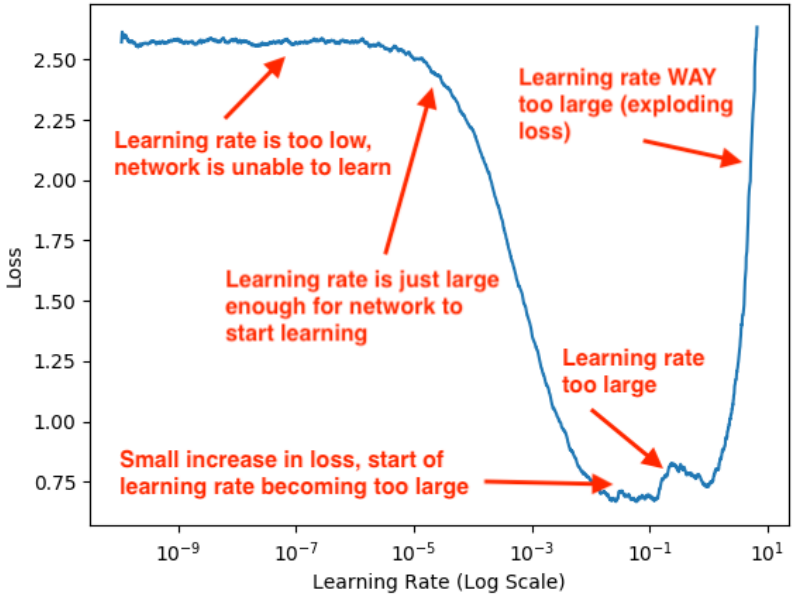
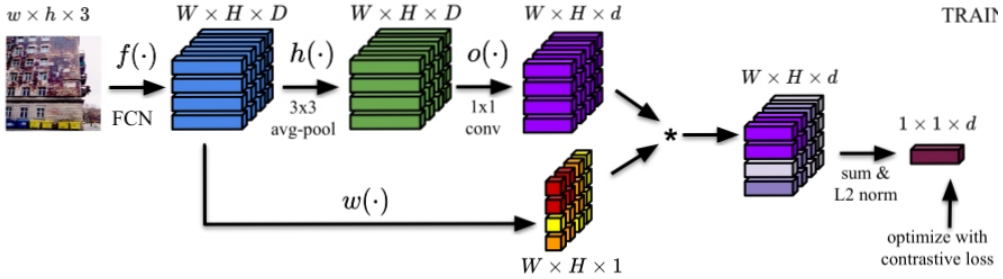
N-D Parameter Finder

- LR Finder (fastAi) is a nice algorithm to find an adequate starting LR (s. plot right)
- Task: expand to N-dimensions, e.g. incorporating weight decay, momentum, etc.
- Requirement: Deep Learning knowledge
- 5 ECTS
- Contact: vincent.christlein@fau.de



Writer Identification

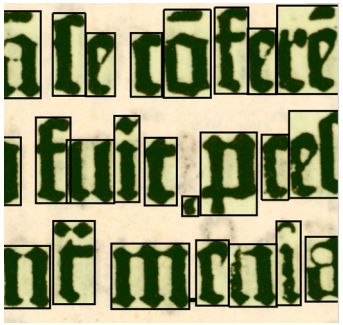


- Evaluate novel Image Retrieval Methods for Writer Identification
- Extend with regional dropout and other regularization techniques
- Requirement: Deep learning knowledge
- 5/10/15 ECTS
- Contact: vincent.christlein@fau.de

Self-supervised Learning for Multi-Task Document classification

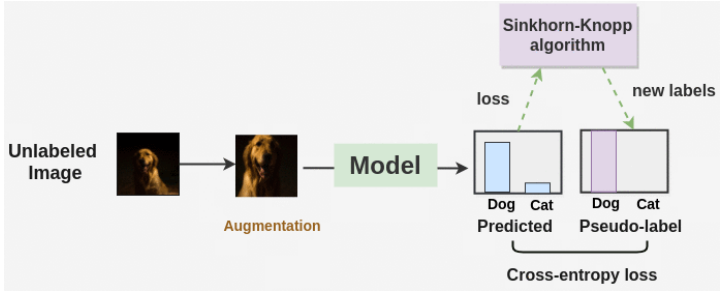
- Implement and evaluate SSL methods for different document analysis tasks
- Requirement: Deep learning knowledge
- 5/10 ECTS
- Contact: vincent.christlein@fau.de

Glyph Segementation by OCR



- Combine different OCR-D processors to segment single glyphs from medieval printed texts
- 5/10 ECTS
- Contact: vincent.christlein@fau.de, mathias.seuret@fau.de

Cluster-based BatchNorm



- Idea: extend current clustering-based self-supervised-learning techniques and make more use of the clusters. For example cluster-based BatchNorm
- Requirement: Deep learning knowledge
- 10/15/30 ECTS
- Contact: vincent.christlein@fau.de, mathias.seuret@fau.de

Procedural Terrain Generation using Generative Adversarial Networks

Problem statement:

- Procedural terrain generation is important for computer games or VR simulations and should be both realistic and diverse
- According to recent research, GANs are suitable for the task by predicting faithful height maps and/or textures

Task:

- Research on state of the art methods
- Implementation of a GAN Architecture that jointly generates both height maps and textures of an artificial terrain

- 10 ECTS Project
- **Requirements:**
  - Solid knowledge on Deep Learning
  - Experience or interest concerning GANs
  - Strong Python programming skills
- **Interested?** Contact: **denise.moussa@fau.de**

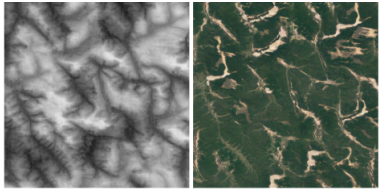


Figure: GAN generated heightmap and texture for terrain rendering (Spick et al., 2019)

