Digital Support of the Maritime Sector
Classification of objects

Rom, 06.12.2018

Dr.-Ing. Kristine Bauer

Prof. Uwe Freiherr von Lukas

Fraunhofer-Institut für Graphische Datenverarbeitung - IGD
Dept. Maritime Graphics

Joachim-Jungius-Str. 11
18059 Rostock / Germany

Tel.: +49 381 4024 100
Fax: +49 381 4024 199

Email: Kristine.Bauer@igd-r.fraunhofer.de

http://www.igd-r.fraunhofer.de

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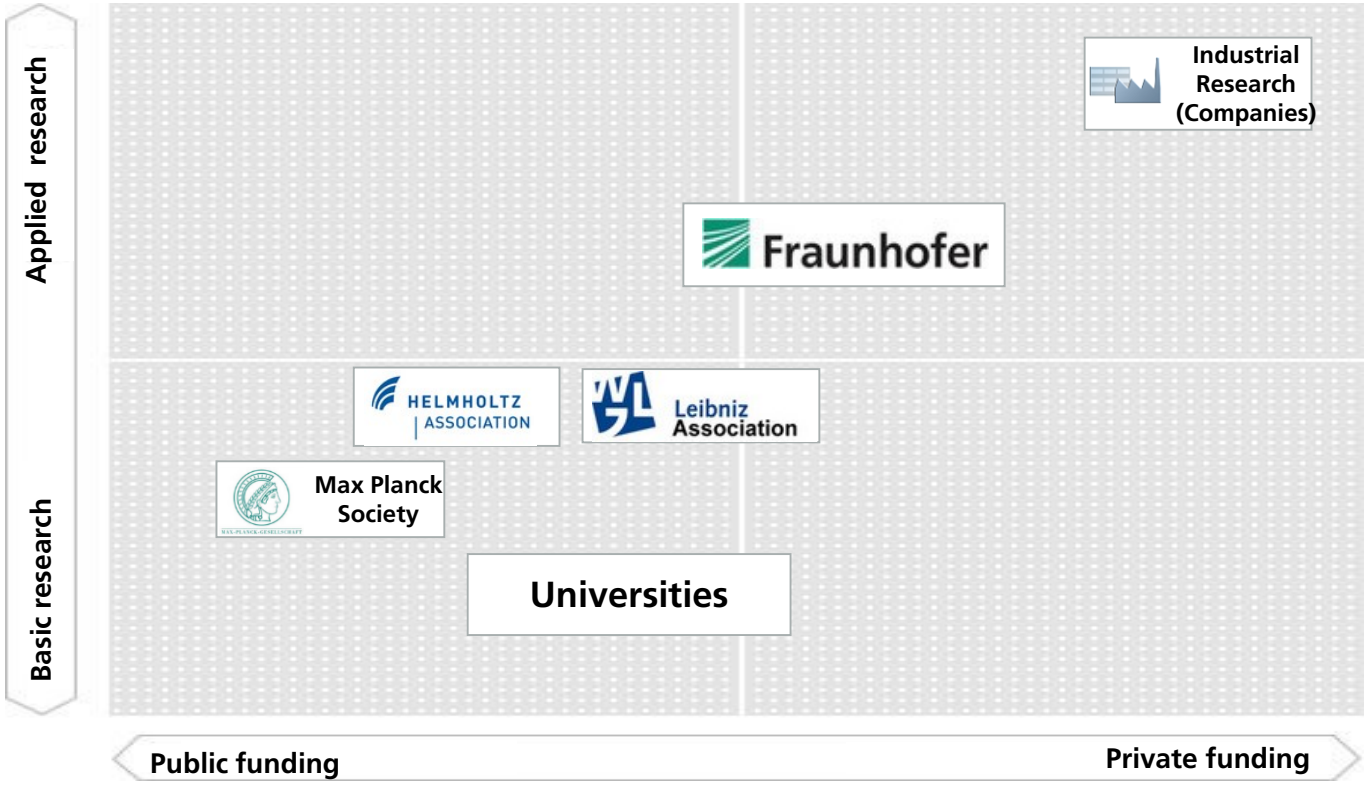
Outline

1. Fraunhofer
2. Basics and Applications of Visual Computing
    1. Color correction
    2. Detail enhancement
3. Basics and Applications of Computational Intelligence
    1. Neuronal Nets
4. Munitect
5. Future work

The German Research Landscape



Source: BMBF Germany (simplified)

The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society.

