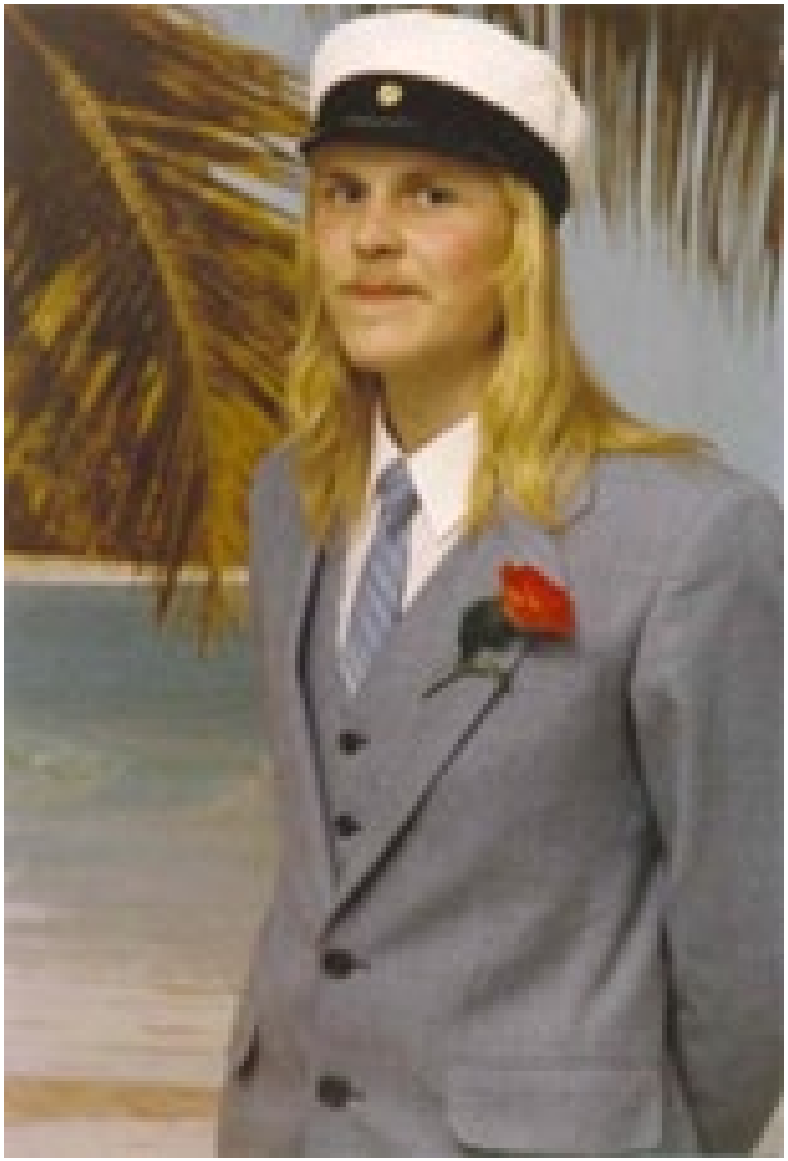
Data-Centric Engineering:
Computer Vision and Pattern Recognition

Professor Heikki Kälviäinen

Professor of Computer Science and Engineering
Computer Vision and Pattern Recognition Laboratory (CVPRL)
Department of Computational Engineering
School of Engineering Science

Finnish CoE in Inverse Modeling and Imaging
LUT University, Lappeenranta, Finland
heikki.kalviainen@lut.fi

