Practices in visual computing 1

Lab8: Image Segmentation 1

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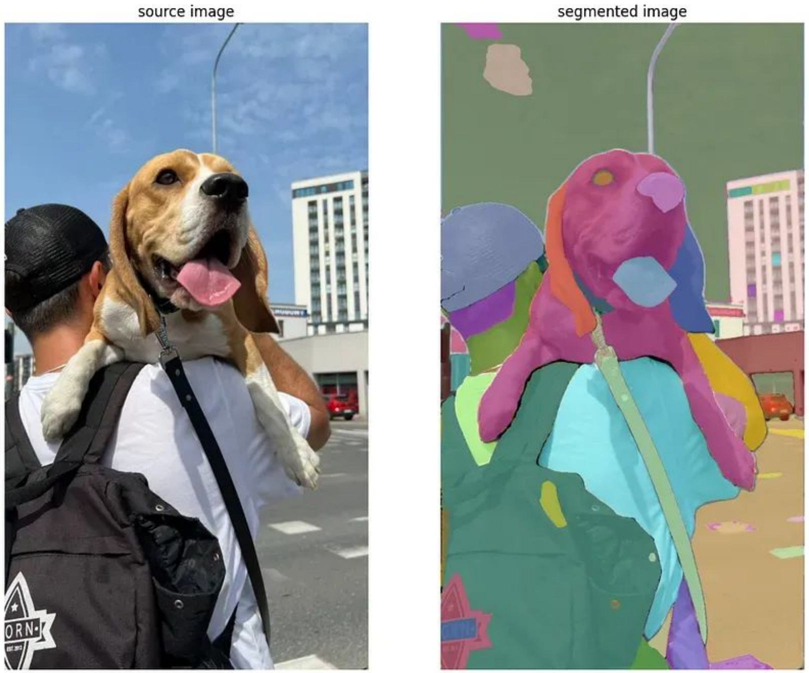
What is Image Segmentation?

Image segmentation divides an image into meaningful regions by assigning a label to each pixel based on shared characteristics.



Why is Segmentation Important?

Medical Imaging (tumor segmentation)

Autonomous Driving (road and obstacle detection)

Satellite Imagery (land-use classification)

Photo Editing (object background removal)

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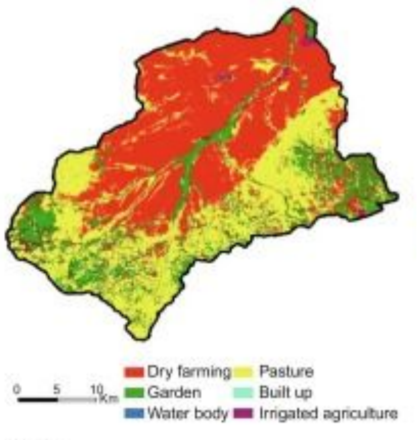

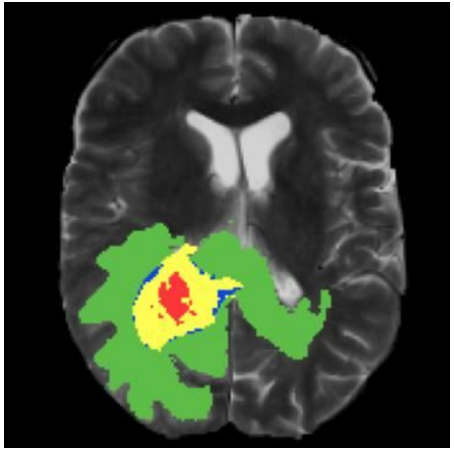

Types of Image Segmentation

1. Semantic Segmentation: Assigns each pixel a class label, e.g., distinguishing car, road, and pedestrian.

2. Instance Segmentation: Extends semantic segmentation by labeling each object instance, e.g., three different pedestrians in one scene.