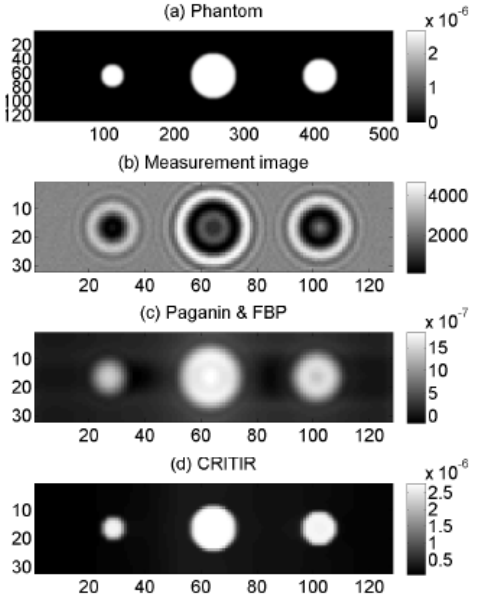
Direct Model-based Tomographic Reconstruction of the Complex Refraction

- Optimization-based approach (ADMM) to avoid reconstruction artifacts in phase tomography [1]
- Prototypical implementation in C is available

Research Project: (5 or 10 ECTS)

- Understand the ADMM optimization tasks
- Adjust the code and apply it to X-ray refraction scans at the material sciences department

Contact: Lina Felsner (lina.felsner@fau.de), C. Riess



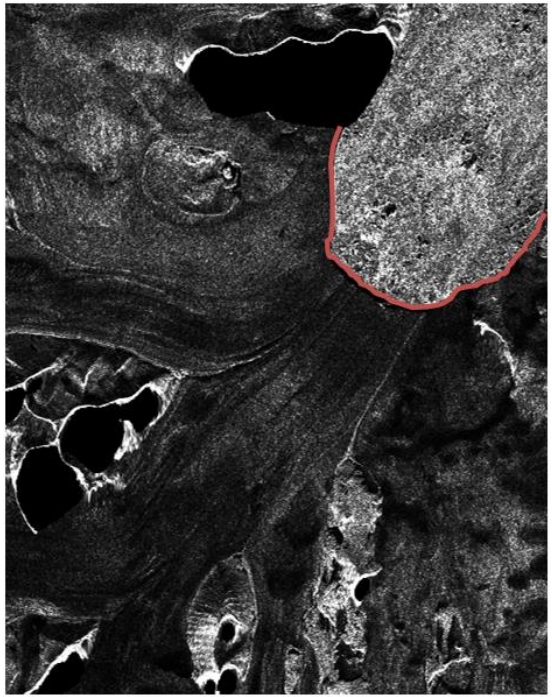
Example results from [1]

[1] K.A. Mohan, X. Xiao, and C. A. Bouman. *IEEE International Conference on Image Processing (ICIP)*, 2016.

Evaluation of Different Losses for Highly Unbalanced Segmentation

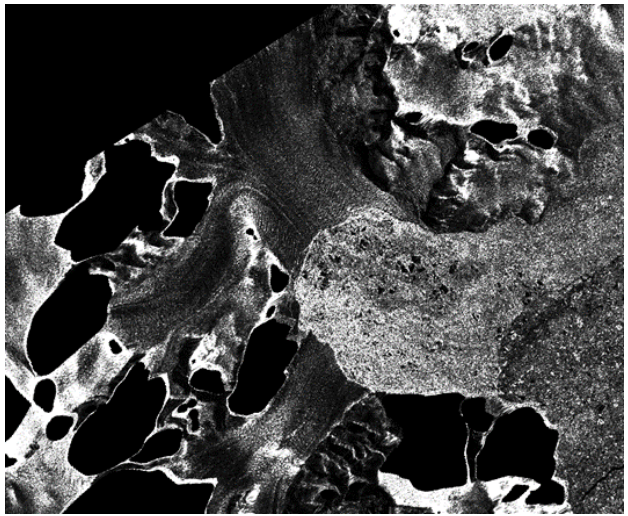
- Glacier front detection is a highly unbalanced segmentation
- Losses specifically designed for unbalanced segmentation (e.g. Boundary Loss) shall be searched and evaluated

- Contact: nora.gourmelon@fau.de
- 10 ECTS Project



Partial Convolution for No-Information Areas in SAR Images

- Due to record modalities of Synthetic Aperture Radar (SAR) the captured images show regions, where no information is given
- A U-Net shall be expanded to use Partial Convolution for these areas and a comparative evaluation of the segmentation results has to be included



- Contact: nora.gourmelon@fau.de
- 5 ECTS

Network Deconvolution as Sparse Representations

[Research Project - 5/10/15 ECTS (can be converted to thesis)]

Motivation

Real world is highly correlated. Learning a decorrelation method can help improve discriminative ability of the networks. Network Deconvolution [1] is one way of generating sparse representations.

Tasks

1. Apply Network Deconvolution to object/person detection problem
2. Compare it with other normalisation methods like group norm and batch norm

Requirements

1. Practical Knowledge of working with Deep Learning with frameworks like PyTorch/Tensorflow.
2. Taken either of the courses with good grades: Intro to Pattern Recognition, Pattern Recognition, Deep Learning.

