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CHENNAI

MarineNN - A real-time color correction model for underwater images using a truncated U-Net architecture

01 Introduction

Introducing Marine NN, a powerful and efficient solution for real-time color correction in underwater images. Designed with a truncated U-Net architecture, our project addresses the challenges of distorted colors in underwater photography, enhancing image quality while preserving original content. By prioritizing training and inference speed, Marine NN enables rapid, high-quality results, making it an ideal choice for divers and underwater autonomous vehicles seeking to capture true-to-life underwater visuals.

02 Objectives

1. Develop an efficient and effective underwater image enhancement model for real-time color correction and dehazing applications, suitable for systems with limited hardware resources.
2. Preserve fine details and minimize artifacts in enhanced images, ensuring visually appealing and accurate output for various underwater applications.
3. Optimize the MarineNN model for diverse underwater environments, enabling its adaptability to specific conditions and lighting scenarios.
4. Create a user-friendly tool that can be easily adopted by individuals and organizations, regardless of their level of expertise or available resources.
5. Conduct extensive experimentation and evaluation using diverse underwater image datasets, including the University of Minnesota's Enhancing Underwater Visual Perception (EUVP) collection.
6. Demonstrate the effectiveness and generalizability of the MarineNN model compared to existing methods, highlighting improvements in image detail preservation and color accuracy.
7. Investigate the potential for fine-tuning the model to cater to specific underwater environments and conditions for optimal performance.
8. Explore the integration of MarineNN into underwater autonomous vehicles and other systems for real-time image enhancement and environmental monitoring.

03 Methodology

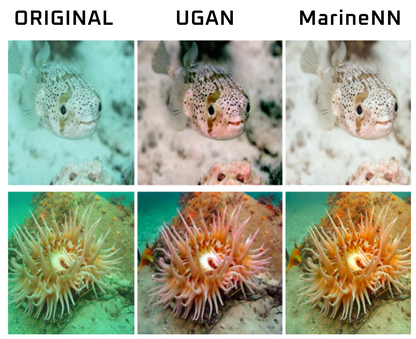
1. **Model Selection:** A truncated U-Net architecture was chosen for the MarineNN project, based on its performance in preserving image details, flexibility with input image sizes, and the balance between model complexity and computational efficiency.
2. **Data Collection and Preparation:** The University of Minnesota's Enhancing Underwater Visual Perception (EUVP) dataset was used for training and validation. The dataset consists of 5,885 paired underwater image sets for training and 1,400 for validation.
3. **Model Training:** The model was trained using the Mean Structural Similarity Index (MS-SS IM) and L1 loss function to optimize image quality, detail preservati on, and color accuracy. Training was performed on available hardware resources, ensuring model efficiency and adaptability.
4. **Ablation Studies:** Various experiments were conducted to compare the performance of different loss functions, such as VGG+MSE and MS-SSIM+L1. The results demonstrated the superior performance of MS-SSIM+L1 in capturing fine-grain details and producing visually appealing images.
5. **Model Evaluation:** The MarineNN model was evaluated using the EUVP dataset to assess its effectiveness in color correction, dehazing, and detail preservation. Comparisons were made with existing methods such as UGAN, highlighting the improvements offered by MarineNN.
6. **User-Friendly Tool Development:** A user-friendly tool was created to allow users with varying levels of expertise to easily adopt and utilize the MarineNN model for underwater image enhancement.

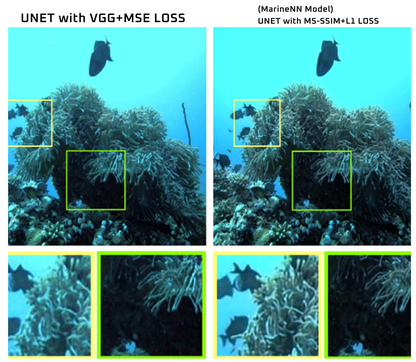
05 Insights & Future Work

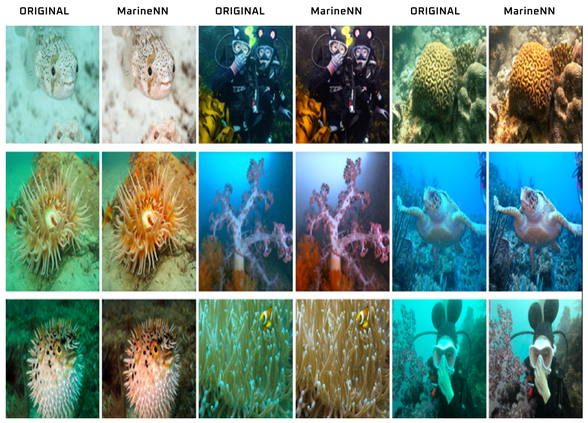
1. **Loss Functions:** Investigate the effectiveness of SSIM and MS-SSIM loss functions in underwater image enhancement, highlighting their respective strengths in capturing fine details and adapting to specific underwater conditions.
2. **Future Models:** Explore advanced model architectures and techniques, such as adopting average-pooling, implementing Attention_Res-UNet or Res-UNet, and diversifying the training dataset to improve generalization and performance in various underwater environments.

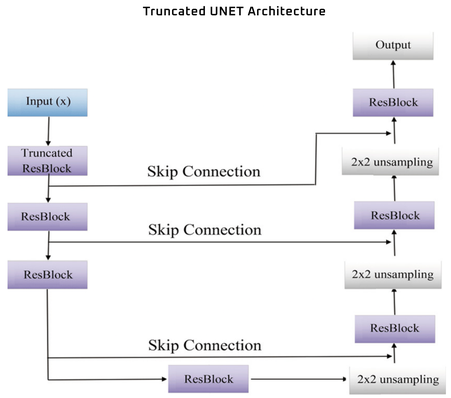
04 Results

1. **Image Quality:** Side-by-side comparisons of original and MarineNN-enhanced images revealed significant improvements in color correction and dehazing, resulting in visually appealing and more accurate underwater images.
2. **Content Preservation:** MarineNN successfully preserved fine details and minimized artifacts in the enhanced images, making it suitable for various underwater applications where precise details are crucial, such as marine biology research and environmental monitoring.
3. **Comparison with UGAN:** In a head-to-head comparison with the UGAN model, MarineNN showed superior performance in retaining image details and eliminating checkerboard artifacts. This further highlights MarineNN's ability to provide better image quality while preserving the original content.
4. **Real-time Enhancement:** MarineNN demonstrated the potential for real-time image enhancement, with a processing speed of up to 20 frames per second (FPS). This makes it suitable for integration into underwater autonomous vehicles and other systems requiring real-time image processing capabilities.









06 Conclusion

The MarineNN project successfully developed an efficient underwater image enhancement model, demonstrating improved color correction and content preservation, with potential applications in marine research, environmental monitoring, and recreational diving, ultimately advancing the field of underwater image processing.

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

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