Semantic Segmentation Using U-Net and DeepLabV3+ for Underwater Image Analysis

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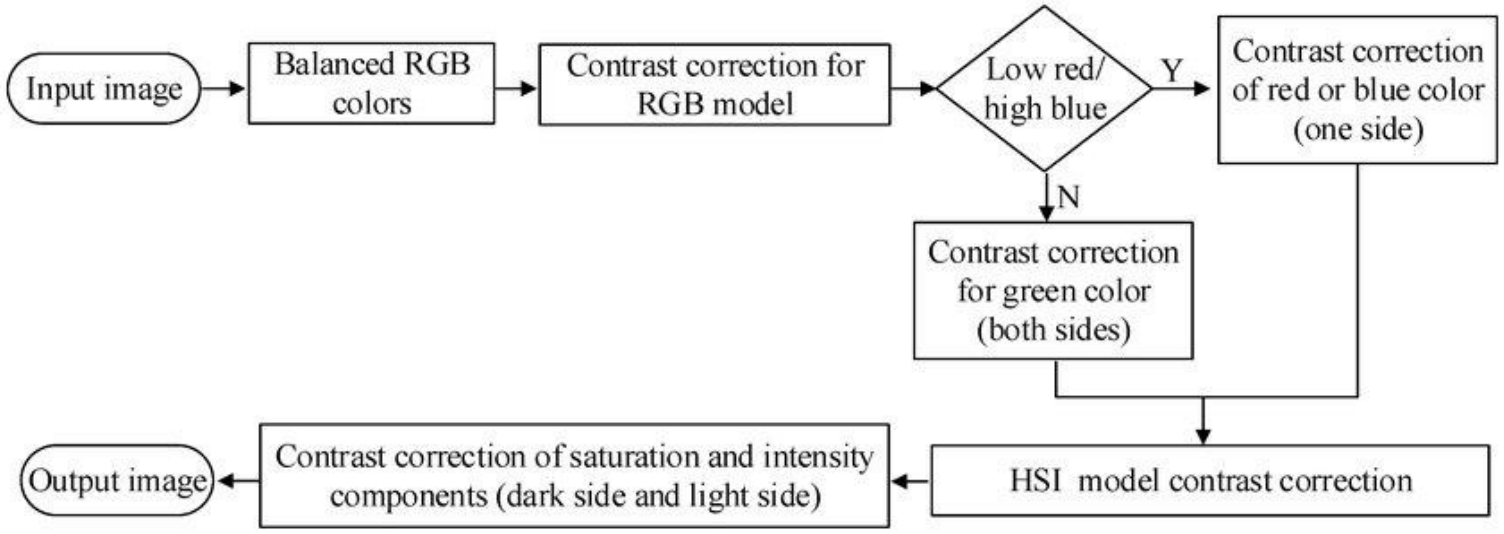
INTRODUCTION:

- Underwater image analysis is essential in:
- Marine biodiversity monitoring
- Underwater robotics
- Environmental research
- Coral reef health assessment
- Pollution tracking
- But underwater images suffer from:
- Color distortion
- Light scattering
- Noise & low contrast
- Motion blur
- So traditional computer vision methods fail.



This creates the need for **deep learning-based semantic segmentation** — pixel-wise classification

PROBLEM STATEMENT

- **The problem:**
  Underwater images are extremely difficult to segment due to inconsistent lighting, suspended particles, color loss, turbidity, and the presence of complex marine objects. Achieving accurate boundary detection using a single model remains challenging.
- **Therefore:**
  A comparative and hybrid approach using U-Net and DeepLabV3+ is needed to improve segmentation performance.

PROJECT OBJECTIVES

- To compare both architectures (U-Net & DeepLabV3+) based on segmentation accuracy on underwater datasets.
- To develop a hybrid/ensemble model that fuses U-Net's fine localization with DeepLabV3+'s multi-scale feature extraction.
- To benchmark the performance using IoU, mIoU, Dice Score, Boundary F1-score, and computational throughput.

LITERATURE REVIEW

Existing Work:

- **U-Net** is widely used in biomedical and underwater tasks due to its encoder–decoder structure and skip connections.
- **DeepLabV3+** improves segmentation using:
    1. Atrous Spatial Pyramid Pooling (ASPP).
    2. Depthwise separable convolutions.
    3. Better context extraction.

Gap Identified:

- Most studies use either U-Net or DeepLabV3+ individually, but very few explore a hybrid or ensemble architecture specifically optimized for underwater imagery, which has unique distortions.
- This gap creates your novelty.