Supported by European Union

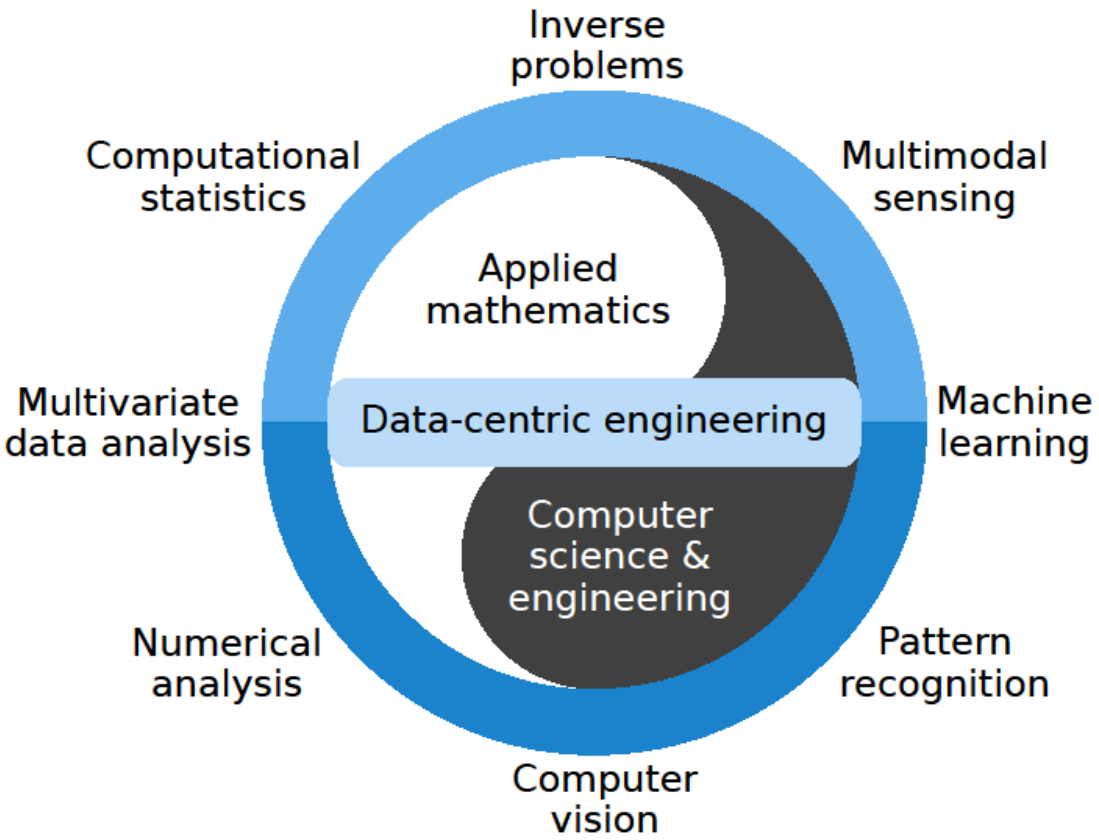


More than
35 Years of
Experience!

Where is LUT and Lappeenranta?

Information: https://www.lut.fi/

Computational Engineering: Data-Centric Engineering



https://www.lut.fi/web/en/admissions/masters-studies/msc-in-technology/computational-engineering/data-centric-engineering

DD application period: Jan 2, 2023 – March 17, 2023

CVPRL: research projects at LUT

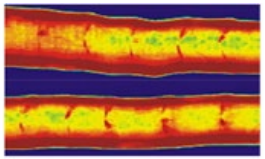
Computer Vision and Pattern Recognition Laboratory:

Applications of Computer Vision,

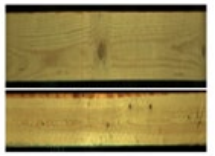
Digital Image Processing and Analysis,

Data Analytics.

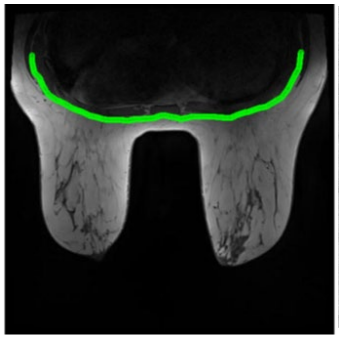
Laser scan (log surface)

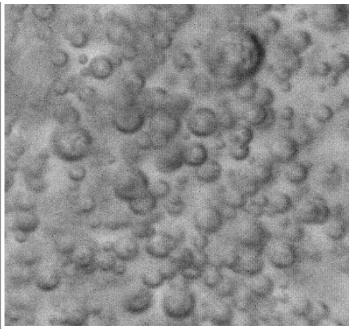


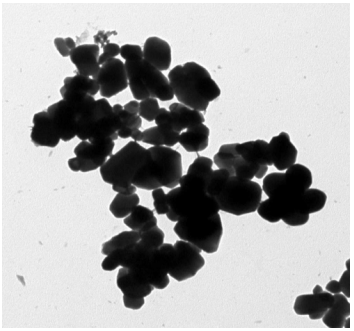
X-ray images (log)

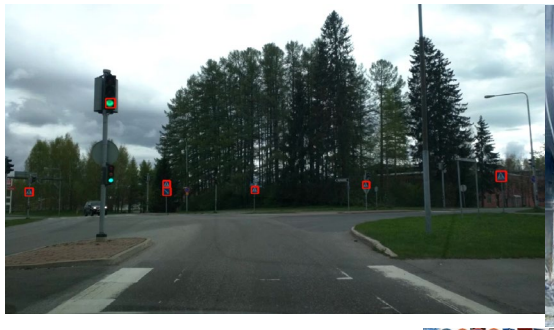


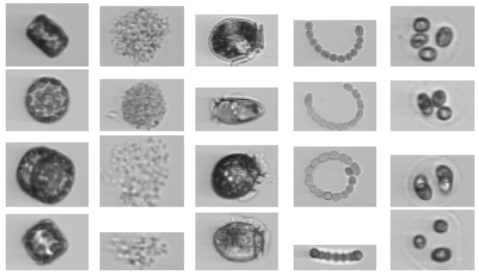
RGB image (sawn timber)

