A Survey on Under Water Images Enhancement Techniques

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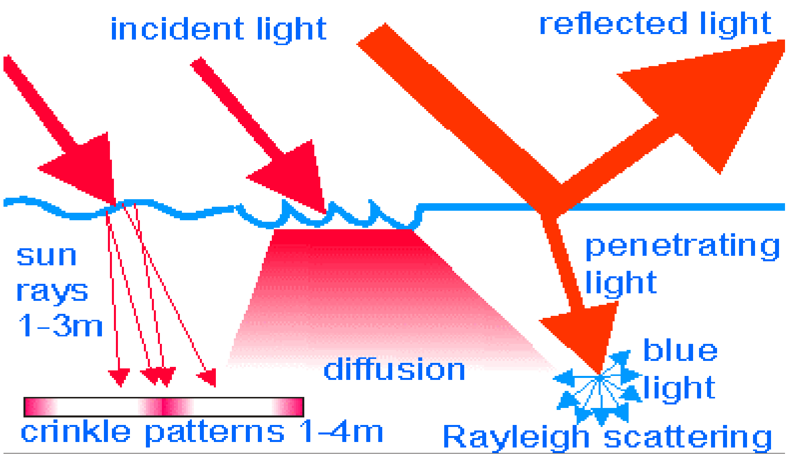
Abstract

The Major causes for the underwater images are light scattering and color change. One of the methods of improving quality of the image is image enhancement. This paper presents a comparative study of various image enhancement techniques used for enhancing under water images. The quality of underwater images is poor because of specific propagation properties of light in water. When capture such images degrade due to many factors like ripples in water, lack of availability of light organic matter dissolved in water etc. and also such images are captured from very small distance so the images must be preprocessed before applying any kind of operation on these images different filtering techniques are available in the literature for preprocessing of under images. The filters used normally improve the image quality, suppress the noise preserve the edge in an image, enhance and smooth the image.

Keywords: Homomorphic filter, Anisotropic filter, Wavelet Filter, Bilateral Filter

I. INTRODUCTION

In order to deal with under water images, we have to consider first of all the light propagation in the water medium. Under water images are essentially characterized by their poor visibility because light is exponentially attenuated as it travels in the water and the scenes result poorly contrasted and hazy. Light attenuation limits the visibility distance at about twenty meters in clear water and five meters or less in dirty water. The light attenuation process is caused by absorption (which removes light energy) and scattering (which changes the direction of light path).the absorption and scattering processes of the light in water influence the overall performance of underwater imaging systems. Forward scattering (randomly deviated light on its way from an object to the camera) generally leads to blurring of the image features. Backward scattering (the fraction of the light reflected by the water towards the camera before it actually reaches the objects in the scene) generally limits the contrast of the images, generating a characteristic veil that super imposes itself on the image and hides the scene. Absorption and scattering effects components such as dissolved organic matter or small observable floating particles. The presence of the floating particles known as “marine snow” (highly variable in kind and concentration) increase absorption and scattering effects. Finally, as the amount of light is reduced when we go deeper, color drop off one by one depending on their wavelengths. In summary, the images we are interested on can suffer of one or more of the following problems: limited range visibility, low contrast, non uniform lighting, blurring, bright artifacts, color diminished (bluish appearance) and noise. Underwater sea images needs to be preprocessed due to lower quality of sea water images.



Water Surface Effects

II. ENHANCEMENT TECHNIQUES

In this section, we present filters are employed sequentially on degraded images.

Homomorphic filtering

Homomorphic filtering is one such technique for removing multiplicative noise that has certain characteristics. It is most commonly used for correcting non-uniform illumination in images. The illumination-reflectance model of image formation says that the intensity at any pixel, which is the amount of light reflected by a point on the object, is the product of the illumination of the scene and the reflectance of the object(s) in the scene, i.e.,

$I(x,y)=L(x,y)\,R(x,y)$

Where I is the image, L is scene illumination, and R is the scene reflectance. Reflectance R arises from the properties of the scene objects themselves, but illumination L results from the lighting conditions at the time of image capture. To compensate for the non-uniform illumination, the key is to remove the illumination component L and keep only the reflectance component R. If we consider illumination as the noise signal (which we want to remove), this model is similar to the multiplicative noise model shown earlier.

