Underwater Image Enhancement

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The Problem

Pictures taken underwater without specialized equipment look pretty bad

We have to deal with:

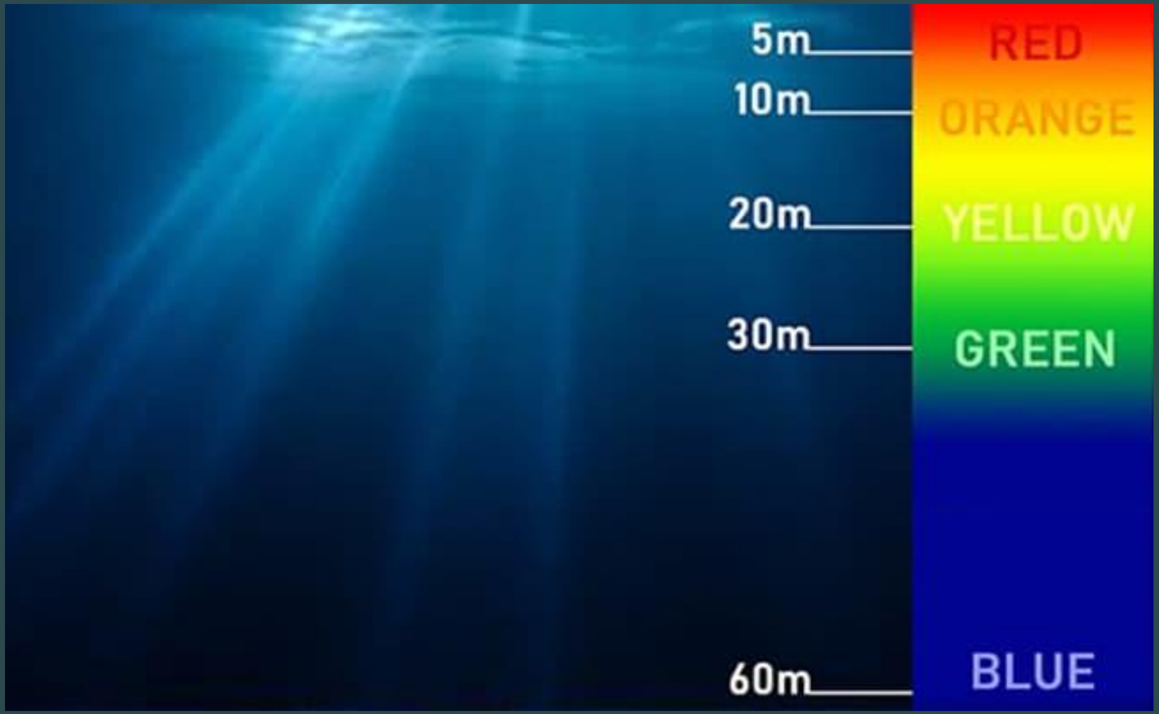
- Red and blue channel atennuation
- Loss of contrast
- Loss of details (edges)
- Haze

Atennuation Compensation

Reevaluate the values for the red and blue channels based on the average value of the green channel – essentially compensating the atennuation.

The red light atennuation occurs because it has a longer wavelength. This problem gets worse the deeper underwater we go.

The presence of algae in the water makes green overrepresented in underwater images, so we also need to compensate for the blue channel



Grey World Pt. 1

The Grey World assumption proposes that, for a color-balanced picture, the average value of all color channels is a neutral gray.

This algorithm improves our color correction strategy.

Grey World Pt. 2

Grey World steps:

- Linearize RGB representation, undoing any previous contrast correction
- Convert to XYZ color space
- Calculate illuminant: reference white of the image and shift to a new, corrected reference
- Utilize the Bradford matrix for shifting colors alongside long-medium-short (LMS) cone representation
- Convert back to RGB

Contrast

The gamma of an image determines how dark (or light) the shadows in a picture are.

Thus, gamma correction improves the contrast of our underwater picture.

