

Data-Centric Engineering (DCE): Computer Vision and Pattern Recognition



Professor Heikki Kälviäinen

Professor of Computer Science and Engineering (LUT)
Visiting Professor of Brno University of Technology (BUT)

Computer Vision and Pattern Recognition Laboratory (CVPRL)

Department of Computational Engineering

School of Engineering Sciences

LUT University, Lappeenranta, Finland

heikki.kalviainen@lut.fi

Finnish CoE in Inverse Modeling and Imaging

Flagship of Advanced Mathematics for Sensing, Imaging and Modelling



More than
38 Years of
Experience!



Where is LUT and Lappeenranta?



Information:

<https://www.lut.fi/en/>

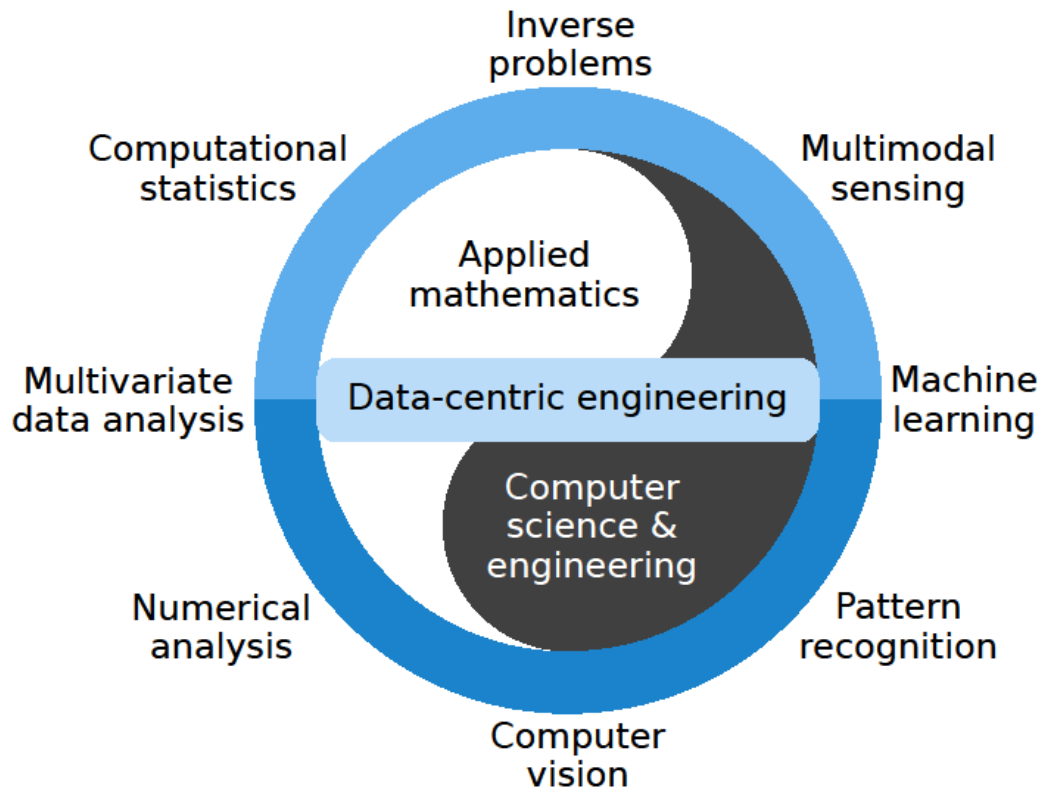


LUT Strategy



336 (LUT in QS ranking), the 3rd best university in Finland

Computational Engineering: Data-Centric Engineering



Computer Vision and Pattern Recognition Laboratory (CVPRL)

Specialization in Data-Centric Engineering: Computer Vision and Pattern Recognition (CVPR)

<https://www.lut.fi/en/research-groups/computer-vision-and-pattern-recognition-laboratory-cvprl>

