Chapter 6

Image Enhancement and Restoration Methods for Underwater Images

C. J. Prabhakar
Kuvempu University, India

P. U. Praveen Kumar
Kuvempu University, India

ABSTRACT

In this chapter, the authors provide an overview of state-of-the-art image enhancement and restoration techniques for underwater images. Underwater imaging is one of the challenging tasks in the field of image processing and computer vision. Usually, underwater images suffer from non-uniform lighting, low contrast, diminished color, and blurring due to attenuation and scattering of light in the underwater environment. It is necessary to preprocess these images before applying computer vision techniques. Over the last few decades, many researchers have developed various image enhancement and restoration algorithms for enhancing the quality of images captured in underwater environments. The authors introduce a brief survey on image enhancement and restoration algorithms for underwater images. At the end of the chapter, we present an overview of our approach, which is well accepted by the image processing community to enhance the quality of underwater images. Our technique consists of filtering techniques such as homomorphic filtering, wavelet-based image denoising, bilateral filtering, and contrast equalization, which are applied sequentially. The proposed method increases better image visualization of objects which are captured in underwater environment compared to other existing methods.

INTRODUCTION

Underwater 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 turbid water. The light attenuation process is caused by absorption (which removes light energy) and scattering (which changes the direction of the 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. On the other hand, 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 superimposes itself on the image and hides the scene.

Absorption and scattering effects are not only due to the water itself but also to other 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 of and concentration) increase absorption and scattering effects. The visibility range can be increased with artificial lighting but these sources not only suffer from the difficulties described before (scattering and absorption), but in addition tend to illuminate the scene in a non uniform fashion, producing a bright spot in the center of the image with a poorly illuminated area surrounding it. Finally, as the amount of light is reduced when go deeper; colors drop off one by one depending on their wavelengths.

The most commonly used imaging systems for underwater environment are optical imaging system, SONARs and LIDARs. Optical imaging is cost effective compared to SONARs and LIDARs, but there are some limitations of using the optical imaging system as it provides a limited range of visibility compared to SONARs and LIDARs. The range is visibility of optical imaging for clear water is up to 20 meters, and in turbid water, it is less than 5 meters. And the captured underwater images suffer from non-uniform lighting, low contrast, blurring, and diminished colors due to propagation properties of light in underwater environment. These images cannot be directly employed for applying computer vision and pattern recognition techniques. There has been a great effort from the last few years to improve the quality of underwater images and many methods have been derived to fulfill the task. The processing of underwater images can be addressed from two different points of view: as an image restoration technique or as an image enhancement method. The image restoration aims to recover a degraded image using a model of the degradation and of the original image formation; it is essentially an inverse problem. These methods are rigorous, but they require many model parameters (like attenuation and diffusion coefficients that characterize the water turbidity).

Some of the image restoration methods have been proposed in the literature based on the physical model that describes the light propagation in water. These approaches consider behavior of light propagation and its interaction with the water medium. The constructed physical model is used to estimate this model's parameters in order to minimize the effects on image formation and to correct image intensity distribution. The literature survey reveals that popular image enhancement techniques have been proposed for enhancement of degraded underwater images and for color correction of the image. Image enhancement technique uses qualitative subjective criteria to produce a more visually pleasing image, and they do not rely on any physical model for the image formation. These kinds of approaches are usually simpler and faster than deconvolution methods.

In the last few years, different methods for image quality assessment have been proposed. Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE) are the most widely used objective image quality/distortion metrics. In the last decades, however, a great effort has been made to develop new objective image quality assessment methods which incorporate perceptual quality measures by considering human visual system characteristics.

APPLICATIONS

Underwater imaging is widely used in the field of scientific research and technology. Computer vision methods are being used in this mode of imaging for various applications, such as mine

16 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:
www.igi-global.com/chapter/image-enhancement-and-restoration-methods-for-underwater-images/79722

Related Content

Human Face Region Detection Driving Activity Recognition in Video
Anastasios Doulamis, Athanasios Voulodimosand Theodora Varvarigou (2018). *Computer Vision: Concepts, Methodologies, Tools, and Applications (pp. 2102-2123).*
www.irma-international.org/chapter/human-face-region-detection-driving-activity-recognition-in-video/197043

Individual Differences Among Users: Implications for the Design of 3D Medical Visualizations
Madeleine Keehner, Peter Khooshabehand Mary Hegarty (2008). *User Centered Design for Medical Visualization (pp. 1-24).*
www.irma-international.org/chapter/individual-differences-among-users/30622

Reversible Data Hiding Based on Statistical Correlation of Blocked Sub-Sampled Image
Mona Nafari, Mansour Nejati Jahromiand Gholam Hosein Sheisi (2012). *International Journal of Computer Vision and Image Processing (pp. 42-59).*
www.irma-international.org/article/reversible-data-hiding-based-statistical/68003

Electromyogram and Inertial Sensor Signal Processing in Locomotion and Transition Classification
Deepak Joshiand Michael E. Hahn (2017). *Computational Tools and Techniques for Biomedical Signal Processing (pp. 195-211).*
www.irma-international.org/chapter/electromyogram-and-inertial-sensor-signal-processing-in-locomotion-and-transition-classification/162866

Foreign Circular Element Detection in Chest X-Rays for Effective Automated Pulmonary Abnormality Screening
Fatema Tuz Zohoraand K.C. Santosh (2017). *International Journal of Computer Vision and Image Processing (pp. 36-49).*
www.irma-international.org/article/foreign-circular-element-detection-in-chest-x-rays-for-effective-automated-pulmonary-abnormality-screening/183659