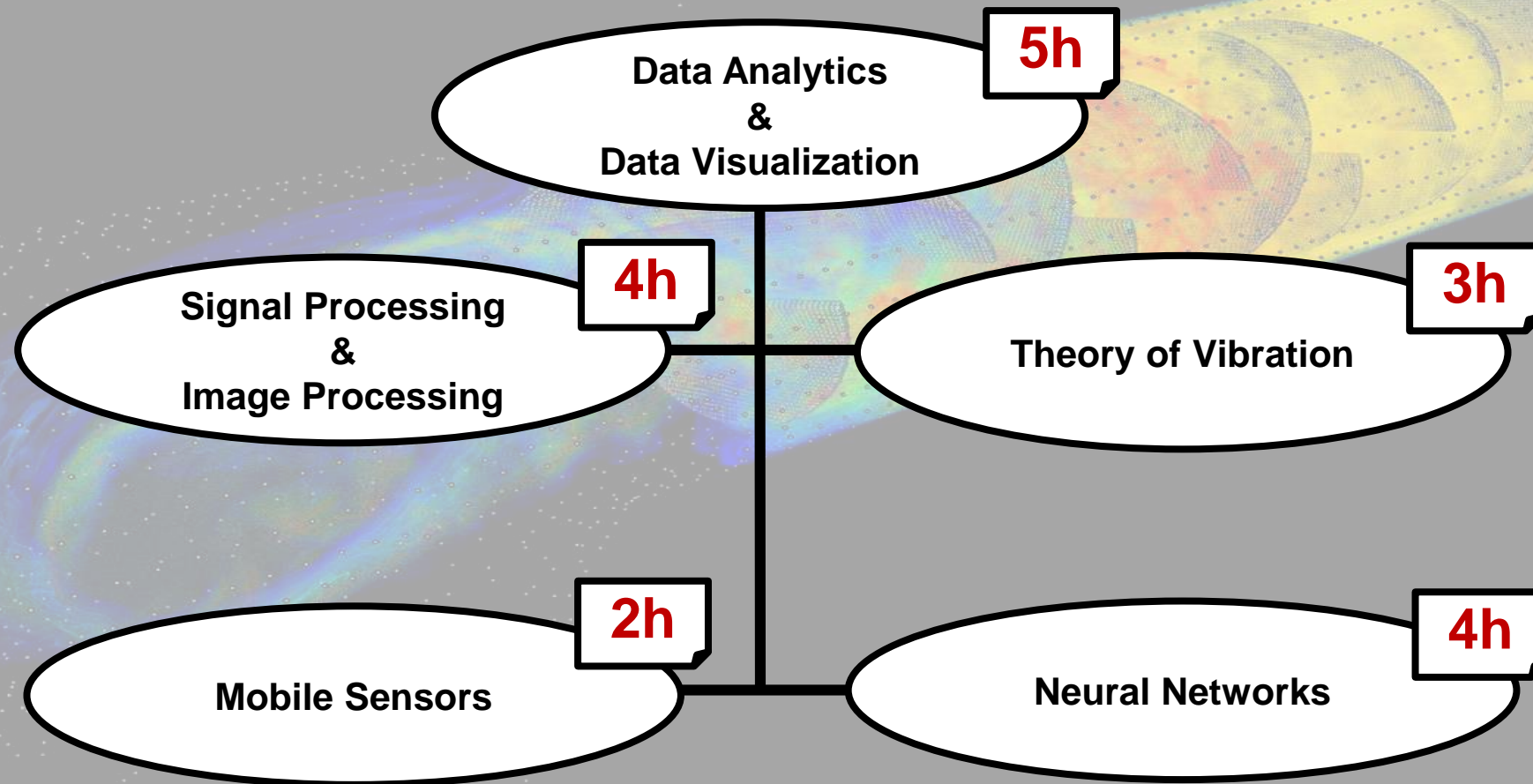
Day 2: 5-6h

Getting Help!



