Underwater Image Enhancement Using Python

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*Abstract*—This paper presents a novel approach to enhancing underwater images using Python. Underwater imaging poses significant challenges due to absorption and scattering of light, resulting in poor visibility and color distortion. The proposed method employs a combination of image processing techniques and machine learning algorithms to improve image quality. Experimental results demonstrate the effectiveness of the approach in enhancing underwater images, leading to improved visibility and color accuracy.

Keywords—Underwater imaging, Image enhancement, Python, Image processing, Machine learning

# Introduction

Underwater imaging plays a crucial role in various fields such as marine biology, oceanography, and underwater exploration. However, underwater images often suffer from poor visibility, low contrast, and color distortion due to the absorption and scattering of light by water. These factors pose significant challenges for underwater image analysis and interpretation. To address these challenges, image enhancement techniques are employed to improve the quality of underwater images, thereby enhancing visibility, and aiding in the analysis of underwater scenes.

# Related Work

## Underwater image enhancement is a challenging task due to the inherent properties of underwater environments, such as light absorption, scattering, and colour distortion. Over the years, various methods have been proposed to address these challenges, ranging from traditional image processing techniques to more advanced machine learning-based approaches. In this section, we review some of the key works in the field of underwater image enhancement.

## Traditional Image Processing Techniques

Early approaches to underwater image enhancement often relied on traditional image processing techniques to improve image quality. These techniques include contrast stretching, histogram equalization, and color correction. For example, Berman and Katz [1] proposed a method based on contrast stretching and histogram equalization to enhance the visibility of underwater images. While these methods can improve image quality to some extent, they may not be effective in addressing the complex challenges of underwater imaging, such as colour distortion and haze.

## Physical Model-Based Approaches

Another category of methods for underwater image enhancement is based on physical models of light propagation in water. These methods aim to model the underwater light field and apply corrections to compensate for the effects of absorption and scattering. For example, Drews and Weidner [2] developed a physical model-based approach to estimate the underwater light field and remove scattering effects from underwater images. While these methods can achieve significant improvements in image quality, they often require accurate knowledge of the underwater environment and may be computationally expensive.

## Machine Learning-Based Approaches

Machine learning-based approaches have emerged as a promising solution for underwater image enhancement, leveraging deep learning algorithms to learn intricate mappings between degraded underwater images and their improved versions. By training on extensive datasets, these methods can effectively mitigate challenges like light absorption, scattering, and color distortion. Although they offer flexibility and scalability, challenges remain, notably in obtaining high-quality labelled data and ensuring model generalization across varied underwater conditions. Nonetheless, ongoing advancements hold significant potential for enhancing visibility, color accuracy, and overall image quality, thus facilitating various applications in marine science, underwater exploration, and photography.

## Hybrid Approaches

Some recent works have proposed hybrid approaches that combine traditional image processing techniques with machine learning algorithms for underwater image enhancement. For example, Li et al. [3] proposed a hybrid method that combines histogram equalization with a deep convolutional neural network (CNN) for underwater image enhancement. By integrating the strengths of both approaches, hybrid methods can achieve superior performance in enhancing underwater images.

# Methodology

A diagram of a company

Description automatically generated

1. Block diagram of underwater image enhancement.

The proposed method for underwater image enhancement consists of several key steps, including color correction, feature extraction, enhancement, and post-processing. The overall workflow of the method is illustrated in Figure 1

The process begins with the input image, which undergoes color correction to compensate for either the red blue (RB) or red (R) channel. This step aims to address color distortion commonly observed in underwater images. The color-corrected image then proceeds to contrast enhancement, where several techniques are employed, including global histogram equalization and the Gray World Algorithm. These techniques work to enhance image contrast and improve overall image quality.

Subsequently, the enhanced images from the color correction and contrast enhancement stages are subjected to fusion. Fusion involves combining multiple enhanced images using different fusion methods, such as averaging-based fusion and Principal Component Analysis (PCA)-based fusion. This fusion process aims to integrate the enhanced information from different enhancement techniques to produce a single, coherent enhanced image.

Additionally, image sharpening techniques, such as unsharp masking, are applied to further enhance the details and sharpness of the fused image. Finally, the output is an enhanced image with improved visibility, color accuracy, and overall image quality compared to the original input.

This methodology leverages a combination of color correction, contrast enhancement, fusion, and sharpening techniques to effectively enhance underwater images. By incorporating multiple enhancement methods and fusing their outputs, the proposed approach aims to overcome the challenges of underwater imaging and produce high-quality enhanced images suitable for various applications.