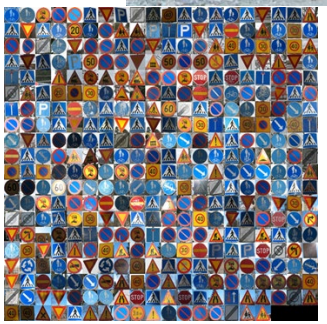


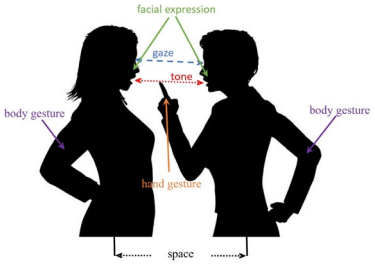


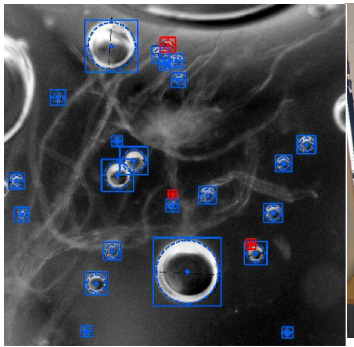


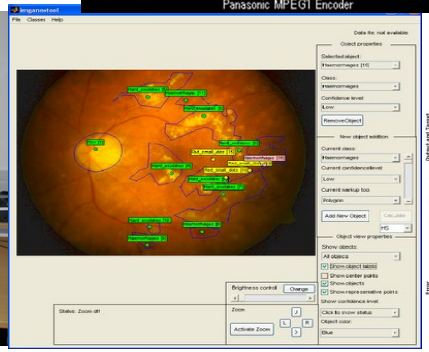


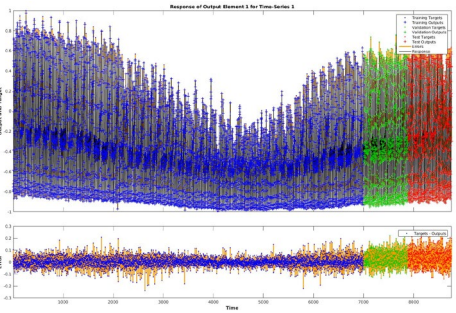












Master's thesis topics are directly related to the CVPRL research areas

2021-2022 (examples of theses)

- Deep image registration for composing spectral retinal images.
- One-to-many and many-to-many matching for Saimaa ringed seal re-identification.
- Deep learning for point cloud segmentation with applications to the sawmill industry.
- Active learning for plankton recognition.
- Skeleton-based human action recognition using graph neural networks.
- Machine learning techniques applied to energy behavior.

Theses available: https://lutpub.lut.fi/

Master's thesis topics are directly related to the CVPRL research areas

2022-2023 (examples of offered new topics)

- Conditioned diffusion models for generating retinal images.
- Fine-grained plankton recognition.
- Species-agnostic animal pattern extraction.
- Modelling knots in X-ray CT scans of logs.
- Multimodality non-contact human vital signs sensing.
- Forecasting renewable energy production with transformer neural networks.

Medical Image Analysis: Diagnosis of Diabetic Retinopathy

Prof. Lasse Lensu et al.

IMAGERET/REVISION:
Kuomed, Mawell, Perimetria, Santen
Tekes, Academy of Finland,
LUT, UEF, Tampere U,
Birmingham U, Bristol U,
Czech TU, UC at Berkeley