3. Panoptic Segmentation: Combines both, where each pixel has a class, and instances are identified.

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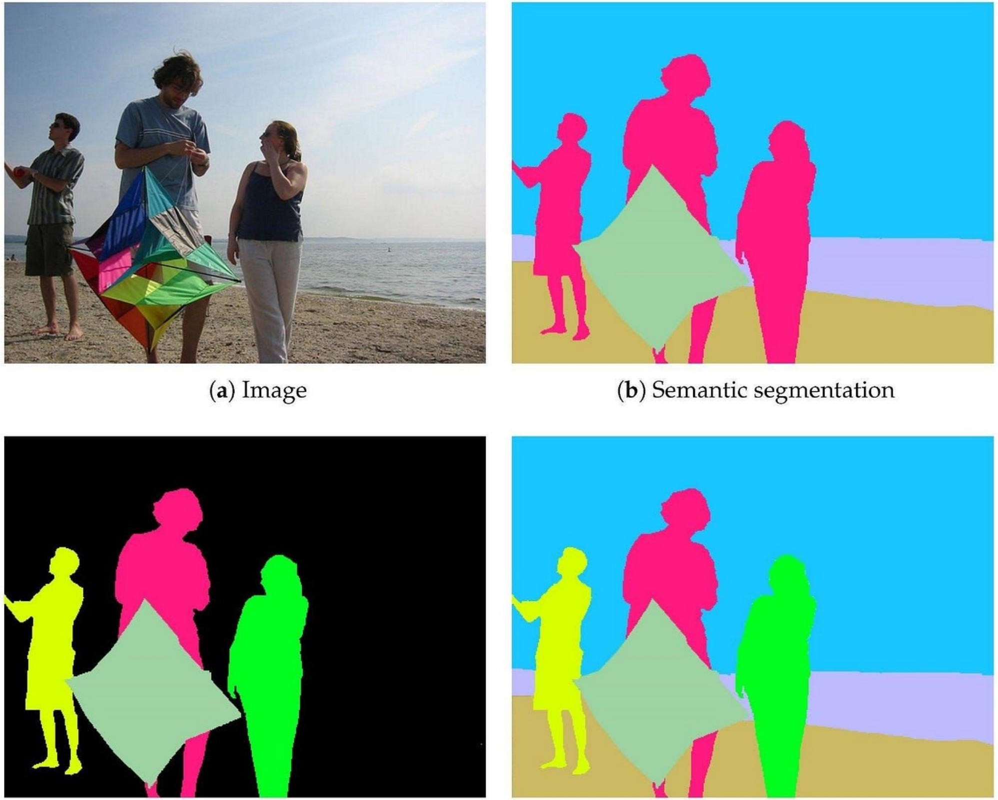


(a) Image

(b) Semantic segmentation

(c) Instance segmentation

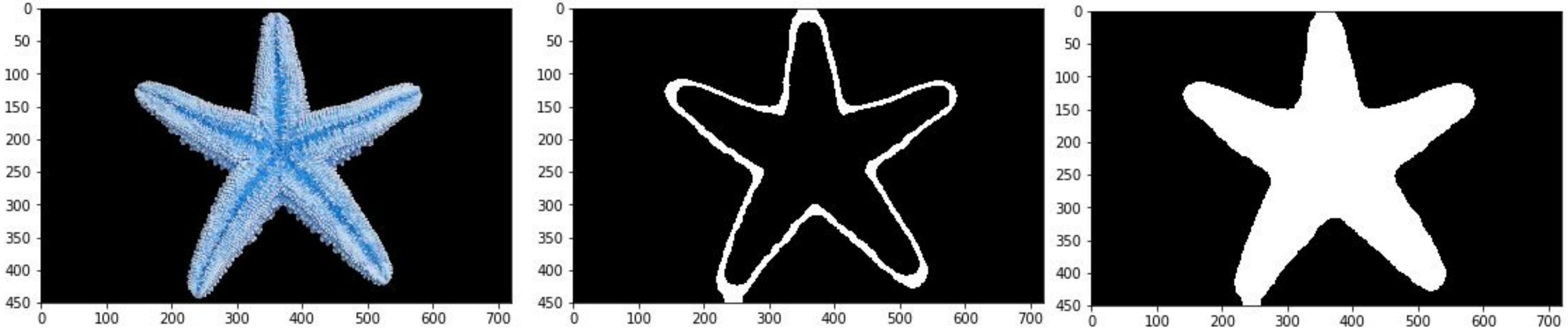
(d) Panoptic segmentation

Basic Segmentation Techniques

Thresholding: Assigns pixels to categories based on intensity thresholds.