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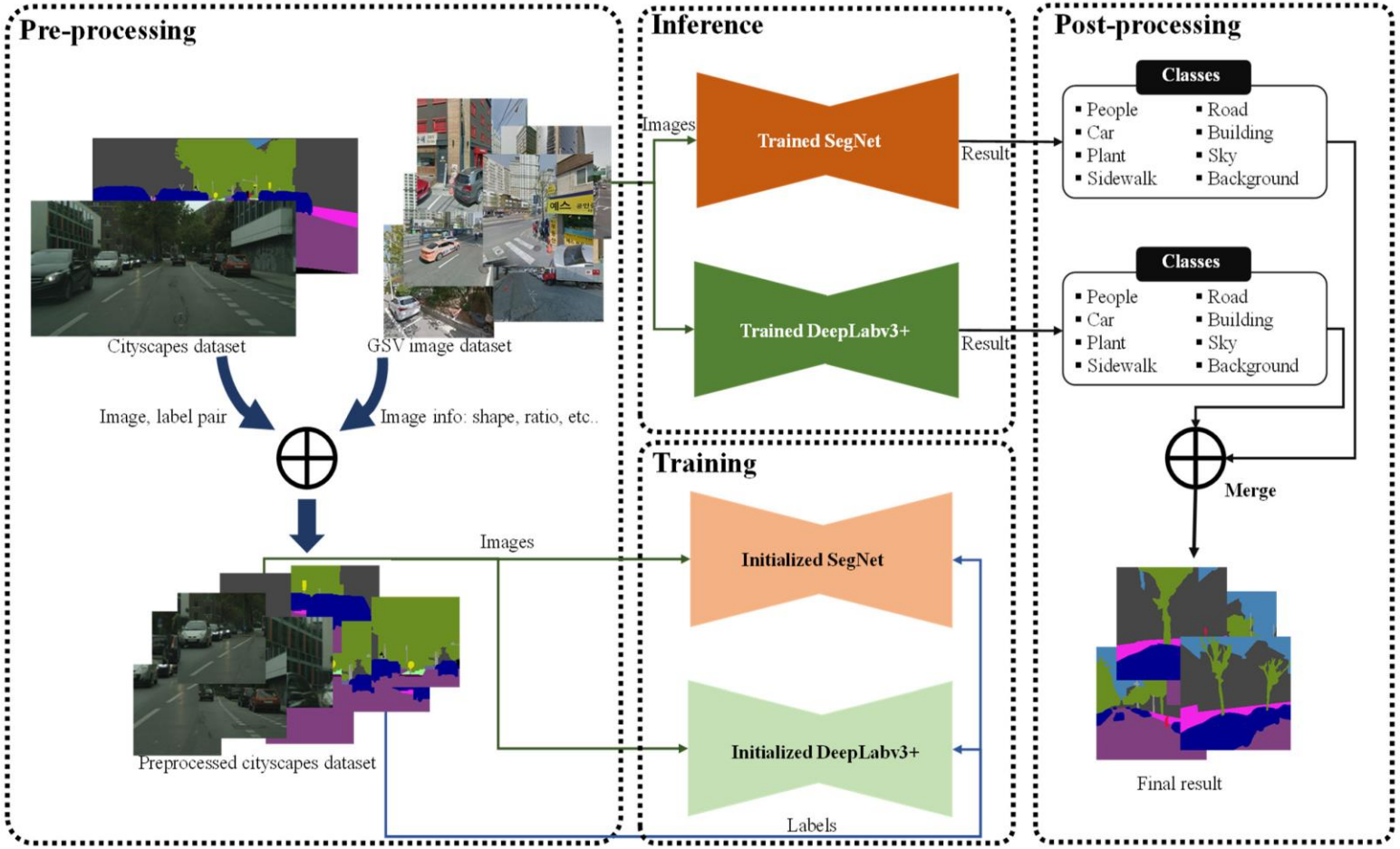
NOVELTY

- **What makes your project unique?**
- A **comparative + hybrid** approach instead of using a single model.
- Targeted specifically at **underwater images**, which is under-researched.
- Your ensemble aims to:
  - Improve object boundaries
  - Produce stable segmentation under noise
  - Increase robustness across datasets
  - This shows **CO3 (Creativity & Innovation)** clearly.