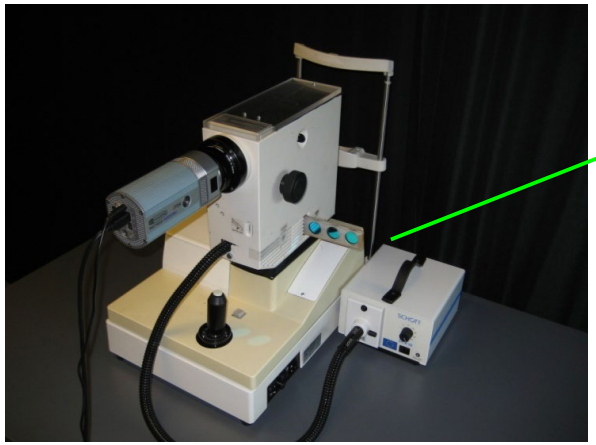
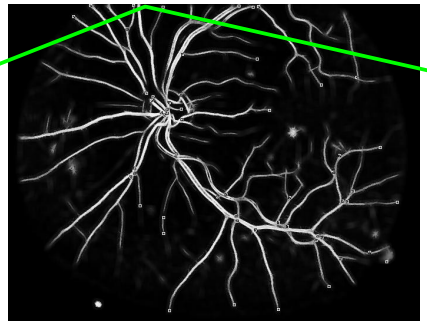
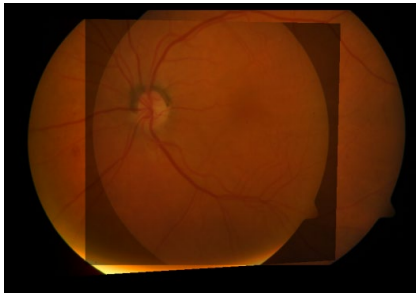
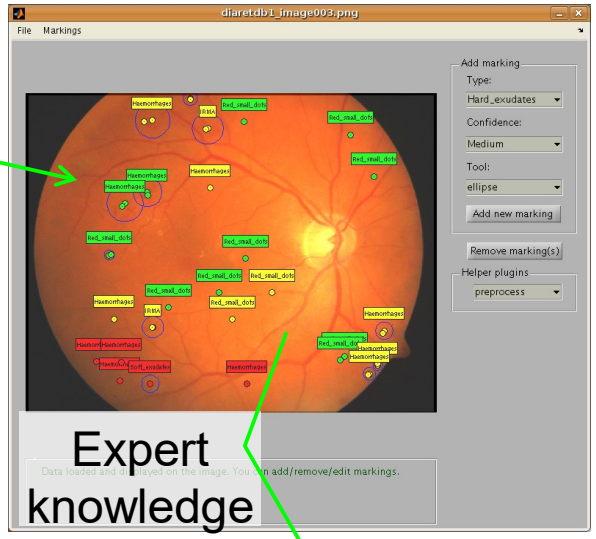


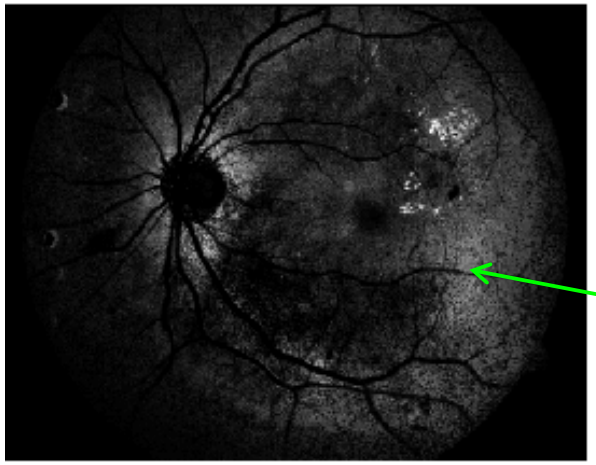
Image pre-processing



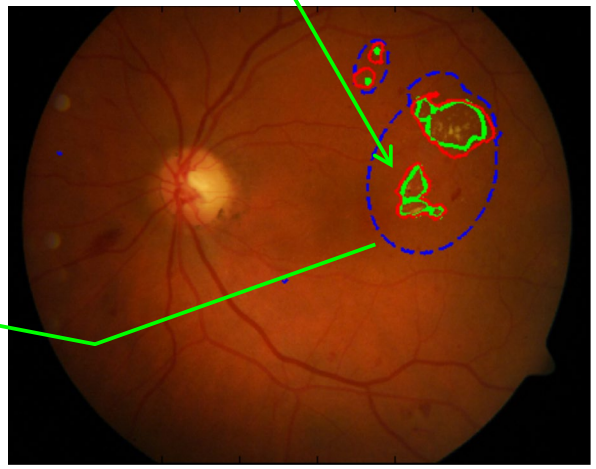




Expert knowledge



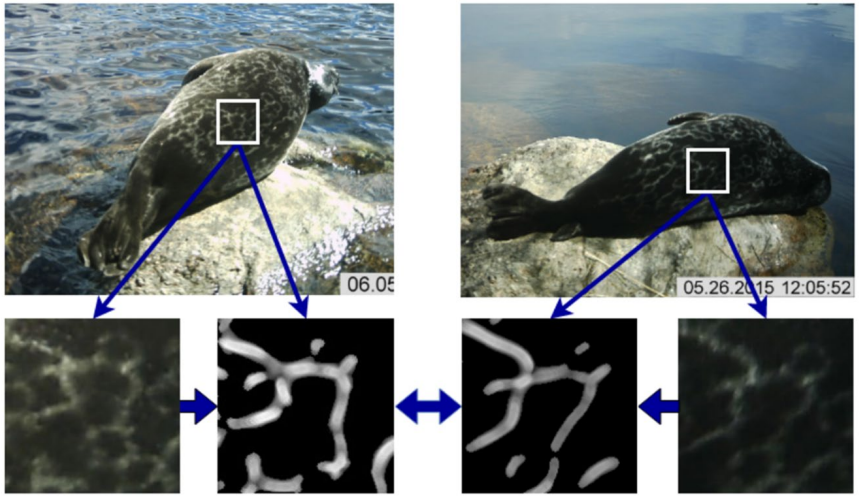
Statistical modeling of image information



CoExist&SealVision:

Could you help me by recognizing me?