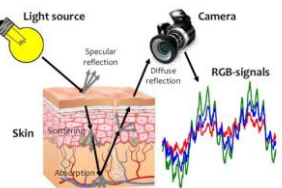
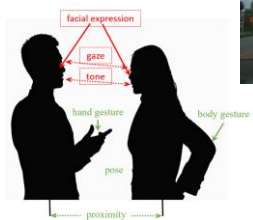
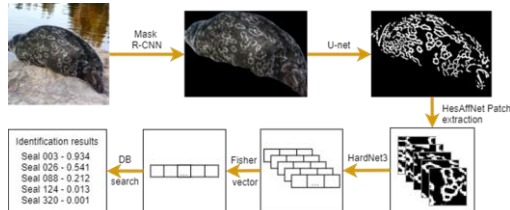
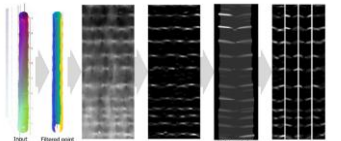
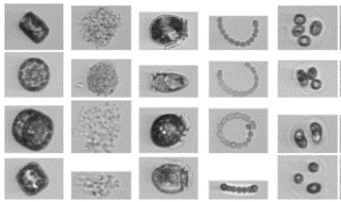
<https://www.lut.fi/web/en/admissions/masters-studies/msc-in-technology/computational-engineering/data-centric-engineering>

Language proficiency requirements: the discussion in the interview, no official language certificate in English needed.

CVPR: Computer Vision and Pattern Recognition Laboratory

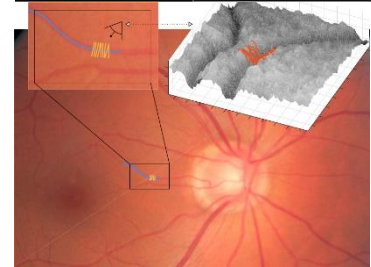
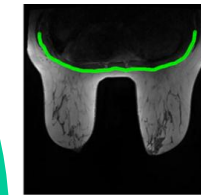
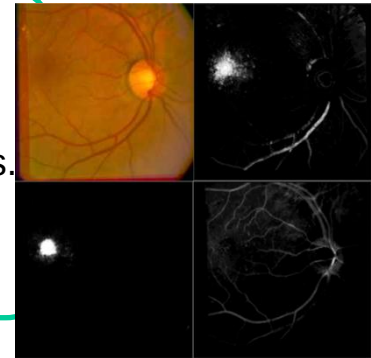
Computer Vision Applications

- Plankton recognition.
- Re-identification of fur-based animals such as Saimaa ringed seals.
- Virtual sawing and tracing of timber.
- Traffic.



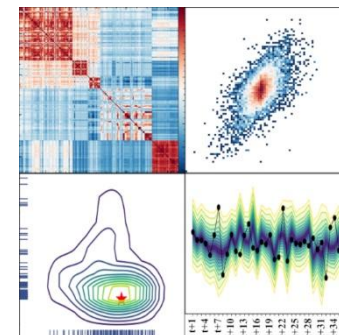
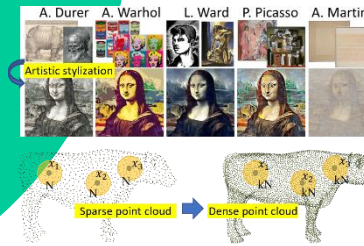
Biomedical Imaging

- Color and spectral imaging.
- Retinal image analysis based on deep learning.
- Deep generative image synthesis.
 - End-to-end learning for visual regression.
 - Cancer research.



Data Analytics

- Deep forecasting and profiling of energy prosumption.
- 2D/3D superresolution.
- Image and video style transfer.
- Machine learning with edge computing.



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

2023-2024 (examples of theses done at CVPRL)

- Open-set **plankton detection**.
- Fine-grained **plankton recognition**.
- Prompt-based segmentation for **animal re-identification**.
- Explainability and generalizability of **glaucoma** detection models.
- Exploring multimodality **micro-gesture** detection for **emotion** understanding.
- Using dense X-ray reconstructions for developing **virtual sawing** method (LUT-BUT DD)
- Fusing image and non-grid-like data for **object segmentation**. (LUT-BUT DD).

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

Master's thesis topics (continued)

2023-2024 (theses done in companies)

- Accelerated annotation of 3D **medical images** using interactive segmentation.
- Estimating glue-layer defects in **plywood** through computer vision methods. (Company)
- **Multi-camera calibration** using semantic features.
- **Material classification** in the industry.
- Predicting late payment of **sales invoices** with statistical learning methods.

Several thesis projects in companies are going on currently.