MATLAB Course: MATLAB Introduction

Applications in Engineering



MATLAB: Application in Engineering

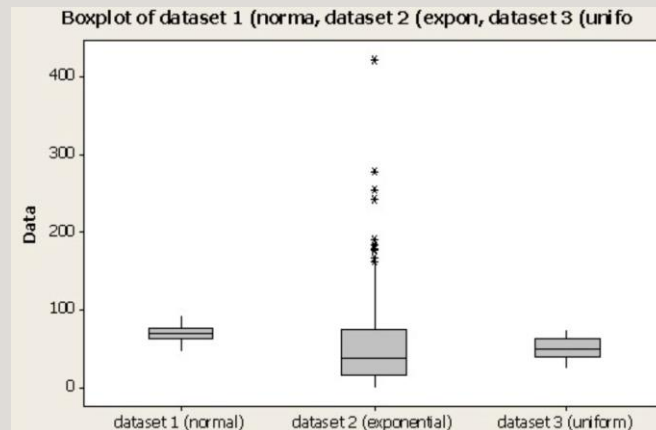
Data Analysis & Data Visualization

Data Preprocessing

1. Data import / export
2. Data wrangling
3. Preanalysis, descriptive-preanalysis)
4. Data cleansing
5. Data reduction

Data Visualization

- Histograms
- Scatter-plots
- Box-plots/Whisker-plots

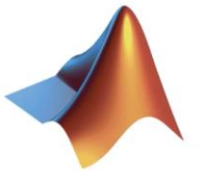


Data Analysis

- Cross correlation/covariance
- Data curve fitting
- Data models

Einführung in MATLAB

Jérémy Huard
Applikationsingenieur



MATLAB: Application in Engineering

Signal and Image Processing

DICOM Images

Read "image.dcm" data

```
info = dicominfo('CT-MON02-16-ankle.dcm')
```

```

  Filename: [1x89 char]
  FileModDate: '11-Dec-2000 11:06:43'
  FileSize: 524288
  Format: 'DICOM'
  FormatVersion: '1.0'
  MetaInformationLength: 1024
  FileMetaInformationVersion: '1.2.840.10008.5.1.4.1'
  MediaStorageSOPClassUID: '1.2.840.10008.1.2'
  MediaStorageSOPInstanceUID: '1.2.840.113619.6.5'
  TransferSyntaxUID: '1.2.840.10008.1.2'
  ImplementationClassUID: '1.2.840.113619.6.5'
  ...
  ...

```

```
I = dicomread('CT-MON02-16-ankle.dcm');
```

```
imshow(I, 'DisplayRange', [])
```

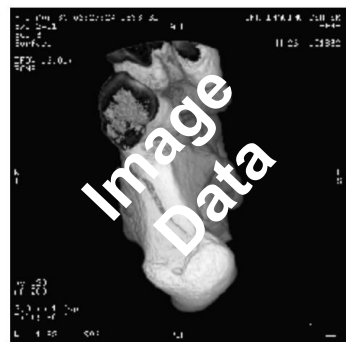
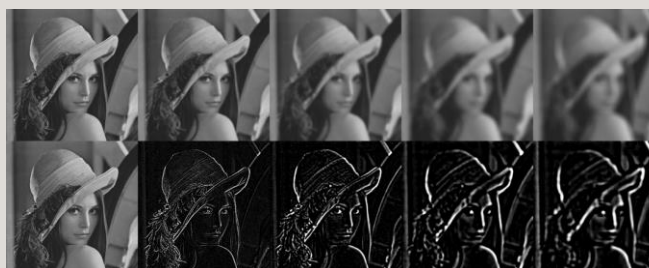


Image Enhancement



Sobel-filter: Edge-sharpening

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

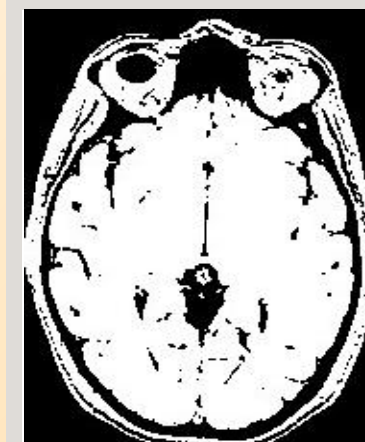
G_x

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

G_y

Image Analysis

Segmentation

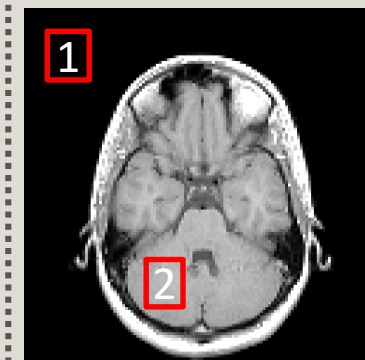


```

load('image.dcm', 'I')
I = im2bw(I, 0.5);
imshow(I, 'DisplayRange', [])

