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Title:

Underwater Image Enhancement Based on Improved Water-net Model

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INTRODUCTION

With the advancement of marine resource exploitation, ocean research, and underwater detection technology, there is an increasing demand for high-quality underwater images. However, issues such as color deviation, low contrast, and blurring in raw underwater images significantly hinder the progress of ocean research. Therefore, the development of underwater image enhancement technology is crucial to obtain higher quality images that can support and advance these important areas of research.

METHODS

Inspired by the Water-net approach, We designed our network architecture, UWater-net , based on the original baseline network.

- For the three preprocessing of the original image, Color Balance based on Gray-World Assumption (GWA_CB) , CLAHE, and Gamma Correction (GC) were selected.
- The original feature enhancement input module has been improved with the introduction of an AquaBlend ConvModule (ABCM) enhancement module

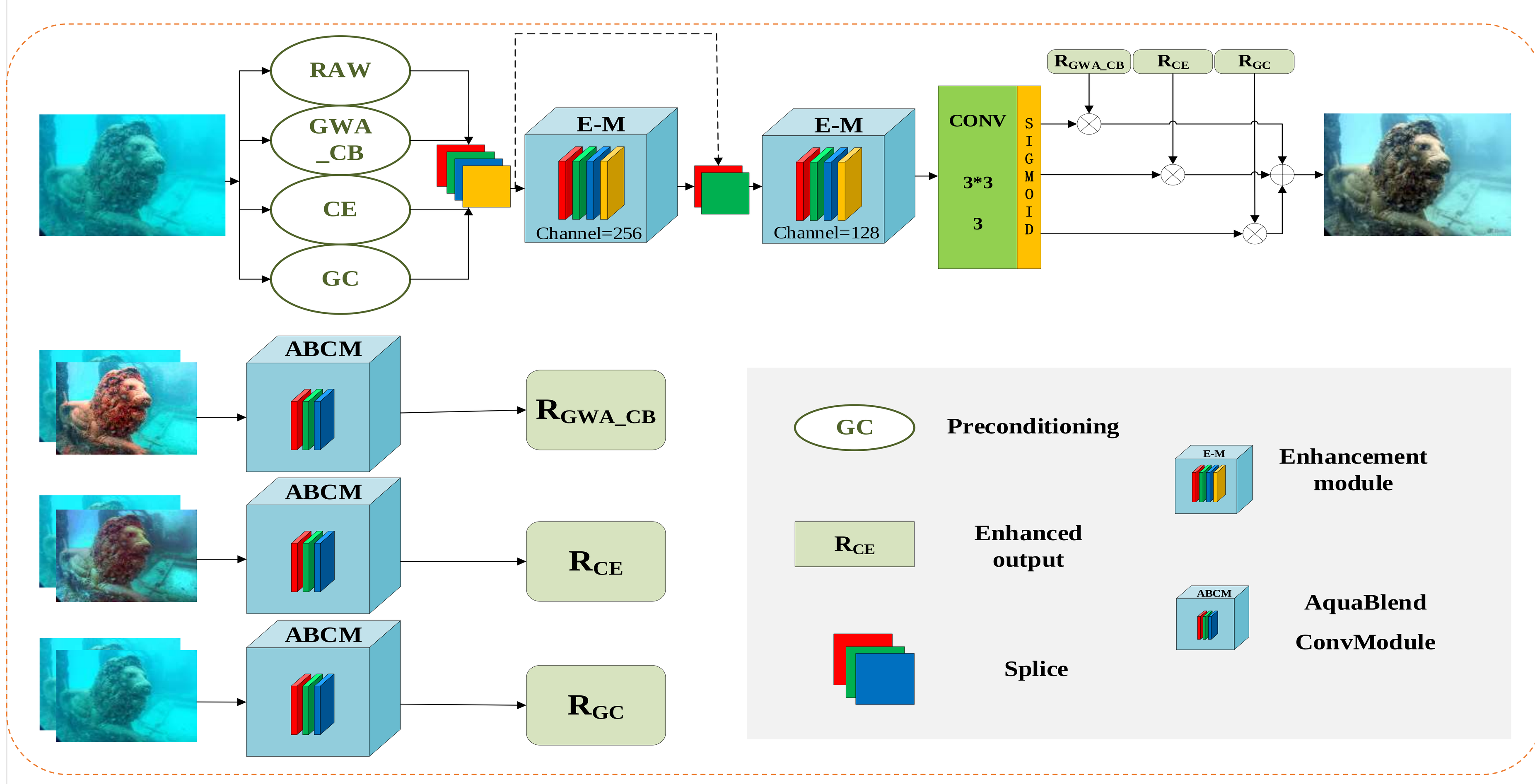

Fig. 1 DEEP LEARNING NETWORK FRAMEWORK

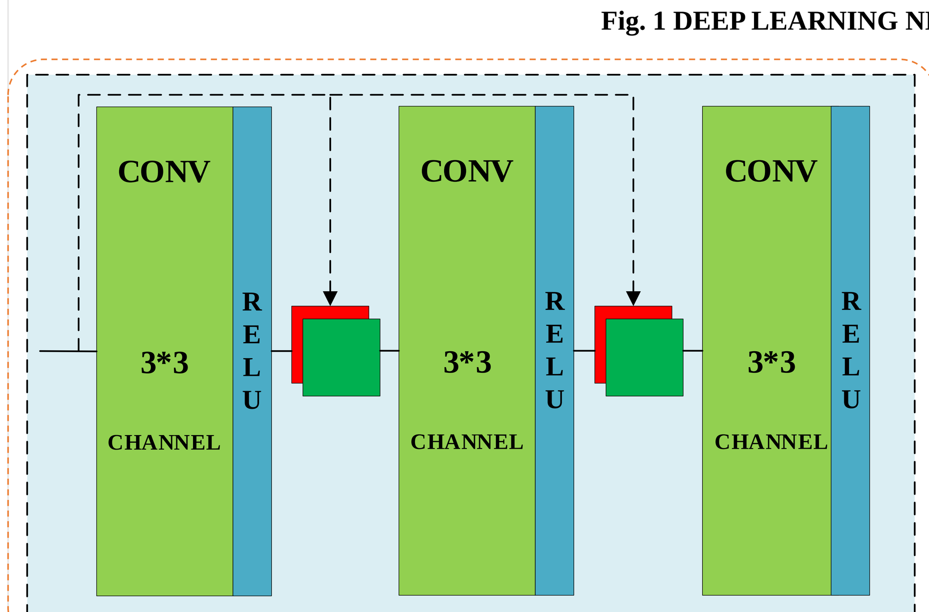

Fig. 2 AquaBlend ConvModule

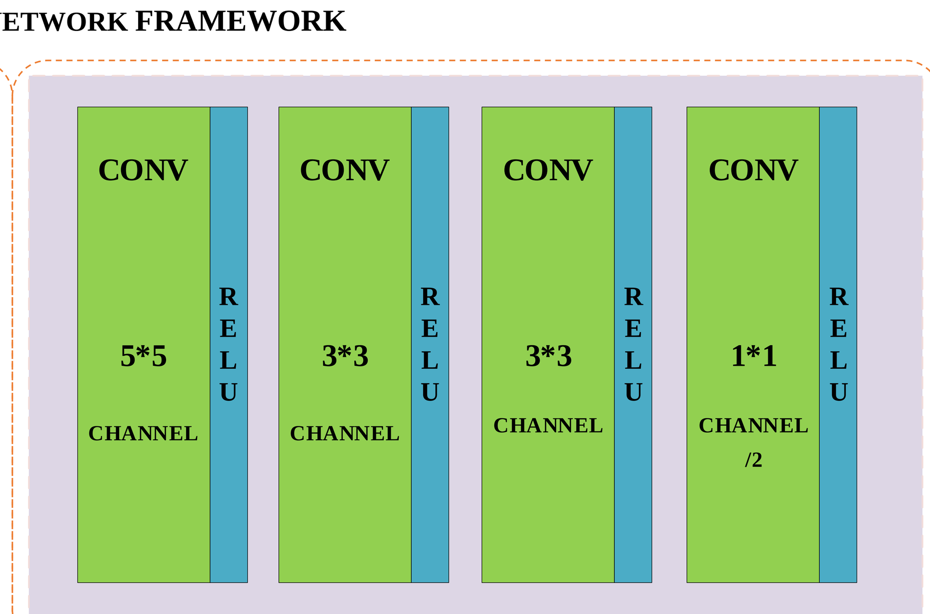

Fig. 3 Enhancement Module

Loss Function:

$$L_j^{\phi} = \frac{1}{C_j H_j W_j} \sum_{i=1}^{N} \| \phi_j(I_{en}^i) - \phi_j(I_{gt}^i) \|$$

EXPERIMENTS