Prof. Heikki Kälviäinen et al.



Nepovinnykh, E., Eerola, T., Kälviäinen, H., Siamese Network Based Pelage Pattern Matching for Ringed Seal Re-identification, *WACV, Workshop*, 2020.

CBC 2014-2020
SOUTH-EAST FINLAND - RUSSIA

TOWARDS SUSTAINABLE COEXISTENCE OF SEALS AND HUMANS

RAIJA JA OSSI TUULIAISEN SÄÄTIÖ

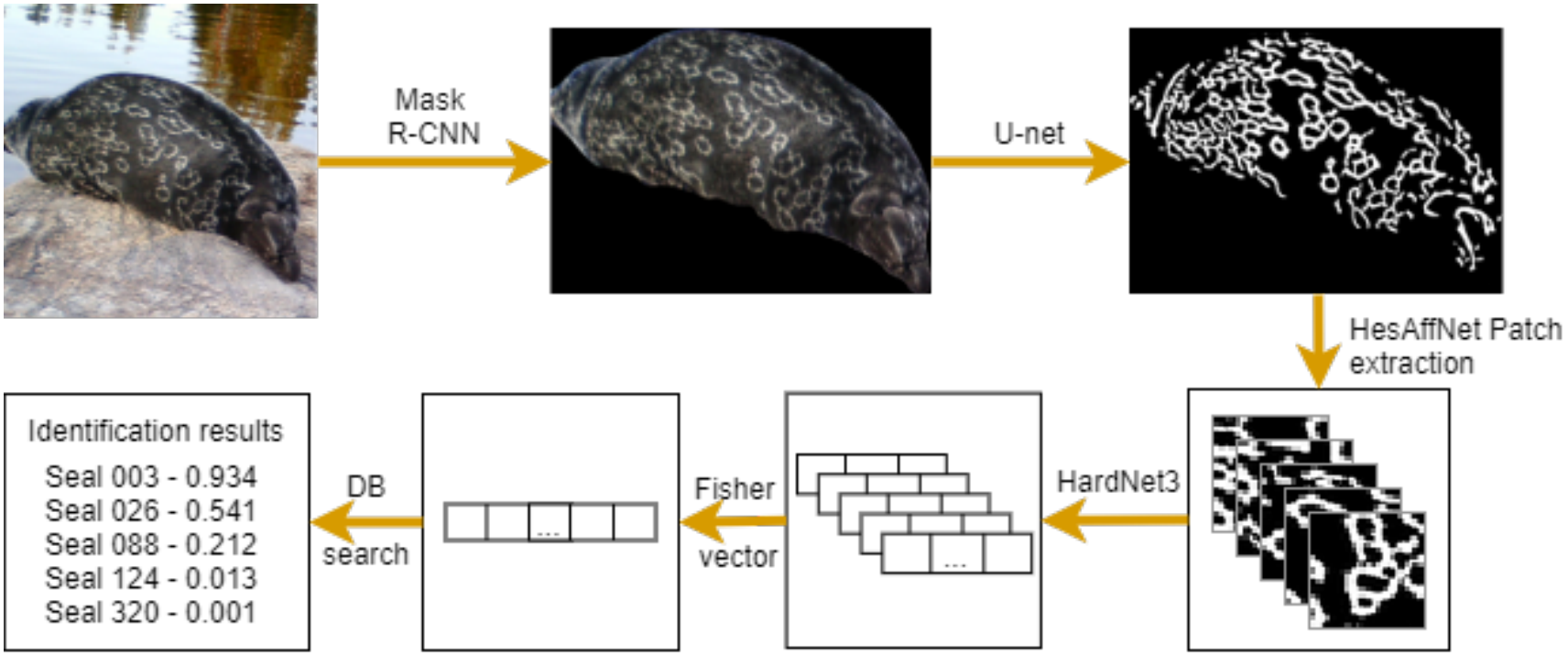
Only around 450 Saimaa ringed seals (“saimaannorppa” in Finnish) left in Lake Saimaa.

Detection and identification of **individual Saimaa ringed seals** based on the fur pattern using computer vision and machine learning for conservation of nature.

“Biometric passport” for seals (wild life photo ID).

Cooperation with biologists: UEF, Finland & BFNC, Russia (Lagoda ringed seals).