Clustering (e.g., K-means): Groups similar pixels together in color space.

Edge Detection: Detects object boundaries using gradients (Sobel, Canny).



Deep Learning and Segmentation

Deep Learning transformed segmentation by automating feature extraction.

UNet

Mask R-CNN

DeepLab

Attention mechanisms

Other methods

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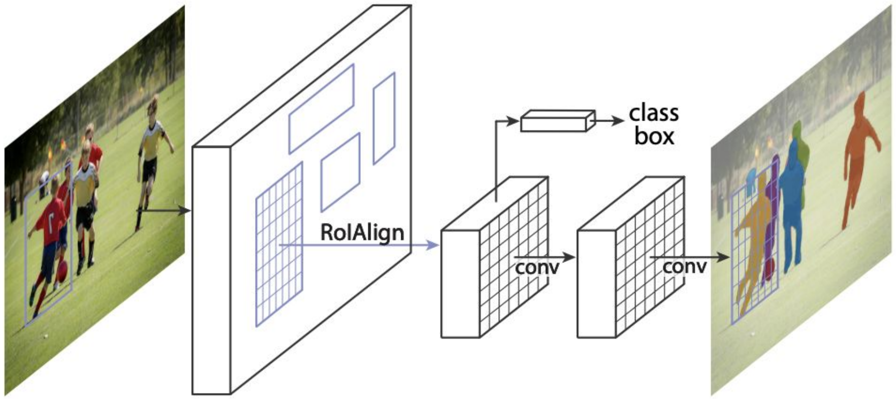

Evaluation Metrics for Segmentation

Pixel Accuracy: Measures correctly classified pixels.

Intersection over Union (IoU): Calculates overlap between prediction and ground truth for each class.

Mean IoU: Average IoU across all classes.

Dice Coefficient: Measures similarity between predicted and actual areas, common in medical imaging.

Datasets for Segmentation

Pascal VOC: 20 classes, general-purpose segmentation.

Cityscapes: Urban street scenes, essential for autonomous driving research.

COCO: For both detection and segmentation with 80 object categories.

ADE20K: Diverse classes and environments.

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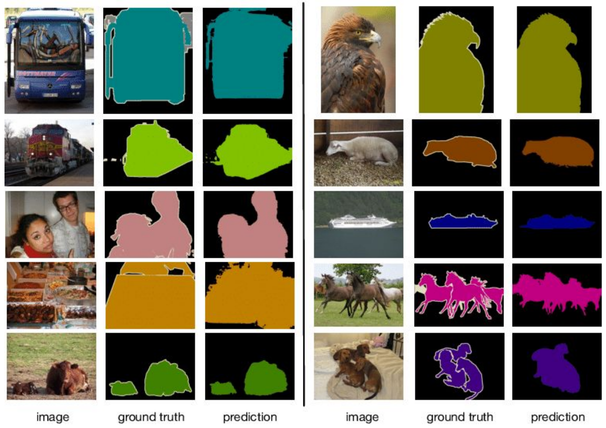


Training a Segmentation Model (High-Level)

1. Model Selection: Choose appropriate architecture (e.g., UNet for medical images, Mask R-CNN for instance segmentation).

2. Data Preparation: Preprocess images, apply augmentations.

3. Training: Configure the optimizer, loss function, and learning rate.

4. Evaluation: Monitor metrics like IoU and adjust as needed.

Challenges in Image Segmentation

Class Imbalance: Some classes dominate (e.g., background).

Occlusion: Objects that partially overlap or are hidden.