```

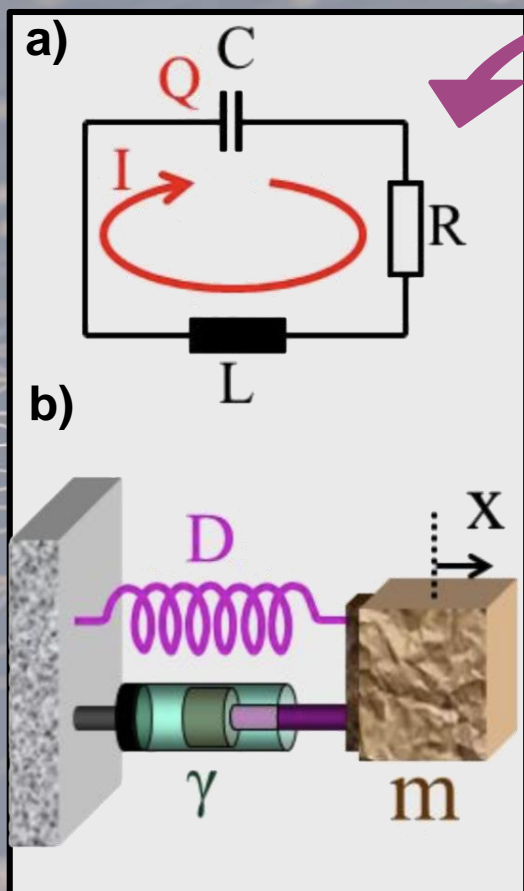
Properties



SNR
CNR

MATLAB: Application in Engineering

Theory of Vibration



Electronics vs. Mechanics

Electronics ↔ Mechanics

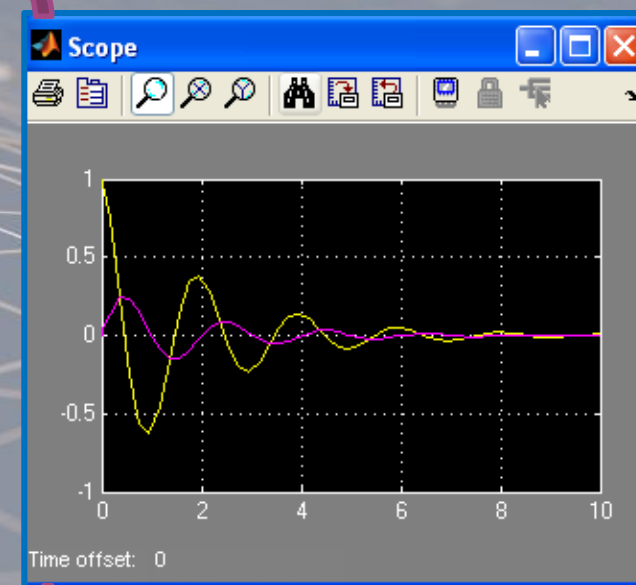
Q	↔	x
1/C	↔	D
R	↔	y
L	↔	m

1. Set up *DE*

$$a) \frac{1}{C} \cdot Q + R \cdot \dot{Q} + L \cdot \ddot{Q} = 0$$

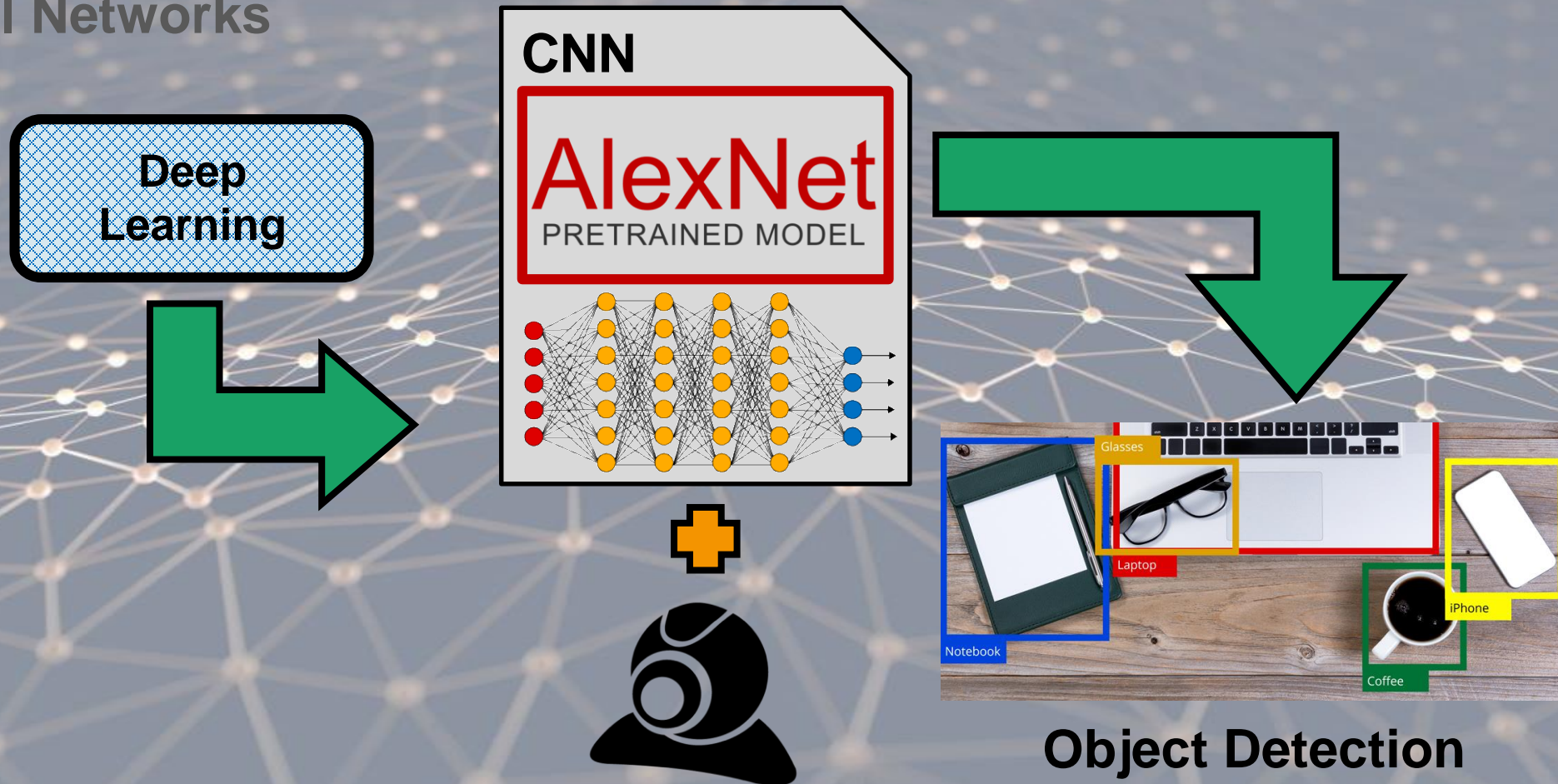
$$b) D \cdot x + y \cdot \dot{x} + m \cdot \ddot{x} = 0$$

