

U-Nets for medical Image-Segmentation

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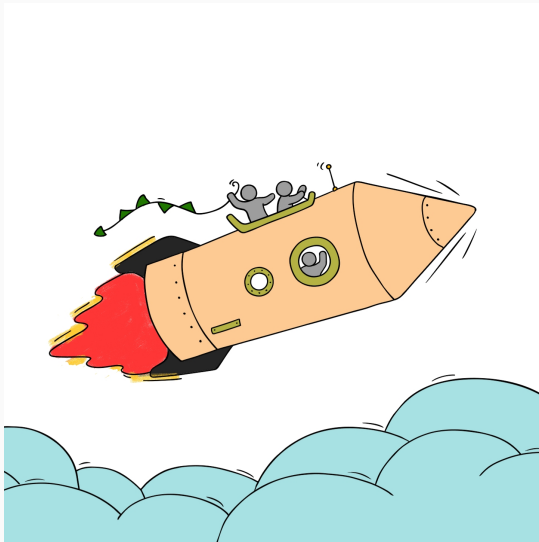
Motivation

The U-Net architecture

Loss function and Evaluation metric

Motivation

What is Segmentation?



Segmentation Types

- Semantic Segmentation: Classify each pixel in the image
- Instance Segmentation: Classify pixel based on the instances of the object
- Panoptic Segmentation: Semantic + Instance Segmentation

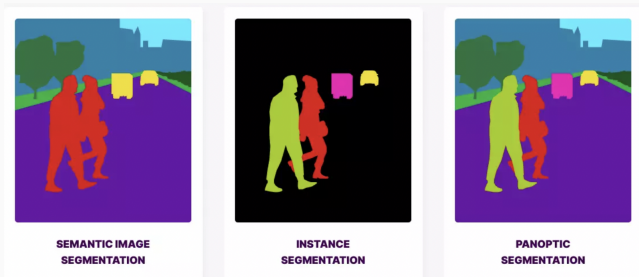


Figure: Types of segmentation.[Blo22]

Image segmentation in robotics

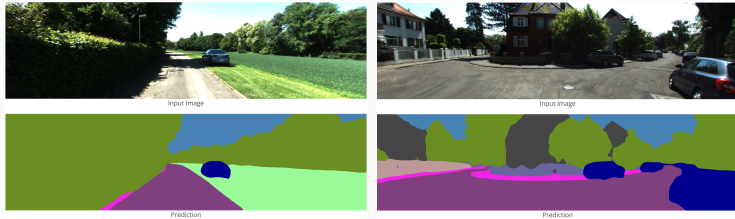


Figure: Images from the semantic kitti road scene segmentation dataset [Gei+13].

Autonomous Driving - Laser segmentation

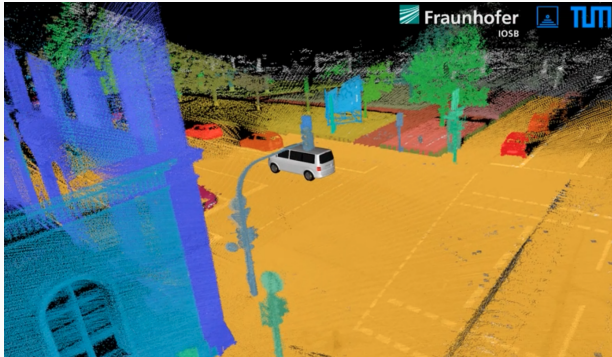


Figure: A part of segmented point-cloud from TUM City Campus dataset [Geh+17]. Full video can be found [here](#).

Medical Image segmentation

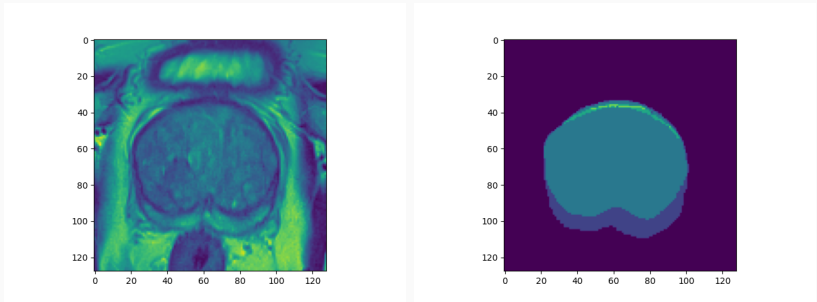


Figure: A transversal prostate image and its expert segmentation [Mey+19].