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

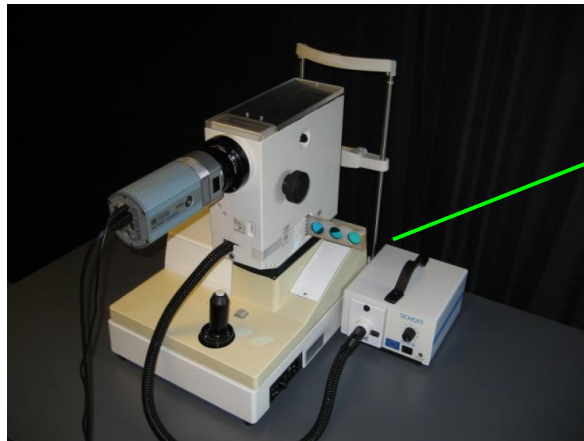
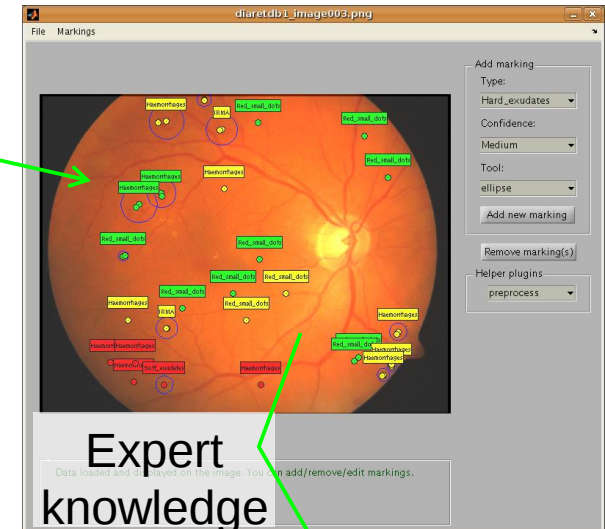
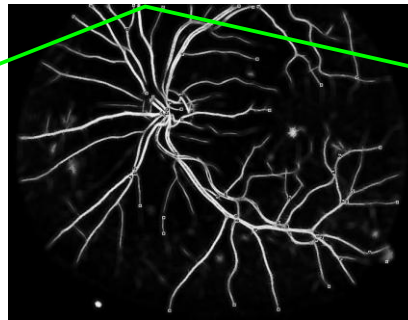
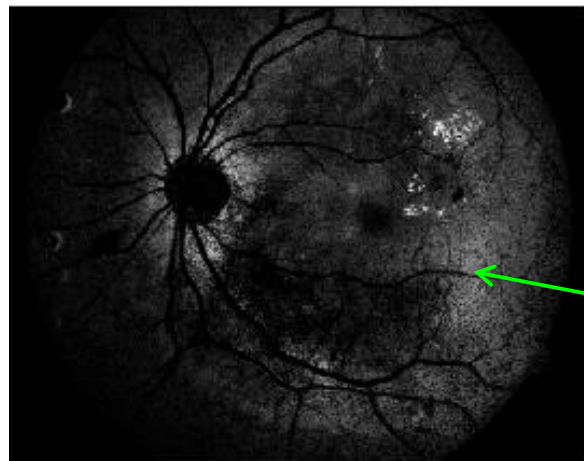