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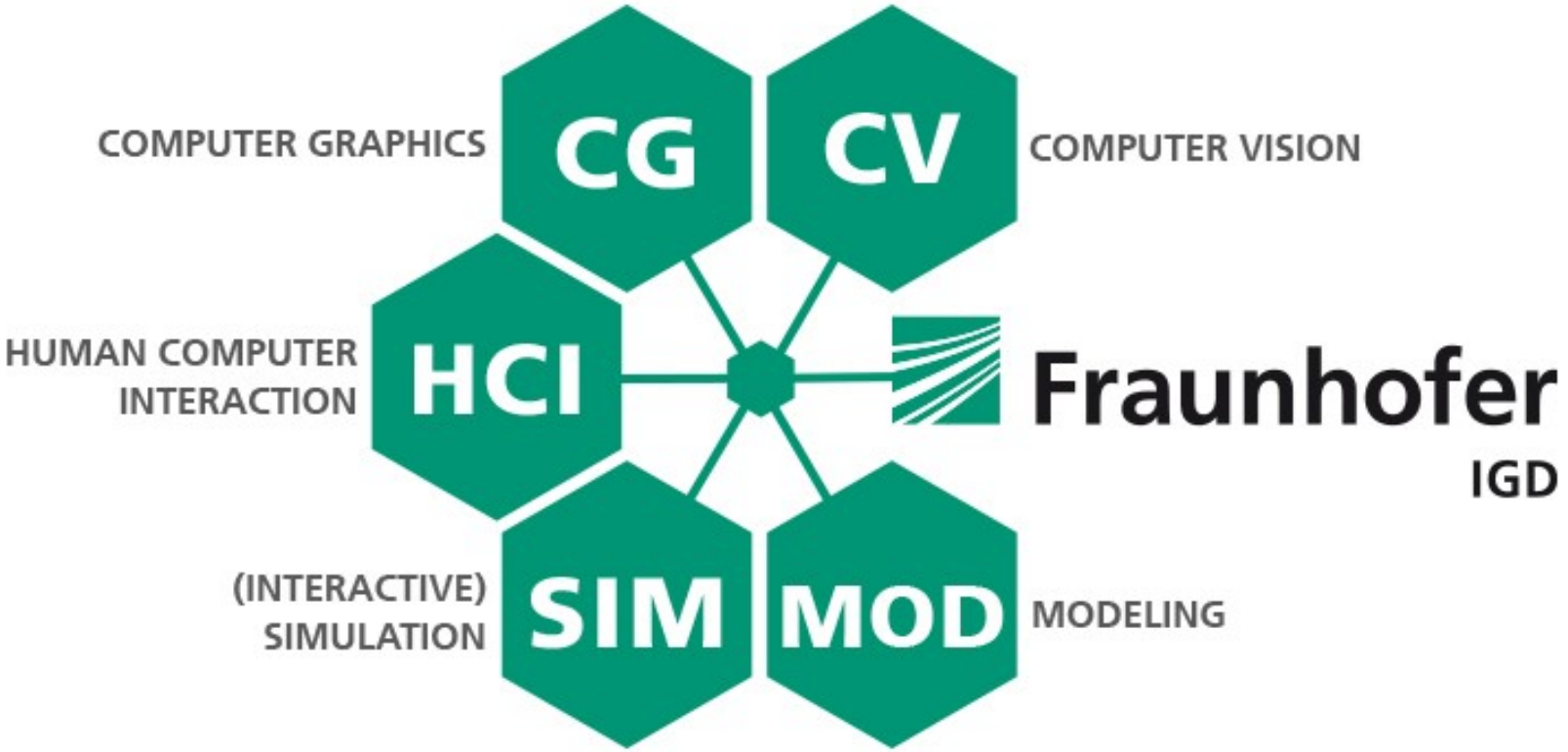
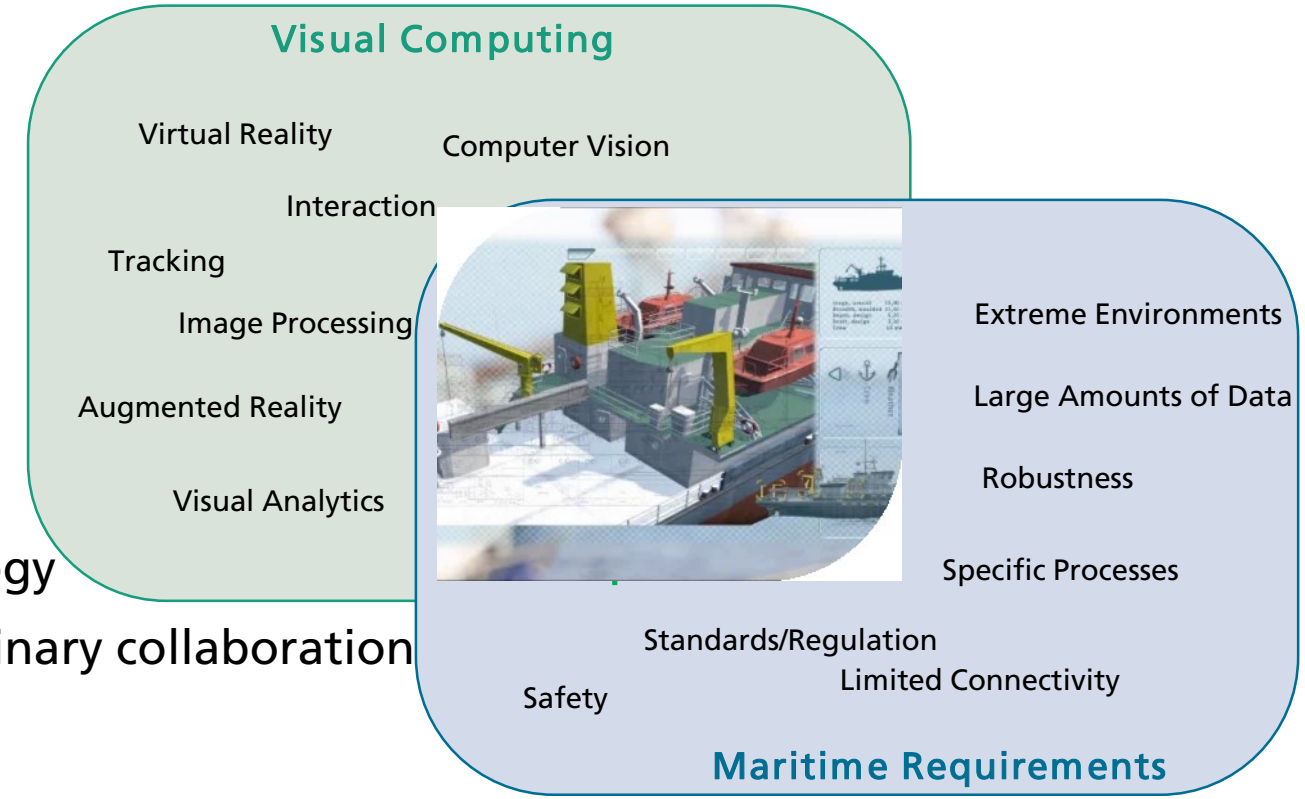
Research Areas in Visual Computing