The U-Net architecture

The U-Net structure [RFB15]

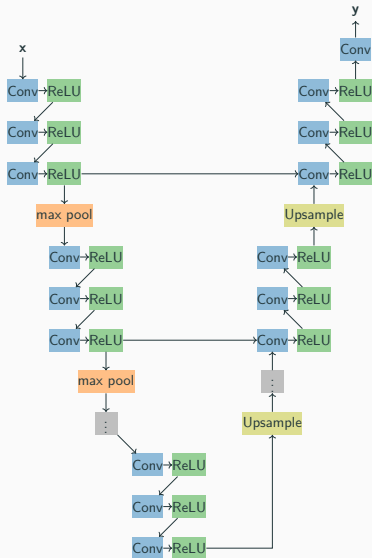


Figure: The U-Net architecture [RFB15].

UNet - Prostate segmentation

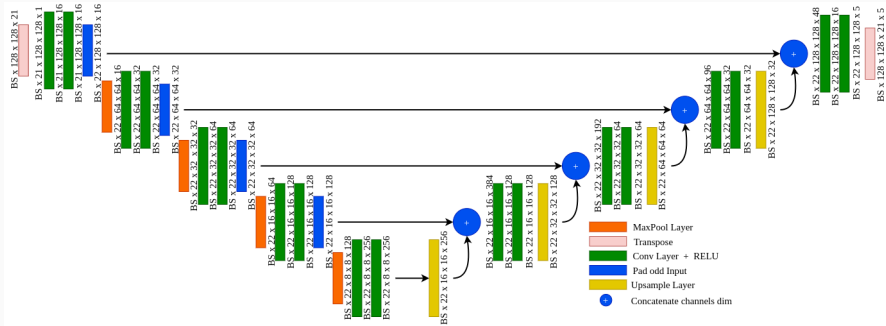


Figure: UNet to be implemented for Prostate segmentation exercise

Loss function and Evaluation metric

The focal loss for segmentation problems

Focal loss functions are a standard approach in image segmentation, it originally appeared in [Lin+17]. The general idea is to increase the weight of rare classes. If classes are mutually exclusive use,

$$\mathcal{L}(\mathbf{o}, \mathbf{l}) = -\mathbf{l} \cdot (1 - \sigma_s(\mathbf{o}))^\gamma \cdot \alpha \cdot \ln(\sigma_s(\mathbf{o})) \quad (1)$$

to train your U-Net.

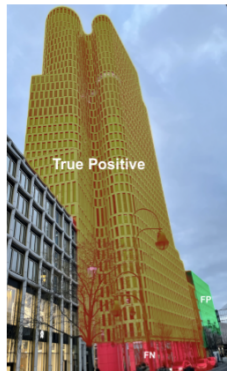
Intersection over union



Ground Truth Mask



Predicted Mask



IoU

Intersection over union (IoU)

IoU is calculated as a fraction of area of intersection and area of union between GT and predicted masks.

From above example, IoU can be calculated using confusion matrix by the below formula

$$\text{IoU} = \frac{\text{TP}}{\text{TP} + \text{FP} + \text{FN}}$$

where TP, FP and FN are True Positives, False Positives and False Negatives respectively.

References

- [Blo22] Mindy news Blog. ***What is Image Segmentation: The Basics and Key Techniques.*** <https://mindy-support.com/news-post/what-is-image-segmentation-the-basics-and-key-techniques/>. Accessed: 2023-09-26. 2022.

- [Geh+17] Joachim Gehrung, Marcus Hebel, Michael Arens, and Uwe Stilla. “**An approach to extract moving objects from MLS data using a volumetric background representation.**” In: *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 4 (2017), pp. 107–114.
- [Gei+13] Andreas Geiger, Philip Lenz, Christoph Stiller, and Raquel Urtasun. “**Vision meets Robotics: The KITTI Dataset.**” In: *International Journal of Robotics Research (IJRR)* (2013).

- [Lin+17] Tsung-Yi Lin, Priya Goyal, Ross Girshick, Kaiming He, and Piotr Dollár. “**Focal loss for dense object detection.**” In: *Proceedings of the IEEE international conference on computer vision*. 2017, pp. 2980–2988.
- [Mey+19] Anneke Meyer, Marko Rakr, Daniel Schindele, Simon Blaschke, Martin Schostak, Andriy Fedorov, and Christian Hansen. “**Towards patient-individual PI-Rads v2 sector map: CNN for automatic segmentation of prostatic zones from T2-weighted MRI.**” In: *2019 IEEE 16th International Symposium on Biomedical Imaging (ISBI 2019)*. IEEE. 2019, pp. 696–700.

- [RFB15] Olaf Ronneberger, Philipp Fischer, and Thomas Brox. **“U-net: Convolutional networks for biomedical image segmentation.”** In: *Medical Image Computing and Computer-Assisted Intervention–MICCAI 2015: 18th International Conference, Munich, Germany, October 5–9, 2015, Proceedings, Part III* 18. Springer. 2015, pp. 234–241.