Edge Sharpening

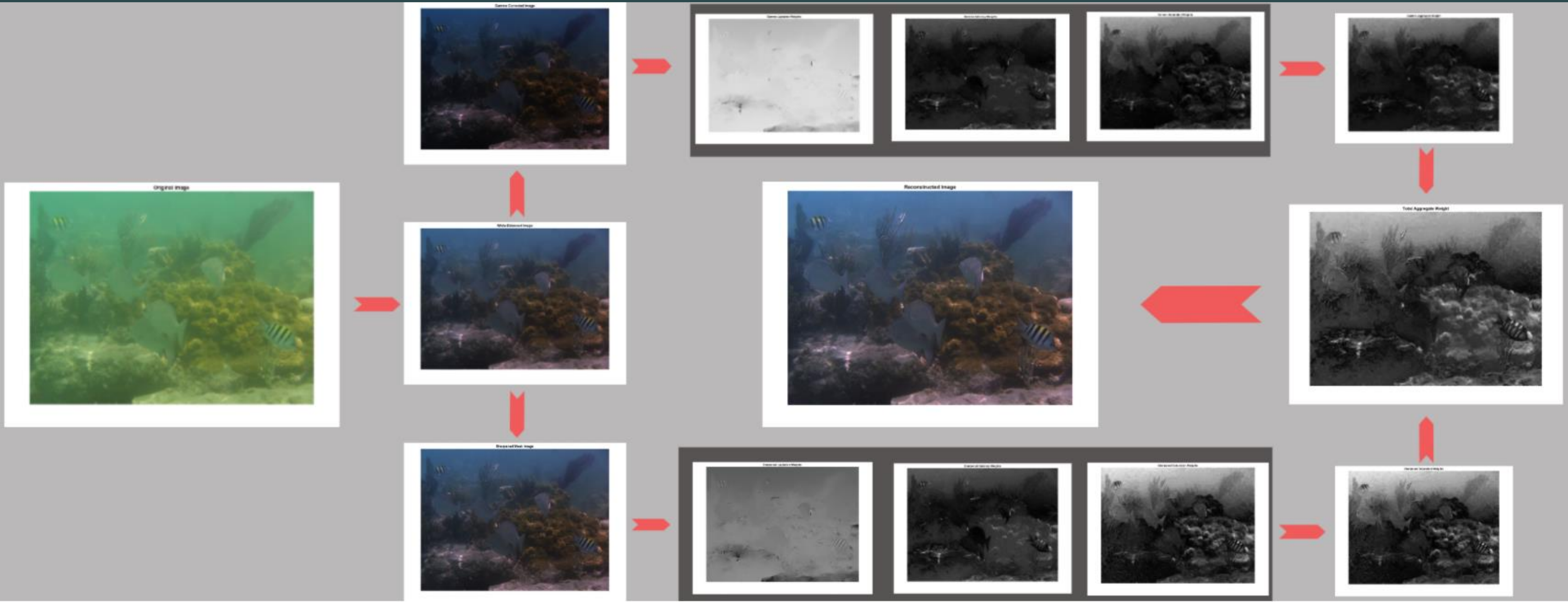
Implement an edge sharpening algorithm to recover edges of objects.

Utilize histogram equalization (redistribution of pixels to better cover range) and a Gaussian filter to detect edges.

The Weights

Then the two images (gamma correction and edge sharpening) are used to calculate three weight maps each (Laplacian, Saliency and Saturation weights), totalling 6 maps.

The 6 weights are then unified into just 2 weights (one for gamma correction and another for edge sharpening.



Laplacian Weight

A Laplacian filter is an approximation of the second spatial derivative of an image -> detects sudden changes in pixel values (edges)

Essentially acts as a high-pass filter.

Saliency Weight

Highlights pixels with values that stand out from neighboring pixels. In practice, it emphasizes objects/animals from their surroundings.

Saturation Weight

Saturation: intensity of color of an image. Higher saturation means more colorful, lower saturation means more pale.

Saturation weight based on variation from mean pixel value -> keeps track of chromatic information

Weight Unification

We add each trio of weight maps to form a pair of final weights by simply adding them together.

Then, the pair is put into a single weight map by summing them both while also undergoing normalization.

Image Fusion

We use the final weight map alongside our original image and join them into a single, final image.

Through this process we aim to restore color balance, contrast and edges, as well as remove most of the haze we see in underwater images.

Some Examples


Evaluation: Image Segmentation

Image segmentation is used to distinguish objects from their background.

As our algorithm performs dehazing and edge sharpening, image segmentation should perform better on our enhanced image.