Maritime Graphics: Visual Computing for the maritime sector

- Growing research team of Fraunhofer IGD in Rostock
- Target industries
  - Shipbuilding
  - Ship operation
  - Offshore
  - Marine Technology
- Strong interdisciplinary collaboration



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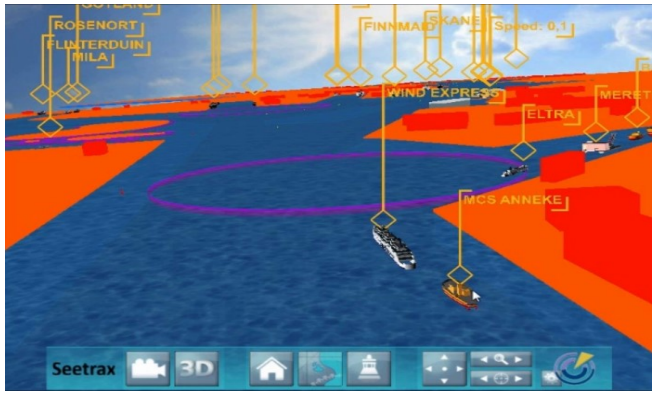
Maritime 4.0: Supporting E-Navigation

Advanced visualization and interaction using

- Sea charts
- Terrain data
- Sensor data
- Traffic data
- Simulated data

in various maritime application areas

- Ship operation
- Port operation and security
- Marine research
- Marine mining



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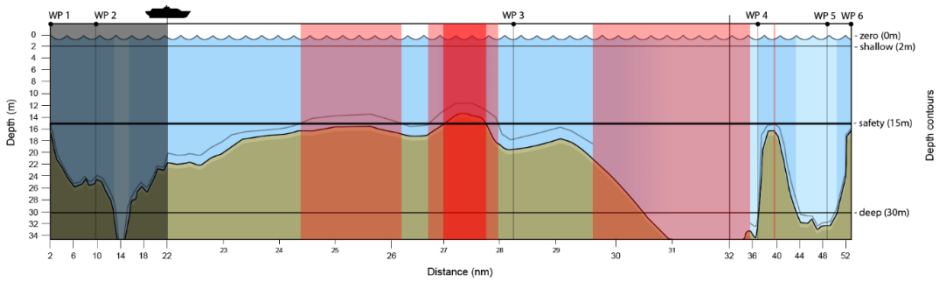
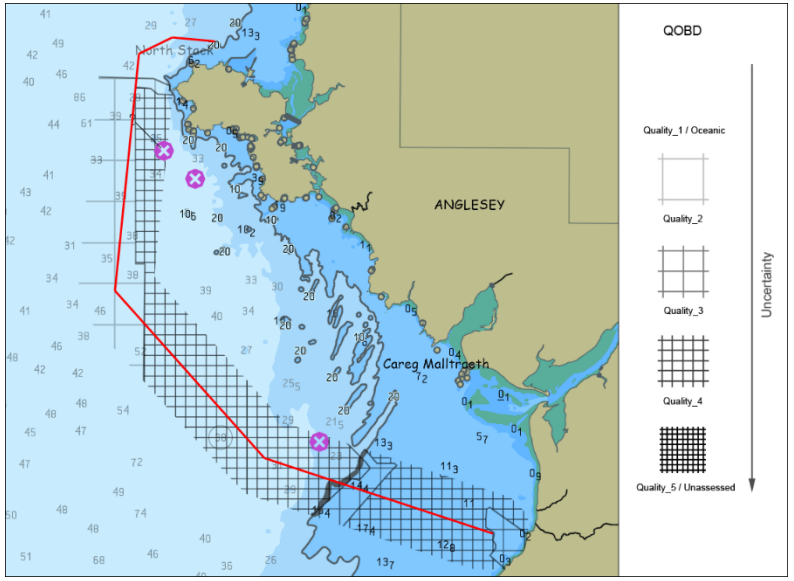
Maritime 4.0: Visualization of data uncertainty in electronic sea charts

Feasibility study

- Objective: New approach for visualization of data uncertainty (bathymetry data sets) in ECDIS
  - As input for IHO standard S-101
- Customer: Federal Maritime and Hydrographic Agency
- Applications:
  - Planning safe shipping routes
  - Monitoring under keel clearance