Image
pre-processing



Expert
knowledge

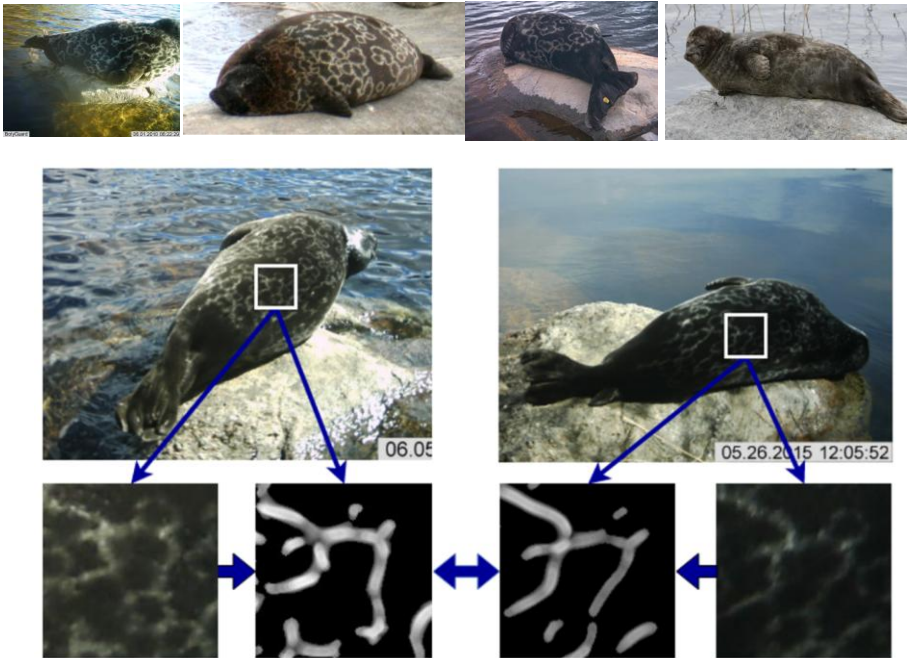


Statistical
modeling of
image
information



Animal biometrics: 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.



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).

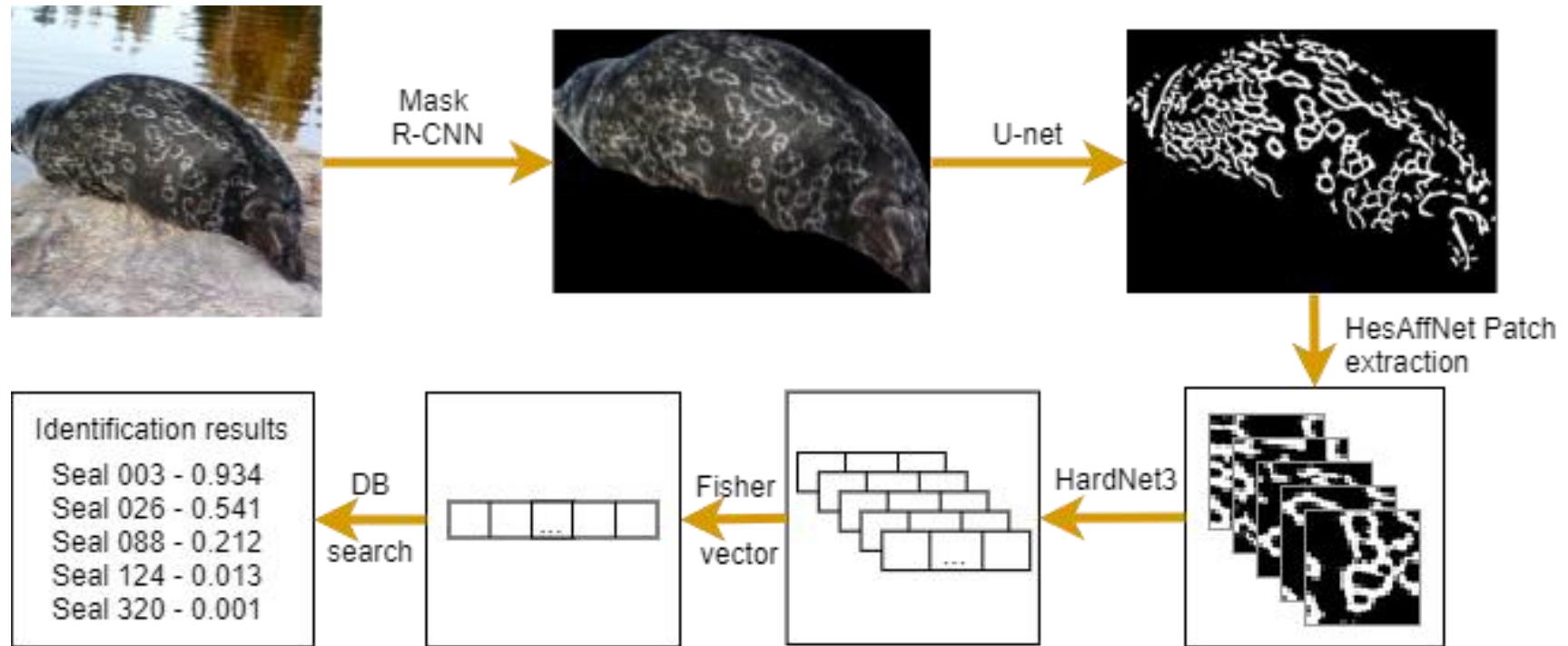
Cooperation with biologists: UEF, Finland & BFNC, Russia (Lagoda ringed seals).

