**Project number:** 1.1.1.2/VIAA/2/18/348

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**Position:** Researcher

**Project title:** The Study of Computer Vision Algorithms for Underwater Fish Inspection

### Visibility problems and underwater image enhancement methods:

Image preprocessing can greatly increase the reliability of an optical image. In this part, we describe recent methods of denoising and enhancement of underwater optical images.

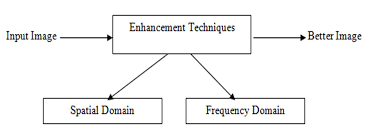
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Enhancing image quality involves improving the visual perception of the signal by transforming its components while avoiding generating artifacts or amplifying existing defects and distortions.

Most often, this operation is accompanied by some undesirable effects such as amplification of the noise or the saturation effect in certain sensitive areas in the case of contrast enhancement. Eliminating noise or reducing artifacts such as block effects in JPEG-compressed images inevitably cause blurring and degrade image quality. It is therefore important to control and think about these unpredictable effects in the design of image quality enhancement methods.

Generally, image enhancement can be done in:

* Special domain
* Frequency domain

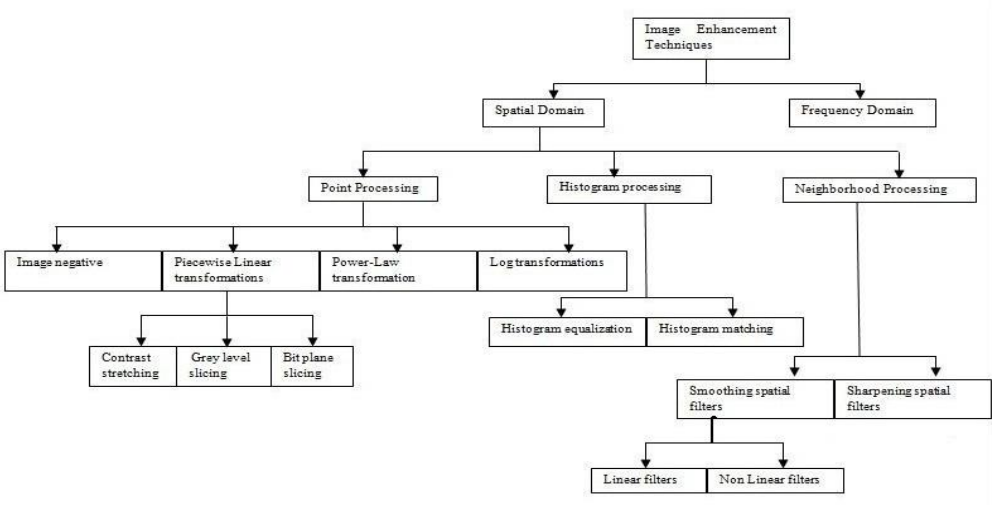


**Frequency domain:**

example: low/ high pass filter, pseudo color image processing, homomorphing filter.

**Spatial domain** transformation are:

* Point processing
* Histogram processing
* Neighborhood processing



Different optimization criteria will be chosen, depending on the use or the subsequent processing of the image, as well as the knowledge that one can have a priori of this image.

Degradations suffered by an image can be caused by different phenomena (measurement noise, camera shake ...). The restoration algorithms will differ according to the type of degradation observed, in particular depending on the system chosen to model the degradation. This model can be simply the addition of a noise (measurement noise, or transmission noise), or the convolution of the original image with a function representing the degradation. This function can model a variety of impairments such as camera shake, defocus or diffraction of the camera, and so on. It is usually referred to in the "Point Spread Function" (PSF) [1].

As follows recent image enhancement methods underwater in the litterature, we distinguish two big classes:

* Non-model-based methods
* Prior based methods

**Non-model-based methods :**

|  |  |
| --- | --- |
| **Method** | **Enhancement technique** |
| UCM[2] | Unsupervised color balance and histogram stretching |
| MSRCR[3] | Multiscale retinex with color restoration |
| CLAHE[4] | Contrast-limited adaptive histogram equalization |
| CLAHE-MIX[5] | Mixture RGB and HSV CLAHE |
| Fusion[6] | White Balance, bilateral filtering, image fusion |
| Ghani[7] | minimizes under-enhanced and over-enhanced areas |
| **Prior-based methods** | |
| **Method** | **Physical prior** |
| BP[8] | Radiance attenuation |
| P.Drews-Jr[9] | Underwater DCP on g,b |
| UHP[10] | Color distribution |
| ENOM[11] | Underwater DCP |
| Li[12] | Underwater DCP |
| LDP[13] | Histogram distribution prior |
| Peng [14] | Blurriness& Light Absorption |
| WCID[15] | Residual energy ratios |
| Galdran[16] | Red channel prior |
| Lu[17] | UDCP with median filter |
| Li[18] | UDCP with median filter |
| Yang[19] | UDCP with median filter |
| DPATN[20] | Learning-based UDCP |

**Discussion:**

Unlike conventional natural images taken in the open air, underwater images are characterized by a strong dominance of bluish and greenish colors. Moreover, the strong light attenuation in the water and a high diffusion of the incident light have the consequence of considerably reducing the visibility. Thus, objects at long distance from the acquisition system are hardly visible and poorly contrasted in relation to their environment, but also at medium distances, or even relatively short in some cases. In addition, in the presence of particles suspended in water (sand, plankton, algae, ...), the incident light is reflected by these particles and forms a kind of inhomogeneous mist that adds to the observed scene. This turbidity of the water, most often white, also affects the visibility but also the color dynamics of the objects contained in the image by tarnishing or veiling them. On the other hand, the formation of an underwater image is highly dependent on the nature of the water in which it was acquired. Natural waters can have very varied constitutions in terms of plants or minerals dissolved or suspended in water. The behavior of the propagation of light in such a medium is strongly governed by this factor.

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