Contact

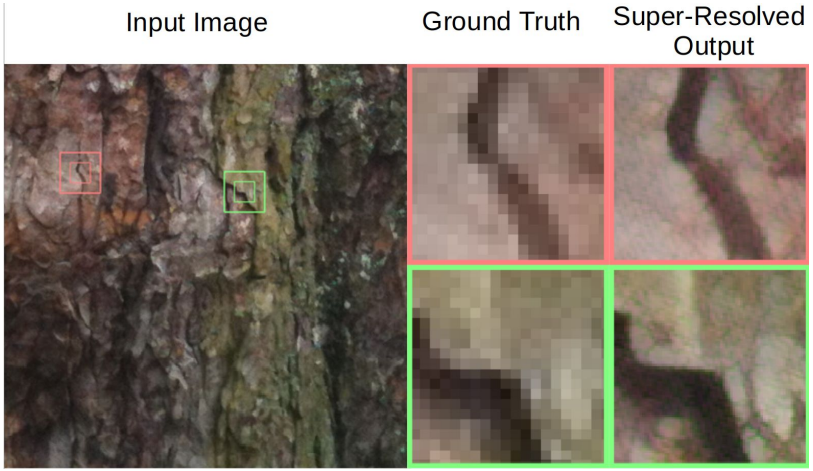
Ronak Kosti (ronak.kosti@fau.de)

Reference

[1] Ye, Chengxi, Matthew Evanusa, Hua He, Anton Mitrokhin, Tom Goldstein, James A. Yorke, Cornelia Fermüller, and Yiannis Aloimonos. "Network deconvolution." arXiv preprint arXiv:1905.11926 (2019). https://openreview.net/forum?id=rkeu30EtvS

Super-Resolve real world images (master/bachelor thesis)

Tasks



- Implementation of the paper "Unsupervised Learning for Real-World Super-Resolution [1]"
- Use "Deep Image Prior [2]" to improve the pipeline
- Requirements:
  - Python : keras, fastai, pytorch, tensorflow (any one of these)
  - Keen interest in programming

[1] Lugmayr, Andreas, Martin Danelljan, and Radu Timofte. "Unsupervised learning for real-world super-resolution." arXiv preprint arXiv:1909.09629 (2019).
[2] Ulyanov, Dmitry, Andrea Vedaldi, and Victor Lempitsky. "Deep image prior." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2018.

Contact: Prathmesh Madhu (prathmesh.madhu@fau.de) and/or Ronak Kosti (ronak.kosti@fau.de)

Pose Estimation - Greek Vase Paintings [*Master/Bachelor Thesis **OR** 5/10 ECTS Project*]

Motivation

Pose estimation is challenging for cross domain applications. In Greek Vase Paintings characters play a central role. Pose-based analysis of such data sheds more light into the narratives of the paintings and also exposes special techniques/skills used by the artists.

Tasks

1. Use [1] and adapt geometric and affine transformations as data augmentations to improve pose estimation
2. Use online style generation [2] to create end-end training pipeline as compared to 2 step in [1].
3. Allow, end-end differentiation for online styles [2].

Requirements

1. Practical Knowledge of working with Deep Learning with frameworks like PyTorch.
2. Taken either of the courses with good grades: Intro to Pattern Recognition, Pattern Recognition, Deep Learning.

Contact: Ronak Kosti (ronak.kosti@fau.de), Prathmesh Madhu (prathmesh.madhu@fau.de)

Reference

[1] Madhu, P. et al. “Enhancing Human Pose Estimation in Ancient Vase Paintings via Perceptually-grounded Style Transfer Learning.” ArXiv abs/2012.05616 (2020).

[2] Luo, Y., Liu, P., Guan, T., Yu, J., & Yang, Y. (2020). Adversarial style mining for one-shot unsupervised domain adaptation. arXiv preprint arXiv:2004.06042.

Emotion Recognition Guided by Context, Saliency and Gaze: *ECTS: 5/10/ Thesis*

Goal:

Understand the effects of gaze, saliency and context on emotion recognition[1].

Tasks:

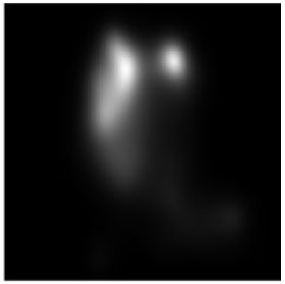
- Further experiments with existing pipeline
- Expansion of the pipeline to include a Graph Neural Networks module

Requirements:

- Knowledge on Deep Learning + Frameworks (PyTorch) + Python
- Experience with Computer vision and Pattern recognition
- Interest on the problem

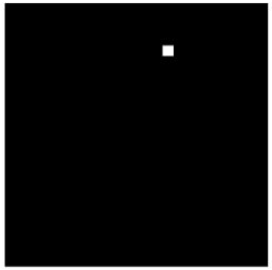
Contact: luis.rivera@fau.de

Image

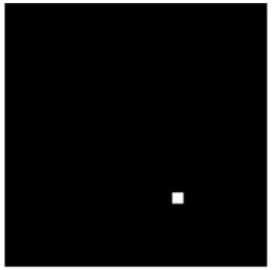


Saliency Map

Face



Eyes Location



Gaze Location

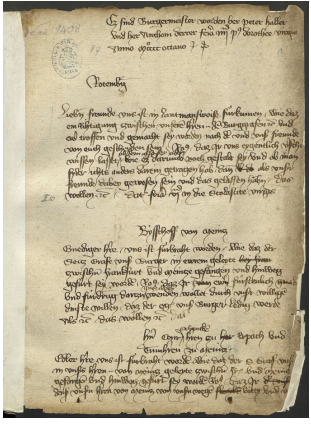
[1] Kosti, R., Alvarez, J. M., Recasens, A., & Lapedriza, A. (2019). Context based emotion recognition using emotic dataset. *IEEE transactions on pattern analysis and machine intelligence*, *42*(11), 2755-2766.

