5-2015

Ambiguity of Underwater Color Measurement and Color-based Habitat Classification

Yuri Rzhanov
University of New Hampshire, Durham, Yuri.Rzhanov@unh.edu

Shachak Pe'eri
University of New Hampshire, Durham, shachak.peeri@unh.edu

A. Shashkov
Klaipeda University

Ambiguity of underwater color measurement and color-based habitat classification

Y. Rzhanov[1], S. Pe'eri[1], A. Shashkov[2]

[1] University of New Hampshire, Durham, NH, 03824, USA
[2] Klaipeda University, Klaipeda, LT 92294, Lithuania
email: yuri.rzhanov@unh.edu

Summary

The paper discusses ambiguities in recording color underwater. Routinely collected RGB imagery can be used for classification and recognition utilizing the proposed probabilistic approach. The device for collection of spectral signatures, necessary for this approach is described.

Introduction

Color is probably the most informative cue for classification of facies and habitats using underwater imagery. It carries a wealth of useful information– from health of vegetation to identification of debris. However, attempts to use color directly were not very successful. In previous work we have tried to assign specific palettes of colors to corresponding micro-habitats and to estimate their percentages of coverage on photo mosaics constructed from HD footage collected from an ROV. This approach worked reasonably well, but the key factors of success were constant ROV altitude and flatness of the seafloor. Each set of mosaics requires manual selection of different palette. Thus, light absorption in the water column remained a constant, albeit unknown factor. Similar approach in a setup where imagery had significant range of depths failed dramatically.

To demonstrate ambiguity in reconstruction of a "true" (in-air) color from underwater measurement a numerical experiment has been conducted. Color forming process is nonlinear and involves integration over visible spectrum of the product of functions describing spectral dependencies of a light source, object of interest (OOI) reflectivity, light absorption in the medium, and camera sensitivity function. Certain spectral signature for the observed object was chosen, and then trichromatic color at known distance in water with given properties was calculated. To prove existence of ambiguity it is sufficient to find another spectral signature which leads to different "true" (in-air) color and exactly the same color recorded underwater (with the same imaging range, and camera and water properties). These signatures could be found only in numerical experiment, using optimization in 9-dimensional parameter space. Monte Carlo search for distribution of "true" colors appearing similarly underwater leads to an example shown in Figure 1 (in CIE L*a*b* color space, with L omitted). An underwater observation marked with a red cross may be a result of any of the infinite number of spectral signatures leading for in-air measurements to colors depicted as black dots in the chart.

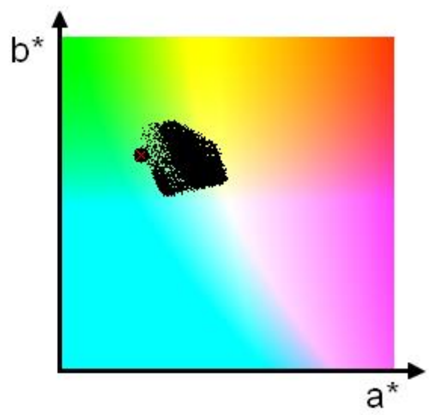

Fig. 1. Distribution of a*b* components of colors leading to the same color recorded by a sensor underwater.

Discussion

The best way to classify an underwater scene would be to acquire spectral signatures on a regular spatial grid of points. Each point can then be classified and thus an OOI distribution map would be produced. This is, however, difficult, as snapshot hyperspectral imagers are not commercially available. In this paper we report about the approach allowing to classify RGB imagery routinely collected underwater. This approach requires spectral information about the OOI, source of illumination (ambient or artificial), light absorption in water, and sensor response. Camera and light source properties are calibrated in the laboratory conditions. Ambient light and water properties are measured *in situ*. Spectral signatures of expected types of OOI are collected in advance *in situ* too and constitute the reusable catalogue. As it was shown above, 100% reliable reconstruction of the “true” color for each pixel of the imagery is not possible. However, it is possible to estimate a probability of a pixel to depict certain class of OOI. In many cases it is sufficient to build an informative classification map.

The specialized device, Underwater Recorder Of Spectral Signatures (UROSS) has been designed and built. In functionality it is similar to UWSS04 described in [1], but serves a different purpose. UROSS is diver-oriented, and is certified for depths up to 20 meters. A unique white broadband LED is used as a calibrated light source and reflected light is recorded by a miniature spectrometer. Light in both directions travels through a custom-made bifurcated fiber-optic cable. Low-range RGB camera is used to take an image of the object prior to taking spectral signature (for documentation purposes). Data acquisition and storage is done by a mini computer. The operating diver has access to a limited number of controls – to power up and down, to acquire spectral signature, to trigger the camera, etc.

The paper describes the results of preliminary testing of UROSS.

References

[1] C. Roelfsema *et.al., Underwater Spectrometer System 2006 (UWSS04)*, Centre for Remote Sensing and Spatial Information Science for The University of Queensland, 2006.