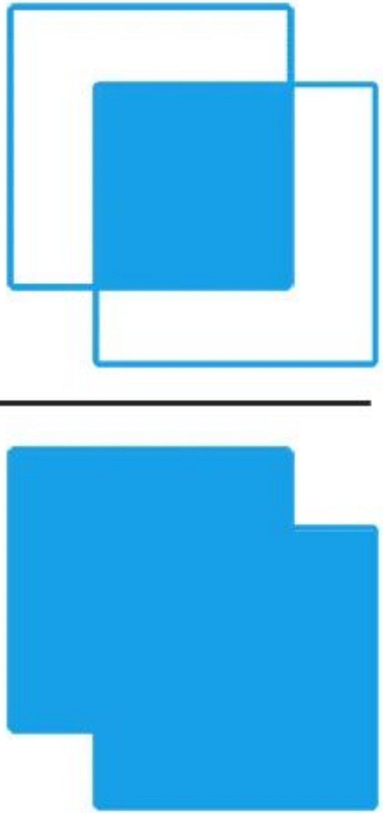
Computational Cost: Segmentation is resource-intensive.

Solution:

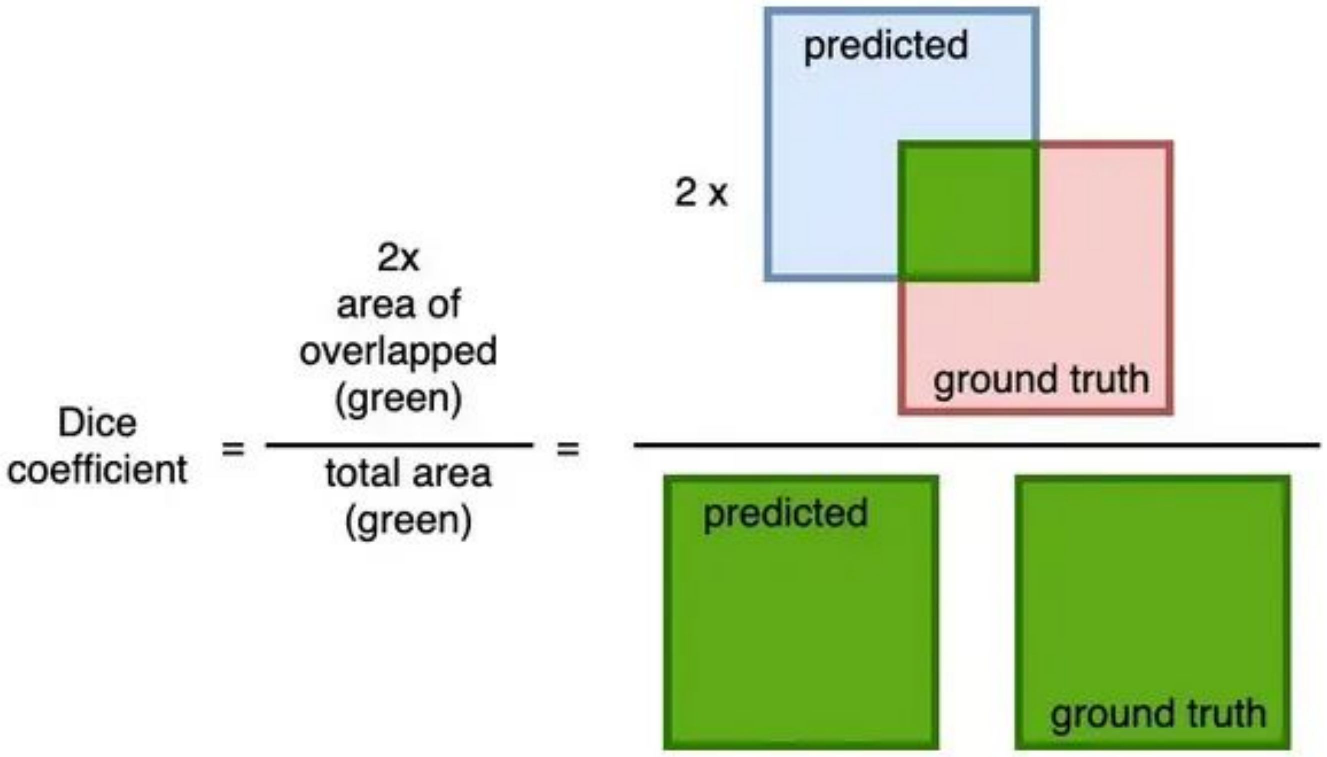
Use data augmentation, class weighting, and efficient models.