2. Solve *DE*



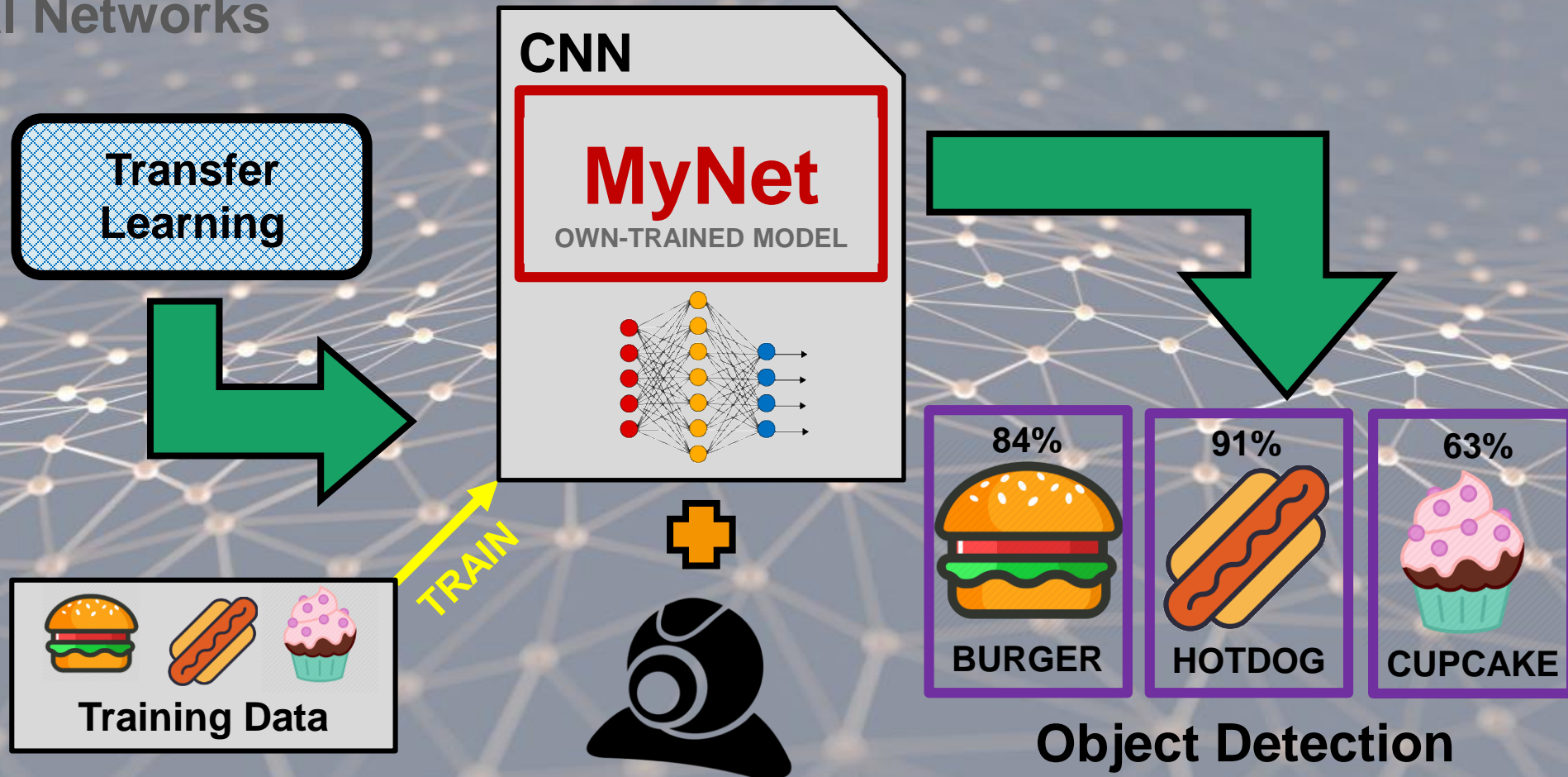
MATLAB Course: Applications

MATLAB: Application in Engineering Neuronal Networks



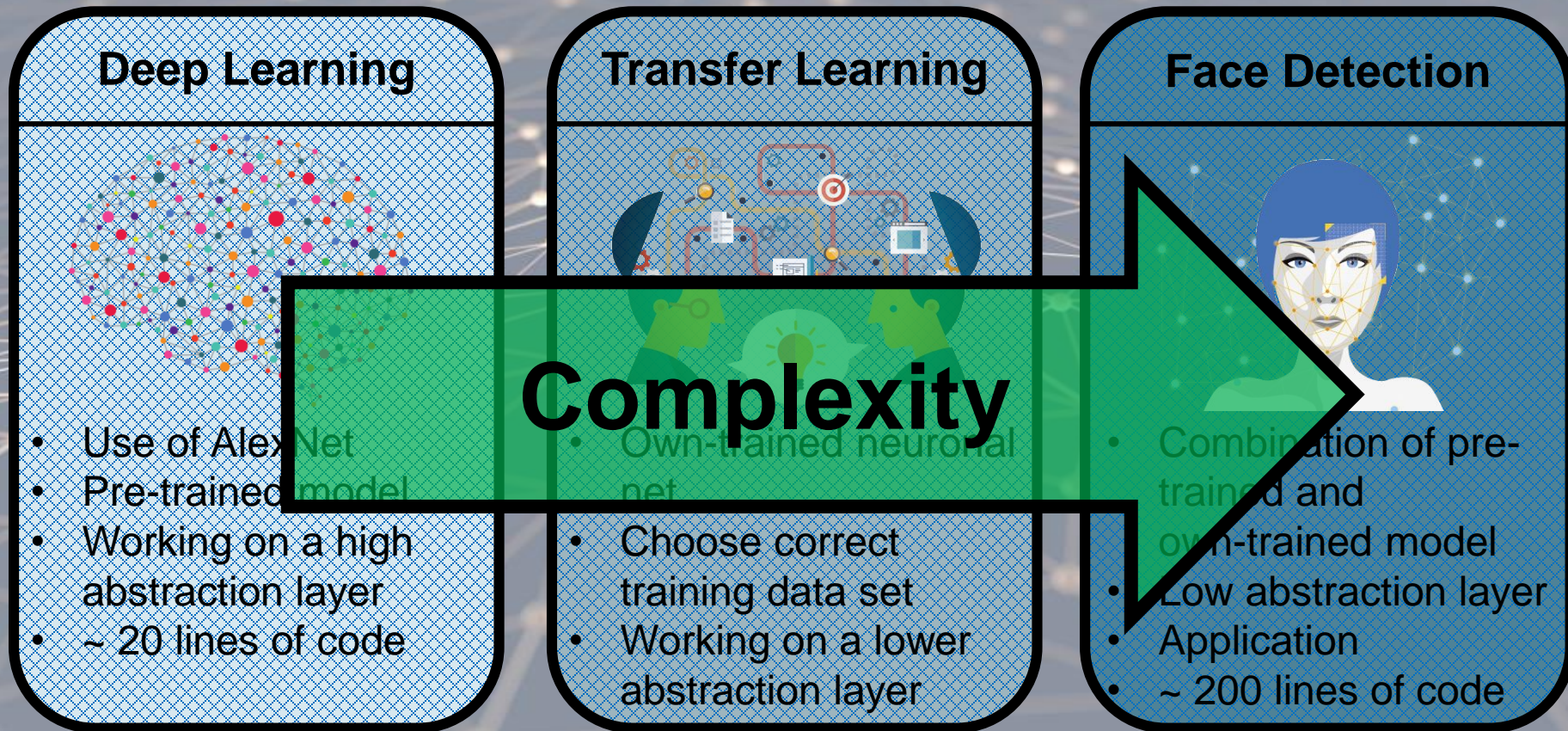
MATLAB: Application in Engineering

Neuronal Networks



MATLAB: Application in Engineering

Neuronal Networks



MATLAB Course: Research Project

MATLAB in research projects



- In-vitro investigation on the influence of ionizing radiation on active medical implants (energy range: 50kV – 15MV, realistic application/test set-up).
- Development of a standardized test method for the functional control of AIMDs under the influence of ionizing radiation.

Cooperation partners:

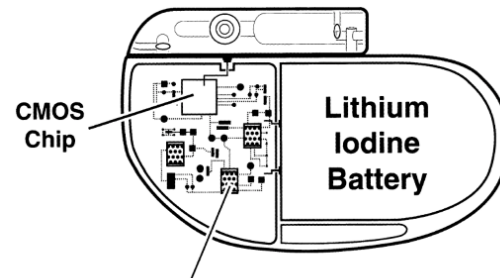


Supported by:

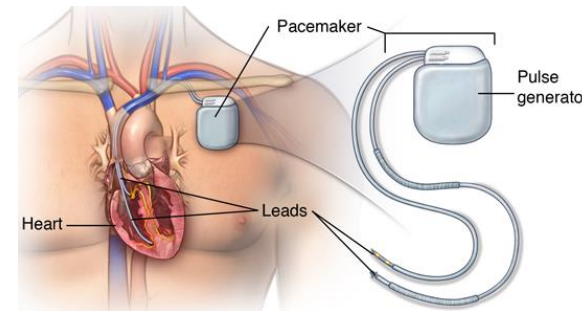


MATLAB Course: Research Project

MATLAB in research projects



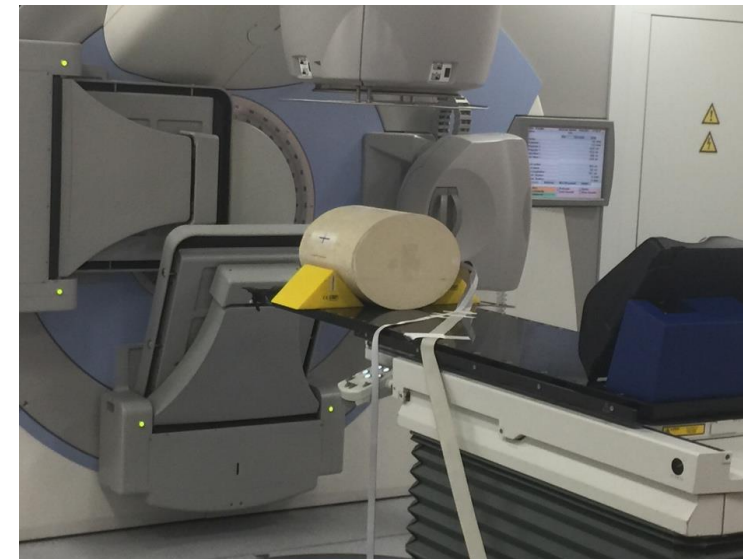
- Oversensing
- Device resets (to initial state)
- Pulse generator damage
- Damage of lead tissue interface
- Reset to factory programming



- Decrease in pacing amplitude
- Decrease in shock energy (ICD)
- Shock coil failure (ICD)
- Total, catastrophic defect

MATLAB Course: Research Project

MATLAB in research projects



MATLAB Course: Research Project

MATLAB in research projects



Data Acquisition



Data Analysis

MATLAB Course

MATLAB Live Editor

MATLAB Live Script: Lecture 01 (Manuel Stich) Statistics & Data Analytics for Medical Engineering

Study subject: parameters in descriptive statistics & data visualization

In der ersten Einheit beschäftigen wir uns mit der deskriptiven Statistik. Die Präsentationsfolien werden durch dieses MATLAB Live-Skript ergänzt. Dabei unterstützen die Textkommentare die Aufgaben und Übungen in MATLAB.

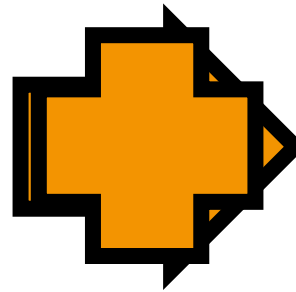
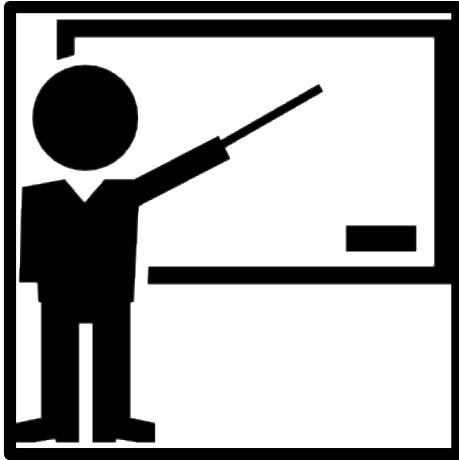
1. Wichtige deskriptive Parameter

```
clear all;  
close all;  
clc;  
  
%% Load a new MATLAB sample data set  
load carbig
```

- Manuscript and code in one document
- Equation/image/text embedding
- Code sectioning and easy structuring
- Result appear next to code