LUT NORPPA method: https://www.youtube.com/watch?v=EvtnRUZ-D_o



NORPPA: AUTOMATIC RINGED SEAL RE-IDENTIFICATION

Conservation of nature: automatic image-based re-identification of ringed seals

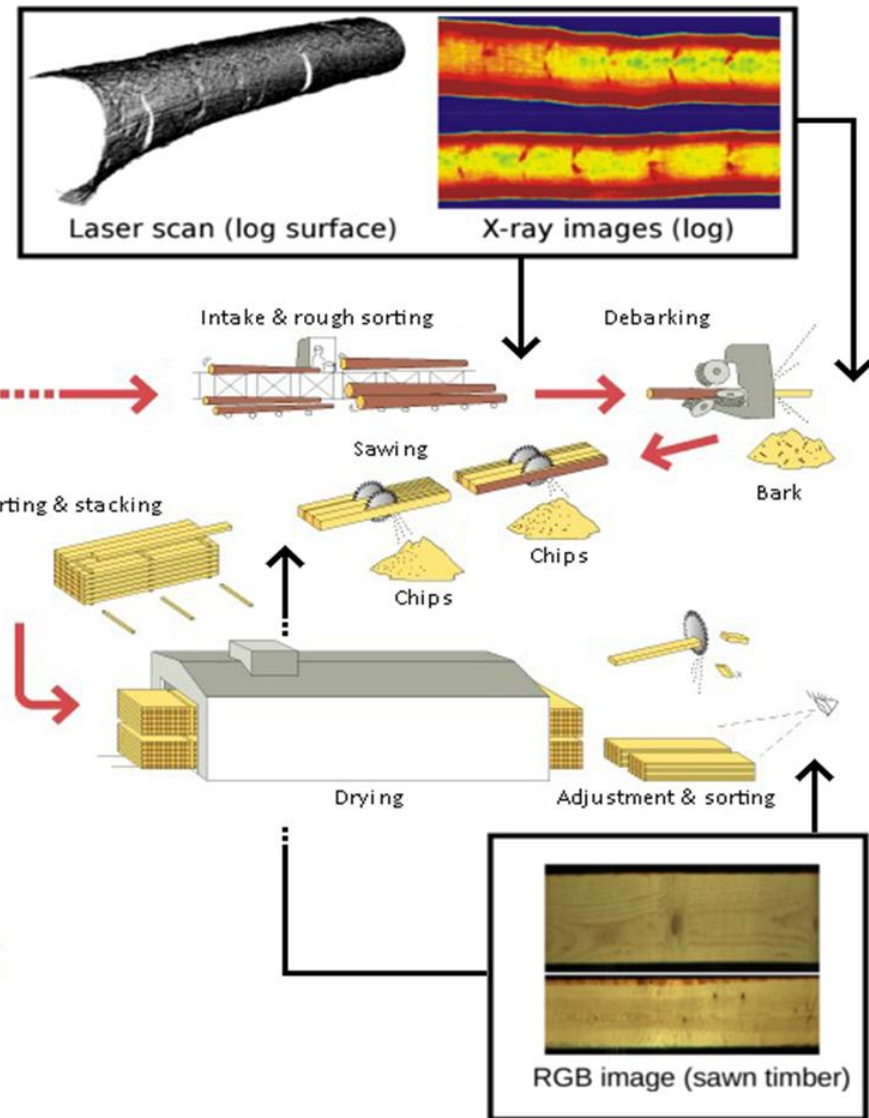


Nepovinnykh, E., Chelak, I., Eerola, T., Kälviäinen, H., NORPPA: NOvel Ringed seal re-identification by Pelage Pattern Aggregation arXiv:2206.02498, 2022. <https://arxiv.org/abs/2206.02498>

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.

New partner: Prof. Charles Stewart, Rensselaer Polytechnic Institute, Troy, NY



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.