Digital Ocean Lab: Infrastructure for efficient testing of underwater technologies

https://www.youtube.com/watch?v=On5BQRmdOkk

SMN
subsea monitoring network

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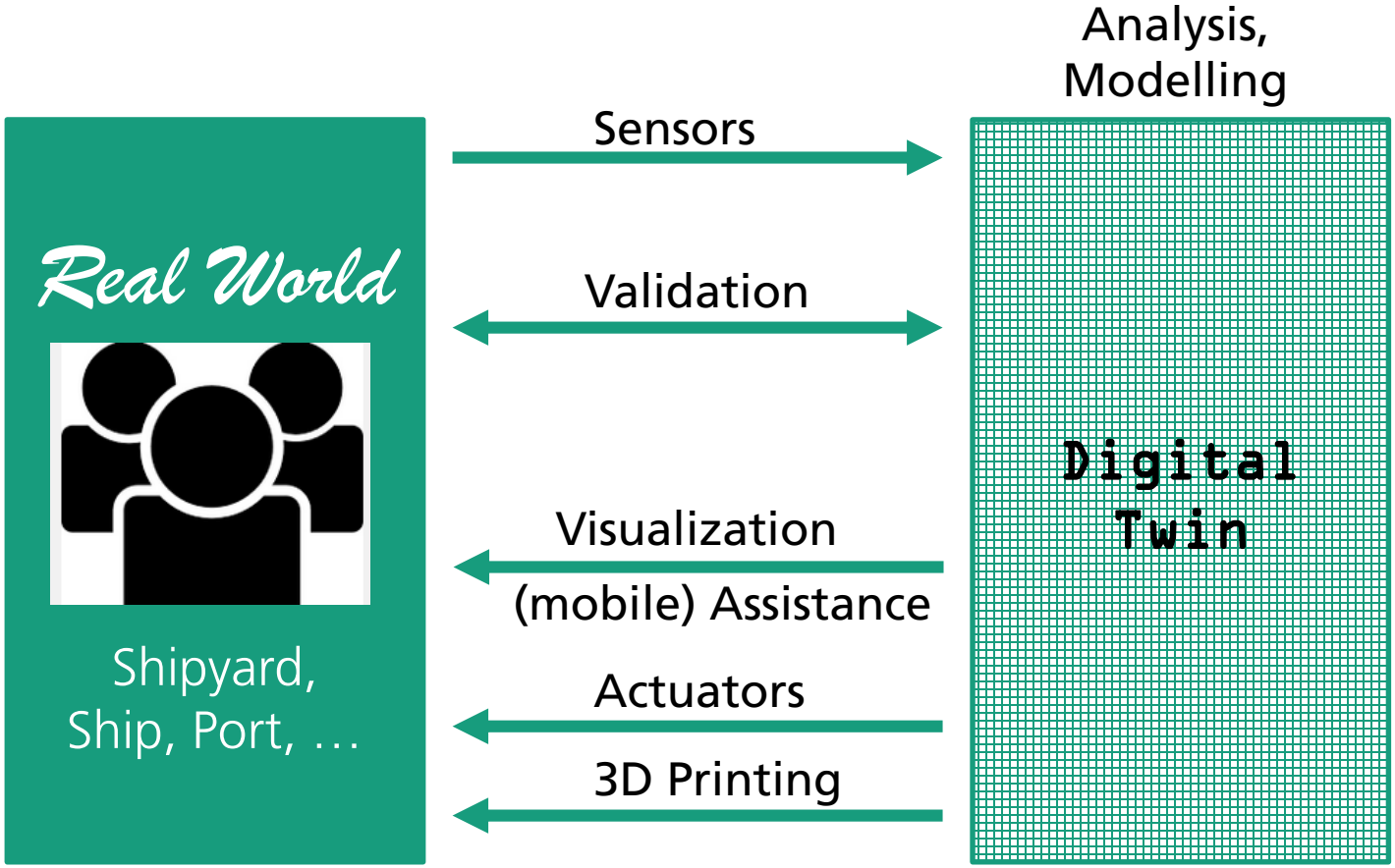
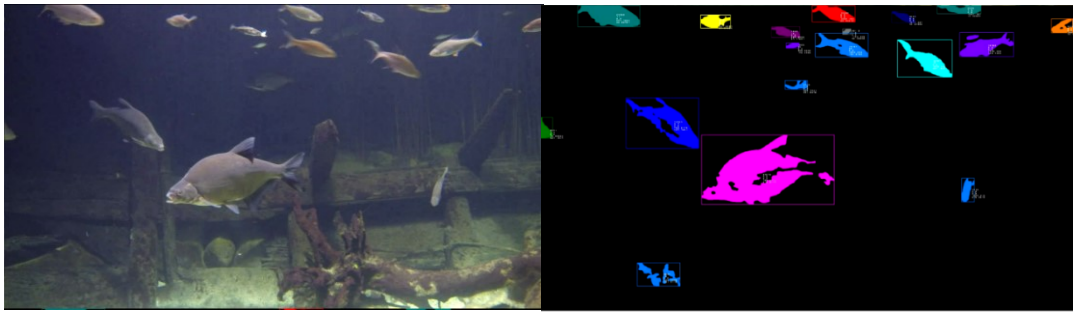
Technology view
Basics of Visual Computing



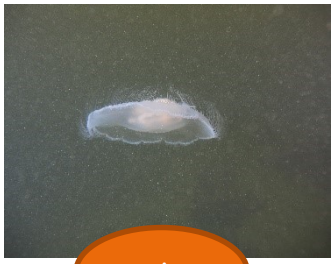
Topic: Images and Videos

The quality of underwater images plays a pivotal role in scientific missions:

- Geological or biological research
- Military
- Advanced image processing
- …

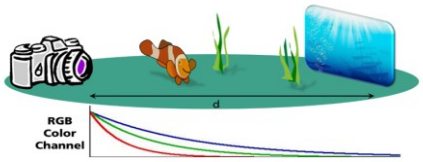


General challenges

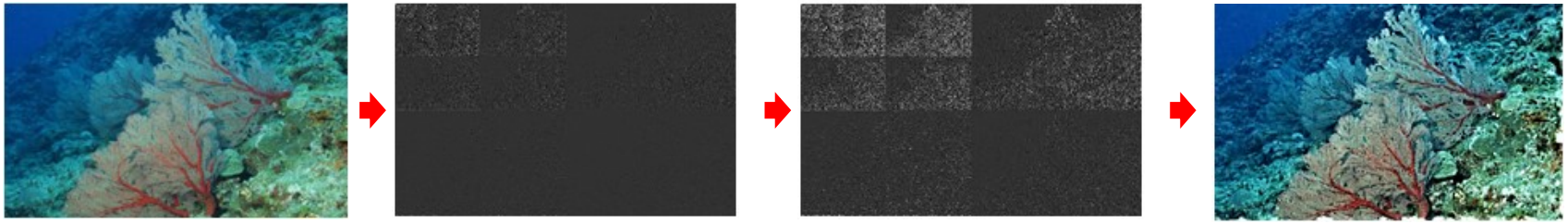


Developed Solution: Color Correction, Detail Enhancement

- Color correction supported by distance information
  - Feature based
  - General objects based



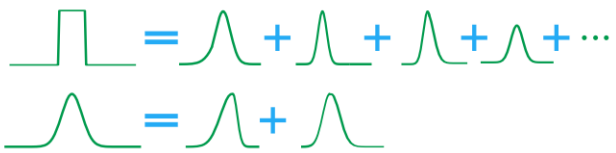
- Image enhancement in wavelet domain
  - Multi-scale analysis
  - Isolate edge channel [1]



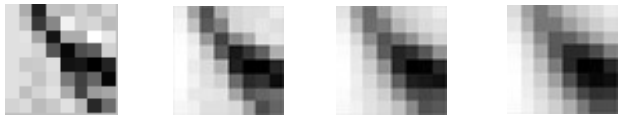
[1] Fattal, R. (2009). Edge-avoiding wavelets and their applications. ACM Transactions on Graphics,

Approaches: Super-resolution

- Single image blur map estimation based on sparse representation:



Fixed sparsity: 5



camera scene distance:	0m	12m	22m	32m
Error in representation:	0.765	0.2103	0.1149	0.0592

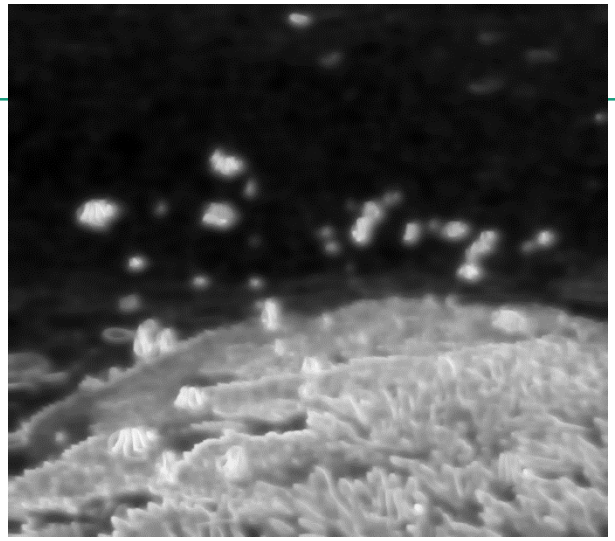
- Super-resolution and de-blurring:

Sparse coding of the low-resolution Patch using a learned low-res. dictionary

construct the high res. patch using the same sparse representation coefficients, imposed on a high-resolution dictionary

