

TDT 4195 - 2019

Visual Computing Fundamentals

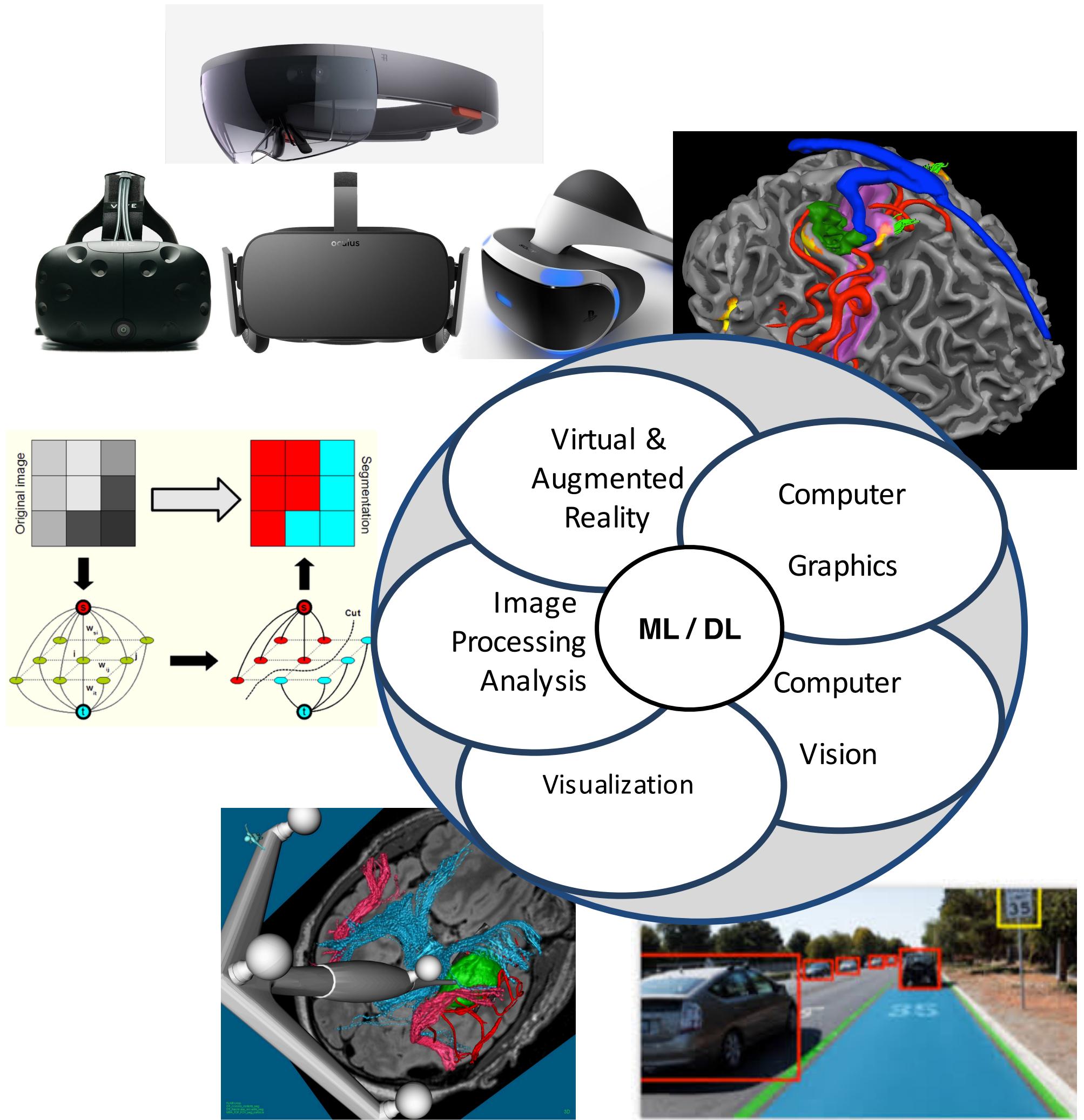
(IP-part)

Info

Frank Lindseth, IDI, IE, NTNU

Frank Lindseth

- Med Im Comp & Viz, **SINTEF** MedTech, 20 years
- **NTNU, IDI, Visual Computing (VC)**, from 2016
 - **Computer Vision & AI / ML / DL**
- Computing group (VC sub-group) @IDI
- Core member of Norwegian Open AI Lab
- Key interest:
 - Autonomous Vehicles (AV)
 - Medical Image Computing (MIC)
 - XR (VR/AR/MR)
 - Digital Twins



Agenda

- Motivation
- Course information
- Image processing (IP) intro
- Spatial filtering: Point processing
- DL: FCNNs, forward pass



NAP Lab (NTNU Autonomous Perception Lab @ IDI, IE, NTNU)

Education, research and innovation related to **autonomous, connected, shared** and electric vehicles in a **nordic** environment



- Focus on converting **sensor** input (camera, LiDAR, radar etc.) to **control** output (steering, throttle, brake and shifting)
- Modular approaches to autonomous vehicles (AVs) (i.e. mapping and localization, perception and prediction, planning and control)
- End-to-end approaches to AVs like imitation and reinforcement learning
- Simulated environments for AVs
- Privacy and Security.
- AVs as mobile sensor platforms (inc. ITS, V2I, V2V, Digital Road Twins, HD maps)
- Mobility as a Service - MaaS (inc. NAPApp)

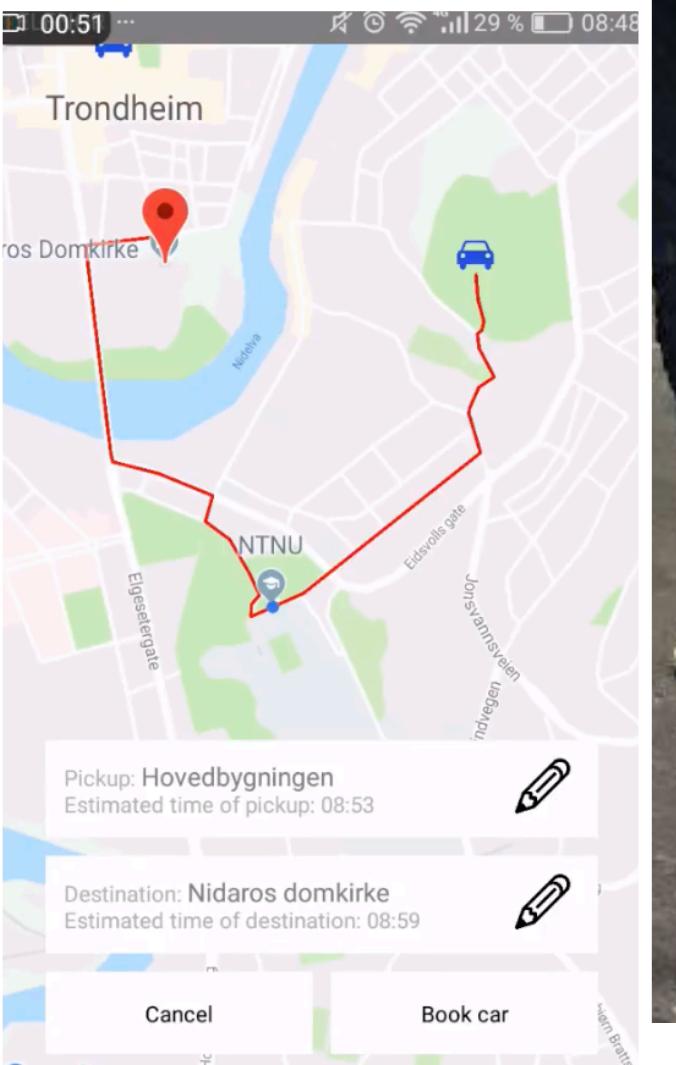
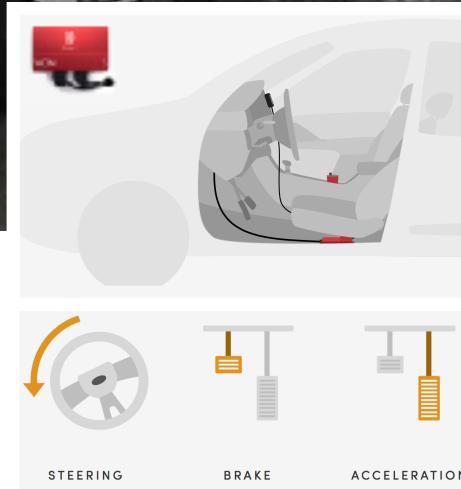