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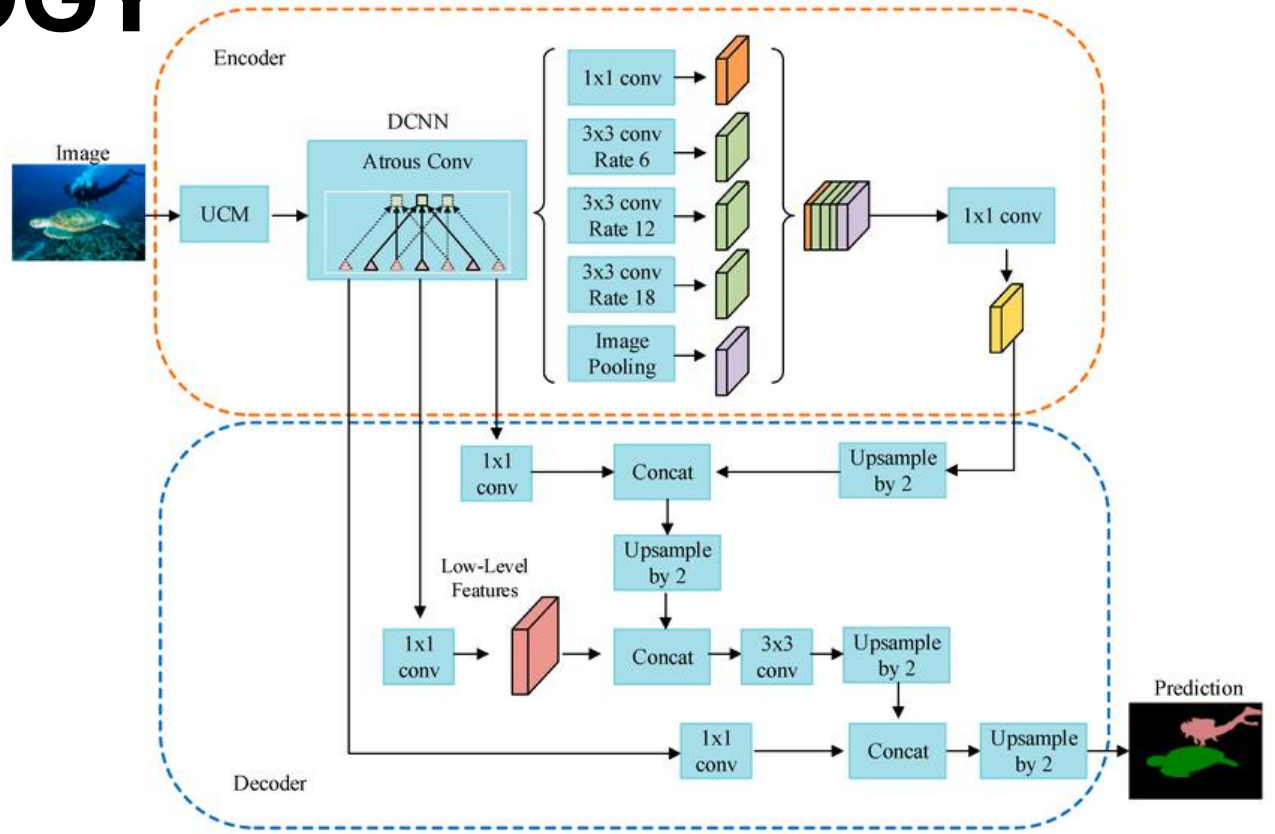
PROPOSED METHODOLOGY

- **Step 1: Dataset Collection**
- Possible datasets: SUIM, UWSeg, UIEB
- **Step 2: Pre-processing**
- Color correction, Denoising, Image resizing, Normalization
- **Step 3: Train U-Net**
- Evaluate pixel accuracy & boundaries
- **Step 4: Train DeepLabV3+**
- Use ASPP for multi-scale features
- **Step 5: Hybrid Model Development**
- Possible strategies:Weighted averaging, Pixel-wise voting, Feature fusion
- **Step 6: Performance Comparison**
- Using metrics: IoU, mIoU, Dice Coefficient, Boundary F1, FPS (throughput)



