Underwater Image Enhancement

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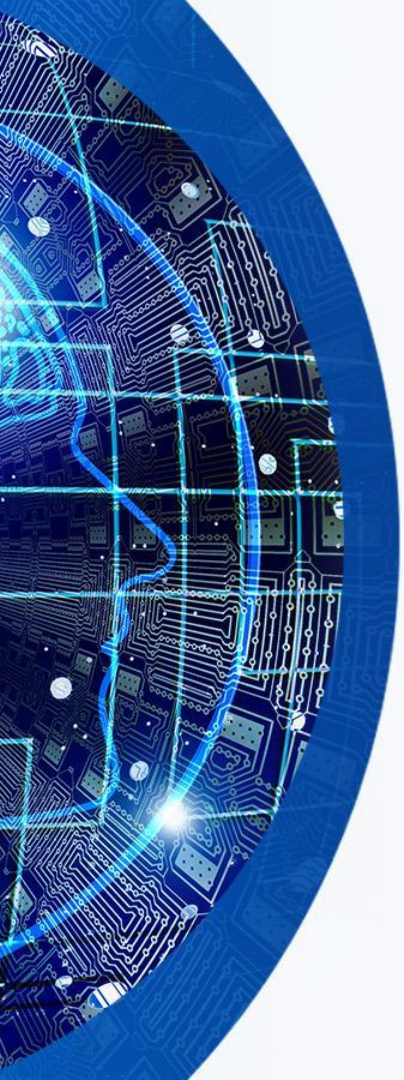

PROBLEM STATEMENT

Given a degraded underwater image, the goal is to enhance the quality of the image. The major challenge is that these images are hazy, greenish/blueish, blurry, etc.

Underwater environment pose unique challenges due to light absorption and scattering, resulting in subpar image quality. Currently data driven approaches for UIE faces two significant hurdles.

1. Limited Dataset
2. Inconsistent Attenuation

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1. Limited Dataset

The absence of a comprehensive, large scale dataset containing a wide variety of underwater scenes and high-fidelity reference images restricts the ability to develop and evaluate robust UIE methods.This scarcity hinders the development and evaluation of effective enhancement methods.

2. Inconsistent Attenuation

In underwater imaging, the attenuation of light varies inconsistently across different color channels and spatial regions. Current UIE techniques often fails to adequately account for these variations, resulting in suboptimal image enhancement.

Our Approach

• Analyzing Color

Examining the color distribution and characteristics of underwater images to understand the color issues typically observed in such images, which are often affected by the underwater lighting conditions.

• Color Correction

It refers to the process of adjusting and enhancing the colors in underwater images to address issues like bluish or greenish appearances caused by the underwater environment.

• White Balancing

In underwater photography, the color of the water and the specific lighting condition can introduce color casts, typically appearing as bluish or greenish tints. White balancing is used to neutralize these color shifts.

Our Approach 💡

- **Contrast Enhancement**

  It involves adjusting the image to increase the difference between the darkest and lightest areas, making details more distinct and enhancing the overall appearance.

- **Sharpening**

  Underwater images often suffers from reduced sharpness due to factors like water distortions and scattering of light. The sharpening step aims to improve the visual quality by making edges and fine details more pronounced.

- **Fusion**

  Fusion step is essential to integrate the enhancements made in previous stages, such as color correction, white balancing and sharpening, into a cohesive and enhanced underwater image

Implementation

1.We can see in our dataset, most of the images have a bluish and greenish appearance, that's why we plotted the histogram of RGB channels for our image to see the changes.

2. In plot_histogram(image), we can see that in all the images, the red channel is more concentrated on the left side of the histogram as the red color gets absorbed due to a higher wavelength.

3. In channel_split(image) , we can see the all components R,G,B which display the degradation of each channel. It was also observed that for images with a greenish appearance, the histogram of the B channel is also concentrated towards the left.