SotA: Waymo (1.48)

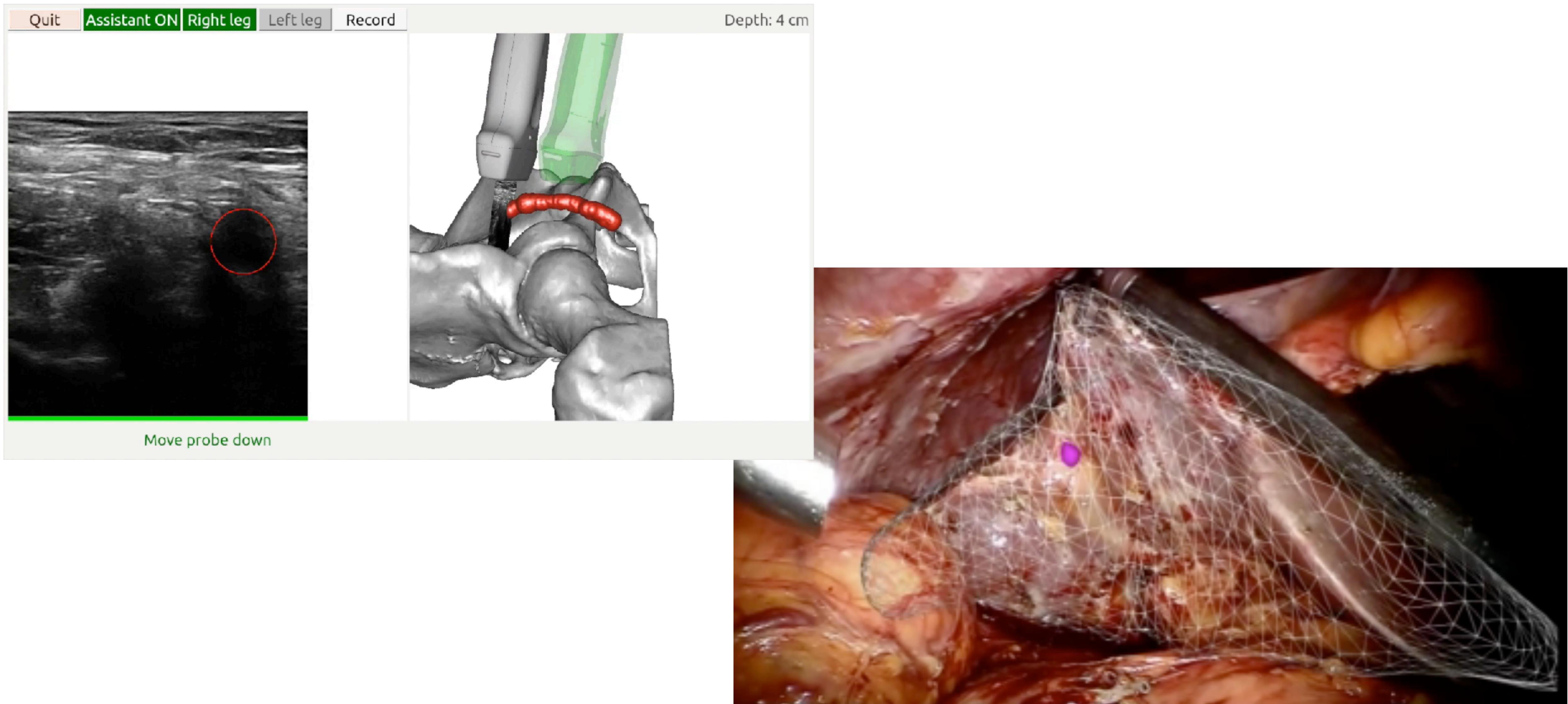
NAP Lab - Web

NAP Lab - YouTube

V#1 V#2 V#3 V#4 V#5



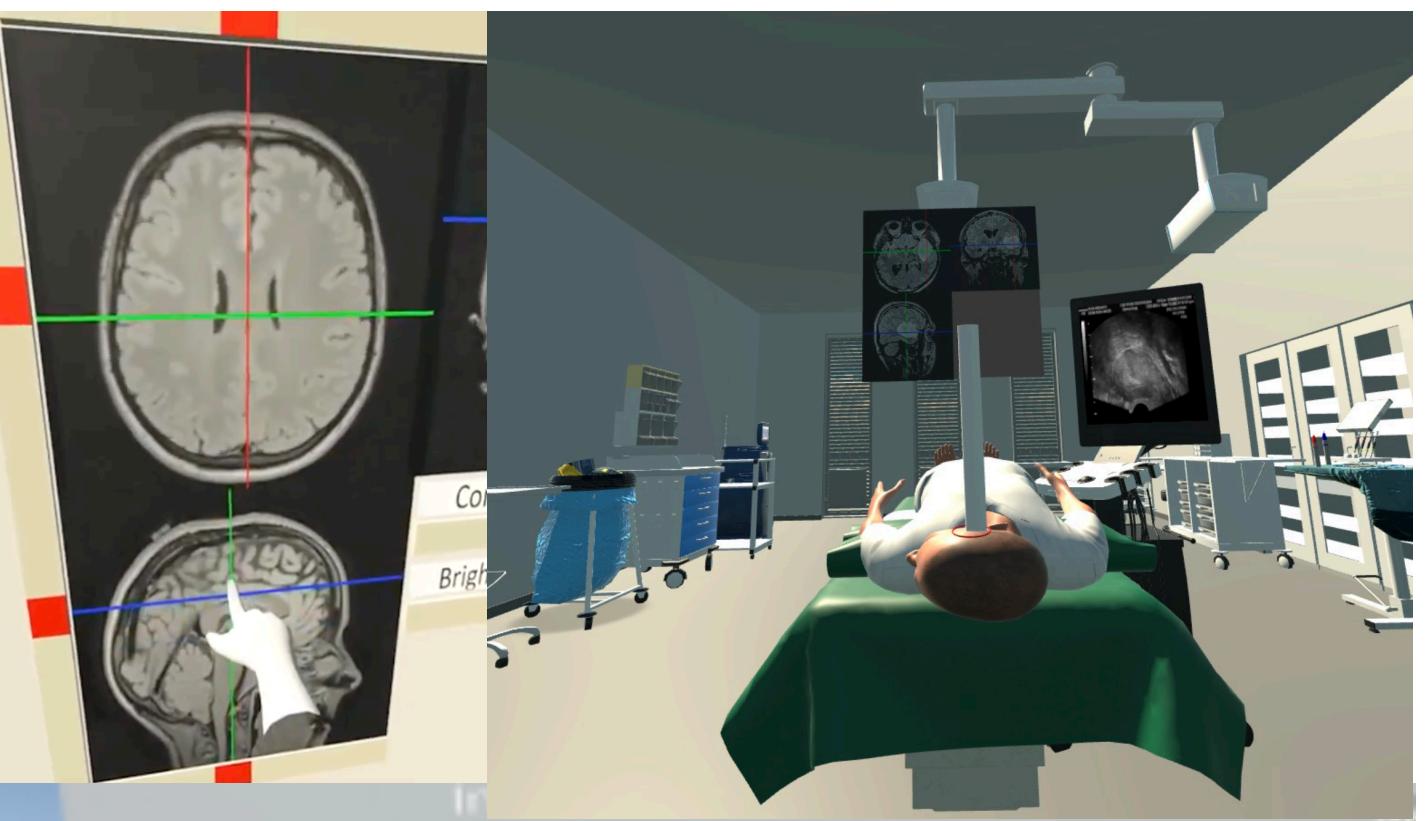
Medical image computing (MIC)





XR

VR & Collaboration: e.g. BIM / DTs
Virtual Hospital / Virtual University (UniVRsity)

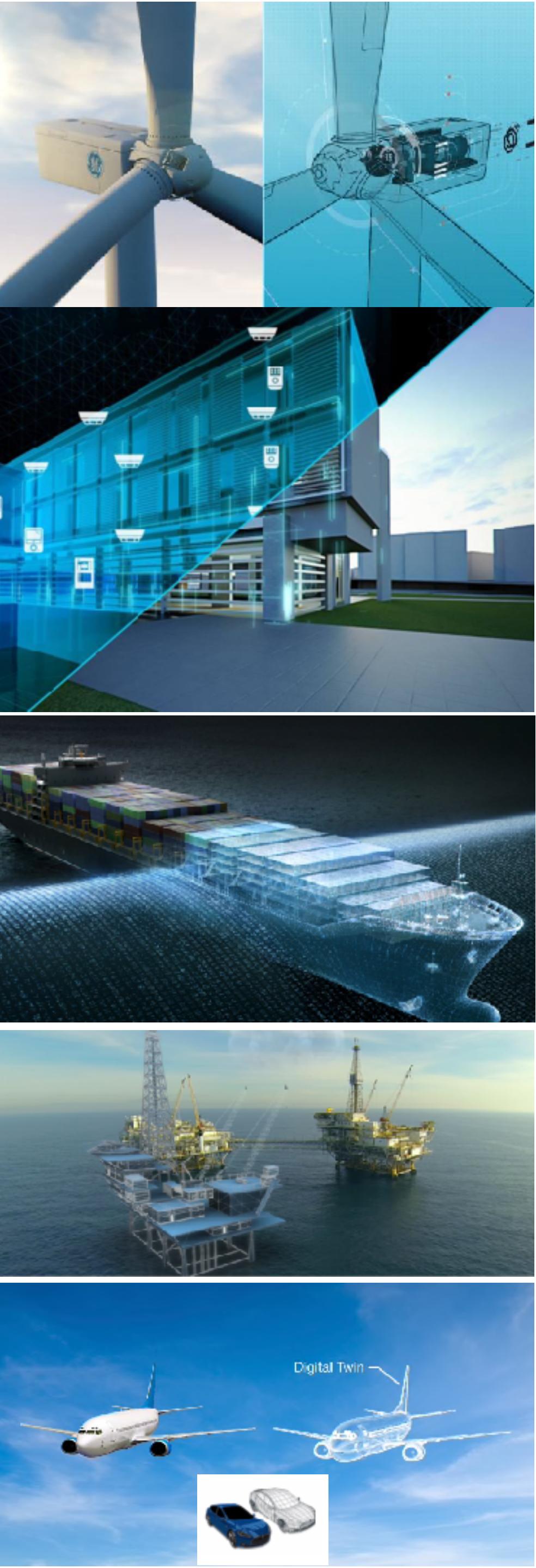


VirSam



XR4AI 1

XR4AI 2



Digital Twins (DTs)

a digital copy or model of a physical object with sensors bridging the two

DTs & Wearables

DTs & Self-management

DTs & Sensors

Digital Twin

DTs & Ethics

DTs & BigData

DTs & AI/ML/DL

DTs & Cloud

DTs & 5G

DTs & XR/VR/AR/MR

DTs & GUI / HCI

DTs & Data Lake

DTs & IoT

DTs & Hybrid models (data + physical models)

DTs & Simulation

DTs & Security

DTs & Trusted and explainable AI (XAI)

