Enhancing Underwater Object Detection with the Improved TC-USOD Model

Alluri L. Narendra, Attunuri P. Reddy, Kapse Karthik

Indian Institute of Technology Dharwad

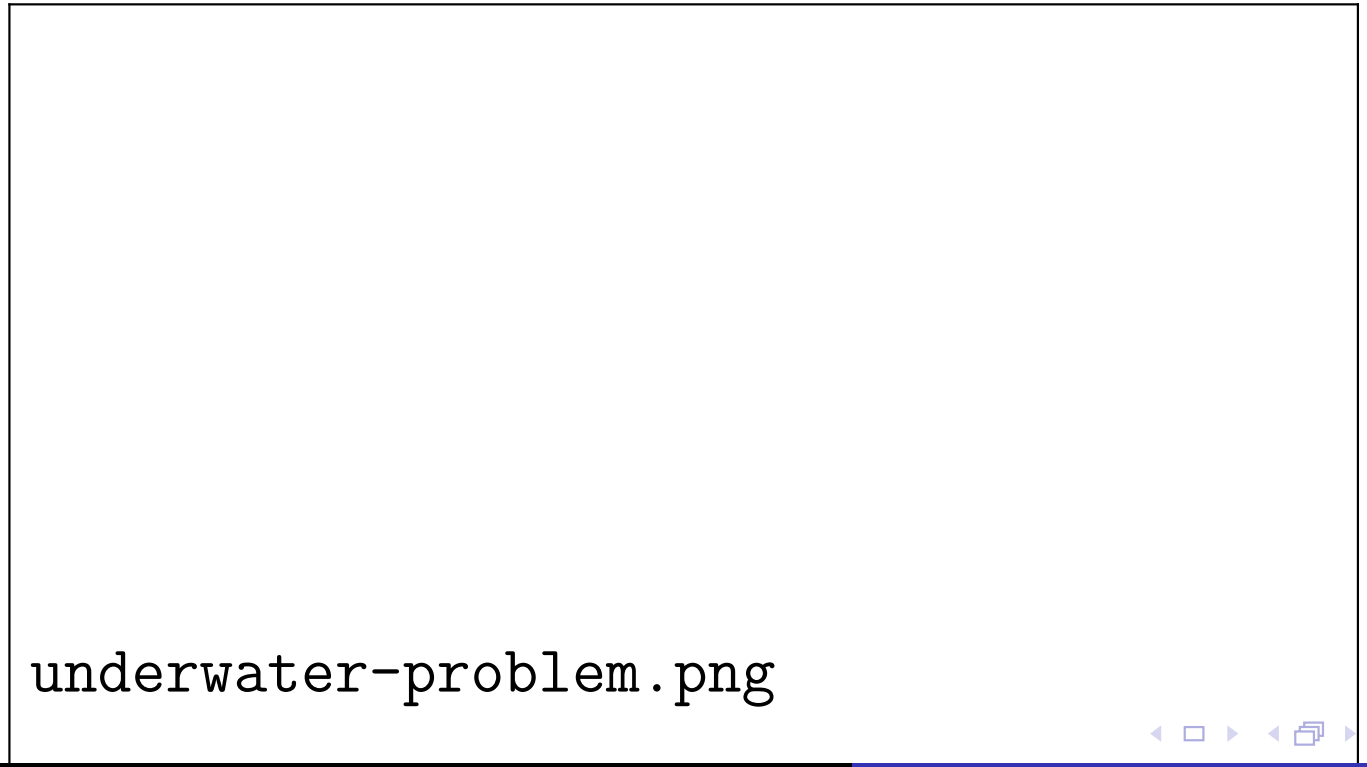
November 28, 2024

Problem Statement

Challenges of Underwater Imaging:

- Light scattering and absorption reduce visibility.
- Color distortions degrade object detection.
- Depth maps are noisy and inconsistent.

Goal: Develop a robust model that addresses these challenges and improves detection accuracy in underwater environments.



Our Contributions

- Developed an advanced **Depth Auxiliary Module (DAM)** to integrate RGB and depth features.
- Introduced **Multi-Level Feature Fusion** to combine global and local details.
- Designed a **Hybrid Loss Function** combining BCE, IoU, Dice, and SSIM losses for better boundary detection.
- Enhanced preprocessing of the USOD10K dataset using color balance and fusion techniques.