4. So, the first step in enhancing the underwater images is color correction

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5. For color correction,

First, we need to compensate for the degradation of the R channel and in cases where images have a greenish appearance B channel also needs to be compensated. The compensation process is to add a fraction of the green channel to the Red and Blue(when required) channel as it is the least degraded channel.

(compensatedimage1 = compensate_RB(image1,0))

The formula for the compensated red channel Irc at every pixel location (x)

Irc(x) = Ir(x) + (g - r) * (1 - Ir(x)) * Ig *I* *I* (x)

The formula for the compensated blue channel Ibc at every pixel location (x)

Ibc(x) = Ib(x) + (g - b) * (1 - Ib(x)) * Ig *I* *I* (x)

Ir, Ig represent the red and green color channels of the image I, *I*r, *I*g, *I*b denote the mean value of Ir , Ig , and Ib respectively.

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6. After performing compensation, 2nd step in color correction is to perform white balancing using gray world algorithm. (whitebalanced1 = gray_world(compensatedimage1)),this is color corrected image .

7. Now this color corrected image is observed to have low color distortion but it still has low contrast, ans edges are also not clearly visible, so we will use sharpenedimage1 = sharpen(whitebalanced1, image1) in which we first smooth this color corrected image first using gaussian filter and then sharpen this using unsharp masking .

8. Also we will enhance the contrast of the color-corrected image using Global Histogram Equalization, in which first convert the image into HSV domain then equalizing the Value component as this component primarily represents brightness and intensity and then contrast-enhances image is then obtained by concanating original Hue component, original Saturation component, and equalized Value component.

contrastenhanced1 = hsv_global_equalization(whitebalanced1)

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9.Now, we have both the contrast-enhanced image and sharpened image and our work now is to fuse these two and get final enhanced image.

10.There are two ways we implemented for fusion of these two images.

10.1 Averaging-based Fusion

In this the fused image is obtained by taking average intensity of corresponding pixels from both the input image.

$F(i,j) = A(i,j) + B(i,j) /2$

$A(i,j)$, $B(i,j)$ are input images and $F(i,j)$ is fused image.

10.2 PCA-based Fusion

● First, the components for both images are flattened to make a column vector.

● Then, a 2*N (N=x*y, x, y is the size of the image) matrix is created by concatenating the two column vectors obtained above.

● Next, find the mean of each column and subtract it from the respective column

● Now, find the covariance matrix of the matrix obtained above after subtracting the mean. ● Find the eigenvalues and eigenvectors for the covariance matrix.

● The coefficient are obtained as follows:

○ Select the eigen vector corresponding to the highest eigen value, it will be a column vector of dimension 1*2

○ Coefficient1 = V[0] V[0] + V[1

] ○ Coefficient2 = V[1] V[0] + V[1]

After obtaining the coefficient for both the images for each channel, a fused image is obtained by multiplying the coefficient of the respective channel to their respective images for each pixel value

11. After the Fusion we get our final enhanced image and by using MSE and PSNR to compare the quality of the enhanced image with the original image and reference image.

Result

On compensation with (0) red, blue via green

- MSE & PSNR of PCA fused image

	MSR	PSNR
Reference vs Original	307.7587848574467	23.24869902316836
Reference vs Fused	260.5616049361293	23.971699402544537

- MSE & PSNR of Average fused image

	MSR	PSNR
Reference vs Original	307.7587848574467	23.24869902316836
Reference vs Fused	255.4328558006708	24.058036019452572

Result

flag = 1 for Red Compensation via green channel from PIL import Image, ImageStat

- MSE & PSNR of PCA fused image

	MSR	PSNR
Reference vs Original	307.7587848574467	23.24869902316836
Reference vs Fused	261.79443743446217	23.95119946373507

- MSE & PSNR of Average fused image

	MSR	PSNR
Reference vs Original	307.7587848574467	23.24869902316836
Reference vs Fused	254.08060501793537	24.081088459756078

Thank You :-)