DTs & Automation

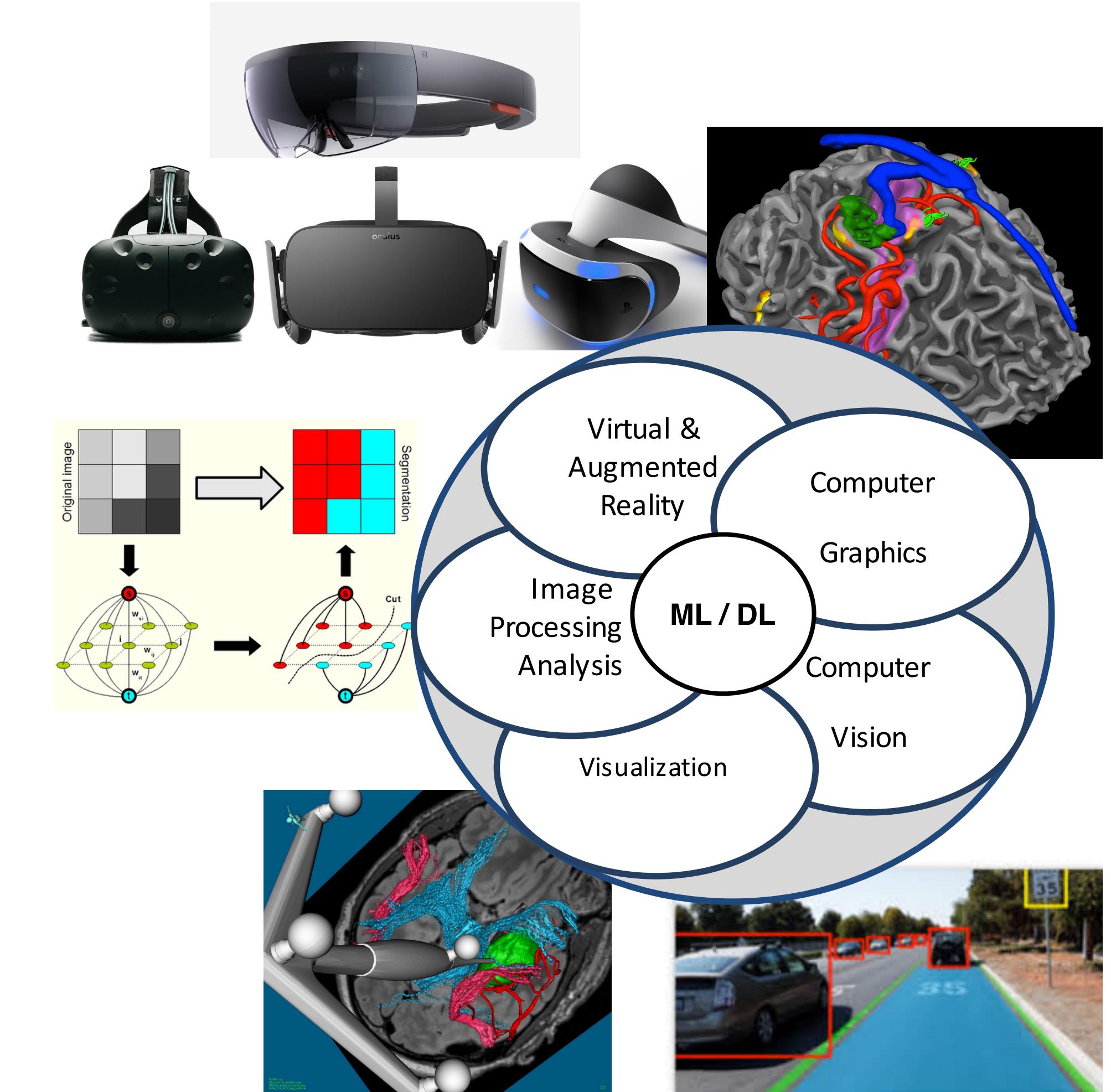
DTs & collaboration

DTs & BIM/GIS/CAD

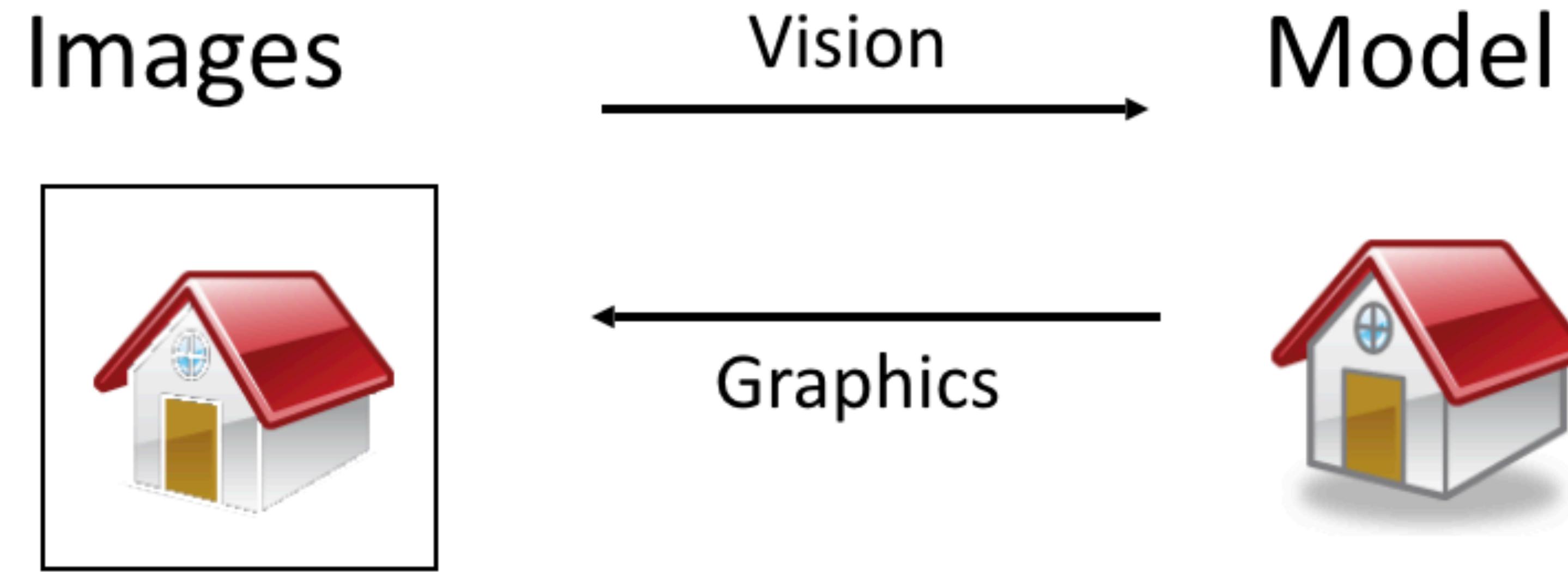
Life-cycle: from before cradle to after grave - planning, design, simulation, optimization, construction & production, monitoring, decision support, automation & control, maintenance, demolition & destruction and historical documentation

Visual Computing

- *Image analysis:*
 - Image processing / image analysis
 - **Computer vision (CV)**
- *Image synthesis:*
 - Computer graphics
 - Visualization
- *XR (VR/AR/MR)*