Results: Super-resolution and de-blurring

Low-resolution



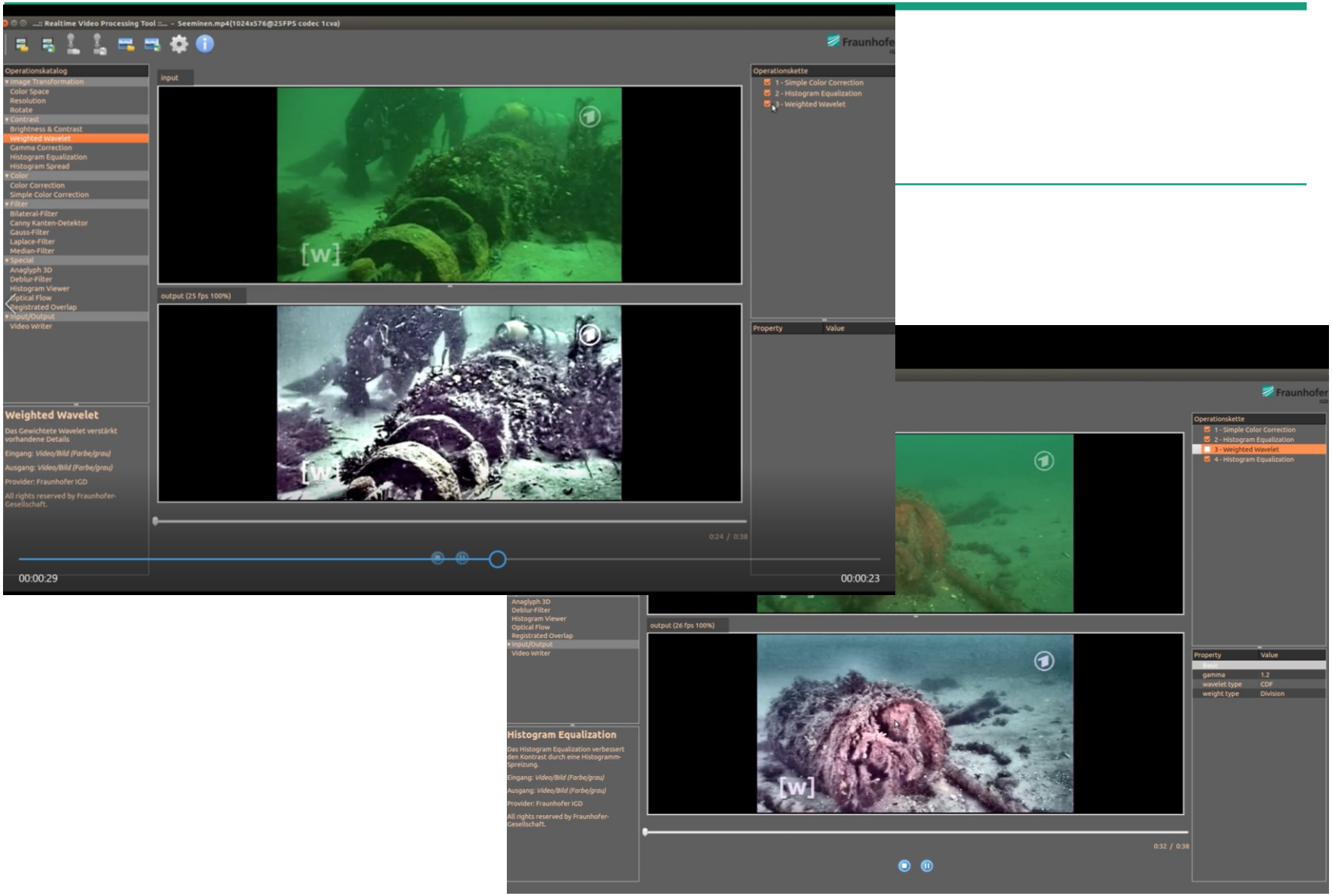
Blur estimation

High-resolution

Low-resolution

High-resolution

Dr.-Ing. Kristine Bauer, Dec. 2018



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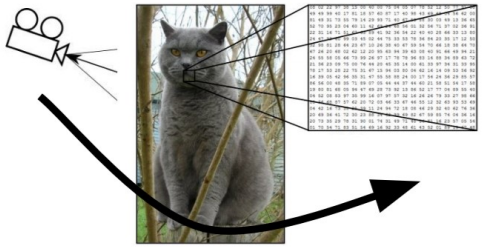
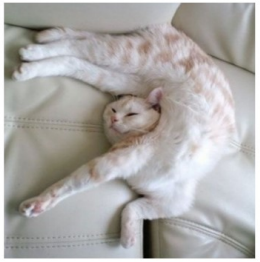
Technology view
Basics of Computational Intelligence

Camera pose



Illumination

Deformation



Occlusion

Background clutter

Intraclass variation

Fei-Fei Li & Andrej Karpathy & Justin Johnson,
http://cs231n.stanford.edu/slides/2016/winter1516_lecture3.pdf

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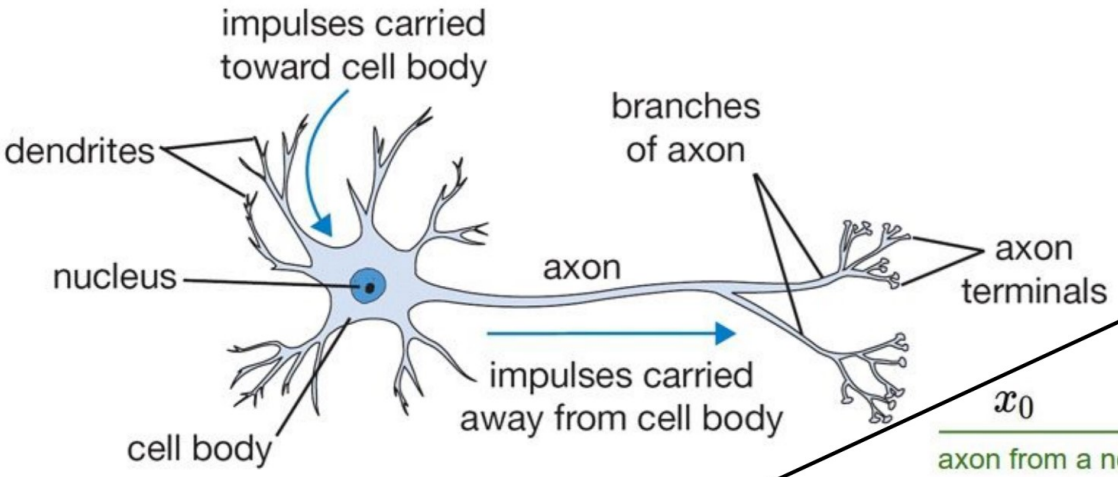
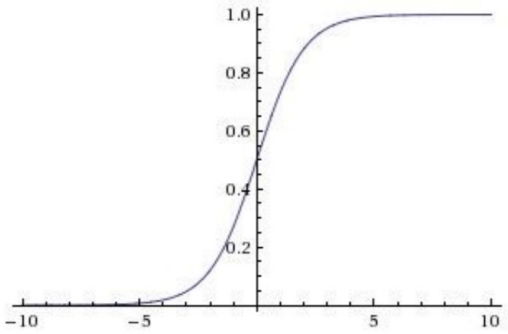
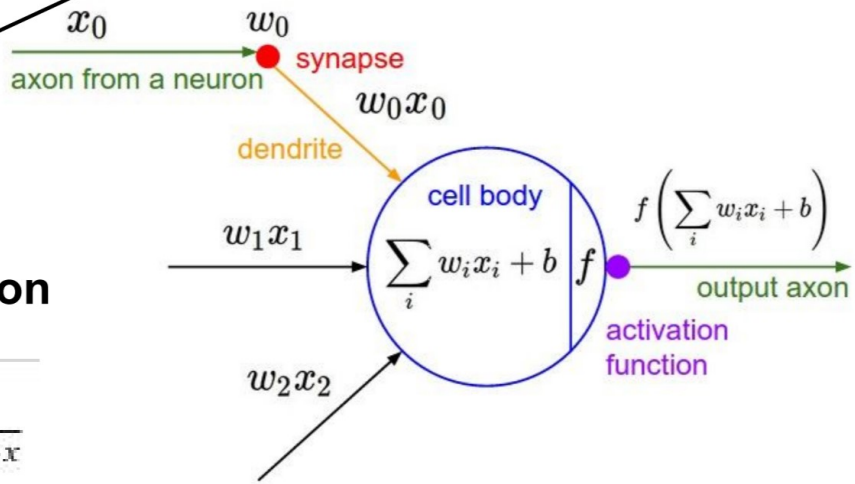
Neuronal Networks