Decipher Ancient Documents with Handwritten Text Recognition System

Implement HTR approach to decipher Nuremberg Letters of Correspondences

- Reproduce results of HTR method on benchmark dataset (IAM)
- Train and run it on ancient documents

- 5 ECTS project
- Contact: martin.mayr@fau.de



Pattern Recognition Lab

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
FACULTY OF ENGINEERING

Neural Cellular Automata for Handwriting Generation

Build a neural cellular automata for producing handwriting with only local update rules but global text information

- Reimplement Growing Neural Cellular Automata
- Include global knowlegde (target text) into update rule
- Use GAN loss and HTR on word-level for training

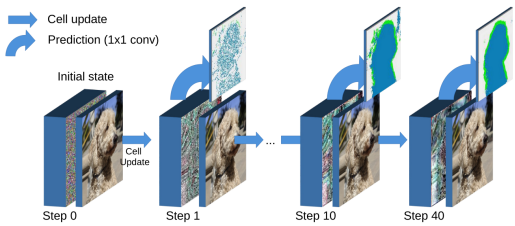
- 10 ECTS project
- Contact: martin.mayr@fau.de

Neural Cellular Automata for Binarization

Build a neural cellular automata for binarization which only uses local update rules

- Reimplement Image Segmentation via Cellular Automata
- Adjust it for binarization

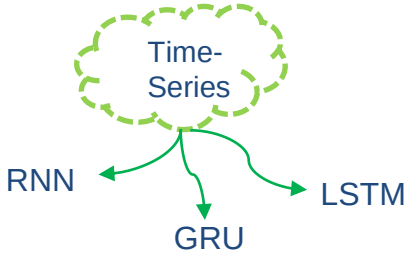
- 10 ECTS project
- Contact: martin.mayr@fau.de



Sheet Metal Forming Limits Determination Using DL_Time-Series

- Growing interest in CO2 emission reduction, low usage of petrol and complex design of automobiles has lead the automotive industry to think of using new, high-strength, light weight materials that differ significantly from the conventional ones. This project uses deep learning methods to correctly define the forming capacity of the new materials.

- **Objective:** Sheet metal forming capacity determination
  Data: Recorded video sequence using Digital Image Correlation (DIC) systems/cameras and recorded vibration and sound via Piezoelectric wafer active sensors (PWAS) both during the formation procedures



- **Main Tasks:**
  - Image/ signal processing using **time-series** algorithms

- The tasks in this project are suitable for 5, 10, or 30 ECTS.
- **Interested?** Please contact Faezeh Nejati (**faezeh.nejati@fau.de**)
- **Requirements:**
  - B+ or higher python programming language skills,
  - Solid knowledge on deep learning basics and time series algorithms

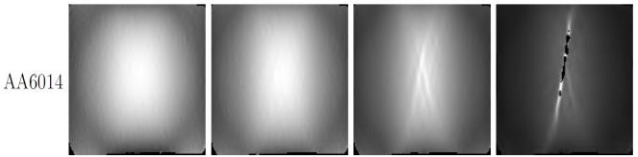


Figure1: Different formation stages of AA6014 (AA6014 is a light-weight aluminum alloy of the 6xxx series, that is used in car-body structures)

Sheet Metal Forming Limits Determination Using DL_Denoising

- **Objective:** Sheet metal forming capacity determination
  Data: Sound and vibration, recorded via Piezoelectric wafer active sensors (PWAS) during metal formation procedure

- **Main Tasks:**
  - State-of-the-art **denoising** algorithms for **signals**

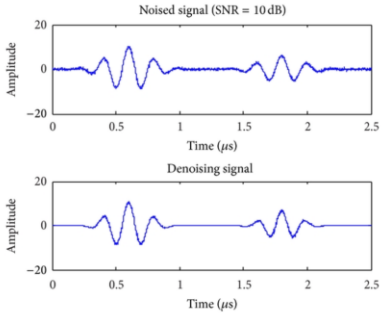


Figure 1: Noisy and Denoised signals [1]

- The tasks in this project are suitable for 5, 10, or 30 ECTS.
- **Interested?** Please contact Faezeh Nejati (**faezeh.nejati@fau.de**)
- **Requirements:**
  - B+ or higher python programming language skills,
  - Solid knowledge on deep learning basics and time series algorithms

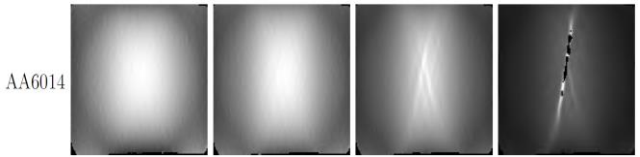


Figure 2: Different formation stages of AA6014 (AA6014 is a light-weight aluminum alloy of the 6xxx series, that is used in car-body structures)

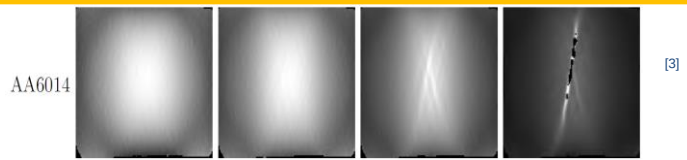
[1] Cai, Haichao, et al. "Study on the thick-walled pipe ultrasonic signal enhancement of modified S-transform and singular value decomposition." Mathematical Problems in Engineering 2015 (2015).

Sheet Metal Forming Limits Determination Using DL_FEM/ FEA

- Growing interest in CO2 emission reduction, low usage of petrol and complex design of automobiles has lead the automotive industry to think of using new, high-strength, light weight materials that differ significantly from the conventional ones. This project uses deep learning methods to correctly define the forming capacity of the new materials.

