# Explainable image segmentation with wavelet-network

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# Content

Motivation

## Reliability

- Safety critical domains $\Rightarrow$ reliable model
- Reliability can be achieved by introducing self-explainable models
    - prototype $\Rightarrow$ basis of the explanation
    - feature extraction $\Rightarrow$ large convolutional neural networks $\Rightarrow$ random and memory demanding
- WaveProtoPNet
    - Wavelets $\Rightarrow$ feature extractors
    - Promising results in image classification
    - Can we use the system for **segmentation**?
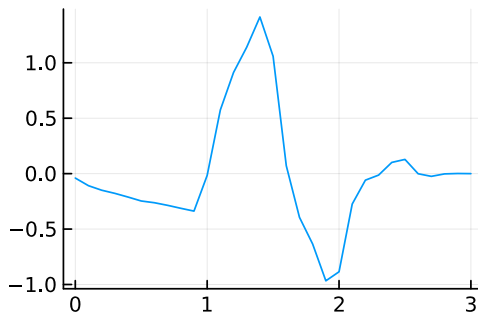
# Wavelet transform

# Wavelets



Figure: Daubechies-2 wavelet

- It is similar to the Fourier transform, but keeps information about both time and frequency components of the function.
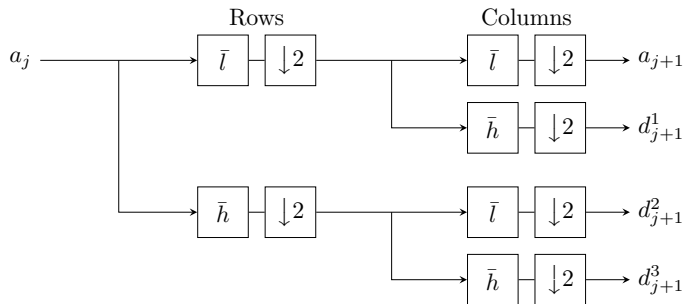
## Wavelet-decomposition



Figure: 2 dimensional fast wavelet transform

- wavelet - can be built up from high- and low-pass filters
- fast wavelet transform - with the filters
- result: $4$ quarter-sized image
- reconstruction similarly

# WaveProtoSeg

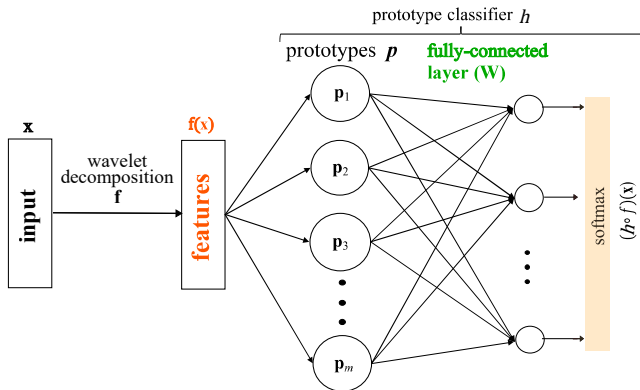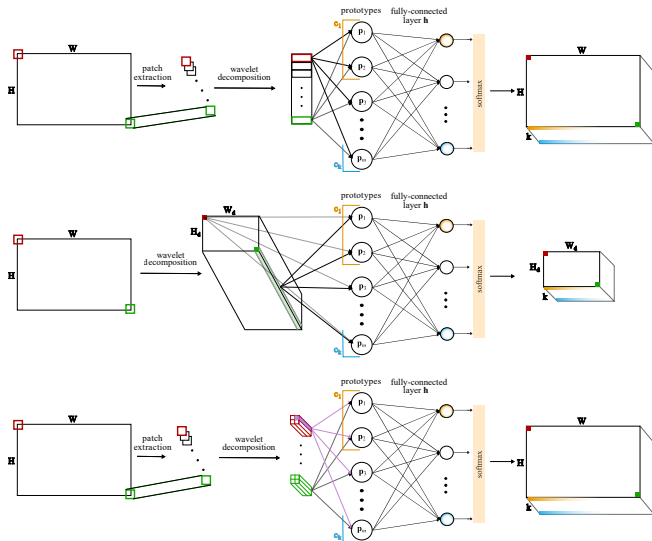# Starting point: WaveProtoPNet modell



Figure: Structural parts of WaveProtoPNet.

# Segmentation modell: WaveProtoSeg



Implementation approaches:

1. Patch extraction at the beginning + patch-sized prototypes.

2. Patch extraction via wavelet decomposition.

3. Patch extraction at the beginning + prototypes smaller than the size of a patch
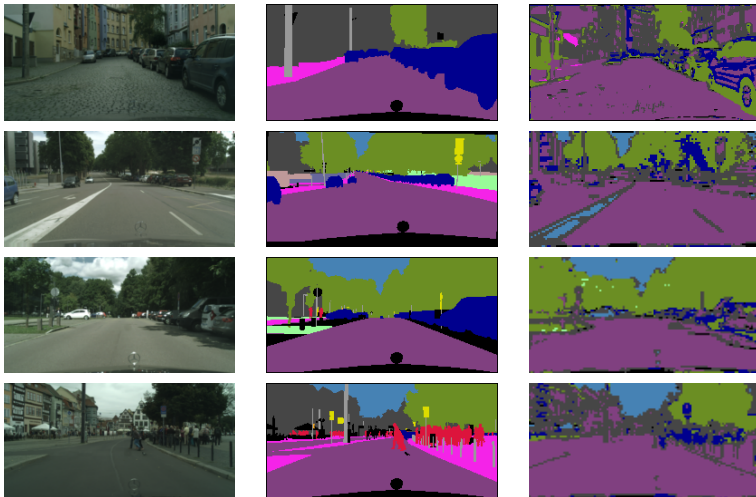
# Experiments

# Dataset



Cityscapes dataset

- 20 classes
- 5000 images
- $128 \times 256$ RGB

# Results

- Best result:
  3. modell type,
  $41.19\%$ **train** and $39.21\%$ **test** mIoU (mean Intersection over Union)
- Faster but less accurate:
  2. modell type,
  $35.43\%$ **train** and $33.86\%$ **test** mIoU

# Classification - example

# Prototypes

20 prototype/class          5 proto/class



- Only a few classes yield representative prototypes; the others are mostly noisy.

Conclusions, future work

# Conclusions, future work

- Low mIoU
  - underrepresented classes
  - wavelet decomposition is not sensitive enough to the data
  - small receptieve field
- It would be worth trying on another data set
- Using the results of wavelet decomposition from multiple levels

# Questions?

# Bibliography I

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[3] Stéphane Mallat. *A Wavelet Tour of Signal Processing*. Elsevier, 2009.

[4] Wojciech Samek et al. "Explaining Deep Neural Networks and Beyond: A Review of Methods and Applications". In: *Proceedings of the IEEE* 109 (Mar. 2021), pp. 247–278. DOI: 10.1109/JPROC.2021.3060483.