sigmoid activation function

$$\frac{1}{1+e^{-x}}$$



Fei-Fei Li & Andrej Karpathy & Justin Johnson,
http://cs231n.stanford.edu/slides/2016/winter1516_lecture4.pdf

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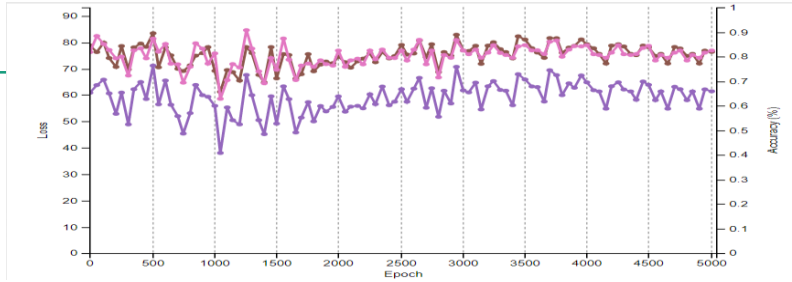
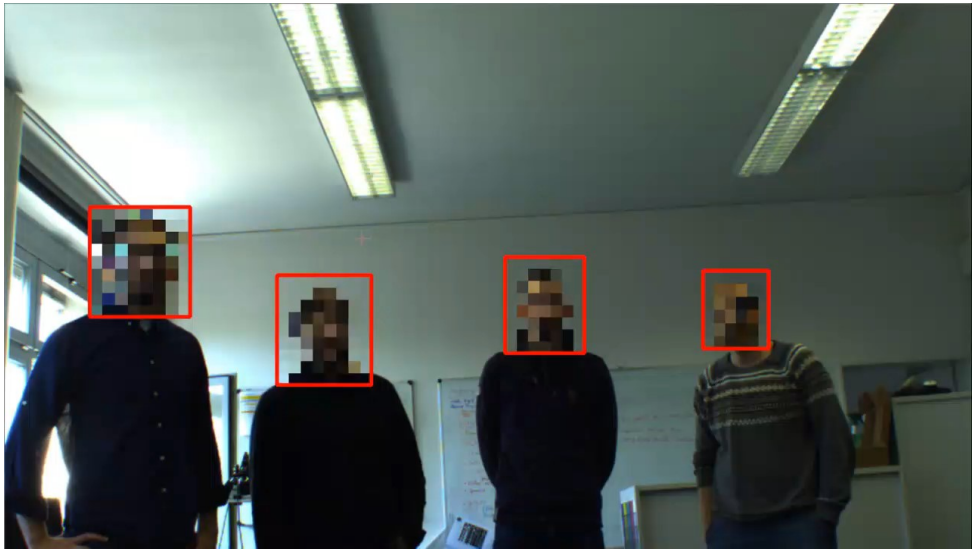
Deep Learning Detection



Mean average precision (MAP)

Example:

- Make faces and licence plates unrecognizable
- Detection rate: 99,99%



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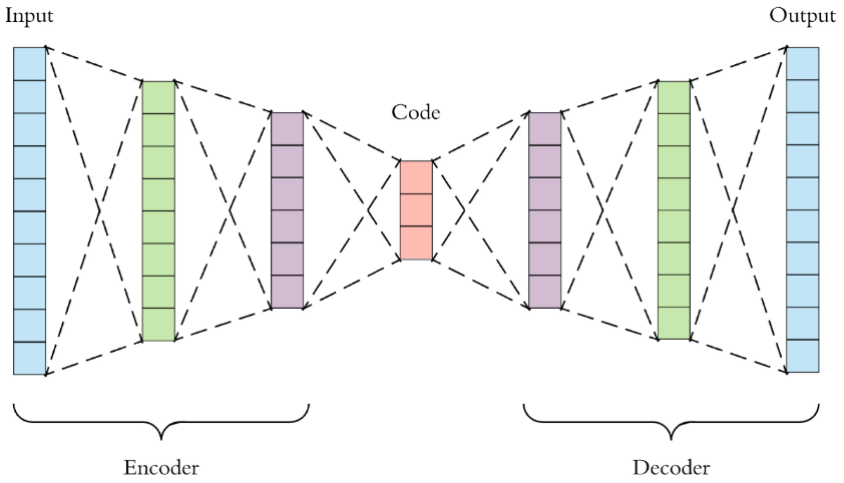
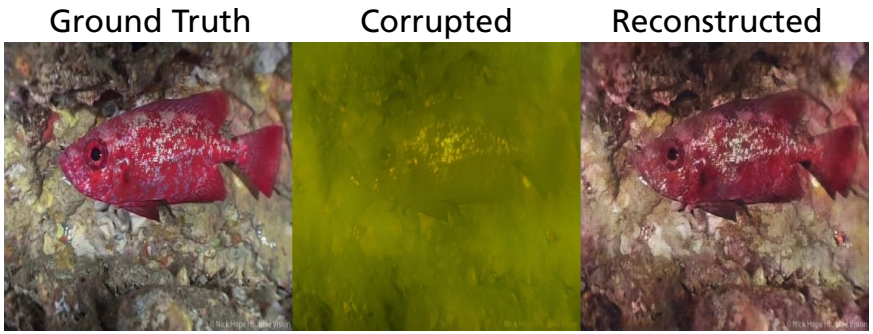
Autoencoders for Image Enhancement