Intersection over Union

$$\mathrm{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$



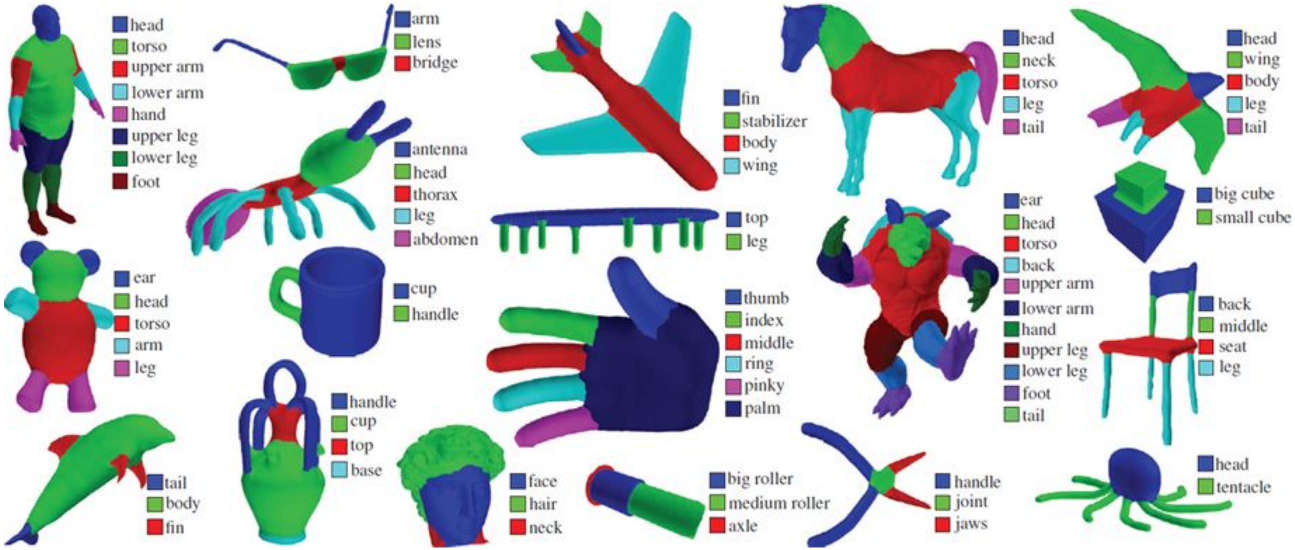
Dice Loss



2x
area of
overlapped
(green)
Dice
coefficient
=
total area
(green)
=
2 x
predicted
ground truth
predicted
ground truth

Future of Segmentation

3D and Video Segmentation: Extending 2D segmentation to video and 3D scenes.



SMITE: Segment Me In TimE

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ASIA: Adaptive 3D Segmentation using Few Image Annotations