- **Main Tasks:**
  - **Simulation** using the Finite Element Methods (**FEM**)
    + Graph Neural Network
- A cool video related to **a similar study** to this project idea (Don't miss it! ;))**:**
  - https://www.youtube.com/watch?v=2Bw5f4vYL98

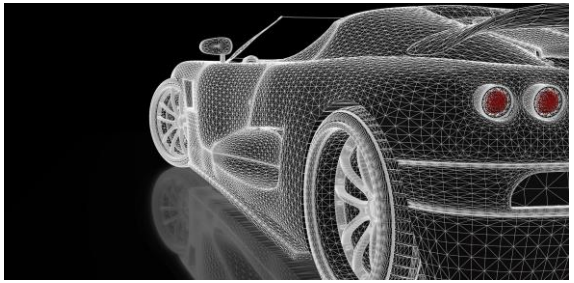
- The tasks in this project are suitable for 5, 10, or 30 ECTS.
- **Interested?** Please contact Faezeh Nejati (**faezeh.nejati@fau.de**)
- **Requirements:**
  - B+ or higher python programming language skills,
  - Solid knowledge on deep learning basics and time series algorithms



[3]

Figure 3: Different formation stages of AA6014 (AA6014 is a light-weight aluminum alloy of the 6xxx series, that is used in car-body structures)

[1]



[2]

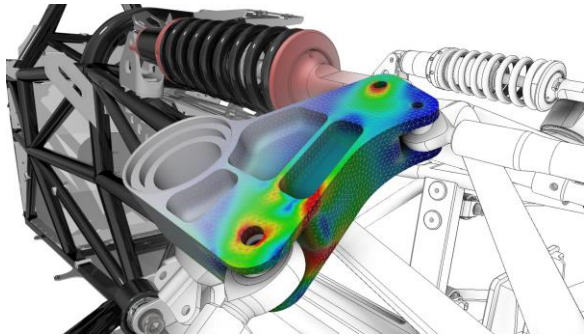
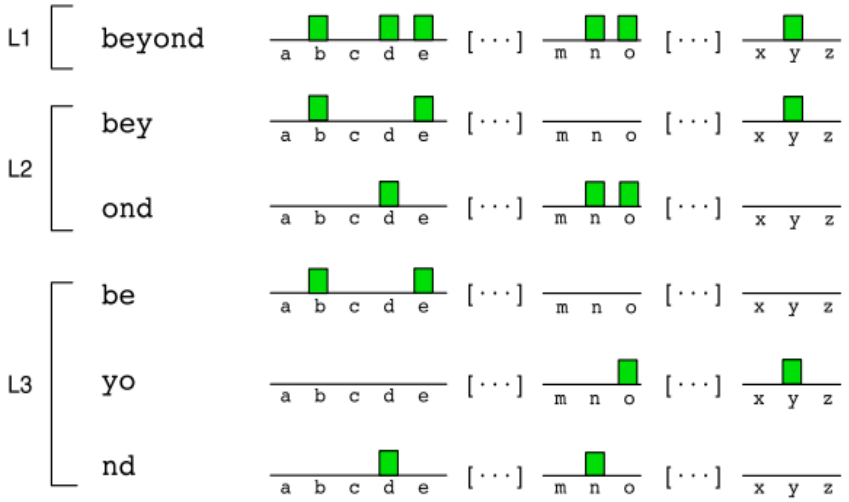


Figure1,2: Finite Element Analysis (FEA) Simulations
[1] https://www.fea-simulations.com,
[2] https://simonstoneengineering.com/services/simulation-analysis-fea/

Compressing PHOC-like representations

- PHOC-like: An vector representation of a string that can be generated from word-images
- Can we compress them? Will standard compression techniques work?
- Do they preserve their their joint image-string searchability



Contact: ***anguelos.nikolaou@fau.de***

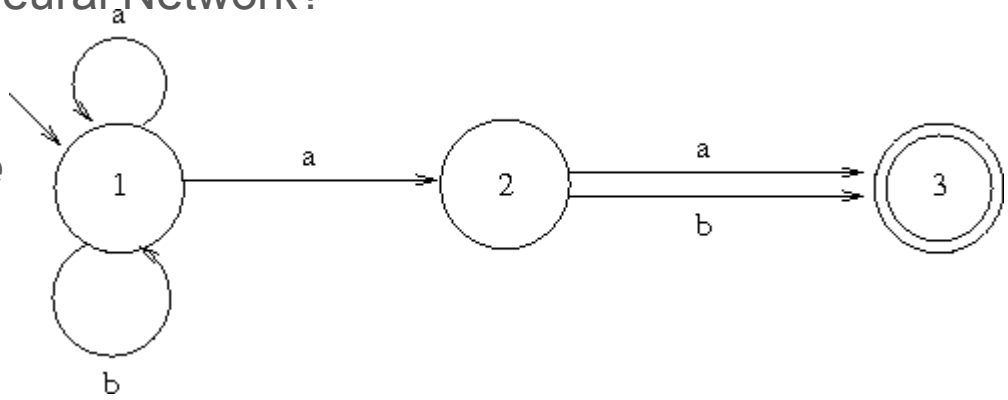
ECTS: 5/10/MT (depends)

Deep regular expressions

- Regular expressions are easily compiled to NFA (Non-discrete Finite-state Automata)
- Typically regular expression engines are implemented by compiling NFA to larger DFA (Discrete Finite-state Automata)
- Can we work directly on NFA?
- Can we use it on top of a Deep Neural Network?
- What are the benefits?

Contact: ***anguelos.nikolaou@fau.de***

ECTS: 5/10/MT (depends)



Neural Network Weight Factorization
Decomposing 2D Convolutions

- 2D Convolutions complexity: N^2
- Two consecutive 1D Convolutions complexity N*2
- How much do we lose if we train on 2D and do inference on 2x1D?
- How much do we lose if we train on 2x1D and do inference on 2x1D?

Contact: ***anguelos.nikolaou@fau.de***

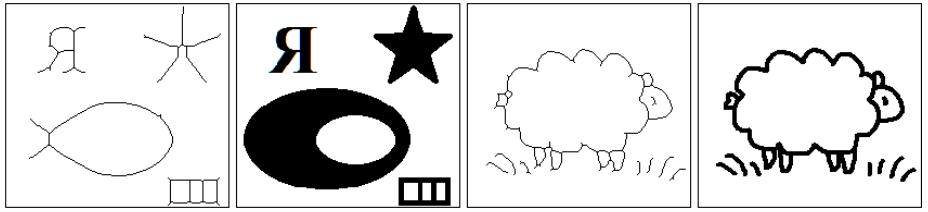
ECTS: 5

Stabilising skeletons

- We need skeletons for handwriting analysis
- They are unstable
- Using distance transform to make the skeleton more stable
- Can we use the stable transform for self supervision

Contact: ***anguelos.nikolaou@fau.de***

ECTS: 5/10/MT (depends)



Do androids dream of electric sheep?