Another research for conservation of nature: automatic image-based re-identification of ringed seals



Collaboration: Saimaa ringed seal research group, University of Eastern Finland.
Generalization: Saimaa ringed seals, Ladoga ringed seals, other seals, other animals with fur patterns, etc.

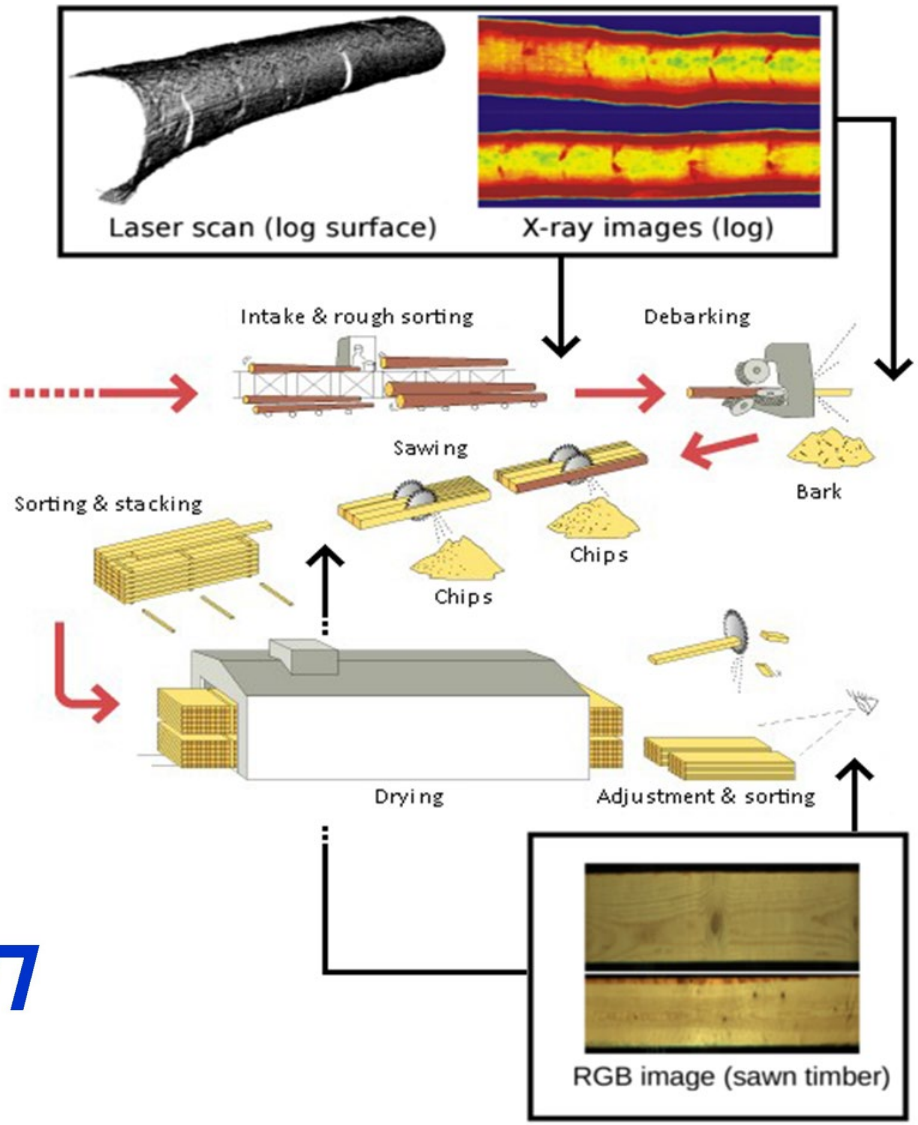
LUT University

DigiSaw

DigiSaw:
Leap of Digitalization for the Sawmill Industry

- Optimized sawing.
- Quality prediction of the end product from raw material.
- More efficient sorting of logs and sorting of the end products.