Computer Vision vs. Computer Graphics



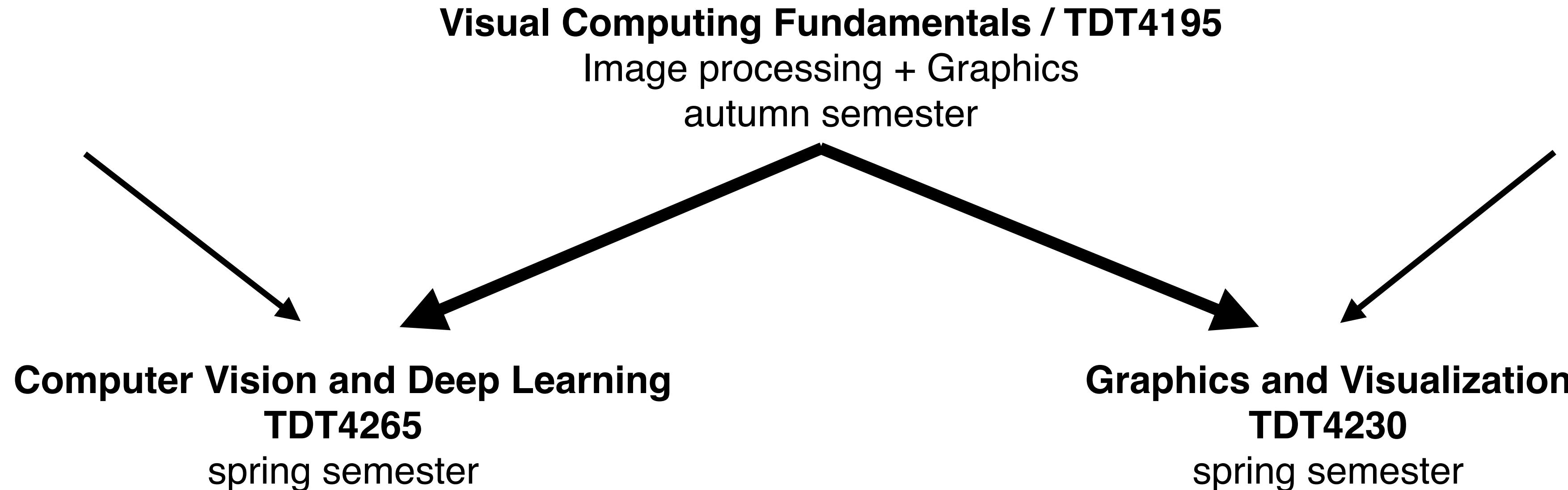
Inverse problems: analysis and synthesis

Image Analysis / Computer Vision

- Making sense of images / video.
- Make computers understand images and video.
- What kind of scene?
- Where are the cars?
- How far is it to the building?



VC courses at NTNU / IDI



Schlumberger Price in VC

- The aim of this prize is to stimulate students to follow this important area of computing
- It is offered at the end of each academic year to the best performing student within the three Visual Computing courses:
 - TDT4195: Visual Computing Fundamentals
 - TDT4230: Graphics and Visualization
 - TDT4265: Computer Vision and Deep Learning
- Normally it is awarded to a student who has taken all 3 courses.
- THE VALUE OF THIS PRIZE IS NOK **25 000**



TDT 4195:
Image Processing (IP) part
Course Info

People involved (IP part)

- **Teaching (IP):**
 - Frank Lindseth: frankl@ntnu.no
- **Teaching assistant (IP):**
 - Håkon Hukkelås: hakon.hukkelas@ntnu.no
- **Student assistant (IP):**
 - Navjot Singh: navjots@stud.ntnu.no

When & where (IP-part)

- **Course info**
- **Lectures:**
 - Wednesdays: 14:15 - 16:00 in S1 (Sentralbygget)
 - Thursdays: 12:15 - 14:00 in KJL2 (Kjelhuset)
- **Assignments (lab hours):**
 - Tuesdays: 14:15 16:00 in «Cybele»
 - Thursdays: 14:15 16:00 in «Cybele»

Timeline (IP-part)

- Academic calendar
 - Teaching period: Aug 19 - Nov 22 (week 34 - 47)
 - Teaching period IP-part: Oct 7 - Nov 22 (week 41 - 47 = 7 weeks)
 - **First lecture IP part:** Wednesday Oct 9, 14:15 - 16:00 in S1 (Sentralbygget)
 - **First assignment IP part:** Out: week 41, In: week 43 (Oct 25)
 - Examination period: Nov 25 - Dec 20 (week 48 - 51)
 - Exam: **2019-11-28 at 15:00** (Thursday, week 48, digital exam)

Content (IP-part)

- Info / Motivation / Intro
- Spatial domain
- Intro to DL-based Image Analysis
 - FCNNs and Forward / Backward pass
 - CNNs and Image Classification
- Frequency domain
- Segmentation
- Morphology

Schedule (Lectures)

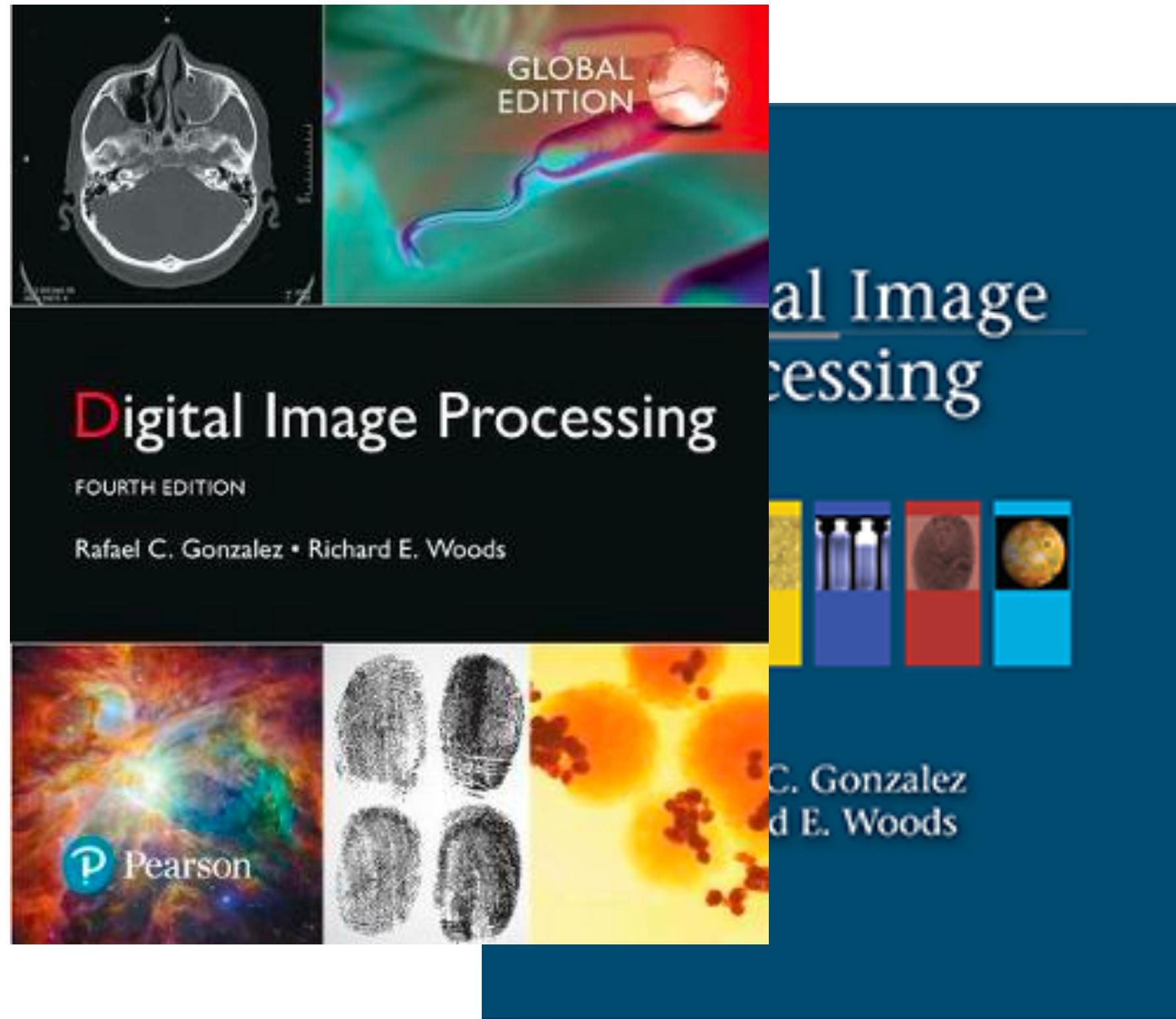
Type	Week	Day	Date	Time	Where	Topic (away)
Lecture	41	Wed	Oct. 09	14:15 - 16:00	S1	Info, motivation and intro
Lecture	41	Thu	Oct. 10	12:15 - 14:00	KJL2	Spatial domain 1 & DL:FCNN
Lecture	42	Wed	Oct. 16	14:15 - 16:00	S1	(KI-KTH eval)
Lecture	42	Thu	Oct. 17	12:15 - 14:00	KJL2	DL: FCNN
Lecture	43	Wed	Oct. 23	14:15 - 16:00	S1	Spatial domain 2
Lecture	43	Thu	Oct. 24	12:15 - 14:00	KJL2	(Inspiration day)
Lecture	44	Wed	Oct. 30	14:15 - 16:00	S1	DL:CNNs (Image classification)
Lecture	44	Thu	Oct. 31	12:15 - 14:00	KJL2	Frequency domain
Lecture	45	Wed	Nov. 06	14:15 - 16:00	S1	Segmentation
Lecture	45	Thu	Nov. 07	12:15 - 14:00	KJL2	(Unimore)
Lecture	46	Wed	Nov. 13	14:15 - 16:00	S1	Morphology
Lecture	46	Thu	Nov. 14	12:15 - 14:00	KJL2	(EiT-DT)
Lecture	47	Wed	Nov. 20	14:15 - 16:00	S1	«Leftovers 1»
Lecture	47	Thu	Nov. 21	12:15 - 14:00	KJL2	«Leftovers 2»

