Calibration of the Undersea Camera Array for 3D Stereo Reconstruction

Timothy Yau and Herb Yang, Dept of Computing Science, University of Alberta

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The use of stereo images to extract 3D information from a scene has been widely studied and continues to be an active area of research. State of the art algorithms in multi-view stereo are able to achieve sub-millimeter accuracy on standard benchmarks. However, much less attention has been paid to the problem of achieving similar accuracy in underwater environments, where the refraction of light as it passes through different media produces distortions in the image captured by the camera. While stereo algorithms have been directly applied to underwater images with reasonable success, recent research efforts have aimed to improve these results through the explicit modeling of refraction.

In this talk we describe our work in underwater camera calibration, in which the optical properties of a camera and its watertight housing are incorporated into a physically-correct refraction model, and the parameters of this model are estimated to compensate for image distortions due to refraction. We introduce a new method that exploits the wavelength-dependent nature of refraction, using a unique device that emits a calibration pattern consisting of two different wavelengths. Our experiments show that it allows the model parameters to be estimated more accurately compared to existing methods. To analyze the impact of using a physically-correct refraction model on 3D reconstruction accuracy, we present synthetic-data results under various scene and camera configurations. Lastly, we outline our current work on adapting existing stereo algorithms for underwater camera arrays, such as the system installed on NEPTUNE's Folger Pinnacle platform.