- Denoising Autoencoders remove noise from images and perform color correction.
- The encoder compresses the corrupted input image into a latent space representation (code layer).
- The decoder tries to reconstruct the image by minimizing the loss function between the decoder output and the ground truth.





https://towardsdatascience.com/applied-deep-learning-part-3-autoencoders-1c083af4d798

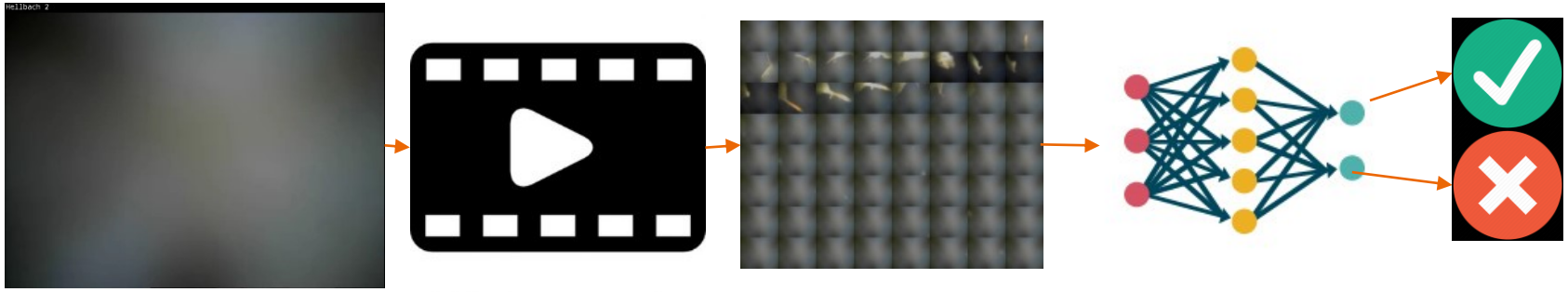
Autoencoders for Image Enhancement

- Advantage: using Autoencoders the enhancement process is not parameterized anymore.
- Results:

Environmental Monitoring

- Routing protocol of sea trouts
- Full automatical counting of fishes by camera support at „fish strairs“
- Precision > 99%
  - Difficulties: light changes and reflections, leafs etc.
- Positive: Experts (Biologists) save time in routine-cases and can concentrate on challenging tasks

negative and positive classification
Quelle : FIUM GmbH & Co. KG



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Deep Learning / Multi-class detection

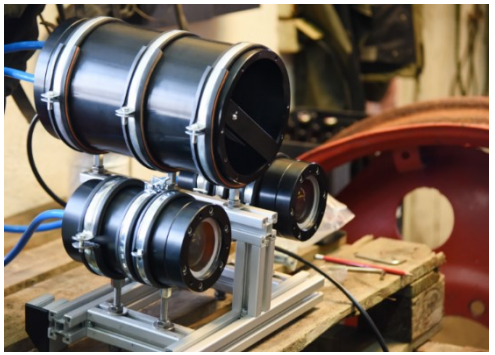
Practical application:

- Detection of river fishes
- Warnow, Wildpark MV
- Detection und classification of species
- Detection rate: > 99%

- Automatical classification
- Trained classes:
  - trout, bream, perch (Forelle/Brasse/Barsch)
- Precision: > 97%

Hardware: SynaptiCam

- Smart camera for real-time enhancement and analysis of (underwater) videos
  - Range of industry cameras with different performance characteristics
  - High light sensitivity
- Embedded system for parallel processing
  - Supports up to 3 cameras
  - Low power consumption (< 20W)
  - Cutting edge machine learning technology
- Potential bandwidth reduction from >100 Mbps to <1Kbps



munitect

- 18 german industrial companies and research institutes
- Main topic: High-performance Detection
- Fields:
  - technology improvement
  - innovative chemical sensors
  - sensor integration for live detection
  - diverless

- Sharing knowledge
- Joint R&D roadmap
- Buisness development
- Testfield Munitions

Energy to use!

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Summary and Outlook

- 1. What we can do **today**:
  - Given videos: train neuronal nets with videos (diver/ROV/AUV)
  - Annotate videos with additional information like bathymetry
    - Real-time and Post-processing
- 2. What we want **tomorrow**:
  - Identification of munitions on the fly
  - Making the decisions of nets understandable

Summary and Outlook

- Our nets can much more:
  - Intelligent Integrated GIS-Systems
    - pattern in sonar data for anomalies
    - Nets on integrated data sets
  - patterns in real water probes for poison or their decendant
  - patterns in metabolic products in real test beds
- 3. What can help?
  - joint projects to combine different technologies
  - more survey data sets, videos and combined measurements to work on

THANKS FOR YOUR ATTENTION