FINNOS

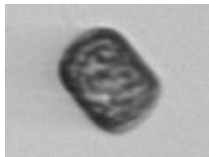
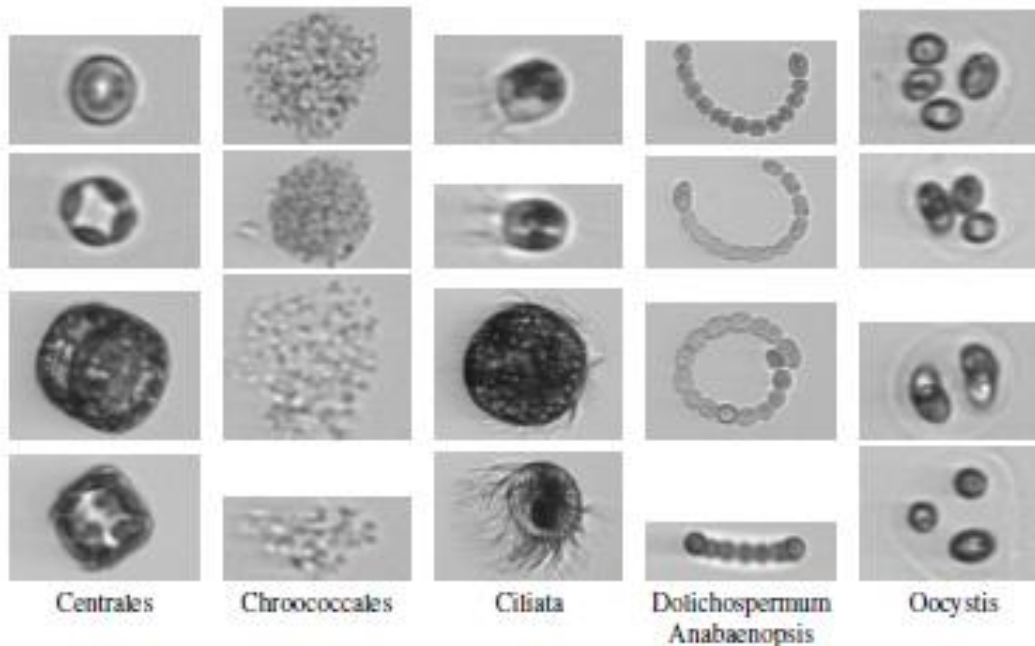
FinScan



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.

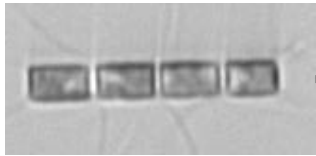
Collaboration: Finnish Environment Institute (SYKE), BUT, CTU, FastVision project.

Plankton recognition using machine learning

Domain adaptation:
Different devices?

Metric learning:
similarity of two samples

Open set classification:
Unknown new classes?

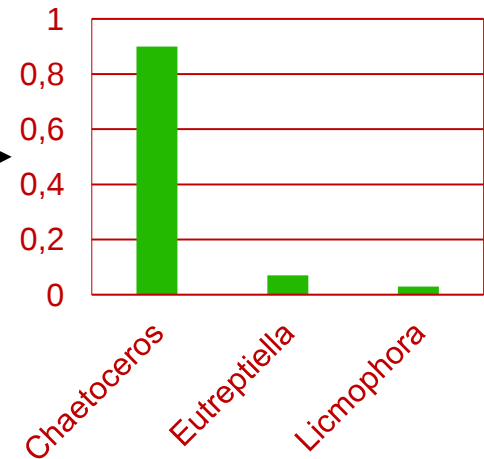


Tuomas Eerola et al., Survey of automatic plankton image recognition: challenges, existing solutions and future perspectives, Artificial Intelligence Review, 2024.

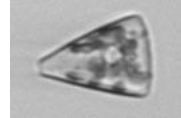
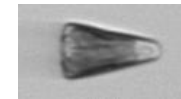
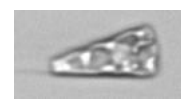
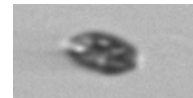
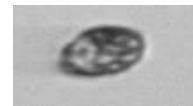
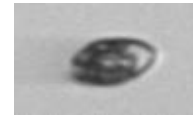
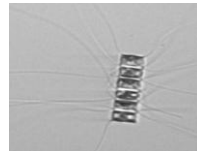


Image classification model

Traditional approach: engineered image features + classifier
Modern approach: feature learning (CNNs, Vision Transformers)



Labeled training data



Chaetoceros sp. Eutreptiella sp. Licmophora sp.