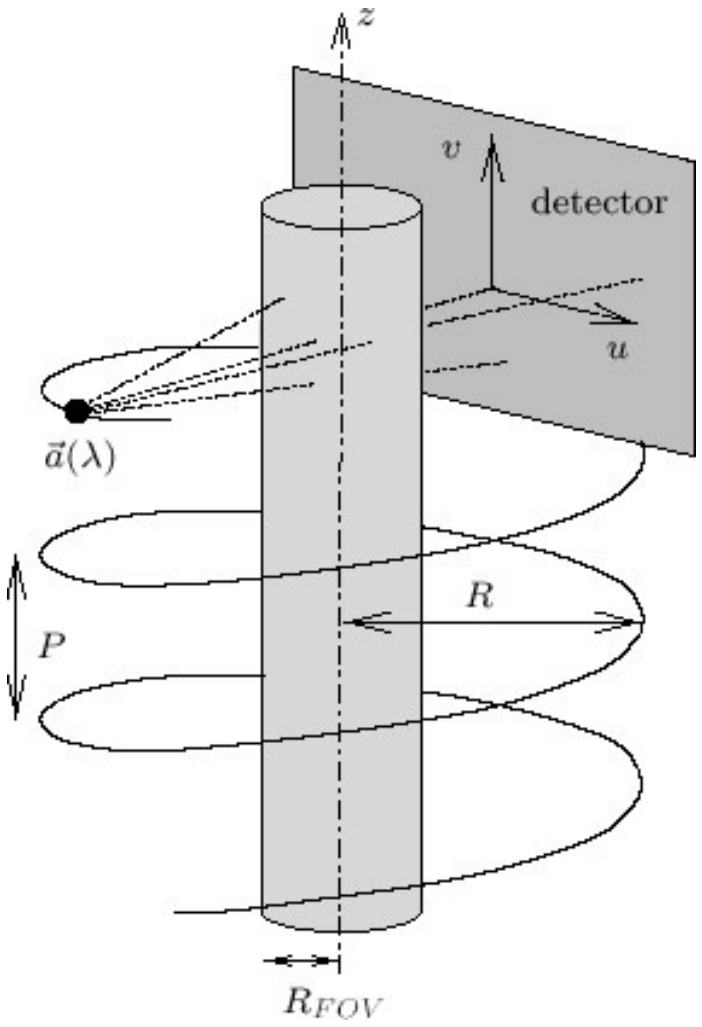
- Publicly distributed Neural Networks are often trained on private data
- Deep-dreams allow to visualise neural network weights
- Can we use deep dreams to reconstruct the private train data?
- Can this be used for a security attack?

Contact: ***anguelos.nikolaou@fau.de***

ECTS: 5/10/MT (depends)

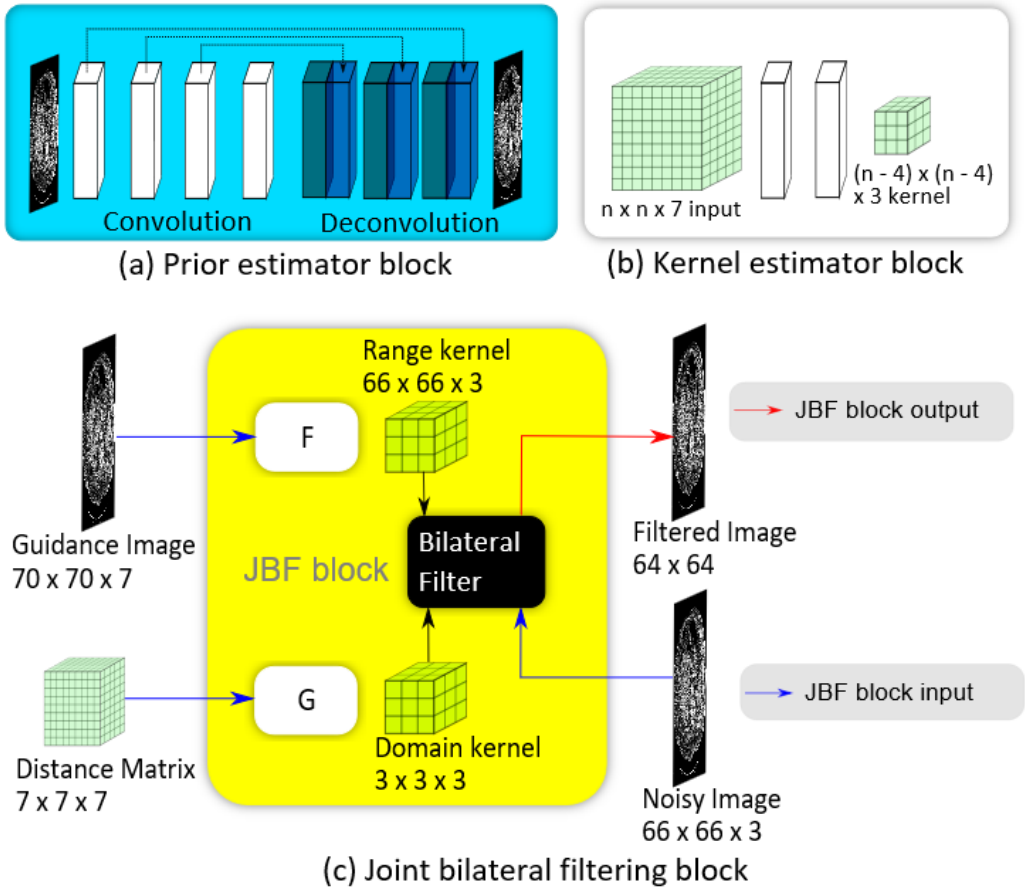
Reconstruction of spiral CT with deep reinforcement learning