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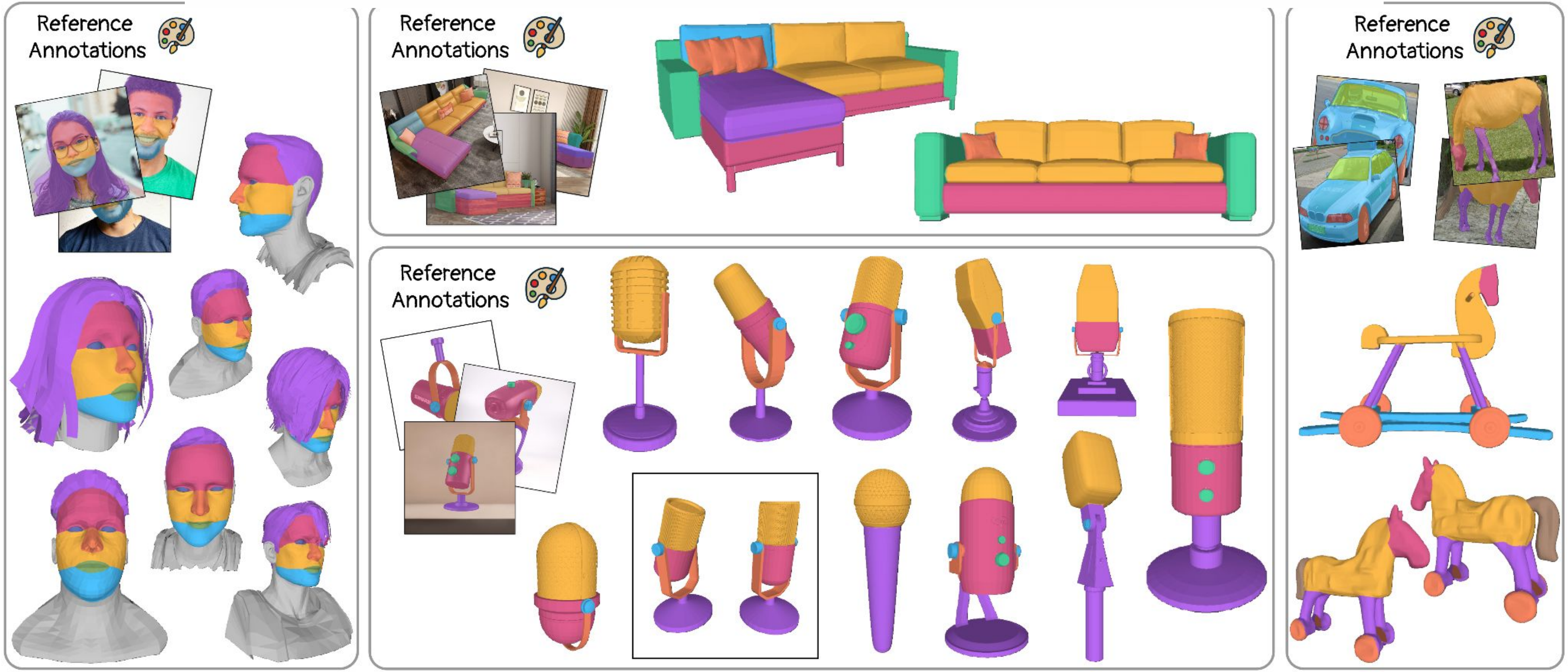
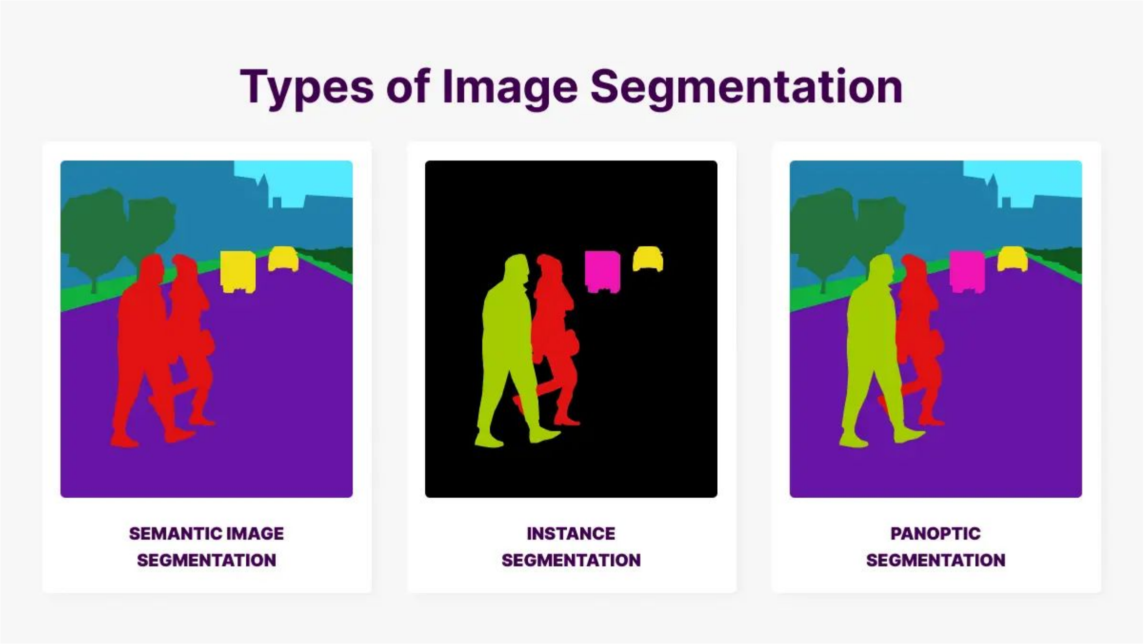
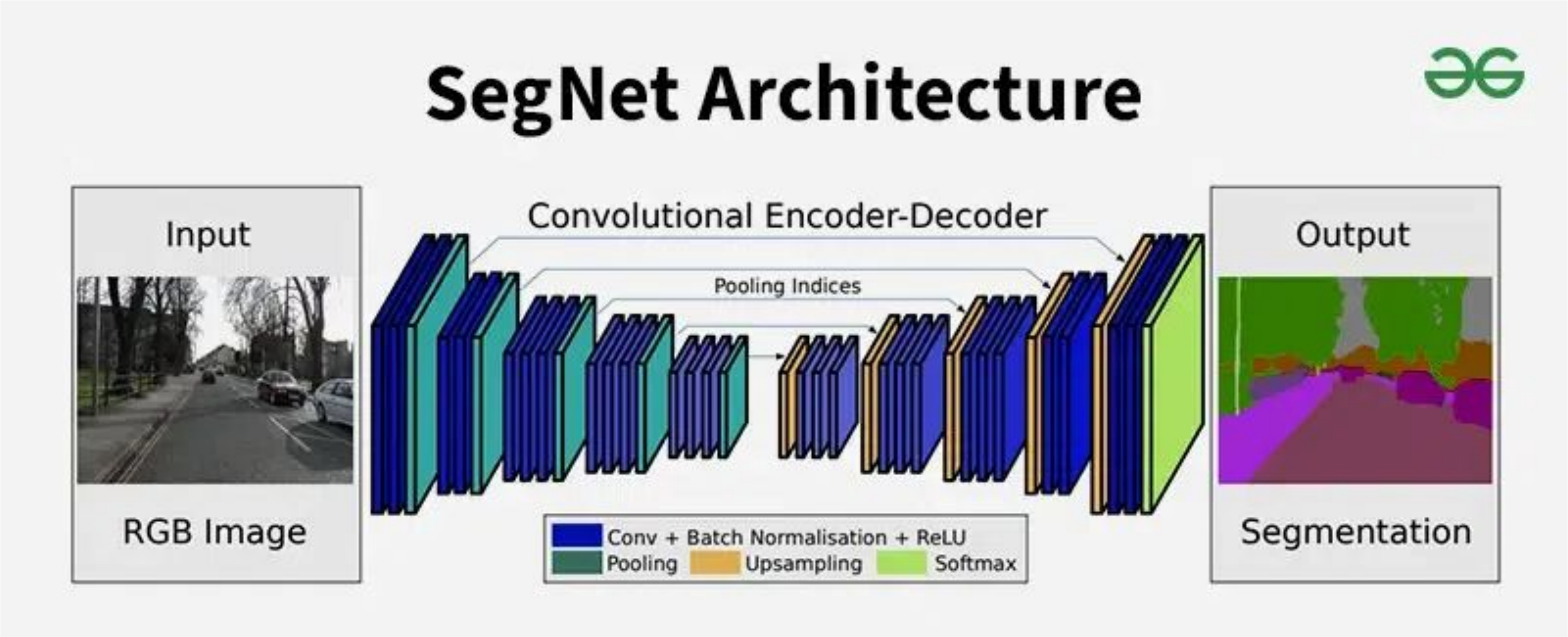


Final Thought

"Image segmentation is a vital field in computer vision, enabling intelligent systems to interpret visual data in increasingly meaningful ways."



Implementation Details



Implementation Details

Model: Segnet

Batch Size: 32

Optimizer: SGD -> LR: 0.01, Momentum: 0.9

Loss: Cross Entropy Loss

Augmentation: RandomBrightnessContrast(p=0.3) - HorizontalFlip() - Rotate(limit=10, p=0.5)