Digital MATLAB Course

Classroom Training



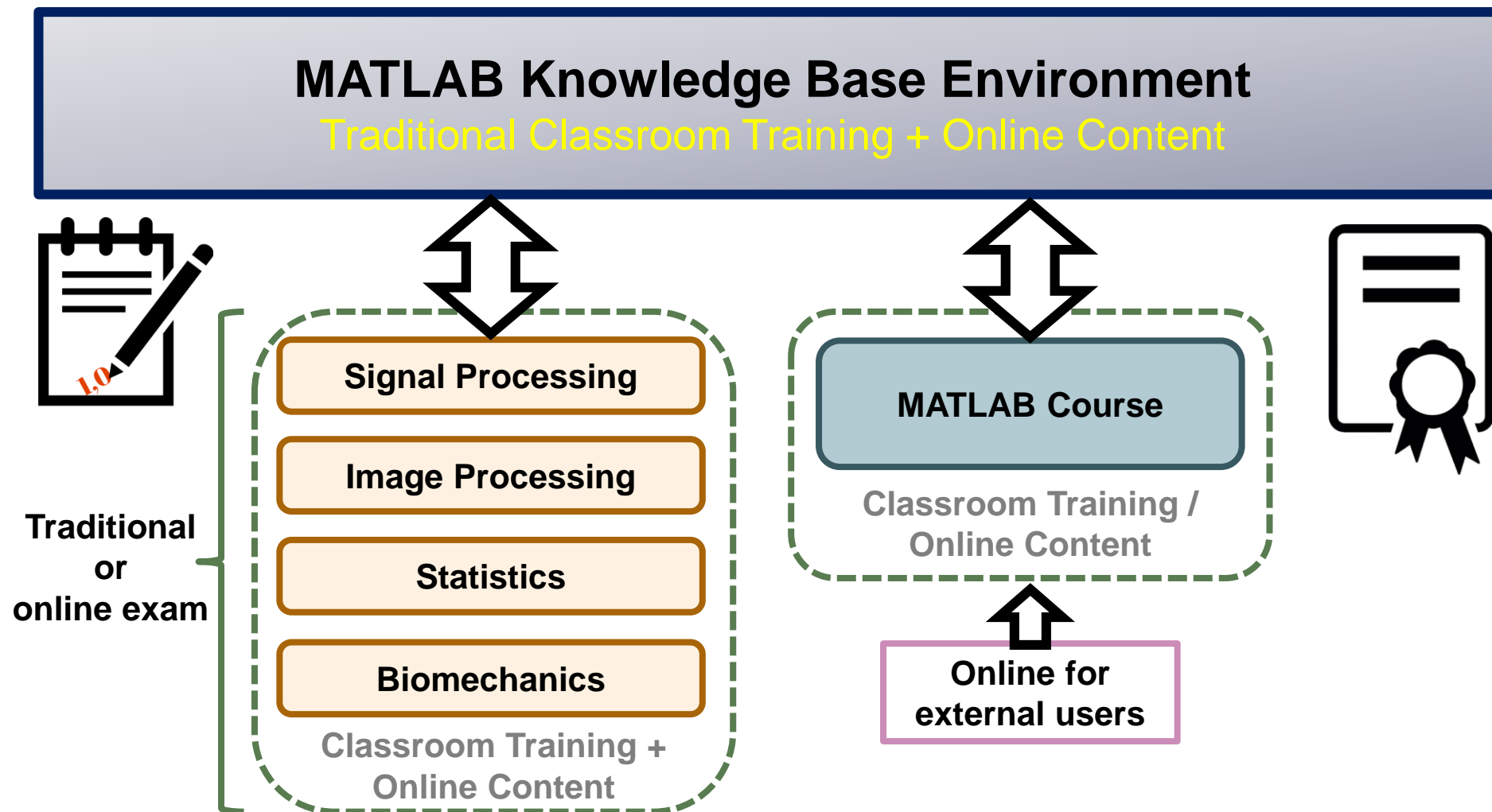
E-Learning



- All participants must be in the same place at the same time
- All participants should have the same relevant prior knowledge so that general learning progress is not hindered
- The learning pace is not individualizable

- Independent of time and place
- No personal contact between the students and the lecturer
- No discussions possible