Tentative plan, could change, will be notified

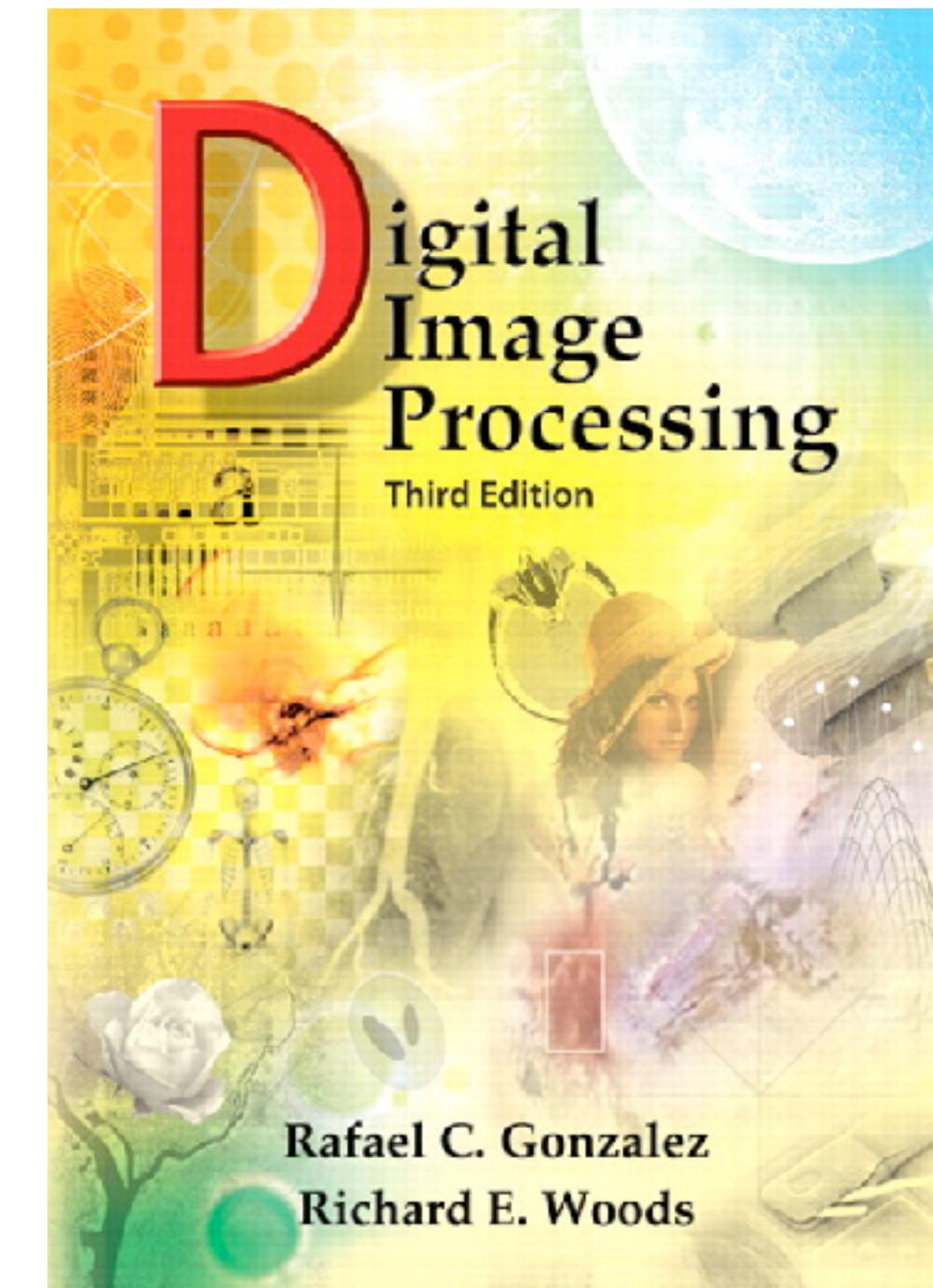
Assignments (IP-part: 15%)

- **Assignment 1:** Deadline: 25th of October
 - Content: Filtering in the Spatial Domain, Fully Connected Neural Networks (FCNNs), Backpropagation
- **Assignment 2:** Deadline: 8th of November
 - Content: Convolutional Neural Networks (CNNs), Image Classification, Filtering in the Frequency Domain
- **Assignment 3:** Deadline: 22nd of November
 - Content: Segmentation, Morphology

Material (books etc.)