Illumination typically varies slowly across the image as compared to reflectance which can change quite abruptly at object edges. This difference is the key to separating out the illumination component from the reflectance component. In homomorphic filtering we first transform the multiplicative components to additive components by moving to the log domain.

$\ln(I(x,y))=\ln(L(x,y)\,R(x,y))$

$\ln(I(x,y))=\ln(L(x,y))+\ln(R(x,y))$

Then we use a high-pass filter in the log domain to remove the low-frequency illumination component while preserving the high-frequency reflectance component. The basic steps in homomorphic filtering are shown in the diagram below:

Homomorphic Filtering

Anisotropic filtering

Anistropic filtering simplifies image features to improve image segmentation. This filter smoothes the images in homogenous area but preserves edges and enhances them. It is used to smooth textures and reduce artifacts by deleting small edges amplified by homomorphic filtering. The previous step of denoising is very important to obtain good results with anisotropic filtering. It is association of wavelet denoising and anisotropic filtering which gives such results. Anisotropic algorithm is usually used as long as result is not satisfactory. Perona and Mailk anistropic diffusion can b applied to radar and medical ultra sound images, underwater images.

Wavelet filtering

Wavelet filter is also used to suppress the noise i.e. the Gaussian noise are naturally present in the camera images and other type of instrument images. While transferring the images Gaussian noise can be added. This wavelet denoising gives very good results compared to other denoising methods because, unlike other methods, it does not assume that the co efficient is independent. Thersholding is a simple non-linear technique; which operates on one wavelet co efficient at a time. In its most basic form, each coefficient is thresholded by comparing against is thersholded, if the coefficient is smaller than threshold, set to zero; otherwise it is kept or modified . Replacing the small noisy coefficients by zero and inverse wavelet transform on the result may lead to reconstruction with the essential signal characteristics and it's the less. A simple denoising algorithm that uses the wavelet transforms consist of the following three steps,

(1) Calculate the wavelet transform of the noisy signal
(2) Modify the noisy detail wavelet coefficients according to some rule
(3) Compute the inverse transform using the modified coefficients.

Bilateral filtering

A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter for images. The intensity value at each pixel in an image is replaced by a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. Crucially, the weights depend not only on Euclidean distance of pixels, but also on the radiometric differences (e.g. range differences, such as color intensity, depth distance, etc.). This preserves sharp edges by systematically looping through each pixel and adjusting weights to the adjacent pixels accordingly.

The bilateral filter is defined as

$$I^{\text{filtered}}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) f_r(\|I(x_i) - I(x)\|) g_s(\|x_i - x\|),$$

where the normalization term

$$W_p = \sum_{x_i \in \Omega} f_r(\|I(x_i) - I(x)\|) g_s(\|x_i - x\|)$$

Ensures that the filter preserves image energy and

- I^{filtered} is the filtered image;
- I is the original input image to be filtered;
- x are the coordinates of the current pixel to be filtered;
- Ω is the window centered in x;
- f_r is the range kernel for smoothing differences in intensities. This function can be a Gaussian function;
- g_s is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function;

As mentioned above, the weight W_p is assigned using the spatial closeness and the intensity difference.[1] Consider a pixel located at (i, j) which needs to be denoised in image using its neighboring pixels and one of its neighboring pixels is located at (k, l). Then, the weight assigned for pixel (k, l) to denoise the pixel (i, j) is given by: $w(i, j, k, l) = e^{\left(-\frac{(i-k)^2+(j-l)^2}{2\sigma_d^2} - \frac{\|I(i,j)-I(k,l)\|^2}{2\sigma_r^2}\right)}$

where σ_d and σ_r are smoothing parameters and I(i, j) and I(k, l) are the intensity of pixels (i, j) and (k, l) respectively. After calculating the weights, normalize them.

$$I_D(i, j) = \frac{\sum_{k,l} I(k, l) * w(i, j, k, l)}{\sum_{k,l} w(i, j, k, l)}$$

where I_D is the denoised intensity of pixel (i, j).

III. CONCLUSION

The literature survey reveals that image based preprocessing algorithms uses standard filter techniques with various combinations. For smoothing the image, the image based preprocessing algorithms uses the anisotropic filter. The main drawback of the anisotropic filter is that iterative in nature and computation time is high compared to bilateral filter. In addition to other three filters, we employ a bilateral filter for smoothing the image. This paper concludes with the certain limitation of existing techniques. The future work will include further evaluation of the enhancement techniques.

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