http://www2.it.lut.fi/project/digisaw/



FINNOS

FinScan

rethink. storaenso

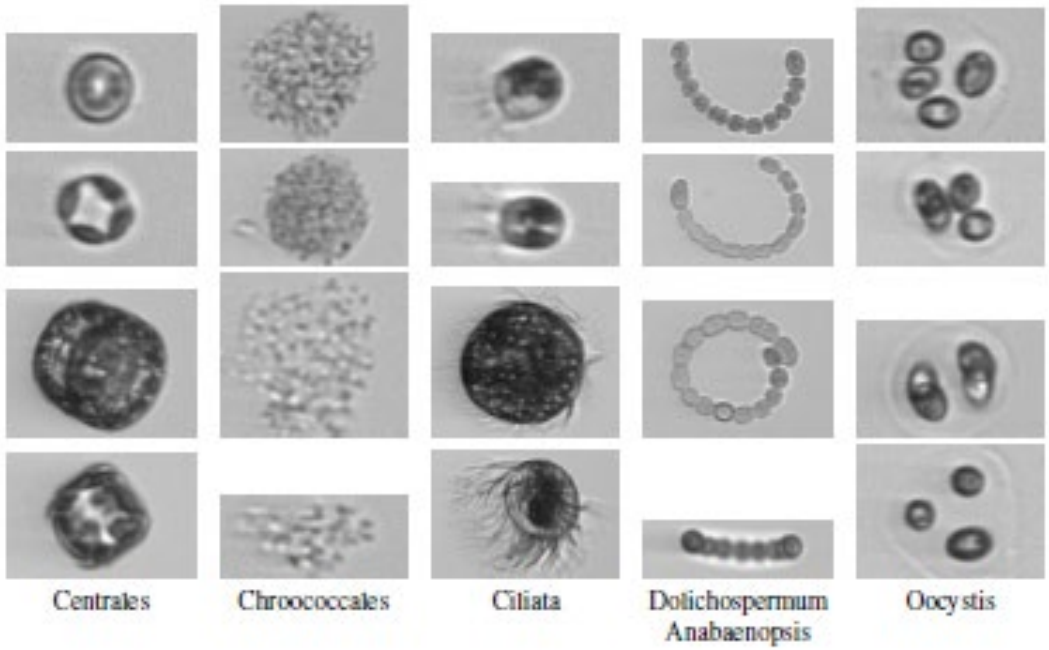
Massachusetts Institute of Technology

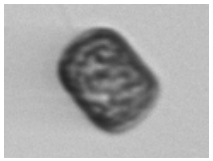
BRNO UNIVERSITY OF TECHNOLOGY

BUSINESS FINLAND

Plankton recognition from imaging flow cytometer data using convolutional neural networks

Prof. H. Kälviäinen, L. Lensu, T. Eerola, et al.





⇒ What plankton type?

A huge amount of data produced by a measuring device from Baltic Sea => how to recognize planktons automatically?

Objective: detect plankton types for analyzing the condition of the Baltic Sea and the climate change.

Collaboration: Finnish Environment Institute (SYKE), BUT, CTU, FastVision project.

LUT University

BRNO UNIVERSITY OF TECHNOLOGY

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

ACADEMY OF FINLAND

SYKE

LUT University

Plankton recognition using machine learning

Domain adaptation:
Different devices?

Metric learning:
similarity of two samples

Open set classification:
Unknown new classes?

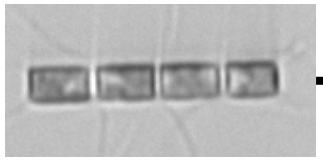
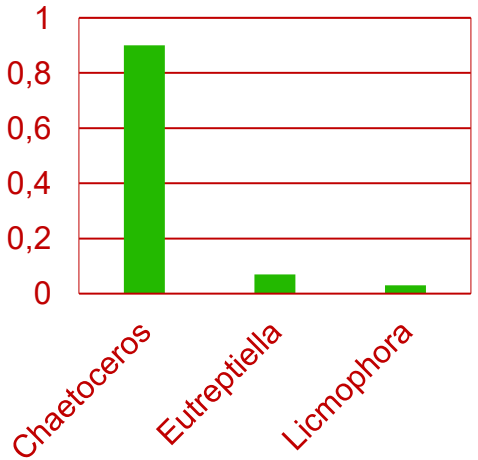
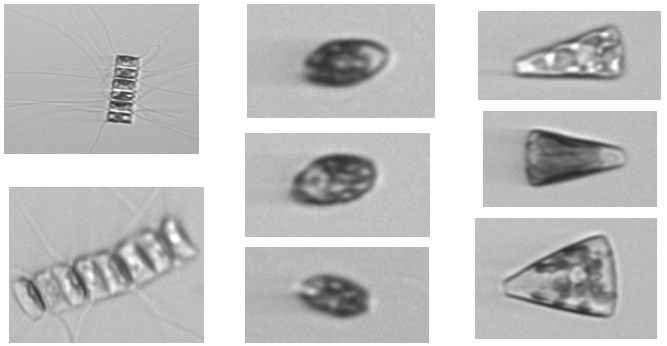


Image classification model

Deep learning approach: feature learning (convolutional neural networks)



Labeled training data



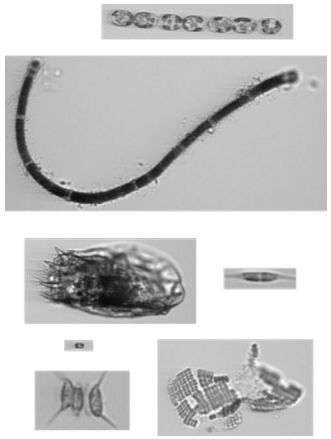
Active learning:
A lot of samples => semiautomatic tools to label samples.