Digital MATLAB Course



Digital MATLAB Course

Currently integrated subjects

Mechanics

Theory of Vibration

Biomechanics

Image Processing

Diagnostic Imaging

Therapeutical Systems

Statistics

Software Engineering

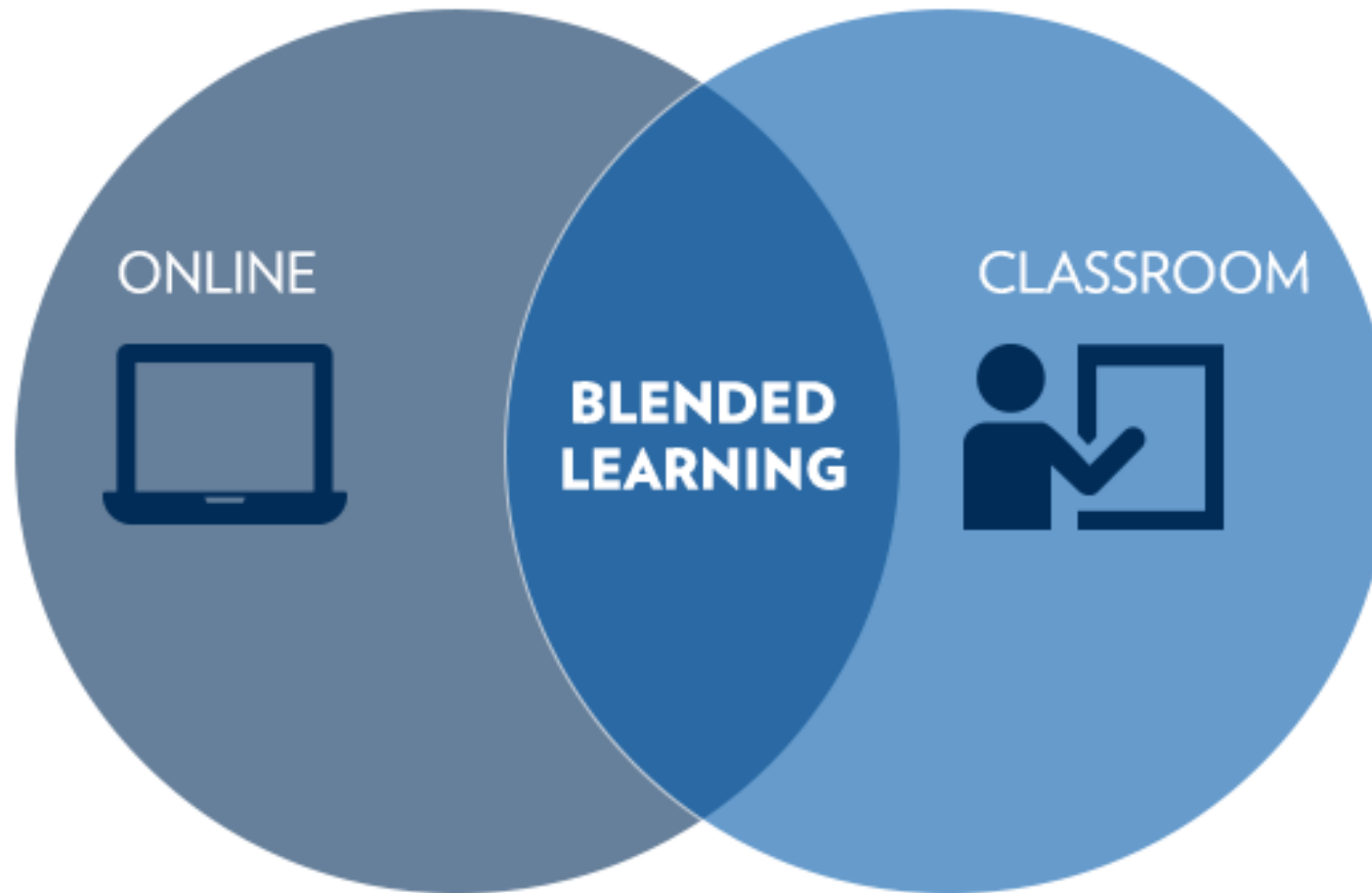
Pattern Recognition

Internships

BA/MA Thesis

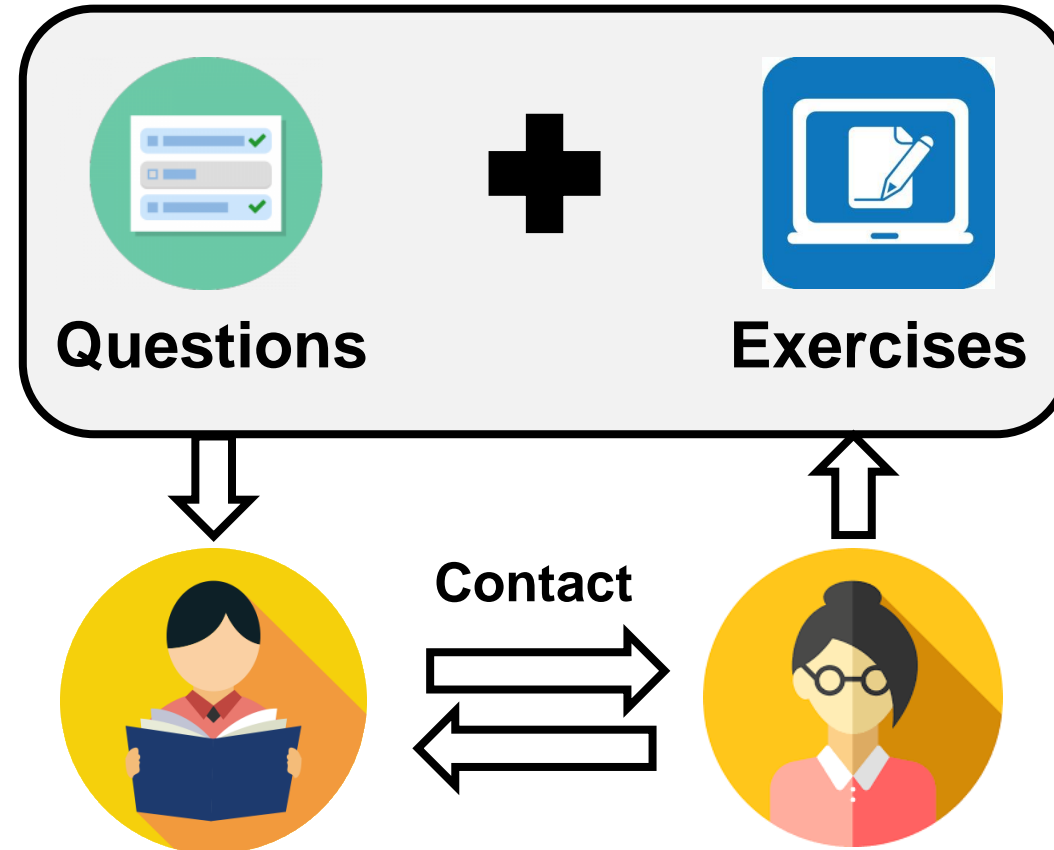
etc.

Digital MATLAB Course



<https://michiganross.umich.edu>

Digital MATLAB Course



- Message-system
- (Online) office hours

MATLAB for Engineers @ Universities



Many Thanks to

- **Prof. Dr. Clemens Bulitta**
Dean, Faculty of Industrial Engineering
- **Prof. Dr. Ralf Ringler**
Professor for Medical Physics,
Great MATLAB Supporter, My Supervisor
- **MathWorks, Munich**
Providing Help, Support with Material

All my students for their
great participation, support
and good suggestions for
improving of the course!