IP & DL



IP & DL

Neural Networks and Deep Learning

Neural Networks and Deep Learning is a free online book. The book will teach you about:

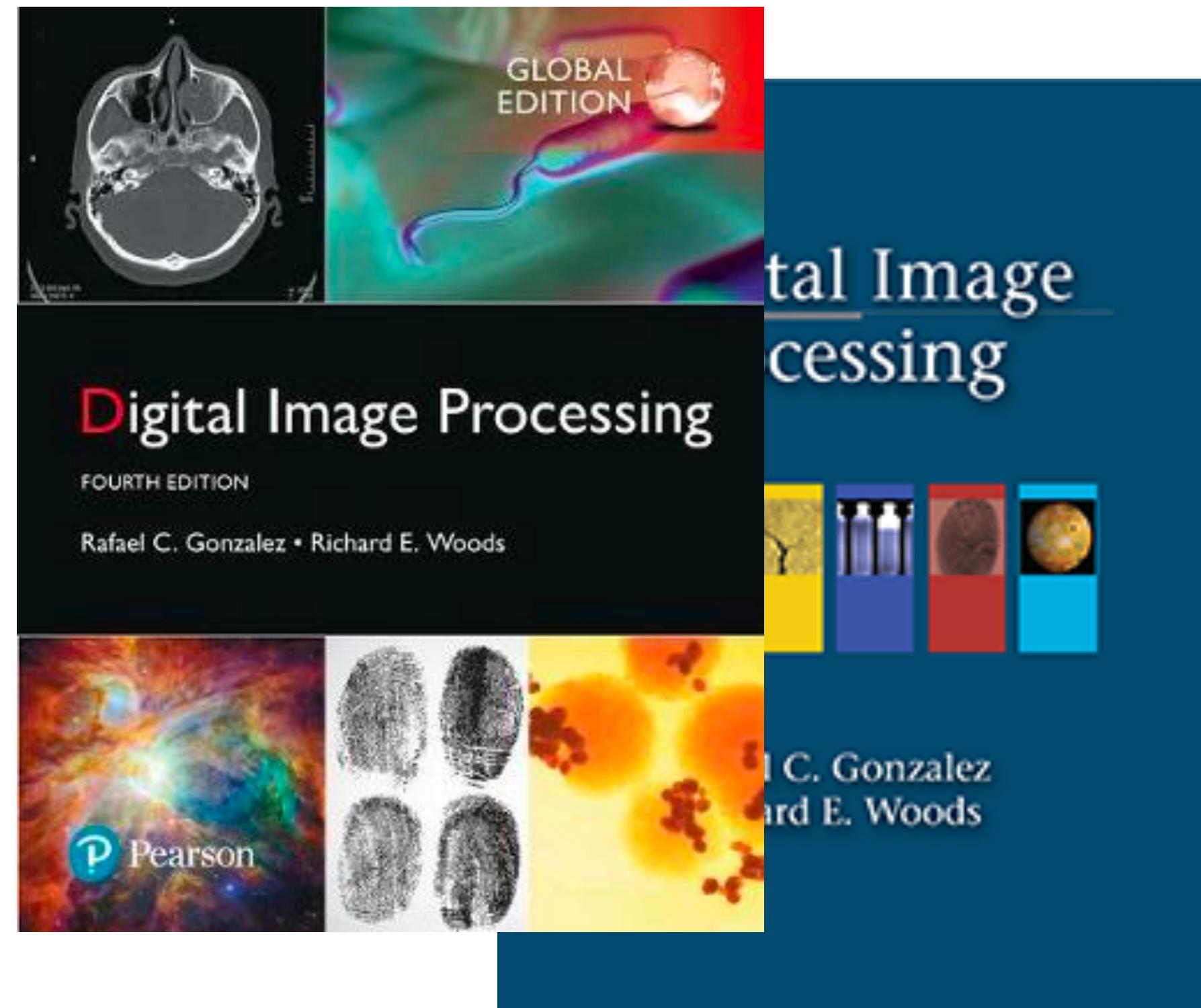
- Neural networks, a beautiful biologically-inspired programming paradigm which enables a computer to learn from observational data
- Deep learning, a powerful set of techniques for learning in neural networks

Neural networks and deep learning currently provide the best solutions to many problems in image recognition, speech recognition, and natural language processing. This book will teach you many of the core concepts behind neural networks and deep learning.

For more details about the approach taken in the book, [see here](#). Or you can jump directly to [Chapter 1](#) and get started.

Book: Digital Image Processing, 4th edition

Digital Image Processing, Global Edition



IP & DL

Basic Information

ISBN number 9780133356724.

Publisher: Pearson

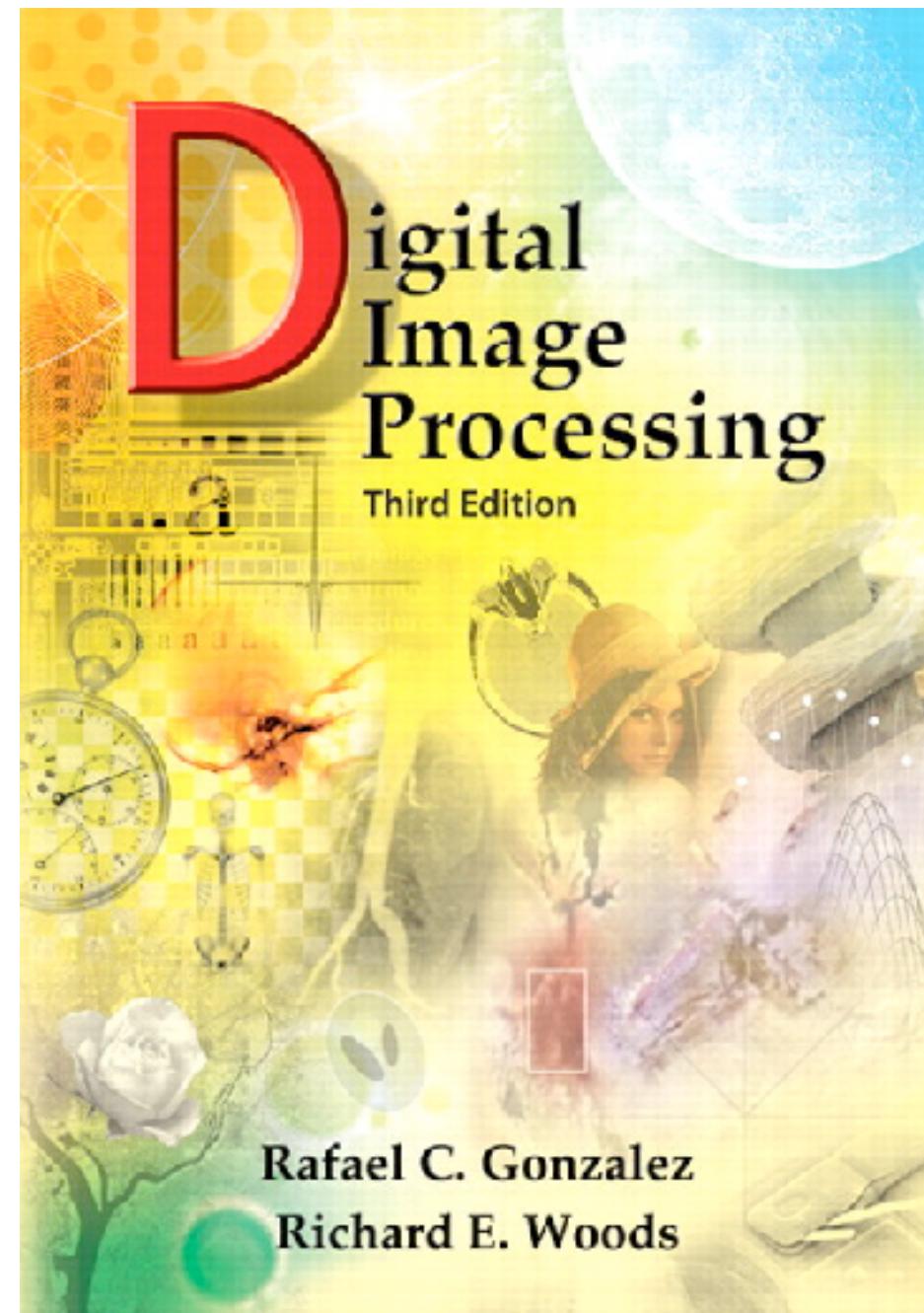
13 chapters.