Comparison: Baseline TC-USOD vs. Improved TC-USOD

Key Improvements:

Aspect	Baseline TC-USOD	Improved T
Depth Integration	Noisy depth maps directly fused with RGB	DAM with C Fusion (CM depth feature
Feature Fusion	Limited feature integration across layers	Multi-Level sion for bette tection
Loss Function	Binary Cross-Entropy (BCE) only	Hybrid Loss: Dice, SSIM
Preprocessing	Basic preprocessing of	Advanced

Graphical Comparison of Results

Key Metrics:

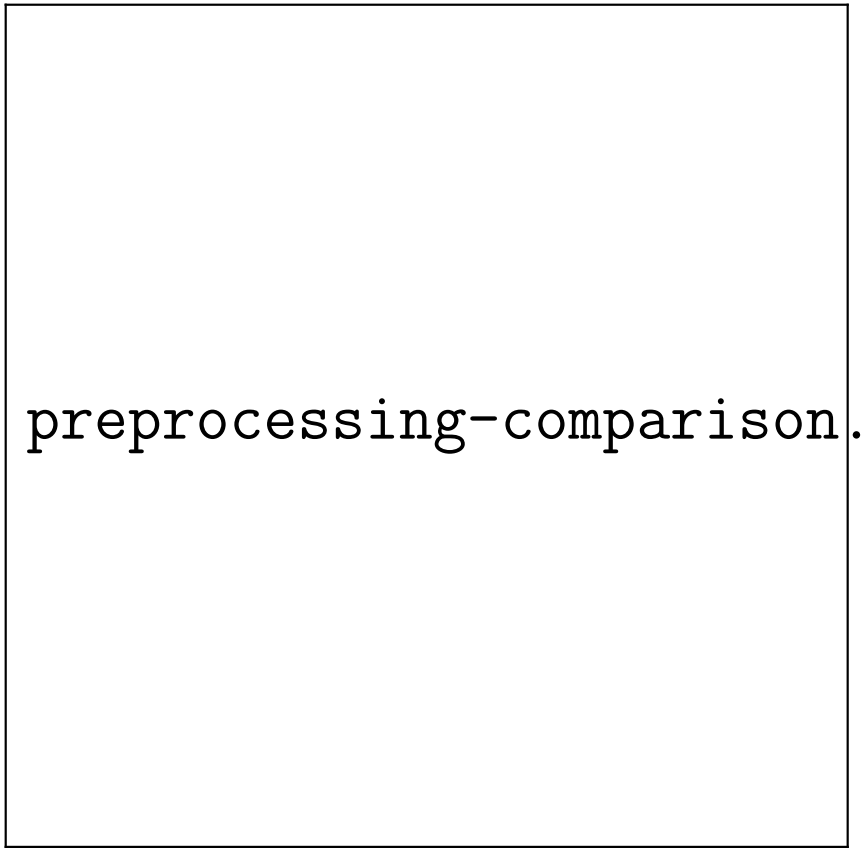
- Improved S-measure, Precision-Recall, and IoU.
- Reduced MAE for better accuracy.

results-comparison.png

Preprocessing Enhancements

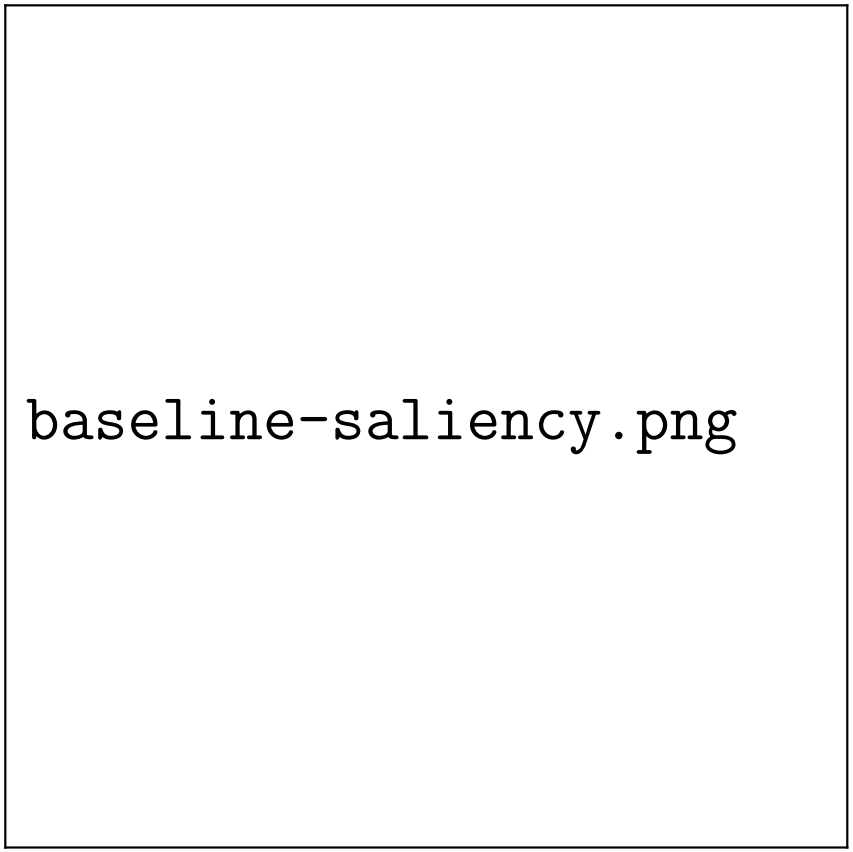
Baseline vs. Improved:

- **Baseline:** Limited preprocessing.
- **Improved:**
  - White balancing corrects color distortions.
  - Gamma correction enhances contrast.
  - Multiscale fusion improves sharpness.