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

Imbalance of data: samples/class, sample size, intra/inter-class

Data-Centric Engineering Master Program

Computer Vision and Pattern Recognition

Double degree (DD) structure:

- 60 credits (ECTS) in your home university.
- 60 credits in LUT University as the following **courses**:

Master's Thesis and Seminar 30 cr (co-supervised)

Maturity Exam 0 cr (related to the master's thesis topic)

Introduction to M.Sc. Studies in Computational Engineering 1 cr

Seminar on Data-Centric Engineering 3 cr

Seminar on Computational Engineering 2 cr

Advanced Data Analysis and Machine Learning 6 cr

Pattern Recognition and Machine Learning 6 cr

Digital Imaging and Image Preprocessing 6 cr

Machine Vision and Digital Image Analysis or Computer Vision 6 cr

Data-Centric Engineering Master Program

Computer Vision and Pattern Recognition

Requirements

- Bachelor degree.
 - The relevant degree needed with sufficient courses.
- Relevant master studies in the first year.
- No official language certificate needed.
- All candidates are interviewed by a LUT professor.
 - Language skills in English.
 - Knowledge about the selected specialization.
 - Applied Mathematics.
 - Computer Vision and Pattern Recognition.

Samuel and Bořek are happy to tell about DD studying



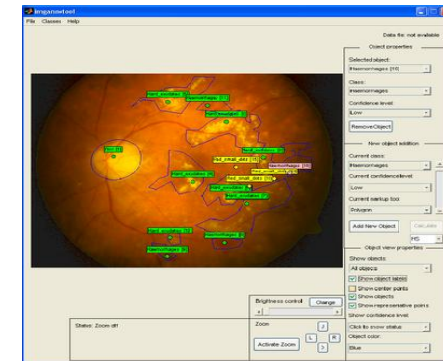
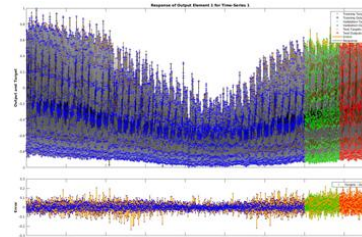
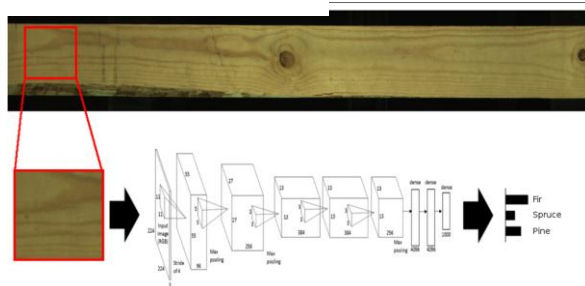
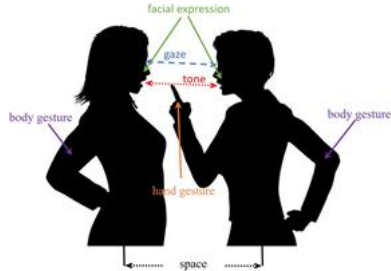
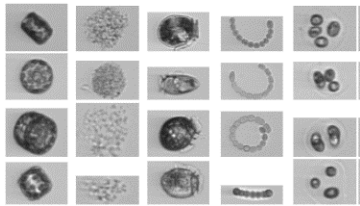
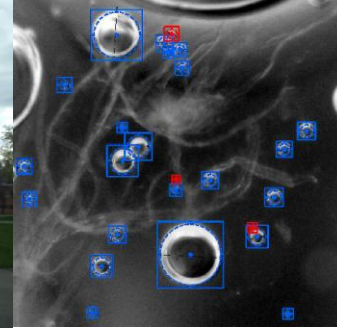
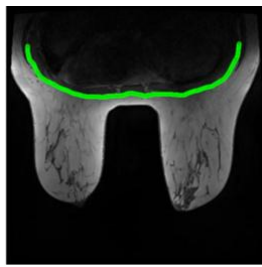
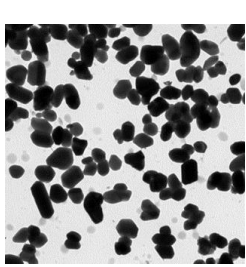
Samuel Repka

Graduated DD master student at LUT from BUT
DDD student at LUT from BUT
Computer Vision and Pattern Recognition (DCE)
samuel.repka@lut.fi
+421907587090



Bořek Reich

DDD student at LUT from BUT
Computer Vision and Pattern Recognition (DCE)
ireich@fit.vut.cz



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

heikki.kalviainen@lut.fi (DCE program)
samuel.repka@lut.fi (student life)
ireich@fit.vut.cz (student life)