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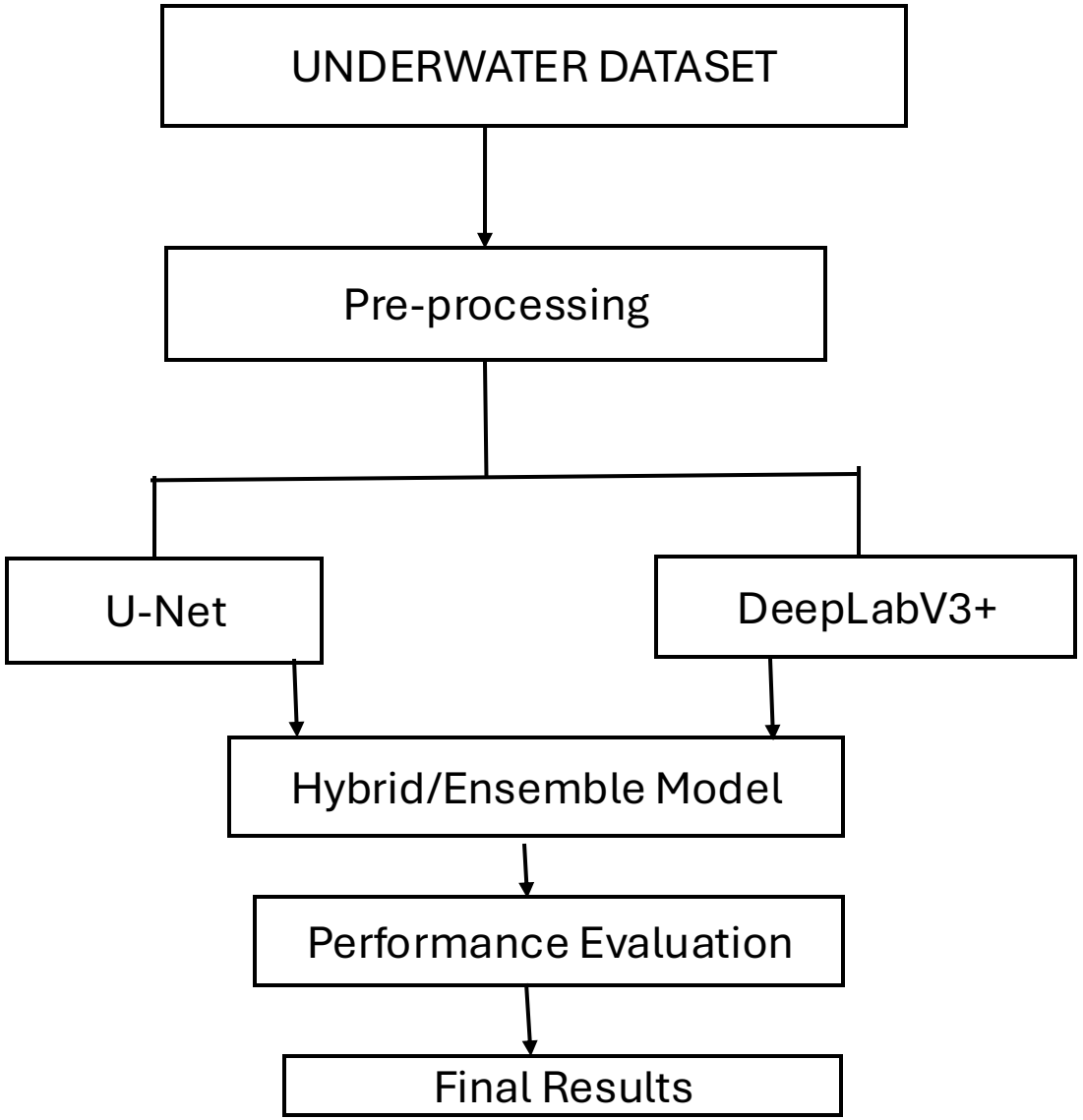
BLOCK DIAGRAM (CONCEPTUAL WORKFLOW)



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WORK PLAN, TOOLS & TECHNOLOGIES

Tasks:	Tools:
Dataset collection & preprocessing	Python
Train U-Net	TensorFlow / Keras
Train DeepLabV3+	OpenCV
Hybrid model design	NumPy
Performance evaluation	Matplotlib, Google Colab / Kaggle

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CHALLENGES EXPECTED

- Dataset quality variations
- Training time (DeepLabV3+ is heavy)
- Ensuring fair comparison
- Designing an effective fusion strategy

EXPECTED OUTCOMES

- A research paper-quality comparative study
- A novel hybrid underwater segmentation model
- Visual segmentation outputs
- Benchmarked performance metrics

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REFERENCES

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Islam, M. J., Xia, Y., & Sattar, J. (2020). *Fast Underwater Image Enhancement for Improved Visual Perception*. ICRA. (Includes U-Net segmentation in underwater domain.)

Ronneberger, O., Fischer, P., & Brox, T. (2015). *U-Net: Convolutional Networks for Biomedical Image Segmentation*.MICCAI.

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THANK YOU

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