Visual Results: Baseline vs. Improved

Comparison of Saliency Maps:



Observation: Improved TC-USOD shows sharper object boundaries and better saliency.

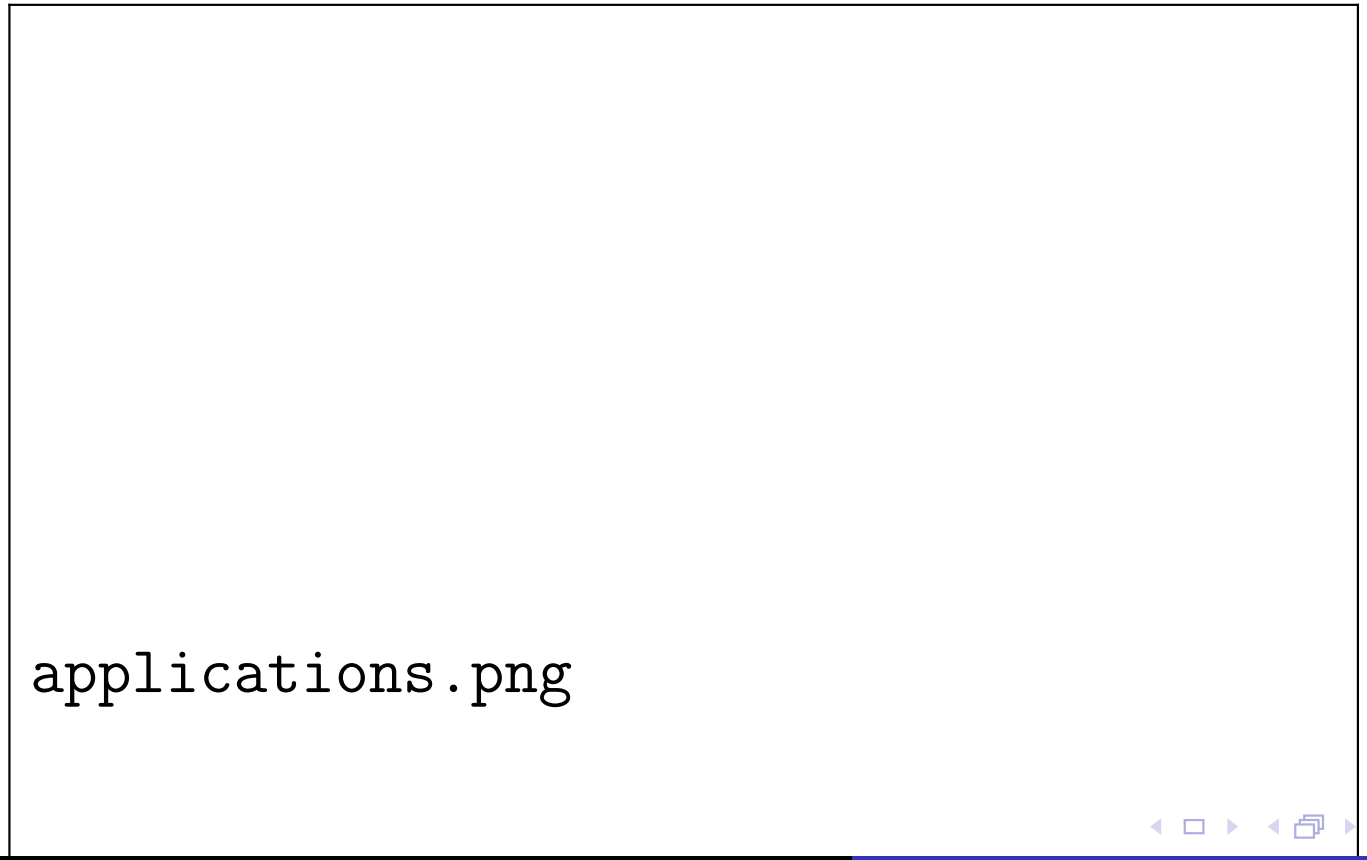
Model Architecture Enhancements

model-enhancements.png

Applications of Improved TC-USOD

Real-World Applications:

- Marine biodiversity tracking and conservation.
- Underwater archaeology and mapping.
- Autonomous underwater vehicle navigation.
- Detection and removal of underwater litter.



Conclusion

Summary:

- Successfully enhanced underwater object detection by improving the TC-USOD model.
- Introduced DAM, feature fusion, and a hybrid loss function.
- Demonstrated superior performance in key metrics and saliency detection tasks.