Explainable Image Segmentation with Prototypes

class- and scale-independence

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The problem of semantic image segmentation

- Safety-critical application areas:
  - self-driving cars,
  - aviation,
  - medical imaging.
- Deep learning models:
  - achieve high accuracy,
  - lack explanations ("black-box" nature).
- Need for interpretable models:
  - reliability and transparency,
  - understanding the model's behavior.

The problem of semantic image segmentation

CityScapes dataset [3]

- standard benchmark dataset for evaluating semantic segmentation
- contains images of urban environments with pixel-level annotations
- 30 semantic classes, including:
  - road
  - sidewalk
  - building etc.
- high-resolution images (1024×2048 pixels)

Self-explaining deep learning models

- built-in interpretability
  - through explanatory components
  - concept, prototype
- explanations understandable by humans
- combination of:
  - **intuitive reasoning** of classical ML models
  - **accuracy** of deep learning models

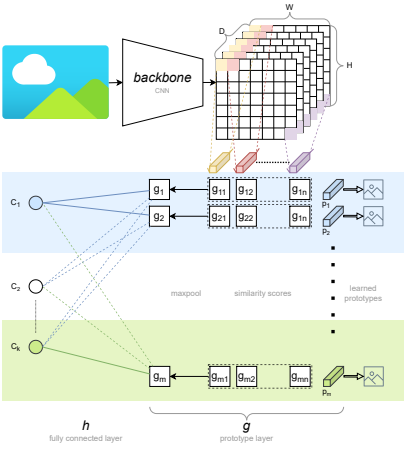
ProtoPNet [1]

strengths:

- patch-level prototypes
- "This looks like..." style reasoning

limitations:

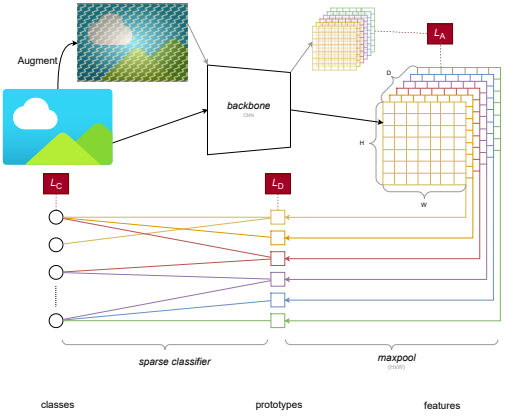
- prototypes have learnable weights
  - prototype – patch representation
- class-specific prototypes



PIP-Net [5]

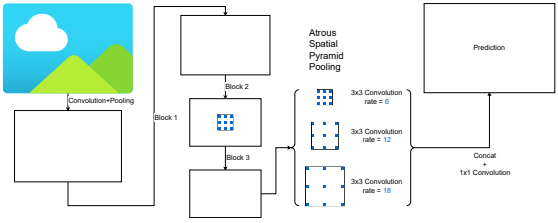
strengths:

- concept activations
  - no learned prototypes
  - unsupervised learning
- "sparse classifier"
- cross-class prototypes



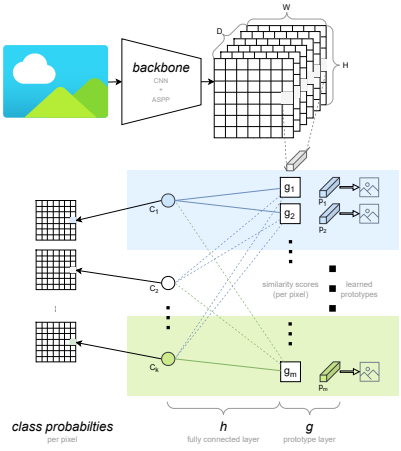
DeepLab v3 [2]

- based on the ResNet [4] architecture
- foundation for multiple prototype-based models
- Atrous Spatial Pyramid Pooling (ASPP) = multi-scale representation



ProtoSeg [7]

- similar to ProtoPNet
- based on the DeepLab v3 architecture
- prototype diversity ensured using Kullback–Leibler divergence

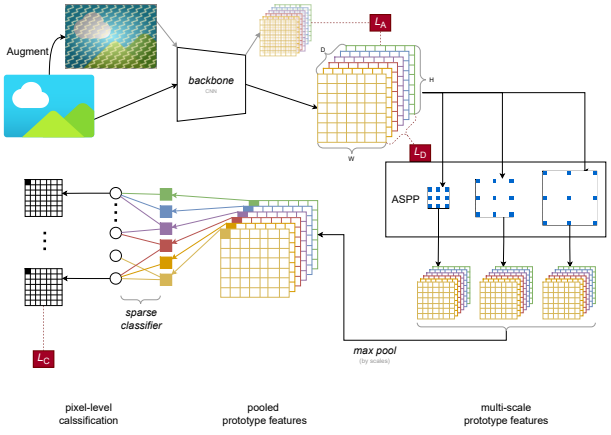


ScaleProtoSeg [6]

- prototypes at multiple scales
- leveraging the capabilities of ASPP

Proposed architecture

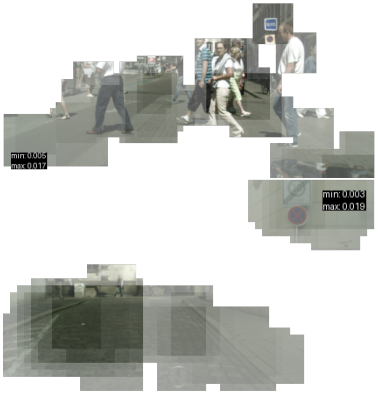
- spatially aligned latent representations
- scale-independent prototypes
  - ASPP: shared weights
  - activations examined at multiple scales
- class independence
  - "sparse classifier"



Several prototypes belonging to one concept

concept contribution to semantic classes:

- road (12.29)
- sidewalk (3.68)
- wall (1.29)
- ground (0.71)



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Thank you for your attention!

Questions?

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