Imbalance of data: samples/class vary, sizes of samples vary

LUT University

FastVision: LUT-BUT joint supervision

- Bureš, Jaroslav, Classification of Varying-Size Plankton Images with Convolutional Neural Network, MSc thesis, Brno University of Technology, 2020.
- Bureš, J., Eerola, T., Lensu, L., Kälviäinen, H., Zemčík, P. Plankton Recognition in Images with Varying Size, ICPR Workshops and Challenges, 2021.
  - Various modifications to the baseline convolutional neural networks are compared to address the extreme size variation in plankton image data.



Model combination	Test accuracy
InceptionV3 (299x299)	0.9228 ± 0.0019
InceptionV3 (299x299) + Jeffrey (128x128)	0.9259 ± 0.0012
InceptionV3 (299x299) + Barazanchi (224x224)	0.9271 ± 0.0018
InceptionV3 (299x299) + Barazanchi_2 (361x181)	0.9262 ± 0.0014
InceptionV3 (299x299) + Barazanchi_4 (448x112)	0.9284 ± 0.0014
InceptionV3 (299x299) + DeepWriter 2x(224x224)	0.9285 ± 0.0027
InceptionV3 (299x299) + Barazanchi_4 (448x112) + DeepWriter 2x(224x224)	0.9303 ± 0.0017

Brno University of Technology (CZ): LUT-BUT-DD master

The content and structure of the Degree Programme

LUT students

TOTAL min 120 ECTS 120

1. semester at LUT (select minimum 30 ECTS) 24

Course name	credits
Digital Imaging and Image Preprocessing	6
GPGPU Computing	6
Pattern Recognition	6
Advanced Data Analysis and Machine Learning	6

2. semester at BUT (select minimum 30 ECTS) 30

Course name	credits
Multimedia	5
Any voluntary course in 2nd or 3rd semester	
Speech Signal Processing	5
Data Communications, Computer Networks and Protocols	5
Physical Optics	5
Computational Geometry	5
Theoretical Computer Science	5

3. semester at BUT (select minimum 30 ECTS) 30

Course name	credits
Mathematical Structures in Computer Science	5
Computer Graphics	5
Term Project	5
Hardware/Software Codesign	5
Advanced Database Systems	5
Any voluntary course in 2nd or 3rd semester	5

4. semester at LUT 36

Course name	credits
Thesis work	30
Machine Vision and Digital Image Analysis *	6
Computer Vision *	6

* select one of the two courses or a compatible course

BUT students

TOTAL min 120 ECTS 122

1. semester at BUT (select minimum 30 ECTS) 30

Course name	credits
Mathematical Structures in Computer Science	5
Computer Graphics	5
Theoretical Computer Science	5
Term Project	5
Hardware/Software Codesign	5
Advanced Database Systems	5

2. semester at BUT (select minimum 30 ECTS) 30

Course name	credits
Multimedia	5
Image Processing	5
Speech Signal Processing	5
Data Communications, Computer Networks and Protocols	5
Physical Optics	5
Computational Geometry	5

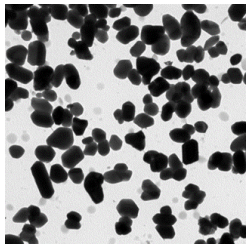
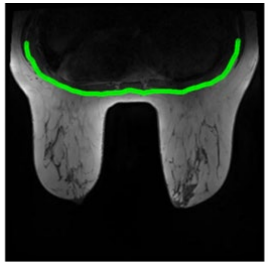
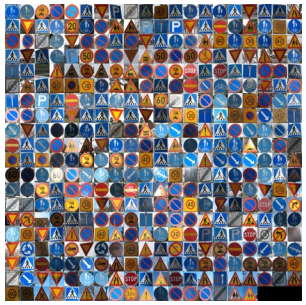
3. semester at LUT (select minimum 30 ECTS) 26

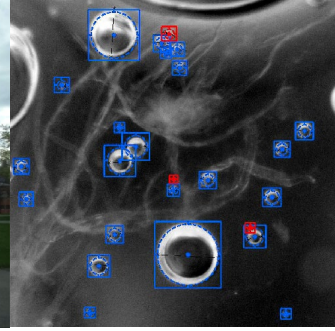
Course name	credits
GPGPU Computing	6
Pattern Recognition	6
Advanced Data Analysis and Machine Learning	6
Seminar in Intelligent Computing	4
Academic Writing in English	4

4. semester at LUT 36

Course name	credits
Thesis work	30
Machine Vision and Digital Image Analysis *	6
Computer Vision *	6

* select one of the two courses




Computational Engineering by CVPRL:
Data-Centric Engineering
Computer Vision and Pattern Recognition