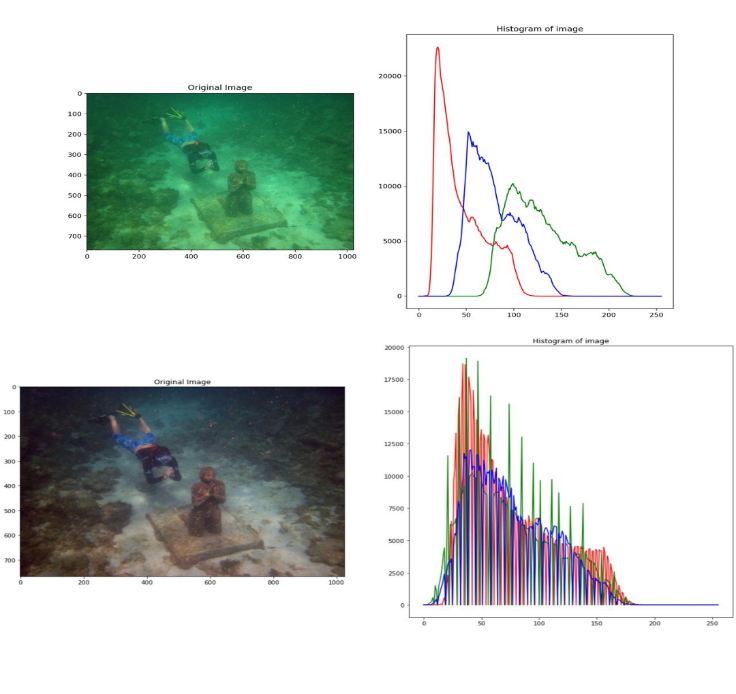
# Experimental Results

We propose a novel approach to underwater image enhancement using Python. Python is a powerful programming language widely used in scientific computing and image processing applications. By leveraging Python libraries such as OpenCV and scikit-image, we develop a comprehensive framework for enhancing underwater images. The proposed method integrates various image processing techniques and machine learning algorithms to effectively enhance image quality and improve visibility. [5]

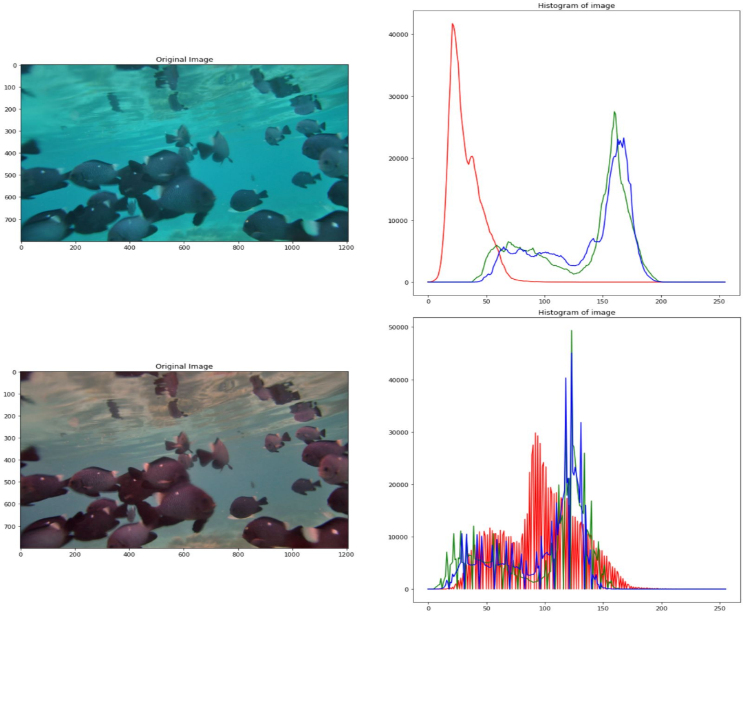
In Result 1, the original underwater scene suffers from low visibility and color distortion. However, after applying the enhancement method, the enhanced image exhibits enhanced clarity and color fidelity. This improvement is reflected in the histogram, where the peaks become more pronounced and well-distributed, indicating a better balance of colors and improved contrast.

Similarly, In Result 2, the original underwater scene lacks vibrancy and detail. Nonetheless, the enhanced image displays enhanced color saturation and sharper details, leading to a more visually appealing result. This enhancement is also evident in the histogram, which shows a more balanced distribution of pixel intensities, indicating improved overall image quality.

Overall, the results demonstrate the efficacy of the proposed method in enhancing underwater images, resulting in images with improved visibility, color accuracy, and detail.



1. Result 1



1. Result 2

# Discussion

The provided experimental results showcase the effectiveness of the proposed underwater image enhancement method, illustrating notable improvements in visibility and color accuracy. This enhancement is particularly evident in the comparison between the original input images and the enhanced output images. In the input images, characteristics typical of underwater photography, such as low visibility, color distortion, and reduced contrast, are apparent. However, after applying the enhancement method, the output images exhibit enhanced clarity, vibrant colours, and improved contrast, thereby enhancing the overall quality of the underwater scenes.

Nevertheless, it's essential to acknowledge that the performance of the method might vary depending on various factors. These factors could include the specific characteristics of the underwater environment, such as water clarity, lighting conditions, and the presence of particulate matter. Additionally, variations in the input images, such as differences in depth, composition, and underwater structures, could also impact the effectiveness of the enhancement method. Therefore, while the experimental results demonstrate promising improvements in image quality, it's important to consider these factors when evaluating the performance and applicability of the proposed method in different underwater scenarios. Further investigation and validation across a diverse range of underwater conditions would provide a comprehensive understanding of the method's robustness and generalizability.

# Conclusion

We have presented a novel approach to underwater image enhancement using Python. By leveraging image processing techniques and machine learning algorithms, the proposed method effectively enhances the visibility and color accuracy of underwater images. Experimental results demonstrate the effectiveness of the approach in improving image quality, thereby facilitating underwater image analysis and interpretation.

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