Image segmentation

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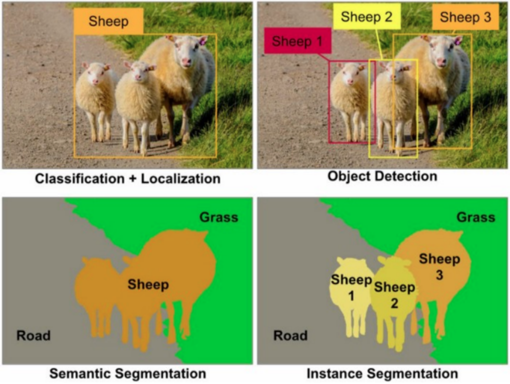
Types of tasks

Different image tasks



Classification + Localization

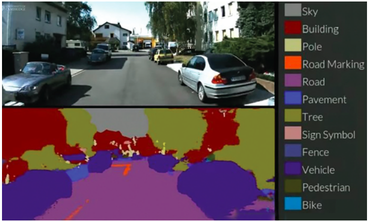
Object Detection

Semantic Segmentation

Instance Segmentation

- Classification+localization could be done by extending classifier to output (x,y,h,w) of the bbox.

Image segmentation[1]



- Segmentation - classification of every pixel of the image.
- Quality measures: pixel accuracy, intersection over union.

[1] Picture source.

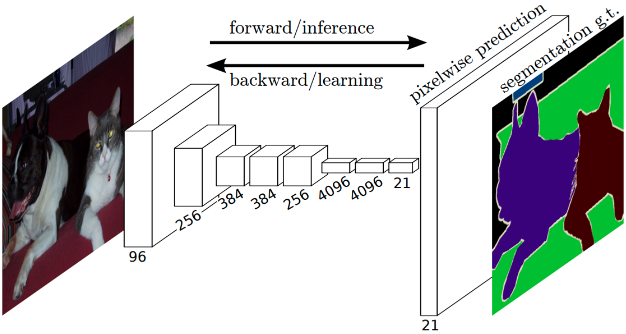
Applications

- satellite photos:
    - segment urban and agricultural areas
    - segment fields with different types of plants, their growth
- autonomous driving
    - segment people, other vehicles, signs, road obstacles
- medical applications:
    - tissues on the skin

Fully convolutional neural networks for semantic segmentation

May use VGG, ResNet as encoder, add upscaling at the end.

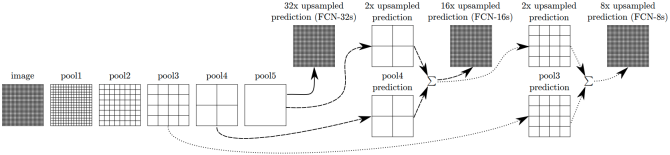
- gives rough imprecise object boundaries on rigid grid.



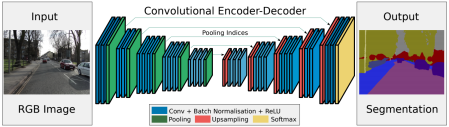
FCN-8s architecture

- Upsampling and addition of prev. layers helps to recover both high and low level info.

Info from previous layers is used

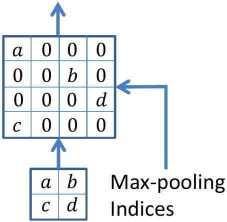


SegNet



- Encoder from VGG, ResNet, can finetune.
- Decoder - reversed encoder with pooling replaced with "unpooling" layer.

Unpooling upscased by placing max values at corresponding positions



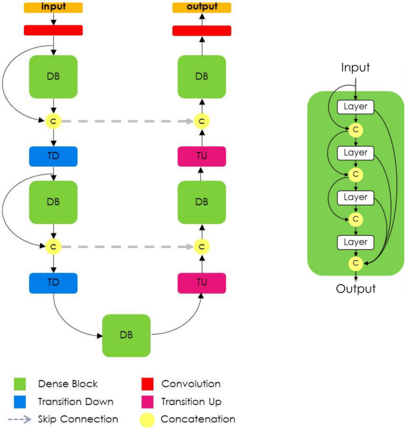
$$\begin{array}{|c|c|c|c|}\hline a & 0 & 0 & 0 \\ \hline 0 & 0 & b & 0 \\ \hline 0 & 0 & 0 & d \\ \hline c & 0 & 0 & 0 \\ \hline \end{array}$$

$$\begin{array}{|c|c|}\hline a & b \\ \hline c & d \\ \hline \end{array}$$

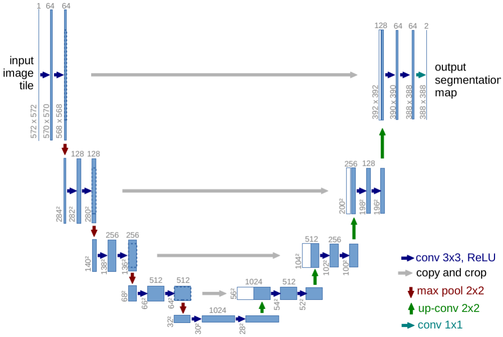
One Hundred Layers Tiramisu

Utilizes dense block - extended ResNet block with more identity connections.

Architecture and dense block



U-net architecture[2]



Horizontal numbers = #[channels]; vertical numbers = spatial size.
White blocks - copied output of earlier layers; up-conv - rescaling & convolution.

[2] Ronneberger et al [2015].

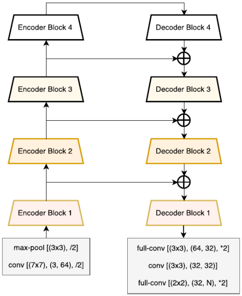
Discussion

Key ideas of U-net:

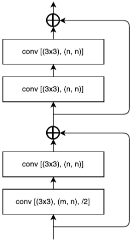
- preserve spatial info at each layer
    - use only convolution, pooling, scaling.
    - don't use vectorization & fully connected layers
- 1st half - encoder; 2nd half - decoder.
- Encoder aggregates wider and wider local information
    - creating more abstract features
- Decoder reconstructs local information from
    - more abstract features (green input on figure)
    - lower level features (gray input on figure)

LinkNet

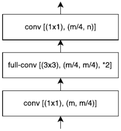
Similar to U-net but uses summation to combine information. ResNet blocks used in encoder. 1x1 conv used in decoder to be leightweight.



LinkNet Architecture



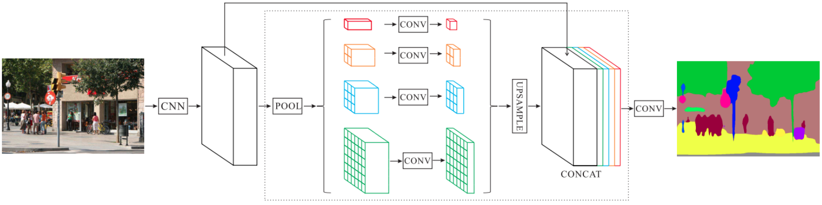
Convolutional modules in *encoder-block (i)*



Convolutional modules in *decoder-block (i)*

PSPNet

Pretrained ResNet as CNN encoder. Pyramidal pooling & upsampling used to combine features with different resolution.



(a) Input Image (b) Feature Map (c) Pyramid Pooling Module (d) Final Prediction

Object detection

- Need to find bboxes for arbitrary number of objects.
- Could apply CNN classifier with rolling window - too slow.
- R-CNN: apply CNN on region proposals (rescaled to std. resolution).
- Fast R-CNN: apply CNN to whole image
- Faster R-CNN: extract region proposals with CNN
- YOLO, SSD