- Research project worth 10 ECTS.
- Can be extended to a Master Thesis.
- Needs good Python and C++ skills. Some knowledge of CT physics is helpful.
- Contact: mayank.patwari@fau.de



Deep Learning with very low number of parameters for CT noise removal

- Research project worth 10 ECTS.
- Can be extended to a Master Thesis.
- Needs good Python and C++ skills. Some knowledge of image processing is helpful. Previous experience with PyTorch is an asset.
- Contact: mayank.patwari@fau.de



Detection and Tracking of Vehicles and License Plates in Videos

Problem statement:

- Detection of vehicles including license-plate for ground truth labeling
- Robust vehicle and license-plate tracking especially for frames with partial occlusion

Task:

- Implementation of Darknet-based license-plate detector
- Possible Extension: License-plate string recognition and extraction from video frames

- Task suitable for 10 ECTS Project
- Extendable to Bachelors/Masters Thesis
- **Requirements:**
  - Solid knowledge on Deep Learning and object detection algorithms
  - Strong Python programming skills
- **Interested?** Please contact Anatol Maier (**anatol.maier@fau.de**)

Figure: Example of vehicle detection and tracking

Perceptual Metric Evaluation on License Plate Images

Problem statement:

- Perceptual metrics like PSNR and SSIM fail to account for many nuances of human perception.
- Recent research suggest deep features based perceptual metrics.

Task:

- Evaluation of various standard perceptual metrics like SSIM, PSNR,
- deep features based perceptual metrics
- and *Learned Perceptual Image Patch Similarity (LPIPS) metric* on license plate images

- Task suitable for 5 or 10 ECTS Project
- **Requirements:**
  - Solid knowledge on Deep Learning
  - Experience in Tensorflow or PyTorch
  - Strong Python programming skills
- **Interested?** Please contact Anatol Maier (**anatol.maier@fau.de**)

GAN-generated License Plates

Problem statement:

- Availability of real-world images and videos of German vehicles with their respective license plate is limited.
- One possible approach is an generative model, able to generate additional data capturing scene dynamics as well as codec-based artifacts.

Task:

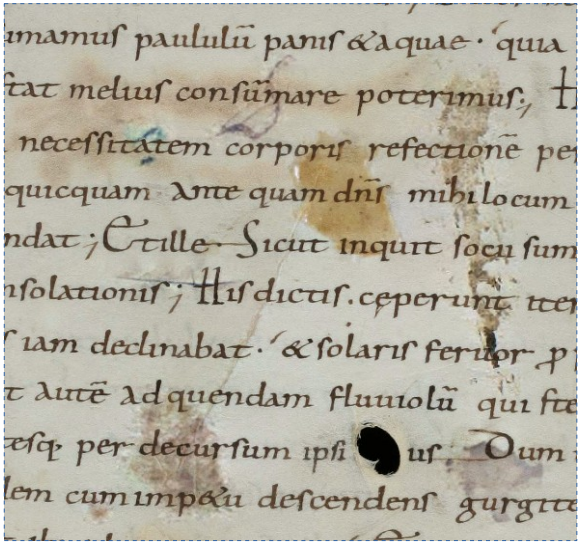
- Implementation and training of a GAN generating license plate images
- Possible Extension: GAN generated videos of license plates with scene dynamics

- Task suitable for 10 ECTS Project
- Extendable to Bachelors/Masters Thesis
- **Requirements:**
  - Solid knowledge on Deep Learning
  - Experience in Tensorflow or PyTorch
  - Strong Python programming skills
- **Interested?** Please contact Anatol Maier (**anatol.maier@fau.de**)

Gradient-domain Data Augmentation : Degradation Model

Color domain

Gradient domain

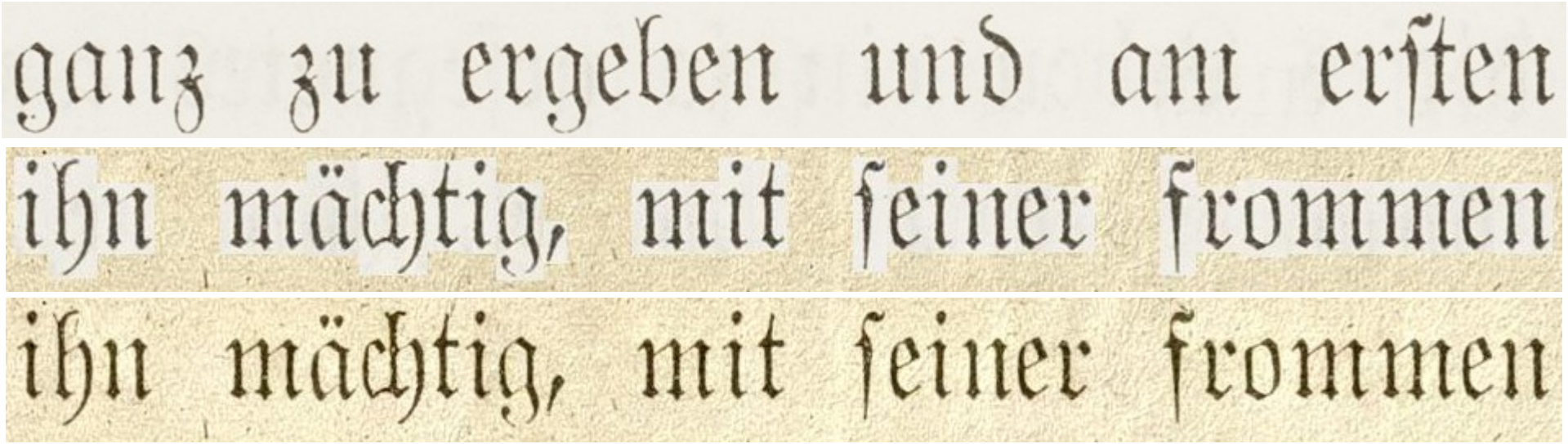


- Data augmentation method
- Paste gradients of stains
- Pixels reconstructed from gradients
- "Fools" human experts