1168 pages.

© 2018.

<http://www.imageprocessingplace.com>

Book: Digital Image Processing, 3rd Edition



Title: *Digital Image Processing, 3rd Edition*

Authors: Gonzalez & Woods

ISBN number: 9780131687288

Copyright: 2008

<http://www.imageprocessingplace.com>

http://www.imageprocessingplace.com/DIP-3E/dip3e_main_page.htm

http://www-elec.inaoep.mx/~jmram/Digital_Image_Processing_GONZALEZ.pdf

Additional books

Neural Networks and Deep Learning

Neural Networks and Deep Learning is a free online book. The book will teach you about:

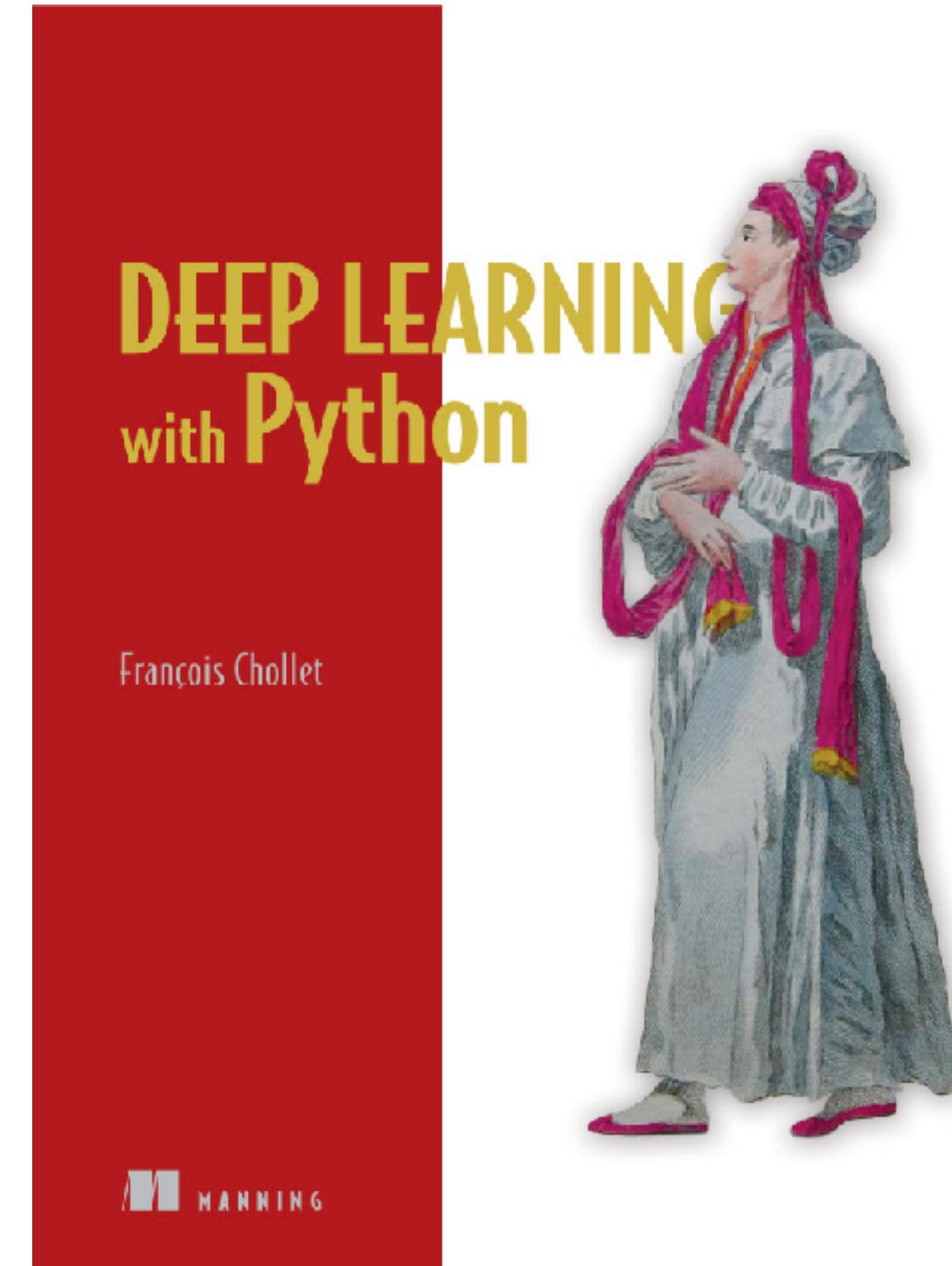
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[**Nilsen: Neural Networks and Deep Learning \(Chap 2 and 6\)**](#)

[**3Blue1Brown: Neural Network**](#)



[**Chollet: Deep Learning with Python**](#)

[**\(practical\)**](#)

Additional information

- «Own stuff»:
 - TheBook (2017)
 - Video Challenge in TDT4265 (2016), IP part

Programming language

- **Python** ((MATLAB)) is recommended (easier to get help, considered good tools for learning image processing in an experimental way, python preferred in terms of DL, preferred DL framework is PyTorch).

Useful tools

- Colaboratory (Jupyter Notebooks)
- Python Numpy Tutorial
- Companion Jupyter notebooks
- Math / LinAlg.
 - Essential Math for Data Science
 - Basic Linear Algebra for Deep Learning
- DL-frameworks
 - Keras (Tensorflow): Introducing Keras, Keras tutorial
 - **PyTorch**: PYTORCH TUTORIALS

Preferred way if you have questions related to the course:

- Discussion Forum
- Ask directly:
 - During the lecture breaks (Frank)
 - During lab hours (Håkon)
- Sending an email and / or agreeing on an appointment is also possible (emails should not be sent directly to the student assistant).