We selected 150 images from the UIEB. We compared our model against several algorithms, including the WB, GWA_CB, CLAHE, GC, and Water-net models. The performance was evaluated using Peak Signal to Noise Ratio(PSNR), Structural SIMilarity index(SSIM), and Mean Square Error(MSE) metrics for all reference indices.

Algorithms	PSNR ↑	SSIM ↑	MSE($*10^3$) ↓
WB	19.3515	0.8362	1.1777
GWA_CB	19.4706	0.8364	1.0954
CE	17.0263	0.6961	1.4821
Water-net	19.3849	0.8197	0.9067
Ours	20.4635	0.8641	0.7588

TABLE Ⅰ OBJECTIVE EVALUATION FOR VARIOUS ALGORITHMS

500 images from the UIEB were used for objective analysis.

Algorithms	PSNR ↑	SSIM ↑	MSE ↓
Baseline model	20.276	0.862	653.720
+Modify input	21.043	0.876	595.247
+ABCM	22.137	0.896	492.851
+Main frame enhancement	22.359	0.911	469.056

TABLE Ⅱ OBJECTIVE EVALUATION FOR ABLATION EXPERIMENT

CONCLUSIONS

Based on the Water-net baseline model proposed by Li, we carry out optimization and improvement. The artifacts produced by the fusion of learning confidence graph are reduced by blending appropriate preprocessing methods. Moreover, an ABCM enhancement module is proposed to improve the enhancement effect while preserving complex image features and preventing overfitting. From the objective analysis of all reference indicators, our proposed model has better results than other enhancement methods. The key modules have also been validated in ablation experiments. In the future, we will continue to optimize the network structure and enhance the image processing effect of loud noise and low brightness, so that the proposed model can play a role in the exploration of underwater bionic robots.