- Noise location model needed (e.g., Fingerprints in margins, or water stains at top/bottom)
- GAN degradations generator, document as parameter
- Train/eval analysis method on augmented data

5-10 ECTS project – contact: mathias.seuret@fau.de

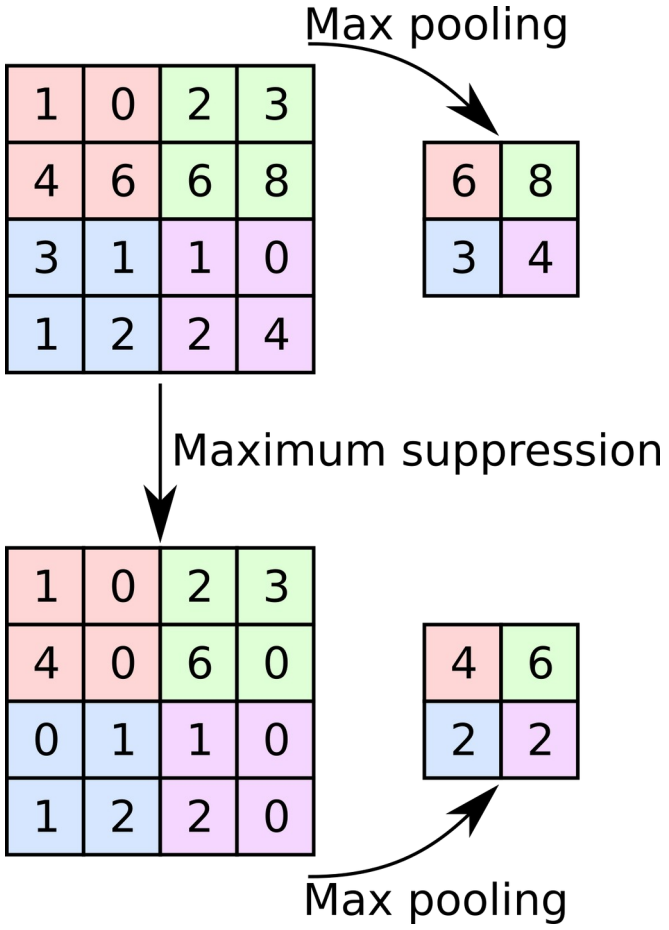
Mimicking Typesetting & Printing



- OCR for ancient documents: open problem
- Synthetic data needed
- Gradient-domain approach
- Toy-example proof of concept
- Automatic character & baseline extraction
- Typesetting rules (with help of book scientist)
- ‘’Print’’ pages with multiple fonts
- Evaluation through OCR

From 5 ECTS to Master project – contact: mathias.seuret@fau.de

Maximum suppression in activation maps



- Max pooling is a typical CNN layer
- Idea: extra-step removing highest value(s)
- Goal: find secondary decision criterions
- Can networks still learn?
- Impact on generalization? On overfitting?

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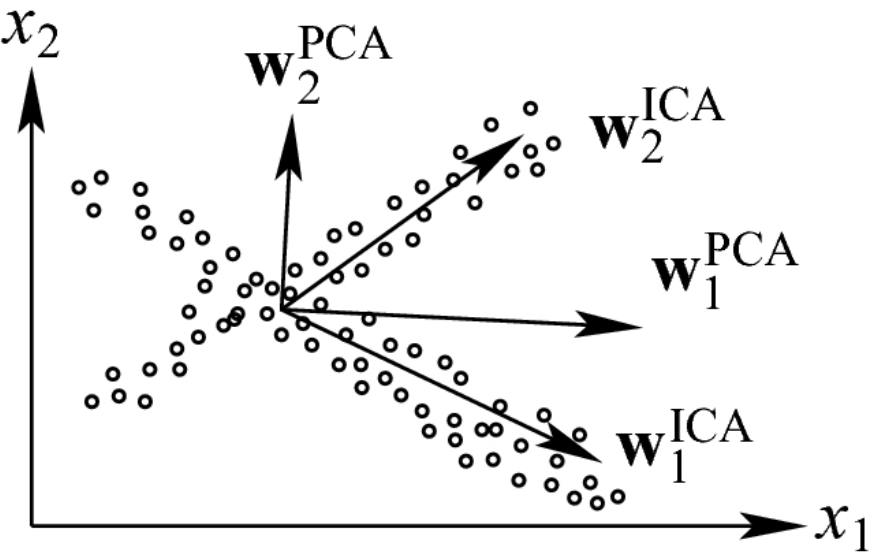
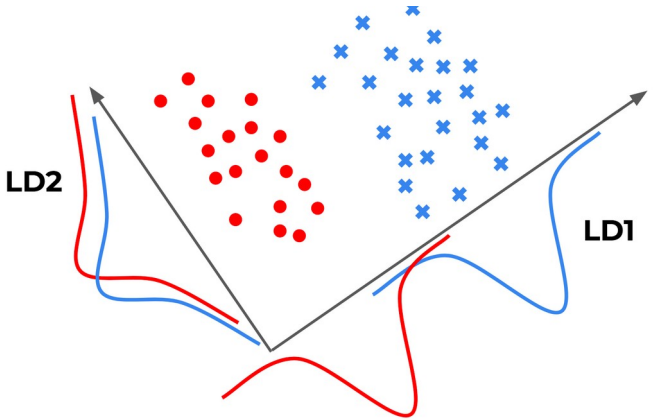
Statistical Initializations for CNNs





- Goal: Quick & good deep CNN initialization

- Goal: PyTorch architecture-independent implementation

- Principal component analysis
- Independent component analysis
- Linear discriminant analysis

- Replace random initialization, pre-training, transfer learning

- Past experiments showed this works on small networks

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